Abstract Book

19th International Symposium on Novel and Nano Materials and the Europe-Korea Advanced Materials and Processing Conference

ISNNM&EKAMP 2026

July 12-17, 2026 / German Hygiene Museum & Fraunhofer Institute, Dresden, Germany

kpmi
Korean Powder Metallurgy & Materials Institute

Abstract Book

19th International Symposium on Novel and Nano Materials and the Europe-Korea Advanced Materials and Processing Conference

ISNNM&EKAMP 2026

July 12-17, 2026 / German Hygiene Museum & Fraunhofer Institute, Dresden, Germany

■ **Date:** July 12-17, 2026

■ **Venue:** German Hygiene Museum & Fraunhofer Institute, Dresden, Germany

■ **Organized by**

kpmi Korean Powder Metallurgy & Materials Institute

■ **Supported by**

KEIT Fraunhofer Fraunhofer IFAM (Dresden Branch of the Institute), Fraunhofer IKTS, Fraunhofer IWS, Fraunhofer FEP

■ **Sponsored by**

Höganäs ASFLOW MTIG Material Technical Innovation Group BKAMSOL 비케이엠솔

KPM Korea Powder Metallurgy Co., Ltd. DIF (주)동양아이에프 EML Eloi MaterialS MK

Table of Contents

Welcome to the ISNNM&EKAMP 2026

It is a great pleasure and a privilege to announce the 19th International Symposium on Novel and Nano Materials (ISNNM) and the Europe-Korea Advanced Materials and Processing Conference (EKAMP), which will be held in Dresden (Germany), 12-17 July 2026.

ISNNM-EKAMP 2026 offers a high-quality scientific program that explores the latest scientific and technological developments in novel/nano materials and bridges diverse knowledge domains under the main topic of ***Challenges and Collaboration in Advanced Materials for the Future***

ISNNM 2026 will cover all areas of the novel and nano materials research, such as Advanced Materials Processing, Advanced Powder Metallurgy, Additive Manufacturing and Printing Technology, Computer-aided Materials Engineering, Energy and Environmental Materials, Electric and Magnetic Materials, Rare Metals and Recycling, Refractory Metals and Hard Materials, and Nanoceramics. Additionally, **EKAMP** conference will provide the latest research results and cutting-edge materials technology in Korea and Germany in collaboration with Fraunhofer IFAM.

ISNNM-EKAMP 2026 will be held in Dresden, a beautiful city where Baroque beauty meets modern flair, hosted by Fraunhofer IFAM. We encourage the participation of students, researchers, engineers, technicians, industrial partners and all people interested in the advancement and development of materials and to share their knowledge and experience to achieve a successful event. Registration and contributions for the ISNNM and EKAMP 2026 in the form of oral or poster presentations are warmly invited and are open to all.

We look forward to seeing you in Dresden in July 2026.

On behalf of the Scientific Committee

Dr. Chang Kyu Rhee

Prof. Dr. Kee-Ahn Lee

Prof. Dr. Thomas Weißgärber

Prof. Dr. Herbert Danninger

Chairs of The International Symposium on Novel and Nano Materials (ISNNM) and the Europe-Korea Advanced Materials and Processing Conference (EKAMP)

Program Overview

<table>
<tr><th colspan="5">7/12(Sun)</th></tr>
<tr><td>15:00~17:00</td><td colspan="4">Registration</td></tr>
<tr><th colspan="5">7/13(Mon)</th></tr>
<tr><th>Room</th><th>Meeting Room 2&3</th><th>Marta-Fraenkel-Saal</th><th>Meeting Room 9.2</th><th>Meeting Room 5</th></tr>
<tr><td>09:00~09:10</td><td rowspan="10"></td><td colspan="3">Opening Ceremony
Opening address by Dr. Chang Kyu Rhee, Dr. Minha Jung, Prof. Hyoung Seop Kim and Prof. Dr. Thomas Weißgärber</td></tr>
<tr><td>09:10~10:00</td><td colspan="3">Plenary Lecture 1 (Prof. Dr. Jürgen Brillo)</td></tr>
<tr><td>10:00~10:10</td><td colspan="3">Coffee Break</td></tr>
<tr><td>10:10~11:10</td><td colspan="3">Keynote Lecture 1 & 2 (Prof. Dr. Christoph Leyens and Prof. Dr. Elizabeth von Hauff)</td></tr>
<tr><td>11:10~12:10</td><td colspan="3">Keynote Lecture 3 & 4 (Dr. Georg Pöhle and Prof. Dr. Martin Gräbner)</td></tr>
<tr><td>12:10~13:10</td><td colspan="3">Lunch (KEIT Sponsored Luncheon)</td></tr>
<tr><td>13:10~13:40</td><td colspan="3">Keynote Lecture 5 (Prof. Dr. Rajarshi Banerjee)</td></tr>
<tr><td>13:50~15:10</td><td colspan="3">KEIT-Supply Chain and Resources
Special Lecture 1 & 2 (Dr. Minha Jung and Dr. Tae-Young Han)</td></tr>
<tr><td>15:20~16:00</td><td rowspan="2">(15:20~17:20)
EKAMP: Life Science</td><td>(15:20~16:20)
ISNNM: Critical Materials and Sustainability</td><td rowspan="2">(15:20~17:40)
EKAMP: Environmental Technology</td></tr>
<tr><td>16:00~17:20</td><td>(16:25~17:10)
ISNNM: MPPM 1</td></tr>
<tr><td>15:00~17:00</td><td colspan="4">Poster 1 (EMM, RMR, MPPM) P01~P35, Meeting Room 2 & 3</td></tr>
<tr><td>19:00~</td><td></td><td colspan="3">Friendship Dinner
(Restaurant Lingnerterrassen)</td></tr>
<tr><th colspan="5">7/14(Tue)</th></tr>
<tr><th>Room</th><th>Meeting Room 2&3</th><th>Marta-Fraenkel-Saal</th><th>Meeting Room 9.2</th><th>Meeting Room 5</th></tr>
<tr><td>09:10~10:00</td><td rowspan="9"></td><td colspan="3">Plenary Lecture 2 (Prof. Dr. Herbert Danninger)</td></tr>
<tr><td>10:00~10:50</td><td colspan="3">Plenary Lecture 3 (Prof. Dr. Thomas Weißgärber)</td></tr>
<tr><td>10:50~11:10</td><td colspan="3">Coffee Break</td></tr>
<tr><td>11:10~12:00</td><td colspan="3">Plenary Lecture 4 (Prof. Dr. Hyoung Seop Kim)</td></tr>
<tr><td>12:10~13:10</td><td colspan="3">Lunch</td></tr>
<tr><td>13:10~14:00</td><td>(13:10~14:30)
EKAMP: Aerospace Applications 1</td><td rowspan="2">(13:10~14:50)
ISNNM: Nanomaterial-Based Next-Generation Energy</td><td>(13:10~14:30)
ISNNM: AI and Simulation Based Novel Catalytic Materials Design</td></tr>
<tr><td>14:00~15:00</td><td rowspan="2">(14:40~16:00)
EKAMP: Aerospace Applications 2</td><td rowspan="2">(14:40~16:05)
ISNNM: CME</td></tr>
<tr><td>15:00~16:00</td><td rowspan="2">(15:00~16:35)
ISNNM: EEM</td></tr>
<tr><td>16:00~17:30</td><td>(16:10~17:30)
ISNNM: MPPM 2
Keynote Lecture 6
(M.Sc. Yuanbin Deng)</td><td>(16:20~17:20)
ISNNM: RCM</td></tr>
<tr><td>15:00~17:00</td><td colspan="4">Poster 2 (AMT, CME, EEM, RCM) P36~P70, Meeting Room 2 & 3</td></tr>
</table>

Program Overview

<table>
<tr><th colspan="5">7/15(Wed)</th></tr>
<tr><th>Room</th><th>Meeting Room 2&3</th><th>Marta-Fraenkel-Saal</th><th>Meeting Room 9.2</th><th>Meeting Room 5</th></tr>
<tr><td>09:10~10:00</td><td rowspan="8"></td><td colspan="3">Plenary Lecture 5 (Prof. Dr. Paweł Zięba)</td></tr>
<tr><td>10:00~10:10</td><td colspan="3">Coffee Break</td></tr>
<tr><td>10:10~11:10</td><td colspan="3">Keynote Lecture 7 & 8 (Prof. Dr. Soon-Jik Hong and Prof. Dr. Seung Ki Moon</td></tr>
<tr><td>11:10~12:10</td><td colspan="3">Keynote Lecture 9 & 10 (Dr. Peter Tatarko and Prof. Dr. Min-Kyu Paek)</td></tr>
<tr><td>12:10~13:10</td><td colspan="3">Lunch</td></tr>
<tr><td>13:10~14:00</td><td rowspan="3">(13:10~14:50)
EKAMP: Energy-Battery Technologies</td><td rowspan="2">(13:10~15:05)
ISNNM: Next-Generation Magnetic Materials
Keynote Lecture 11 &12
(Prof. Edi Suharyadi and Dr. Jung Goo Lee)</td><td>(13:30~14:10)
ISNNM: Additive Manufacturing of Advanced Materials</td></tr>
<tr><td>14:00~15:00</td><td rowspan="2">(14:20~16:10)
ISNNM: AMT</td></tr>
<tr><td>15:00~16:00</td><td rowspan="2">(15:00~17:00)
ISNNM: MPPM 3</td><td>(15:20~16:00)
ISNNM: Industrial Application</td></tr>
<tr><td>16:00~17:20</td><td>(16:30~17:00)
ISNNM: RMR</td><td></td></tr>
<tr><td>18:30~</td><td colspan="4">Gala Dinner
(Ballhaus Watzke)</td></tr>
<tr><th colspan="5">7/16(Thu)</th></tr>
<tr><th>Venue</th><th colspan="4">Fraunhofer Institutes in Dresden</th></tr>
<tr><td>10:00~12:00</td><td colspan="4">Institute Introduction (IFAM, IWS, IKTS, FEP)</td></tr>
<tr><td>12:00~14:50</td><td colspan="4">Guided Lab Tour</td></tr>
<tr><th colspan="5">7/17(Fri)</th></tr>
<tr><td>09:00~17:00</td><td colspan="4">Panel Discussion & Technical Tour</td></tr>
</table>

Oral Presentation *(Marta-Fraenkel-Saal)* Monday, July 13

▸ Opening Ceremony

09:00-09:10 **Opening Ceremony**
Opening address
by Dr. Chang Kyu Rhee, Dr. Minha Jung, Prof. Hyoung Seop Kim and Prof. Dr. Thomas Weißgärber

▸ Plenary & Keynote Lecture

Chair: Dr. Jung Goo Lee (Korea Institute of Materials Science)

09:10-10:00 **Plenary Lecture 1**
Thermophysical properties of liquid Al-Ti-V alloys
Jürgen Brillo[1*], Benedikt Reiplinger[2]
[1]Institute for Frontier Materials on Earth and in Space, German Aerospace Center (DLR), Cologne, Germany)

10:00-10:10 Coffee Break

Chair: Prof. Soon-Jik Hong (Kongju National University), Dr. Thomas Stunitzky (Fraunhofer IFAM)

10:10-10:40 **Keynote Lecture 1**
Innovative Aerospace and Space Structures made by Additive Manufacturing
Christoph Leyens
Fraunhofer Institute for Material and Beam Technology IWS

10:40-11:10 **Keynote Lecture 2**
Advanced Plasma and Electron Beam Processing for Next-Generation Clean-Energy Technologies
Elizabeth von Hauff
[1]Fraunhofer Institute for Electron Beam and Plasma Technology FEP (Dresden, Germany)
[2]TU Dresden (Electrical and Computer Engineering, Dresden, Germany)

11:10-11:40 **Keynote Lecture 3**
Resorbable metallic materials: The key to the next generation of advanced medical implants
Georg Poehle[1*], Christian Redlich[1], Thomas Weissgaerber[1,6], Tom Schroeder[2], Lysann Kroschwald[2], *Guenter Lauer[2], Michael Wagner[3], Maria-Elisa Prieto Jarabo[3], Sems-Malte Tugtekin[3], Utz Kappert[3], Axel Linke[3], Antje Schauer[4], Volker Adams[4], Ali El-Armouche[4] and Peter Quadbeck[5]*
[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany, [2]Department of Oral and Maxillofacial Surgery, University Hospital Carl Gustav Carus, TUD Dresden University of Technology, Dresden, Germany, [3]Clinic for Internal Medicine and Cardiology, Heart Center Dresden, TUD Dresden University of Technology, Dresden, Germany, [4]TUD Dresden University of Technology, Dresden, Germany, [5]Department of Electrical Engineering, Medical Engineering and Computer Science, Offenburg University of Applied Sciences, Offenburg, Germany, [6]Chair of Powder Metallurgy, Institute of Materials Science, TUD Dresden University of Technology, Dresden, Germany

Oral Presentation *(Marta-Fraenkel-Saal)* Monday, July 13

11:40-12:10 **Keynote Lecture 4**

Circular Carbon Technologies – The Potential of Pyrolysis and Gasification in Chemical Recycling

Martin Gräbner*, Jörg Kleeberg

Fraunhofer Institute of Ceramic Technologies and Systems IKTS, Füchsmühlenweg 9D, 09599 Freiberg, Germany

12:10-13:10 **Lunch**

Chair: Prof. Ho Jin Ryu (KAIST)

13:30-13:40 **Keynote Lecture 5**

Solid State Phase Separation and Precipitation During Additive Manufacturing of Metallic Alloys

Rajarshi Banerjee

Department of Materials Science and Engineering and Center for Agile and Adaptive Additive Manufacturing, University of North Texas, Denton, TX, 76207, USA

13:40-14:50 Break

▸ KEIT-Supply Chain and Resources

Chair: Prof. Dr. Min-Kyu Paek (TU Clausthal)

13:50-14:10 **KEIT-Supply Chain and Resources (Special Lecture 1)**

Materials R&D Investment and Global Partnership in Korea

Minha Jung*, Ji In Jung, Dong Geon Ju and Yoon Young Chang

Korea Planning & Evaluation Institute of Industrial Technology (KEIT), 32, Cheomdan-Ro 8-Gil, Dong-Gu, Daegu 41069, Republic of Korea

14:10-14:30 **KEIT-Supply Chain and Resources (Special Lecture 2)**

The Cooperation Equation: The Role of Interfacialists in Advancing Korea–Germany Global Collaborative R&D through K-FAST

Taeyoung Han

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany

14:30-14:50 **KEIT-Supply Chain and Resources (Invited 1)**

Enhancing Public Technology Commercialization Support Systems and International Cooperation: Focusing on Joint TLO Operations and Government Program Linkages

Kyung Won Seo

CODA. Co., Ltd(30, Gangnam-Daero 78-Gil, Gangnam-Gu, Seoul, Republic of Korea, 06243)

14:50-15:10 **KEIT-Supply Chain and Resources (Invited 2)**

Development of an Integrated Urban Turquoise Hydrogen via Advanced Biogas Purification, Adsorption Storage, and Microwave-Catalytic Decomposition

Chul Ho Park[1,2]

[1]Korea Institute of Energy Research (Jeju Center, Hemajihean-ro, 200, 63357, South Korea), [2]University of Science and Technology (Gajeong-ro, Yuseong-gu, Daejeon, 217, 34113, South Korea)

Oral Presentation *(Marta-Fraenkel-Saal)* Monday, July 13

▸ EKAMP: Life Science

Chair: Dr. Burkhard Zimmermann (Fraunhofer FEP)

15:20-15:40 **EKAMP: Life Science (Invited 1)**

Microphysiological Systems – Engineering and Applications

J. Golde[1,2], C. Dittfeld[3], A. Starcke[1], F. Schmieder[1] and F. Sonntag[1*]

[1]Fraunhofer Institute for Material and Beam Technology IWS, Dresden, Germany, [2]Westsächsische Hochschule Zwickau WHZ, Zwickau, Germany, [3]Department of Cardiac Surgery, Faculty of Medicine and University Hospital Carl Gustav Carus, TU Dresden, Heart Centre Dresden, Germany

15:40-16:00 **EKAMP: Life Science (Invited 2)**

Electron Beam-Driven Engineering for Functional Materials in Life Sciences

N. Gürtler, U. König[*]

Biocompatible Materials, Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany

16:00-16:20 **EKAMP: Life Science (Invited 3)**

Pioneering the Future of Nuclear Energy: Advanced Manufacturing & Material Engineering

Suk Hoon Kang[1*], Joowon Suh[1], Wonjong Jeong[2], Seungmun Jung[1] and Ho Jin Ryu[3]

[1]Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea, [2] Korea Institute of Machinery and Materials, Busan, 46744, Republic of Korea, [3]Korea Advanced Institute of Science and Technology, Daejeon, 34141, Republic of Korea

16:20-16:40 **EKAMP: Life Science (Invited 4)**

Cold Sintering processes in application for biomaterials and biomedical devices

A. Sharipova[*], M. Fritsch, and M. Ahlhelm

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany

16:40-17:00 **EKAMP: Life Science (Invited 5)**

Metal fiber structures for implants – the perfect match between strong and soft

Christian Redlich[1*], Georg Pöhle[1], Thomas Weissgaerber[1,5], Ulrike Jehring[1], Cris Kostmann[1], Olaf Andersen[1], Matthias Rüger[2], Ansgar Petersen[3], Peter Quadbeck[4]

[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Branch Lab Dresden, Germany, [2]Department of Paediatric Orthopedics and Traumatology, University Children´s Hospital Zurich, Switzerland, [3]Berlin Institute of Health at Charité (BIH), BIH Center for Regenerative Therapies (BCRT) and Julius Wolff Institute (JWI), Berlin, Germany, [4]Department of Electrical Engineering, Medical Engineering and Computer Science, Offenburg University of Applied Sciences, Offenburg, Germany, [5]Chair of Powder Metallurgy, Institute of Materials Science, TUD Dresden University of Technology, Dresden, Germany

17:00-17:20 **EKAMP: Life Science (Invited 6)**

Data-Driven Real-Time Prediction and Process Optimization of Micro/Nanofiber Additive Manufacturing

Dongwoon Shin[1*], Joonphil Choi[1], Yongrae Kim[1], Phil-Ho Lee[1], Minkyo Jung[1], and Jiyoung Chang[2]

[1]Department of 3D Printing, Korea Institute of Machinery and Materials (KIMM), Daejeon 34103, Republic of Korea, [2]Department of Mechanical Engineering, University of Utah, Salt Lake City, UT 84112, USA

Oral Presentation *(Meeting Room 9.2)* Monday, July 13

▸ (Special Session) ISNNM: Critical Materials and Sustainability

Chair: Dr. Seok Jun Seo (Korea Institute of Industrial Technology)

15:20-15:40 **ISNNM: Critical Materials and Sustainability (Invited 1)**

Development of a Novel EA-P Process for Nickel Recovery from Nickel Pig Iron

Jae Hong Shin[1*], Seounguk Bae[1,2] Myungsuk Kim[1,3], Kyoung-Tae Park[1]

[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Department of Materials Science and Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea, [3]Department of Materials Science and Engineering, Korea University, Seoul, 02841, Republic of Korea

15:40-16:00 **ISNNM: Critical Materials and Sustainability (Invited 2)**

Securing High-Purity Nickel for the Green Energy Era through Carbonyl Metallurgy

Youngjae Kim*

Department of Materials Science and Engineering, Inha University, Incheon, Korea

16:00-16:20 **ISNNM: Critical Materials and Sustainability (Invited 3)**

Pyrometallurgical Recovery of Lithium from Waste Secondary Batteries Using Molten Carbonate Electrolytes and Self-Propagating High-Temperature Synthesis

Seok-Jun Seo, and Kyoung-Tae Park*

Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea

▸ (General Session) ISNNM: Advanced Materials Processing and Powder Metallurgy 1 (MPPM)

Chair: Dr. Nuri Choi (Korea Institute of Materials Science)

16:25-16:40 **ISNNM: Advanced Materials Processing and Powder Metallurgy 1 (Oral 1)**

Microstructure and Properties of Nb_2AlC MAX Phase-Reinforced Aluminum Matrix Composites Fabricated by Pressureless Sintering

Hyeonseo Hwang[1], Hyeonyoung Choi[1], Seyeop Lee[1] and Jongmin Byun[1,2*]

[1]Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea, [2]The Institute of Powder Technology, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea

16:40-16:55 **ISNNM: Advanced Materials Processing and Powder Metallurgy 1 (Oral 2)**

Microstructural and Mechanical Characterization of Ti Grade12–TiN/Nb_2O_5 Specimens Fabricated via Spark Plasma Sintering

Hyun-Su Kim[1], Su-Gwan Lee[1], Dinh Van Cong[1], Jun-Seo Park[1], Jin-Chun Kim[1*], Seung-Ick Lee[2]

[1]Department of Materials Science and Engineering, University of Ulsan, Ulsan, Republic of Korea, [2]KPC Corporation, Daegu, Republic of Korea

16:55-17:10 **ISNNM: Advanced Materials Processing and Powder Metallurgy 1 (Oral 3)**

Correlation between Microstrcuture and Hardness of D2 Steel with Different Cr, Mo, and V Contents

Jeong Woo Kim, Su-Gwan Lee, Hyun Su Kim, Jun Seo Park, Sang Yong Shin, Jin-Chun Kim*

School of Material Science and Engineering, University of Ulsan, Ulsan, Republic of Korea

Oral Presentation *(Meeting Room 5)* Monday, July 13

▸ EKAMP: Environmental Technology

Chairs: Dr. Dong Eung Kim (Korea Institute of Industrial Technology),
Dr. In-Hyuck Song (Korea Institute of Materials Science)

15:20-15:40 **EKAMP: Environmental Technology (Invited 1)**

Surface Functionalization of open-cell metallic foams by advanced coating processes for energy and environmental applications

F. Neupert[1*], N. Eißmann[1], T. Büttner[1], I. Lindemann[1], A. Tillmann[2], M. Al Aiti[3], G. M. Lange[3], P. Falat[3], G. Cuniberti[3], E. Andreou[4], C. Savaniu[4], J. Irvine[4], T. Weißgärber[1,5]

[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany, [2]Alantum Europe GmbH, Munich, Germany, [3]Institute of Materials Science, Chair of Materials Science and Nanotechnology, Faculty of Mechanical Engineering, TU Dresden, Dresden, Germany, [4]School of Chemistry, University of St Andrews, St Andrews, United Kingdom, [5]Institute of Materials Science, Chair of Powder Metallurgy, Faculty of Mechanical Engineering, TU Dresden, Dresden, Germany

15:40-16:00 **EKAMP: Environmental Technology (Invited 2)**

IKTS water technologies - from materials to pilot plants

Burkhardt Faßauer[1*], Anja Gerbeth[2]

[1]Fraunhofer IKTS, Water and Circular Technologies, Winterbergstr. 28, 01277 Dresden, [2]Fraunhofer IKTS, Water and Wastewater Systems Engineering, Winterbergstr. 28, 01277 Dresden

16:00-16:20 **EKAMP: Environmental Technology (Invited 3)**

Coatings for radiation management- a versatile tool for improving sustainability in buildings and devices

Matthias Fahland

Fraunhofer FEP

16:20-16:40 **EKAMP: Environmental Technology (Invited 4)**

The extruded ceramic membrane support and nanopore coating: Recent developments and prospect

In-Hyuck Song*, Hong Joo Lee, Jang Hoo Ha, Jongman Lee

Nano Materials Research Division, Korea Institute of Materials Science (KIMS), Changwon, Korea

16:40-17:00 **EKAMP: Environmental Technology (Invited 5)**

Study of thermal induced reversible devitrification in Zr-Pt amorphous alloys

Song-Yi Kim and Min-Ha Lee*

Research Institute of Intelligent Manufacturing & Materials Technology, Korea Institute of Industrial Technology, Incheon 21999, Republic of Korea

17:00-17:20 **EKAMP: Environmental Technology (Invited 6)**

Subsea Laser Processing

Dr. Jan Hauptmann*, Dr. Madlen Borkmann

Department Laser Ablation and Cutting, Fraunhofer IWS, Dresden, Germany

17:20-17:40 **EKAMP: Environmental Technology (Invited 7)**

Dry processing: A platform for LiB, SSB and next generation batteries

Stefan Kaskel

Fraunhofer IWS

Oral Presentation *(Marta-Fraenkel-Saal)* Tuesday, July 14

▸ Plenary & Keynote Lecture

Chair: Prof. Jai-Sung Lee (Hanyang University)

09:10-10:00 **Plenary Lecture 2**

Sintered steel parts – just shape or also material?
H. Danninger*, R. de Oro Calderon, and C. Gierl-Mayer
Technische Universität Wien, Institute of Chemical Technologies and Analytics, Vienna, Austria

10:00-10:50 **Plenary Lecture 3**

Advanced Powder Metallurgical Techniques and Additive Manufacturing for Next-Generation Functional Materials
Thomas Weißgärber[1,2*], Inge Lindemann[1], Felix Heubner[1], Christian Bernäcker[1], Thomas Studnitzky[1], Kay Reuter[1]
[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany, [2]TUD Dresden University of Technology, Institute of Materials Science, Chair Powder Metallurgy, Dresden, Germany

10:50-11:10 Coffee Break

Chair: Prof. Paweł Zięba (Polish Academy of Science)

11:10-12:00 **Plenary Lecture 4**

Mechanism-Based Constitutive Modeling of High-Entropy Alloys Across Length Scales
Hyoung Seop Kim
POSTECH, Republic of Korea

12:10-13:10 Lunch

▸ EKAMP: Aerospace Applications 1

Chair: Dr. Thomas Stunitzky (Fraunhofer IFAM)

13:10-13:30 **EKAMP: Aerospace Applications 1 (Invited 1)**

Advanced Surface-Engineered Aluminum Powders for High-Performance Space Propulsion
Kyung Tae Kim
Nano Materials Research Division, Korea Institute of Materials Science, Republic of Korea

13:30-13:50 **EKAMP: Aerospace Applications 1 (Invited 2)**

Laser Processing of Advanced Material
Dr. Andreas Wetzig, Prof. Frank Brueckner
Fraunhofer IWS

13:50-14:10 **EKAMP: Aerospace Applications 1 (Invited 3)**

AM of ceramic components for space applications
T. Moritz*, E. Schwarzer-Fischer, U. Scheithauer, L. Gottlieb and J. Abel
Dept. Processes & Components, Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany

14:10-14:30 **EKAMP: Aerospace Applications 1 (Invited 4)**

Innovative coating systems and reliable component cleanliness for high-performance turbines
F.-H. Rögner*, B. Zimmermann, G. Mattausch, St. Saager, F. Fietzke, B. Scheffel
Fraunhofer-Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany

Oral Presentation *(Marta-Fraenkel-Saal)* Tuesday, July 14

▸ EKAMP: Aerospace Applications 2

Chair: Dr. Tassilo Moritz (Fraunhofer IKTS)

14:40-15:00 EKAMP: Aerospace Applications 2 (Invited 5)

Correlative 4D-STEM Characterization of Strain, Structure and Magnetization in Metallic Glasses for Aerospace Applications

Sangjun Kang[1,2*], Wang Di[1], and Christian Kübel[1,2]

[1]Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany, [2]Department of Material- and Geosciences, Technical University of Darmstadt (TUDa), 64287 Darmstadt, Germany

15:00-15:20 EKAMP: Aerospace Applications 2 (Invited 6)

Thermodynamic Modeling for High-Temperature Ni-Based Superalloys: From Unary Optimization to Multi-Component Phase Stability

DongEung Kim[*]

Korea Institute of Industrial Technology, Incheon, Republic of Korea

15:20-15:40 EKAMP: Aerospace Applications 2 (Invited 7)

Joining of SiC and SiC_f/SiC for Aerospace applications

Dang-Hyok Yoon[*], Sebin Park, Jiwoo Jung, Sunghwan Bang, and Inseo Hwang

School of Materials Science and Engineering, Yeungnam University, Gyeongsan, 38541, Republic of Korea

15:40-16:00 EKAMP: Aerospace Applications 2 (Invited 8)

AM of non-weldable Ni- based superalloys in high temperature applications

Thomas Studnitzky[1*], Thomas Weißgärber[1,2]

[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden, Germany, [2]Technische Universität Dresden, Institute of Materials Science, Dresden, Germany

▸ (General Session) ISNNM: Advanced Materials Processing and Powder Metallurgy 2 (MPPM)

Chair: Prof. Soo Hyun Joo (Dankook University)

16:10-16:40 ISNNM: Advanced Materials Processing and Powder Metallurgy 2 (MPPM) (Keynote Lecture 6)

Application of Particle-Based Simulation Methods in Powder Metallurgical Processes

Yuanbin Deng[1,2*], Ziping Sang[2], Meng Zhou[1], Anke Kaletsch[1,2], and Christoph Broeckmann[1,2]

[1]Institute for Materials Applications in Mechanical Engineering, Aachen, Germany, [2]Institute of Applied Powder Metallurgy and Ceramics (IAPK) at RWTH Aachen e. V., Aachen, Germany

16:40-17:00 ISNNM: Advanced Materials Processing and Powder Metallurgy 2 (MPPM) (Invited 1)

Multi-functional Metal Matrix Composite Wire via Axially Continuous Graphene Integration

Wonjune Choi[1*] and Jongmin Byun[2]

[1]Department of Materials Science and Engineering, Dankook University, Cheonan-Si, Republic of Korea, [2]Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea

Oral Presentation *(Marta-Fraenkel-Saal)* Tuesday, July 14

17:00-17:15 ISNNM: Advanced Materials Processing and Powder Metallurgy 2 (MPPM) (Oral 4)

High cryogenic strength and low thermal expansion in $Fe_{43.2}Co_{33}Ni_{10.3}Cr_{3.8}Mo_{9.7}$ alloy via annealing-induced μ-phase precipitation and microstructural heterogeneity

Taehyung Kim[1], Jae Hyuk Lee[1], Jae Wung Bae[2], Hyoung Seop Kim[3], Jongun Moon[4], Sungwook Kim[5], Soo-Hyun Joo[1*]

[1]Department of Materials Science and Engineering, Dankook University, Cheonan, 31116, Republic of Korea, [2]Department of Metallurgical Engineering, Pukyong National University, Busan, 48513, Republic of Korea, [3]Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH), Pohang, 37673, Republic of Korea, [45]Division of Advanced Materials Engineering, Center for Advanced Powder Materials and Parts, Kongju National University, Cheonan, 31080, Republic of Korea, [5]Industrial Materials Research Group, RIST (Research Institute of Industrial Science and Technology), Pohang, 37673, Republic of Korea

17:15-17:30 ISNNM: Advanced Materials Processing and Powder Metallurgy 2 (MPPM) (Oral 5)

Microstructural evolution of liquid metal dealloying-induced 3D porous interfacial architectures in Ti–6Al–4V for dissimilar-material joining

Hyeok Min Kwon[1], Jihye Seong[1], Jae Hyuk Lee[1], Hidemi Kato[2], Takeshi Wada[2], Jae Woong Bae[3], Sung Hyuk Park[4], and Soo-Hyun Joo[1*]

[1]Department of Material Science and Engineering, Dankook University, Cheonan, Korea, [2]Institute of Materials Research, Tohoku University, Sendai, Japan, [3]Department of Metallurgical Engineering, Pukyong National University, Busan, Korea, [4]Department of Materials Science and Metallurgical Engineering, Kyunpook National University, Daegu, Korea

Oral Presentation *(Meeting Room 9.2)* Tuesday, July 14

▸ (Special Session) ISNNM: Nanomaterial-Based Next-Generation Energy

Chairs: Prof. Hong-Baek Cho (Hanyang University),
Dr. Seulgi Kim (Korea Institute of Geoscience and Mineral Resources)

13:10-13:30 **ISNNM: Nanomaterial-Based Next-Generation Energy (Invited 1)**

Development of in-situ operando microscale reverse electrodialysis as an energy harvesting platform

Inhee Cho*

Korea Institute of Industrial Technology(KITECH), Korea National Institute of Rare Metals(KORAM)

13:30-13:50 **ISNNM: Nanomaterial-Based Next-Generation Energy (Invited 2)**

Understanding ion dynamics in electric double-layer for chemo-mechanical energy harvesting

Seongjae Oh[1], Keon Jung Kim[2], and Shi Hyeong Kim[1*]

[1]Textile Innovation R&D Department, Korea Institute of Industrial Technology, Ansan, Republic of Korea, [2]User Convenience Technology R&D Department, Korea Institute of Industrial Technology, Ansan, Republic of Korea

13:50-14:10 **ISNNM: Nanomaterial-Based Next-Generation Energy (Invited 3)**

One-dimensional Nanostructures for Energy Conversion and Storage

Kihyun Cho[1,2]

[1]Department of Energy Engineering, Dankook University, Cheonan 31116, Republic of Korea, [2]Department of Hydrogen Energy, Dankook University, Cheonan 31116, Republic of Korea

14:10-14:30 **ISNNM: Nanomaterial-Based Next-Generation Energy (Invited 4)**

Earth-Abundant Nanocatalysts for Solar Hydrogen Production and Plastic Waste Valorization

Kwang Leong Choy

The Environmental Research Center, Division of Natural and Applied Sciences, Duke Kunshan University, Kunshan, Jiangsu, China

14:30-14:50 **ISNNM: Nanomaterial-Based Next-Generation Energy (Invited 5)**

Improving Lithium–Sulfur Batteries Using 2D Material-Based Strategies

Seulgi Kim*

Resources Utilization Research Center, Korea Institute of Geoscience and Mineral Resources, Daejeon 34132, Republic of Korea

Oral Presentation *(Meeting Room 9.2)* Tuesday, July 14

▸ (General Session) ISNNM: Energy and Environmental Materials (EEM)

Chairs: Prof. Minho Yang (Dankook University),
Prof. Helen Paola TOLEDO JALDIN (Tecnologico de Estudios Superiores de Tianguistenco)

15:00-15:20 ISNNM: Energy and Environmental Materials (EEM) (Invited 1)

Sodium-Ion Batteries as a Complementary Technology to Lithium-Based Batteries: Reducing Critical Mineral Dependence While Meeting New Design Challenges

Gebrekidan Gebresilassie Eshetu

RWTH Aachen University

15:20-15:35 ISNNM: Energy and Environmental Materials (EEM) (Oral 1)

Enhanced Thermal Conductivity and Moisture Stability of AlN/Epoxy Composites via Surface Modification and Trimodal Filler Packing

Minseob Lim[1], Hyung Jin Mun[1], Tae Woong Yun[2], Hoseong Son[2], Kyoungmin Shim[2], Jongryoul Kim[2], Hong-Baek Cho[2], Yong-Ho Choa[1,2,*]

[1]Hanyang Institute of Environmental & Energy Technology, Hanyang University, Ansan 15588, Republic of Korea, [2]Department of Materials Science & Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea

15:35-15:50 ISNNM: Energy and Environmental Materials (EEM) (Oral 2)

Banana Peel-Derived Hierarchical Porous Carbon/MWCNT Hybrid Scaffold for Shape-Stabilized Composite Phase Change Materials with Enhanced Thermal Energy Storage and Management

Hyung Jin Mun[1], Minseob Lim[1], Hoseong Son[2], Hyunji Kang[2], Jongryoul Kim[2], Yong-Ho Choa[1,2*]

[1]Hanyang Institute of Environmental & Energy Technology, Hanyang University, Ansan 15588, Republic of Korea, [2]Department of Materials Science & Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea

15:50-16:05 ISNNM: Energy and Environmental Materials (EEM) (Oral 3)

Improving Zn Anode Reversibility Using Water-in-Salt Electrolytes

Ziyauddin Khan[*]

Laboratory of Organic Electronics, Department of Science and Technology, Linköping University, Sweden

16:05-16:20 ISNNM: Energy and Environmental Materials (EEM) (Oral 4)

Design of a Tb-MOF Advanced Material for Selective Sensing of Flotation Collectors and Sequential Hg^{2+} Detection

Helen P. Toledo-Jaldín[1*], Cristian L. Pinzón-Vanegas[2], Delia M. Ávila-Márquez[1], Alien Blanco-Flores[1], Alejandro Dorazco-González[2]

[1]National Technological Institute of Mexico (TecNM), Technological Superior Studies Tianguistenco, Santiago Tianguistenco, Mexico, [2]Institute of Chemistry, National Autonomous University of Mexico, Mexico City, Mexico

16:20-16:35 ISNNM: Energy and Environmental Materials (EEM) (Oral 5)

MgO-Filled Epoxy Adhesive with Bimodal Particle Packing as an Alternative to Vacuum Brazing for EV Battery Cold Plate Top–Bottom Plate Joining

Hoseong Son, Tae Hoon Kim, Jimin Kim, Hyung Jin Mun, Minseob Lim, and Yong-Ho Choa[*]

Department of Materials Science and Chemical Engineering, Hanyang Univeristy, Republic of Korea

Oral Presentation *(Meeting Room 5)* Tuesday, July 14

▸ (Special Session) ISNNM: AI and Simulation based Novel Catalytic Materials Design

Chair: Prof. YongJoo Kim (Korea University), Sungwook Mhin (Dongguk University)

13:10-13:30 ISNNM: AI and Simulation based Novel Catalytic Materials Design (Invited 1)

Tuning Oxygen Evolution Activity via Water-Induced Interfacial Electronic Effects

Hyeyoung Shin*

Department of Chemistry, College of Science, Kyung Hee University, Seoul, 02447, Republic of Korea

13:30-13:50 ISNNM: AI and Simulation based Novel Catalytic Materials Design (Invited 2)

Active learning approach in designing entropy alloy nanocatalyst

YongJoo Kim*

Department of Materials Science and Engineering, Korea University, Seoul, South Korea

13:50-14:10 ISNNM: AI and Simulation based Novel Catalytic Materials Design (Invited 3)

Electrocatalyst Design for Next-Generation Hydrogen Production from Efficient Water Oxidation to Energy-Saving Urea Oxidation

Thangavel Saktivel[1], Seyoung Park[1], Yueun Jun[1], Tae Joong Kim[1], Hyeyoung Shin[2], Yongjoo Kim[3], Sungwook Mhin[1*]

[1]Department of Energy and Materials Engineering, Dongguk University, 30 Pildong-ro 1-gil, Jung-gu, Seoul, 04620, Republic of Korea, [2]Department of Chemistry, College of Science, Kyung Hee University, Seoul, 02447, Republic of Korea, [3]Department of Materials Science and Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, Republic of Korea

14:10-14:30 ISNNM: AI and Simulation based Novel Catalytic Materials Design (Invited 4)

A New Paradigm in Materials Research Driven by Data and Artificial Intelligence

Minkyu Park*, Minho Lee

Virtual Lab Inc.

▸ (General Session) ISNNM: Computer-aided Materials Engineering (CME)

Chair: Yong Joo Kim (Korea University)

14:40-15:00 ISNNM: Computer-aided Materials Engineering (CME) (Invited 1)

Density-based Thermodynamics and Kinetics of Microstructure Defects: A new path to CALPHAD-integrated Material Design

Reza Darvishi Kamachali[1,2*]

[1]Federal Institute of Materials Research and Testing (BAM), Unter den Eichen 87, 12205 Berlin, Germany, [2]Institute of Materials Physics, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster

15:00-15:20 ISNNM: Computer-aided Materials Engineering (CME) (Invited 2)

AI-Accelerated Multiscale Modeling for Alloy Design and Processing

Jin Hyun Chang[1,2*]

[1]Department of Energy Conversion and Storage, Technical University of Denmark (DTU), Kgs. Lyngby, Denmark, [2]PhaseTree ApS, Søborg, Denmark

Oral Presentation *(Meeting Room 5)* Tuesday, July 14

15:20-15:35 ISNNM: Computer-aided Materials Engineering (CME) (Oral 1)

Convolutional neural network-based prediction of mechanical properties in Ti6Al4V alloy porous material from micro-CT images

Sungjin Kim, Junho Lee, Seunghyeok Choi, Seok-Jae Lee

Jeonbuk National University, Republic of Korea

15:35-15:50 ISNNM: Computer-aided Materials Engineering (CME) (Oral 2)

Random Forest-Guided Design of Al–BN Composites with Enhanced Strength and Thermal Conductivity

Hyojeong Lee[1], Jiyeon Koo[2], Eunsu Park[2], and Hyunjoo Choi[1*]

[1]Department of Advanced Materials Science and Engineering, Kookmin University, Seoul 02707, Republic of Korea, [2]Eloi Materials Co., Ltd., 409, Ace Gwanggyo Tower 3, 77, Changnyong-daero 256beon-gil, Yeongtong-gu, Suwon-si, Gyeonggi-do 16229, Republic of Korea

15:50-16:05 ISNNM: Computer-aided Materials Engineering (CME) (Oral 3)

Rapid Prediction of Precipitate Microstructures in 7000-Series Aluminum Alloys Using DSC–TEM Correlation and Gaussian Process Regression

W.Y. Lee[1], S.Y. Jeon[1], K.H. Lee[1], I.J. Ro[2], S.H. Kim[2], Y.H. Cho[3], K.J. Euh[4], H.J. Choi[1*]

[1]Department of Materials Science and Engineering, Kookmin University, Seoul, Republic of Korea, [2]Department of Materials Science and Engineering, Korea University, Seoul, Republic of Korea, [3]Mobility Metals Research Center, Korea Institute of Materials Science (KIMS), Changwon, Republic of Korea, [4]Department of Materials Processing, Korea Institute of Materials Science (KIMS), Changwon, Republic of Korea

▸ (General Session) ISNNM: Refractory Metals and Ceramic Materials (RCM)

Chair: Dr. Wonjong Jeong (Korea Institute of Machinery and Materials)

16:20-16:35 ISNNM: Refractory Metals and Ceramic Materials (RCM) (Oral 1)

Mechanical Properties and Oxidation Behavior of Niobium-based Refractory Alloys Fabricated by DED and SPS

Sheng Yu[1], Cheolhyeon Lee[1], Muhammad Akmal[1], Wonjong Jeong[2], and Ho Jin Ryu[1,3*]

[1]Department of Nuclear and Quantum Engineering, KAIST, Daejeon, Republic of Korea, [2]Department of Industrial Laser Technology, Korea Institute of Materials and Machinery, Busan, Republic of Korea, [3]Department of Materials Science and Engineering, KAIST, Daejeon, Republic of Korea

16:35-16:50 ISNNM: Refractory Metals and Ceramic Materials (RCM) (Oral 2)

Thermal and mechanical properties of high-entropy ultra-high temperature ceramics depending on the atomic homogeneity

Eui Seon Lee, Minju Son, Jongmin Byun, and Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

Oral Presentation *(Meeting Room 5)* Tuesday, July 14

16:50-17:05 ISNNM: Refractory Metals and Ceramic Materials (RCM) (Oral 3)

Sintering Behavior and Microstructural Revolution of Stellite 6–WC Composites Fabricated by Hot Pressing Process

Seyeop Lee[1], Hyeonyoung Choi[1], Hyeonseo Hwang[1] and Jongmin Byun[1,2*]

[1]Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea, [2]The Institute of Powder Technology, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea

17:05-17:20 ISNNM: Refractory Metals and Ceramic Materials (RCM) (Oral 4)

Effects of LaB_6 Addition on Microstructure and Mechanical Properties of Nb-Si Based Alloys Fabricated by Spark Plasma Sintering

Hyeonyoung Choi[1], Hyeonseo Hwang[1], Seyeop Lee[1] and Jongmin byun[1,2*]

[1]Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea, [2]The Institute of Powder Technology Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

Oral Presentation *(Marta-Fraenkel-Saal)* Wednesday, July 15

▸ Plenary Lecture & Keynote Lecture

Chair: Prof. Jai Sung Lee (Hanyang University)

09:10-10:00 Plenary Lecture 5

Correlative examination of mass transport at moving high angle boundaries of cellular precipitates

P. Zieba[1*], J. Opara[2], M. Chronowski[3], M. Faryna[1]

[1]Polish Academy of Sciences, Institute of Metallurgy and Materials Science, Cracow, Poland, [2]Łukasiewicz – Upper Silesian Institute of Technology, Gliwice, Poland, [3]Knorr-Bremse Polska Sp. z o.o., Rzeszów, Poland

10:00-10:10 Coffee Break

Chairs: Sung-Soo Ryu (Korea Institute of Ceramic Engineering and Technology), Prof. Dang-Hyok Yoon (Yeungnam University)

10:10-10:40 Keynote Lecture 7

Recycled Powder Strategies for Sustainable Metal Additive Manufacturing: From Powder Degradation and Recovery to Final Build Performance

Soon-Jik Hong

Kongju National University, Republic of Korea

10:40-11:10 Keynote Lecture 8

AI-Based Multimodal Sensor Fusion Framework for Quality Prediction in WAAM

Seung Ki Moon*

School of Mechanical and Aerospace Engineering, Nanyang technological University, Singapore, Singapore

11:10-11:40 Keynote Lecture 9

Design and Development of Ultra-High Temperature Ceramics for Extreme Environments

P. Tatarko[1*], H. Ünsal[1], I. Zhukova[1], A. Kovalčíková[2], Z. Chlup[3], M. Tatarková[1], I. Dlouhý[3]

[1]Institute of Inorganic Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia, [2]Institute of Materials Research, Slovak Academy of Sciences, Košice, Slovakia, [3]Institute of Physics of Materials, Czech Academy of Sciences, Brno, Czech Republic

11:40-12:10 Keynote Lecture 10

CALPHAD Approach for the Prediction of Density and Surface Tension in Ti-Al-V Alloy Melt

Min-Kyu Paek[1*], Hosea Simanjuntak[1], Benedikt Reiplinger[2], and Jürgen Brillo[2]

[1]Clausthal University of Technology, Institute of Metallurgy, Clausthal-Zellerfeld, Germany, [2]German Aerospace Center, Institute of Material Physics in Space, Cologne, Germany

12:10-13:10 Lunch

Oral Presentation *(Marta-Fraenkel-Saal)* Wednesday, July 15

▸ EKAMP: Energy-battery Technologies

Chair: Dr. Jens Möller (Fraunhofer IWS)

13:10-13:30 EKAMP: Energy-battery Technologies (Invited 1)

Research on the Application of Agent-Based Artificial Intelligence Using Manufacturing Data
Hyoseop Kim*
Korea Institute of Industrial Technology (KITECH)

13:30-13:50 EKAMP: Energy-battery Technologies (Invited 2)

Toward Stable Li/LATP Interfaces Using Polymeric Ionic Liquids
Seul Ki Choi[1], and Minho Yang[1,2*]
[1]Department of Hydrogen Energy, Dankook University, Cheonan, Republic of Korea, [2]Department of Energy Engineering, Dankook University, Cheonan, Republic of Korea

13:50-14:10 EKAMP: Energy-battery Technologies (Invited 3)

Vacuum-Based Thin Film Technologies for High-Performance Lithium-Ion Batteries
Stefan Saager, Ludwig Decker, Jens-Peter Heinß, Claus Luber, Bert Scheffel, Steffen Straach, Burkhard Zimmermann
Fraunhofer Institute for Electron Beam and Plasma Technology FEP; Winterbergstrasse 28, 01277 Dresden, Germany

14:10-14:30 EKAMP: Energy-battery Technologies (Invited 4)

Cellular Metals for Battery Applications
O. Andersen[1*], T. Seidl[1], V. Pacheco[1], T. Weißgärber[2]
[1]Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden, Germany, [2]Institute of Materials Science, Chair Powder Metallurgy, Technical University of Dresden, Germany

14:30-14:50 EKAMP: Energy-battery Technologies (Invited 5)

Online Process Monitoring in Battery Production: From Powder and Slurry Characterization to Electrolyte Wetting Monitoring
H. Heuer
Fraunhofer IKTS, Testing Systems, Dresden, Germany

▸ (General Session) ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM)

Chair: Prof. Jongmin Byun (SEOULTECH), Prof. Wonjune Choi (Dankook University)

15:00-15:20 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Invited 2)

Probing temperature gradients for materials characterization
Stephanie Lippmann
Friedrich Schiller University Jena

15:20-15:40 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Invited 3)

Optimized stress-relief window for hot-rolled pure tungsten: Elucidating the interplay between prior deformation strain and annealing parameters
Nuri Choi[1*], Jun Young Park[2], Ki-bong Kim[1], Young-Taek Seo[1], and Sangsun Yang[1]
[1]Nano-materials Research Division, Korea Institute of Materials Science, Republic of Korea, [2]Nuclear Safety Research Division, Korea Institute of Materials Science, Republic of Korea

Oral Presentation *(Marta-Fraenkel-Saal)* Wednesday, July 15

15:40-16:00 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Invited 4)

Impact of severe plastic deformation via high-pressure torsion on interdiffusion in the Cu-Ni system

Neelamegan Esakkiraja[1*], Jasper Berndt[2], Stephan Klemme[2], Gerhard Wilde[1], Sergiy. V. Divinski[1]

[1]Institute of Materials Physics, University of Münster, Münster – 48149 Germany, [2]Institute of Mineralogy, University of Münster, Münster – 48149 Germany

16:00-16:15 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Oral 6)

Development of Dense Se-Free n-Type $Bi_{1.8}Sb_{0.2}Te_3$ Thermoelectrics Through Ultralow-Temperature Cold Sintering Processing

Pathan Sharief[1,2*], Ninad B. Velhal[2], Ah-Hyeon Park[2], Ha-Jin Gu[2], Young-Jae Kim[2], Muhammad Uzair[2], Sang-Chae Jeon[1,2*]

[1]Global Institute for Advanced Nanoscience & Technology, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea, [2]School of Materials Science and Engineering, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea

16:15-16:30 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Oral 7)

Significant improvement of strain hardening through massive interfaces in heterogeneous lamellar structured complex-concentrated alloys

T.J. Jang[1,2], Y.N. Lee[1], J. Baek[1], S. Oh[3], Y.T. Choi[3], B. Lee[3], H.S. Kim[4], A. Zargaran[4], S.S. Sohn[1*]

[1]Korea University (Department of Materials Science and Engineering, Seoul, South Korea), [2]Korea Institute of Materials Science (Extreme Materials Research Institute, Changwon, South Korea), [3]Pohang University of Science and Technology (Department of Materials Science and Engineering, Pohang, South Korea), [4]Pohang University of Science and Technology (Graduate Institute of Ferrous and Energy Materials Technology, Pohang, South Korea)

16:30-16:45 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Oral 8)

Laser Surface Cleaning of Corroded 304L Stainless Steel for Chromium-Depleted Layer Removal and Corrosion Resistance Recovery

Hyun Jong Yoo[1], Changkyoo Park[2], and JeoungHan Kim[3*]

[1]Department of Materials Science and Engineering, Hanbat National University, Daejeon, 34158, Republic of Korea, [2]Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Kore, [3]Department of Materials Science and Engineering, Hanbat National University, Daejeon, 34158, Republic of Korea

16:45-17:00 ISNNM: Advanced Materials Processing and Powder Metallurgy 3 (MPPM) (Oral 9)

Effect of mechanical milling on microstructure and mechanical properties of CrMnFeCoNi high-entropy alloy fabricated via spark plasma sintering

Seonghyun Park[1], and Jae-Gil Jung[1,2*]

[1]Division of Advanced Materials Engineering, Jeonbuk National University, Jeonju, Republic of Korea [2]Research Center for Advanced Materials Development, Jeonbuk National University, Jeonju, Republic of Korea

Oral Presentation *(Meeting Room 9.2)* Wednesday, July 15

▸ (Special Session) ISNNM: Next-generation on Magnetic Materials

Chair: Dr. Sumin Kim (Korea Institute of Materials Science)

13:10-13:40 **ISNNM: Next-generation on Magnetics Materials (Keynote Lecture 11)**

Magnetic nanocomposites utilizing bioresources for magnetic hyperthermia and biosensor applications

Edi Suharyadi

Department of Physics, Gadjah Mada University, Yogyakarta, Indonesia

13:40-14:10 **ISNNM: Next-generation on Magnetics Materials (Keynote Lecture 12)**

High-performance Nd-saving hot-deformed permanent magnets

Jung-Goo Lee*, Hee-Ryoung Cha, Su-Min Kim and Tae-Hoon Kim

Nano Materials Research Division, Korea Institute of Materials Science, Changwon, Korea

14:10-14:30 **ISNNM: Next-generation on Magnetics Materials (Invited 1)**

Resource-Efficient Grain Boundary Diffusion Strategies for High-Performance Nd-Fe-B Magnets with Reduced HRE Usage

Vitalii Galkin[1,2*], Hyeonjong Jeong[1], Dong Hyun Lee[1,2], Seong Chan Kim[1], Juyoung Baek[1], Tae-Young Yun[1],

Jong Tae Kim[1], Seok-Hwan Chung[1], Kyoung-Hoon Bae[3] Sang Hyub Lee[3], Donghwan Kim[3], Jongwook Roh[2], Dong Hwan Kim[1*], Jeongmin Kim[1*]

[1]Division of Nanotechnology, Daegu Gyeongbuk Institute of Science and Technology, Daegu, Republic of Korea, [2]Department of Hydrogen and Renewable Energy, Kyungpook National University, Daegu, Republic of Korea, [3]R&D Center, Star Group, Daegu, Republic of Korea

14:30-14:50 **ISNNM: Next-generation on Magnetics Materials (Invited 2)**

Simultaneous Enhancement of Coercivity and Electrical Resistivity in Thick Nd–Fe–B Magnets via Sandwich-Structured Grain Boundary Diffusion

Sumin Kim*

Nano Materials Research Division, Korea Institute of Materials Science (KIMS), Changwon 51508, Republic of Korea

14:50-15:05 **ISNNM: Next-generation on Magnetics Materials (Oral 1)**

Interfacial spin orbit coupling driven magnetization switching at all oxide interface

Mi-Jin Jin[1*], Doo-Seung Um[2], and Jason W.A. Robinson[3]

[1]Center for Multidimensional Carbon Materials (CMCM), Institute for Basic Science (IBS), Ulsan 44919, Republic of Korea, [2]Department of Electronic Engineering, Jeju National University (JNU), Jeju-do 63243, Korea, [3]Department of Materials Science & Metallurgy, University of Cambridge, 27 Charles Babbage Road, Cambridge CB3 0FS, United Kingdom

Oral Presentation *(Meeting Room 9.2)* Wednesday, July 15

▸ (Special Session) ISNNM: Industrial Application

Chair: Dr. Chang Kyu Rhee (KPMI)

15:20-15:40 ISNNM: Industrial Application (Invited 1)

From Research to Industry: Applications and latest Developments in the field of FAST/SPS-Sintering

Jens Huber*

Dr. Fritsch Sondermaschinen GmbH, Fellbach, Germany

15:40-16:00 ISNNM: Industrial Application (Invited 2)

On HIP In-Situ High Pressure Gas Quenching

Anders Magnusson[1*], Joohyun Jeon[2], Mustafa Turkoglu[3], James Shipley[1]

[1]Quintus Technologies (Global BD, Västerås, Sweden), [2]Quintus Technologies (Area Sales, Seoul, Korea), [3]Quintus Technologies (Area Sales, Stuttgart, Germany)

▸ (General Session) ISNNM: Rare Metals and Recycling (RMR)

Chair: Prof. Youngjae Kim (Inha University)

16:30-16:45 ISNNM: Rare Metals and Recycling (RMR) (Oral 1)

Enhanced Separation of Zirconium from Hafnium via Synergistic Solvent Extraction with Cyanex 272 and tributyl phosphate (TBP) in Nitric Acid Solutions

Haroon Kamal[1,2], Jae Hong Shin[1,2], Dong-Hyun Kim[1], Kyoung-Tae Park[1,2*]

[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Convergence Manufacturing System Engineering, KITECH School, University of Science and Technology, Daejeon, Republic of Korea

16:45-17:00 ISNNM: Rare Metals and Recycling (RMR) (Oral 2)

Selective Fe/Ni Separation from Nickel Pig Iron Leachate through Saponification-Controlled Solvent Extraction

Burhan Febrinawarta[1,2], Myungsuk Kim[1,3], Haroon Kamal[1,2], Kyoung-Tae Park[1,2], Jae Hong Shin[1,2*]

[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Convergence Manufacturing System Engineering, KITECH School, University of Science and Technology, Daejeon, Republic of Korea, [3]Department of Materials Science and Engineering, Korea University, Seoul, Republic of Korea

Oral Presentation *(Meeting Room 5)* Wednesday, July 15

▸ (Special Session) ISNNM: Additive Manufacturing of Advanced Materials

Chair: Dr. Kyung Tae Kim (Korea Institute of Materials Science)

13:30-13:50 ISNNM: Additive Manufacturing of Advanced Materials (Invited 2)

Enhancing the High-Temperature Mechanical Performance of Additively Manufactured Inconel 718 through HfC Reinforcement

Wonjong Jeong[1], Joowon Suh[2], Suk Hoon Kang[2], Seungmun Jung[2], In-Dcuk Park[1], Ho Jin Ryu[3*]

[1]Department of Industrial Laser Technology, Korea Institute of Machinery and Materials, Republic of Korea, [2]Materials Safety Technology Development Division, Korea Atomic Energy Research Institute, Daejeon 34057, Republic of Korea, [3]Department of Materials Science and Engineering, KAIST, Daejeon, Republic of Korea

13:50-14:10 ISNNM: Additive Manufacturing of Advanced Materials (Invited 3)

Novel Sc-free Al-Mg-Si-Zr alloy for laser powder bed fusion

Philip Grimm[1,2], Stefan Martin[2], Jongtae Kim[3], Junhee Han[3], and Julia Kristin Hufenbach[1,2*]

[1]Institute of Materials Science, Technische Universität Bergakademie Freiberg, Freiberg, Germany, [2]Institute for Materials Chemistry, Leibniz Institute for Solid State and Materials Research Dresden, Dresden, Germany, [3]Korea Institute for Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea

▸ (General Session) ISNNM: Additive Manufacturing and Printing Technology (AMT)

Chair: Dr. Suk Hoon Kang (Korea Atomic Energy Research Institute)

14:20-14:40 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Invited 1)

Jet Impingement Cooling Plates for High Density AI Data Centers by LPBF(Laser Powder Bed Fusion) Technique using Gas Atomized Cu Powder

Young Ik Seo[1*], Daeyong Kim[2], Hyun Ho Jo[1], Min Hyung Lee[1], Kyoung-Ju Seo[1], and Jinwoo Oh[2*]

[1]Arum Dentistry (Metal 3D Printer Team, R&D Center, Daejeon, Republic of Korea), [2]Chungnam National University (School of Mechanical Engineering, Daejeon, Republic of Korea)

14:40-14:55 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 2)

Additive Manufacturing Approaches for Automotive Thermal Management: A Ni-Based High-Entropy Alloy and an AlSi10Mg TPMS Heat Exchanger

Hyomoon Joo[*]

Materials Processing Technology Development Team, Hyundai Motor Group, Gyeonggi-do, Republic of Korea

14:55-15:10 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 3)

Control of PBF Defects and Evaluation of Microstructure and Mechanical Properties of D2 Tool Steel through Ni Addition

Joon-Suh Park, Hyun-Su Kim, Su-Gwan Lee, Dinh Van Cong, Jeong-Woo Kim, Jin-Chun Kim[*], Sang-yong Shin

University of Ulsan, Ulsan, Republic of Korea

Oral Presentation *(Meeting Room 5)* Wednesday, July 15

15:10-15:25 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 4)

Microstructure-Informed Process Window Refinement of LPBF AlSi10Mg via Integrated Defect and Matrix/Texture Response Mapping

Taehyeob Im[1,2], Seungyeop Chun[3], and Seung Ki Moon[1,2*]

*[1]Hyundai-NTU-A*STAR Corporate Lab, Nanyang Technological University, Singapore, [2]School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore, [3]Additive Manufacturing Solution Team, Hyundai Motor Group, South Korea*

15:25-15:40 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 5)

Nickel-Mediated Regulation of δ-Ferrite Fraction and Morphology and Its Effect on Microstructure–Property Relationships in Binder-Jetted 17-4PH Stainless Steel

Minjae Kang[1], Yuanjiu Huang[1], Hoseong Jeon[2], Kee-Ahn Lee[1*]

[1]Department of Materials Science and Engineering, Inha University, Incheon 22212, Republic of Korea, [2]Jive Solutions, Gyeonggi-Do 18471, Republic of Kore

15:40-15:55 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 6)

Cr-controlled ordering and strain-hardening pathways in additively manufactured γ′-strengthened Ni-Co-Cr alloys

Avinash Chavan[a], Muhammad Akmal[1], Cheol Hyeon Lee[1], Ho Jin Ryu[1,2*]

[1]Department of Nuclear and Quantum Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea, [2]Department of Materials Science and Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

15:55-16:10 ISNNM: Additive Manufacturing and Printing Technology (AMT) (Oral 7)

Texture-by-Scan path Design in PBF-LB/M Inconel 625: From EBSD-Validated Architectures to Tensile Testing and Crystal Plasticity FE Modeling

Oumayma Elmaalouf[1,2*], Patrice Peyre[1], Stefan Dietrich[2], Corinne Dupuy[1], and Justin Dirrenberger[1,3]

[1]Laboratoire PIMM, Arts et Métiers Institute of Technology, CNRS, CNAM, 151 boulevard de l'Hôpital, 75013 Paris, France, [2]Institute of Applied Materials (IAM-WK), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany, [3]Institut Universitaire de France (IUF)

Poster Presentation 1 — Monday, July 13

Meeting Room 2&3 (15:00-17:00)

Chair: Prof. Soo Hyun Joo (Dankook University)

▸ Advanced Materials Processing and Powder Metallurgy (MPPM)

P01 **Standardization of Compressive and Shear Test Methods for Evaluating Agglomerate Properties of Fine Ceramic Powders**
Boram Jeon*, Hyeji Kim
Material Technology Cente, Korea Testing Laboratory, Seoul, Korea

P02 **No lightweight construction without vibration damping!**
Ulrike Jehring[1*], Philipp Breyl[1], Georg Pöhle[1], T. Weißgärber[2]
[1]Fraunhofer IFAM-Dresden, Cellular metallic materials, Dresden, Germany, [2]Dresden University of Technology, Chair of Powder Metallurgy, Fraunhofer IFAM-Dresden, Cellular metallic materials, Dresden, Germany

P03 **Phase Evolution and Mechanical Performance of SPS-Consolidated WMoCoTiCr High-Entropy Alloy**
Ammad Ali[1,2], Kee-Ryung Park[1], Muhammad Aneeq Haq[3], Yoseb Song[1,2], Da-Woon Jeong[1,4], Bum Sung Kim[1,2*]
[1]National Korea Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Industrial Technology and Smart Manufacturing, University of Science and Technology, Daejeon, Republic of Korea, [3]School of Chemical and Materials Engineering, National University of Science and Technology (NUST), Islamabad, Pakistan, [4]School of Mechanical Engineering, Chung-Ang University, Seoul, Republic of Korea

P04 **Enhanced densification of pure tungsten through multimodal particle packing during spark plasma sintering**
Nuri Choi*, Ki-bong Kim, Young-Taek Seo, and Sangsun Yang
Nano-materials Research Division, Korea Institute of Materials Science, Republic of Korea

P05 **Thermal Properties of Unidirectional Mo-Cu Composites Fabricated via Freeze Casting and Spontaneous Melt Infiltration**
Youngmin Kim, Eui Seon Lee, Ji Young Kim, Sung-Tag Oh*
Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

P06 **Effect of nonionic/cationic dispersants on the dispersion stability of water-based WO_3 slurries for freeze casting**
Ji Young Kim, Eui Seon Lee, Youngmin Kim and Sung-Tag Oh*
Department of Materials Science and Engineering, Seoul National University of Science and Technology,
Seoul 01811, Republic of Korea

Poster Presentation 1 — Monday, July 13

P07 **Effect of Zr Addition on the Microstructure and Oxidation Behavior of HIP-Processed Cr-Al Sputtering Targets for ATF Cladding Applications**

Jae Hong Kim[1], Jae-Hyeok Sim[1], Dae-Hyeon Kim[1], Seung-Hye Jeong[1], Min-Ho Shin[1], Junkoo Lee[2], Sangha Park[3], and Soon-Jik Hong[1*]
[1]Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea, [2]HANCAP, Cheonan, Republic of Korea, [3]Daegu Mechatronics & Materials Institute (DMI), Daegu, Republic of Korea

P08 **Wear Properties of Laser-Cladded STS316L/WC Coatings on Gray Cast Iron Brake Discs**

Jae Hong Kim[1], Eun-Ha Go[2], and Soon-Jik Hong[1*]
[1]Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea, [2]InssTek., 154 Shinsung-ro Yuseong-gu, Daejeon, Republic of Korea

P09 **Gas Atomization Process Optimization of Ni-Co-Cr Alloy Powders and Effects of Alloying Elements on Powder Characteristics**

Seunghye Jeong[1], Dae-Hyeon Kim[1], Jae-Hyeok Sim[1], Chaewon Han[1], Youngtae Kim[1], Ankhbayar Odonkhuu[1], Ji-Woon Lee[1], Ho Jin Ryu[2], and Soon-Jik Hong[1*]
[1]Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea, [2]Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-701, Republic of Korea

P10 **The Stability of Copper Nanoparticles in Polyethersulfone Membranes and Their Impact on the Macromolecular Structure**

Axel Kretschmer*, Qiaodan Chen, Steffen Witzleben
Institute of Technology, Resource and Energy-efficient Engineering, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany

P11 **Withdrawn**

P12 **Fabrication of Flake-Shaped Co-Ni Alloy Powders by Mechanical Milling and Their Application to rSOC Current Collectors**

Jung-Yeul Yun*, Min-Jeong Lee, and Hyeon-Ju Kim
Nano Materials Research Division, Korea Institute of Materials Science, Changwon, Republic of Korea

P13 **Phase Stabilization Behavior of Rapidly Solidified SUS316L Micro-Wires Fabricated by the Taylor-Ulitovsky Method**

Junghyun Noh, Seungjae An, Hoseong Rhee, Moonsik Song
R&D Center, Secufibre Co., Ltd., Incheon, Republic of Korea

Poster Presentation 1 — Monday, July 13

P14 **Effect of Latent-Curing Behavior on Ag Neck Formation in Ag Sintering**
So-Jeong Lee*, Je-Yong Jeong, Jun-Ki Kim, Min-Su Kim
Advanced Packaging Integration Center, Korea Institute of Industrial Technology, Incheon, Republic of Korea

P15 **A strong and ductile nano/micro titanium carbide reinforced austenitic steel at 4.2 K**
Young-Kyun Kim* and Young-Sang Na
Korea Institute of Material Science (KIMS), Changwon 51508, Republic of Korea

▸ Electric and Magnetic Materials (EMM)

P16 **Evaluation of Thin Film Properties Deposited Using Al Alloy Targets for Hillock Suppression and Electrical Property Improvement**
Jung-joon Kim, Youngkyun Kim*
Center for Advanced Materials & Processing, Institute for Advanced Engineering, Gyeonggi-do, Republic of Korea

P17 **Impact of Sulfate Recrystallization on the Morphological Development of Gd_2O_2S**
Kee-Ryung Park[1], Ammad Ali[1,2], Yoseb Song[1,2], Da-Woon Jeong[1,3] and Bum Sung Kim[1,2*]
[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Industrial Materials and Smart Manufacturing Engineering, University of Science and Technology, Daejeon, Republic of Korea, [3]School of Mechanical Engineering, Chung-ang University, Seoul, Republic of Korea

P18 **Fine $Tb_{70}Cu_{30}$ Eutectic Alloy Diffusion Sources Prepared by Reduction-Diffusion for Uniform Grain-Boundary Diffusion in Nd-Fe-B Magnets**
Hyeon Seong Kim[1], Jeong Hyun Kim[1], Kyung Shik Yoon[1], Yu Na Kim[1], Hee Yeon Jeon[1], Park Jae Min[1], and Young-In Lee[1,2*]
[1]Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea, [2]The Institute of Powder Technology, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

P19 **Effect of Reduction–Diffusion Conditions on the Synthesis of Fine Ti-Stabilized $SmFe_{12}$-Based Powders and Their Spark Plasma Sintering Behavior**
Kyung-Shik Yoon[1*], Jeong Hyun Kim[1], Hyeong Seong Kim[1], Yu na Kim[1], Hee Yeon Jeon[1], Jae Min Park[1], and Young-In Lee[1,2*]
[1]Department of Material science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea, [2]The Institute of Powder Technology, Seoul National University of Science and Technology, Seoul, Republic of Korea

Poster Presentation 1 — Monday, July 13

P20 **Comparative Study of Gas-Atomized Powder and Melt-Spun Ribbon as Dy-Al-Cu Diffusion Sources for Grain Boundary Diffusion in Nd-Fe-B Sintered Magnets**

Serin Jeong[1,2], Myungsuk Song[1], Dae-Kyeom Kim[1], Kee-Ahn Lee[2], Seung-Yeon Park[1,2*], Kyoung-Mook Lim[1**]

[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Department of Materials Science and Engineering, Inha University, Incheon, Republic of Korea

P21 **Optimization of a DNA-conjugated magnetoplasmonic nanosensor for mutation detection**

N. Ausoni[1*], L. Friedemann[1], M.-C. T. Nguyen[2], J. Lee[2], and M. B. Williams[1]

[1]Institute for Safety and Security Research, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany, [2]Department of Chemistry, Chungnam National University, Daejeon 34134, Republic of Korea

P22 **Tiny Tools, Big Impact: Nanoparticle-Aptamer Sensors for Water Pathogen Detection**

L. Friedemann[1*], K. Kosciow[2], and M. B. Williams[1]

[1]Institute for Safety and Security Research, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany, [2]Institute for the Protection of Terrestrial Infrastructures, German Aerospace Center, Rheinbach, Germany

P23 **Electromechanical Behavior of Auxetic Electrode-Based FPCB for Stretchable Devices under Repeated Stretching**

Sangwoong Baek, Hyojin Bang, Chan-Jae Lee[*]

Display research center, Korea Electronics Technology Institute, Seeongnam, Korea

P24 **Optically Programmed Interlocked Elastomer Dielectrics for Four-Regime Broad-Range Capacitive Pressure Sensing and Wearable Voice Interfaces**

Min Soo Baek[1], Roun Lee[2], Yeonwook Jeong[2], Su Bin Choi[3,4], Han-Ki Kim[1], Chan-Jae Lee[5], Youngmin Kim[5], and Jong-Woong Kim[2*]

[1]Department of Display Engineering, Sungkyunkwan University, Suwon 16419, Korea, [2]Department of Semiconductor Convergence Engineering, Sungkyunkwan University, Suwon 16419, Korea, [3]Department of Electrical and Computer Engineering, University of Virginia, Charlottesville, VA 22904, USA, [4] Department of Electrical and Electronic Engineering, Yonsei University, Seoul 03722, Korea, [5] Display Research Center, Korea Electronics Technology Institute, Seongnam 13509, Korea

Poster Presentation 1 — Monday, July 13

▸ Rare Metals and Recycling (RMR)

P25 **Wet-Chemical Morphology Engineering of Nickel Nanoparticles through Polymer-Mediated Stabilization and Reduction Control**
C. G. Kim[1,2], Y. G. Lee[1,3], J. J Sim[1*]
[1]Korea Institute of Industrial Technology (Korea National Institute of Rare Metals, Incheon, Republic of Korea), [2]Inha University (Department of Materials Science and Engineering, Incheon, Republic of Korea), [3]Korea University (Department of Materials Science and Engineering, Seoul, Republic of Korea)

P26 **Nickel Carbonylation as a Selective Route for Sustainable Nickel Recovery**
Sanghyun Jeon, Youngjae Kim[*]
Material Science and Engineering, Inha University, Incheon, Korea

P27 **Effects of Pressure and Temperature on the Kinetics and Mechanisms of Ni Carbonylation**
Seoung Uk Bae[1,2], Kyoung-Tae Park[1], Seok-Jun Seo[1], Jae Hong Shin[1*]
[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon 21655, Republic of Korea, [2]Department of Materials Science and Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea

P28 **Enhancing Energy Management in Electron Beam Smelting of Molybdenum: A Finite Element Analysis Approach**
Addisu Boshe Botto[1,2], Ui-jun Ko[1,3], Seok-jun Seo[1], Kyoung-tae Park[1], Jae-jin Sim[1*]
[1]Korea Institute for Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Convergence Manufacturing System Engineering, University of Science and Technology, Daejeon, Republic of Korea, [3]Department of Materials science and engineering, Korea University, Soul, Republic of Korea

P29 **Conversion of Fe-Al Sludge from Secondary Battery Recycling into Calcium Aluminate via Phase Transformation**
Hana Lim, Seungyun Han, Yong Hwan Kim[*]
Korea Institute of Industrial Technology (KITECH), Incheon, 21999, Republic of Korea

P30 **The Recovery of Molybdenum from Inorganic Acids Generated as Industrial Waste using Tributyl Phosphate**
Hee-Nam Kang[1], Benyamin Shakib[1,2], Rajesh Kumar Jyothi[3], Tae-Hyuk Lee[1], Jin-Young Lee[1,2*]
[1]Resources Utilization Research Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), 124 Gwahak-ro, Yuseong-gu, Daejeon, 34132, Republic of Korea, [2]Department of Resources Engineering, Korea University of Science and Technology (UST), 217 Gajeong-ro, Yuseong-gu, Daejeon, 34113, Republic of Korea, [3]CSIRO Mineral Resources (CMR), Australian Mineral Research Center (AMRC), 7 Conlon St. Waterford WA 6102, Perth, Australia

Poster Presentation 1 — Monday, July 13

P31 **Sustainable Vanadium Pentoxide Production from Spent Sulfuric Acid Catalysts via an Integrated Hydrometallurgical Approach**
Nityanand Singh[1,2], Tae-Hyuk Lee[1], Hee-Nam Kang[1], Jin-Young Lee[1,2*]
[1]Convergence Research Center for Development of Mineral Resources (DMR), Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon 34132, Korea, [2]Department of Resource Engineering, Korea University of Science and Technology (UST), Daejeon 34113, Korea

P32 **The Effect of Electromagnetic Stirring on the Mechanical Properties of Ti-6Al-4V Alloys**
Tae-Hyuk Lee*
Resources Utilization Division, Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea

P33 **Effect of Al Doping on the Sintering and Ionic Conductivity of $Li_7La_3Zr_2O_{12}$ via Sol-Gel Process**
Sung Gue Heo[1*], Seok-Jun Seo[2], Sang-Hoon Choi[1], Yun Ji So[1], HoByung Kim[1]
[1]Non-Ferrous Metal/Alloy Research Center, Institute for Advanced Engineering, Yongin, Korea, [2]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Korea

P34 **Mechanical Response of Pure Ta under Elevated-Temperature Hydrogen Environments**
Hyojoo Lee, and Hoon-Hwe Cho*
Depetment of Materials Science and Engineering, Hanbat National University, 125 Dongseodaero, Yuseong-gu, Daejeon 34158, Republic of Korea

P35 **Development of Mg–CaO Composite Coating Technology Using Magnesium Process By-products for Hot Metal Desulfurization**
Jaeyun Jeong, Yubin Kang and Hongjun Chae*
Materials Science and Chemical Engineering Center, Institute for Advanced Engineering, Yongin, South Korea

Poster Presentation 2 — Tuesday, July 14

Meeting Room 2&3 (15:00-17:00)

Chair: Prof. Soo Hyun Joo (Dankook University)

▸ Additive Manufacturing and Printing Technology (AMT)

P36 **Microstructure, Tensile Properties, and Fatigue Behavior of Bulk Hastelloy C276 Fabricated by Wire Arc Additive Manufacturing**
Ui-Jong Lee[1], So-Yeon Park[1], Hyungwoo Park[2], Kee-Ahn Lee[1*]
[1]Department of Materials Science and Engineering, Inha University, Incheon 22212, Republic of Korea, [2]B.A.T Partners Inc, Daejeon 34129, Republic of Korea

P37 **Process Evaluation of 7075 Aluminium Alloy Manufactured by Laser Powder Bed Fusion**
Yujin Rhee[*], Sehun Kim, Tae hu Kang, Jongik Lee, Sanghee Jeong and Bin Lee[*]
Department of Advanced Materials Engineering, Kyung Hee University, Youngin, Republic of Korea

P38 **Irradiation-induced hardening and defect characterization in additive manufactured Inconel 718 alloy**
Joowon Suh[1], Wonjong Jeong[2], Sun-Young Park[1], Hyung-Ha Jin[1], Hyun Woo Seo[1], Seunghyun Lee[3], Dong Won Lee[3], and Suk Hoon Kang[1*]
[1]Materials Safety Technology Development Division, Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea, [2]Department of Industrial Laser Technology, Korea Institute of Machinery & Materials, Busan, 46744, Republic of Korea, [3]Nuclear Physics Application Research Division, Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea

P39 **Oxidation and Ignition Resistance of DED-Fabricated Inconel 718 with Haynes 214 Surface Layers Prepared by DED and Plasma Spray Coating**
Minho Shin, Daehyun Kim, Jaehong Kim, Seunghye Jeong, Soon-Jik Hong[*]
Center for Advanced Powder Materials and Parts, Kongju National University, Cheonan, Republic of Korea

P40 **LPBF Process of Al–4Fe Matrix Composites Reinforced with ZrB_2 Particles**
Jungho Choe, Kyung Tae Kim, and Ji Hun Yu[*]
Nanomaterials research Division, Korea Institute of Materials Science, Republic of Korea

▸ Computer-aided Materials Engineering (CME)

P41 **DEM- and Machine Learning-Based Prediction of Powder Packing Behavior for Powder Process Design**
Jung-joon Kim, Hongjun Chae, Youngkyun Kim[*]
Center for Advanced Materials & Processing, Institute for Advanced Engineering, Gyeonggi-do, Republic of Korea

Poster Presentation 2 — Tuesday, July 14

▸ Energy and Environmental Materials (EEM)

P42 **Co/Beta Zeolite Catalyst for Efficient N_2O Decomposition in Oxygen-Containing Gas Streams**
Sanghyeok Seo[1], Myeung-Jin Lee[1], Bora Jeong[1], Donghyeok Kim[1], Nahea Kim[2], Dahye Park[1], Hong-Dae Kim[1*]
[1]Ulsan Technology Application Division, Korea Institute of Industrial Technology Ulsan, Republic of Korea, [2]Low-carborn energy group, Korea Institute of Industrial Technology Ulsan, Republic of Korea

P43 **Mesoporous Silica-Carbon Composites as Anode Materials for Enhanced Stability in Lithium-Ion Batteries**
Yehui Kim[1,2*], Dong-Hyun Kim[1*]
[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea, [2]Department of Material Science and Engineering, Korea University, Seoul, Republic of Korea

P44 **Fabrication and Characterization of Powder Sintered Ti PTL (Porous Transport Layer) for PEM Water Electrolysis**
Young-yo Yoon[1*], Young-min Jin[1], Jung-yeul Yun[2], Man-ho Park[1*]
[1]ENERICH Co. Ltd. (Gyeonggido, Korea), [2]Korea Institute of Materials Science (KIMS, Changwon, Korea)

P45 **Wettability-Modified Hydrovoltaic Modules for Self-Powered Direct Lithium Extraction**
So Hyun Baek[1,2], Seung-Hwan Lee[1], Yu-Na Lee[1], Yewon Do[1], Yongbum Kwon[1], Taeseok Oh[1], Kanghyuk Lee[1], Yoseb Song[1], Bum Sung Kim[1], Yong-Ho Choa[2*], Da-Woon Jeong[1,3*]
[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, [2]Department of Materials Science and Chemical Engineering, Hanyang University, [3]School of Mechanical Engineering, Chung-Ang University

P46 **Effect of Mixed Metal Oxide Composition on Organic Additives Decomposition and Lifetime of the Dimensionally Stable Anodes for PCB Copper Electroplating**
Sung Cheol Park, Jin Man Jang, Wonsik Lee and Seong Ho Son*
Industrial Components R&D Department, Korea Institute of industrial Technology, Incheon, Republic of Korea

P47 **Effects of Cr and Mo on Elongation of Structural Materials for Molten Salt Reactor Applications**
Ji-Hyun Yoon[1*], Sang-Yeob Lim[1], Jaeseong An[2], Jung-Min Kim[3], Chaewon Kim[1], Daejong Kim[1]
[1]Materials Technology Research Division, Korea Atomic Energy Research Institute, Daejeon, South Korea, [2]Department of New Materials Engineering, Chungnam National University, Daejeon, South Korea, [3]Department of Nuclear Science and Technology, University of Science and Technology, Daejeon, South Korea

P48 **Ultrathin TiO_x Nanosheet-Mediated Interface Design for Durable Microsized Silicon Anodes**
Jeong Yun Hwang*, Sol Han, and Kyu Hyung Lee*
Department of Materials Science and Engineering, Yonsei University, Seoul 03722, Republic of Korea

Poster Presentation 2 — Tuesday, July 14

P49 **Eco-friendly Direct Lithium Extraction via LLTO Membrane Driven by Hydrovoltaic Energy**
Seung-Hwan Lee[1,2], So Hyun Baek[1], Yongbum Kwon[1], Kanghyuk Lee[1], Kee-Ryung Park[1], Yoseb Song[1], Bum Sung Kim[1], Yong-Ho Choa[2*], Da-Woon Jeong[1,3*]
[1]Korea Institute of Industrial Technology, [2]Hanyang University Erica, [3]Chung-Ang University

P50 **Oxidation State Engineering of IrO_2 through Strategic Doping for Durable Oxygen Evolution Catalysis**
Youngtae Park[1*], and Changsoo Lee[2]
[1]Department of Materials Science and Engineering, Kumoh National Institute of Technology, Gumi, Gyeongbuk 39177, Republic of Korea, [2]Department of Chemical Engineering Education, Chungnam National University, 99 Daehak-ro, Daejeon 34134, Republic of Korea

P51 **Investigation of the crystallization behavior of NbCoSn amorphous alloy**
Chanwon Jung*
Department of Materials Science and Engineering, Pukyong National University Busan, Korea

P52 **SCILL Catalyst systems for the selective hydrogenation of aromatics and unsaturated hydrocarbons**
M.B. Williams[1], T. Retzer[2], M. Haumann[2]
[1]Angewandte Naturwissenschaften, Hochschule Bonn-Rhein-Sieg, [2]Universität Erlangen-Nürnberg, Lehrstuhl für Chemische Reaktionstechnik, [3]Interface Research and Catalysis, ECRC, Universität Erlangen-Nürnberg

P53 **Electrochemically-mediated Reactive Separation of Nitric Oxide into Nitrate Using Iron Chelate**
DongYeon Kim*, Beomseo Kim, Taeyoul Han, Taeil Kim
Blueone, Research Institute, 70, Hannam-ro, Daedeok-gu, Daejeon, 34430, Korea

P54 **Integrated Gas Diffusion Electrode System for Sustainable Ammonia Synthesis from Dilute Nitric Oxide and Direct Gaseous Recovery**
DongYeon Kim*, Beomseo Kim, Taeyoul Han, Taeil Kim
Blueone, Research Institute, 70, Hannam-ro, Daedeok-gu, Daejeon, 34430, Republic of Korea

P55 **Balancing Activity and Durability: Iridium-Assisted Calcium-Doped Manganese Oxybromide for Acidic PEM Water Electrolysis**
Taeyoul Han[2], Donggyun Yoo[1], DongYeon Kim[2], HyukSu Han[1*]
[1]Hanyang University (Division of Materials Science and Engineering, Seoul, Republic of Korea), [2]Blueone (Research Institute, Daejeon, Republic of Korea)

P56 **Highly Selective Electrochemical Ammonia Production from Flue-Gas-Level NO using Redox-Engineered Fe-MOF-74**
Taeyoul Han[1], Seonjeong Cheon[2], Siranuysh Badalyan[3], DongYeon Kim[1*], Kyubock Lee[3*]
[1]Blueone (Research Institute, Daejeon, Republic of Korea), [2]University of Seoul (Department of Environmental Engineering, Seoul, Republic of Korea), [3]Chungnam National University (Graduate School of Energy Science and Technology, Daejeon, Republic of Korea)

Poster Presentation 2 — Tuesday, July 14

P57 **Potential-Induced Morphological Evolution of Copper Nanoparticles during Electrochemical Nitric Oxide Reduction to Ammonia**
Beomseo Kim[1], Seonjeong Cheon[2], and DongYeon Kim[1*]
[1]Blueone, (Research Institute, Daejeon, Korea), [2]University of Seoul (Department of Environmental Engineering, Seoul, Korea)

P58 **Sustainable NO_X/SO_X Removal Utilizing a Large-Area Water Electrolysis Electrode System: Focusing on Fe(II)EDTA Regeneration Control**
Beomseo Kim, Taeyoul Han, Taeil Kim, and DongYeon Kim[*]
Blueone, (Research Institute, Daejeon, Korea)

P59 **Analysis between Flow-Accelerated Corrosion Surface Morphology and Hydrodynamic Parameter in SA106 Pipes with Elbows**
J. Y. Lee[*], S. I. Moon, D. J. Kim, J. J. Park, S. W. Kim
Materials Safety Technology Research Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea

P60 **A study of Electrochemical Characterization of PolyvinylAlcohol(PVA)/Malonic Acid(MA) Cross-linked Aqueous Binders for Silicon Anodes**
Jun-Gwon Lee, Tae-Hee Lee, and Kwon-Koo Cho[*]
Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea

P61 **Design of high-loading sulfur electrode with interlayer formed by vacuum heat treatment and performance improvement of lithium-sulfur batteries**
Mi-Ji Kim, and Kwon-Koo Cho[*]
Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea

P62 **Electrochemically deposited sulfur electrode on stainless-steel current collector for lithium–sulfur battery applications**
Da-woon Jeong[1], Gyu-Bong Cho[2], and Kwon-Koo Cho[1*]
[1]Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju52828, Republic of Korea, [2]Research Institute for Green Energy Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea

P63 **Influence of Chelating Agents on the Microstructure and Electrochemical Performance of LATP Solid Electrolytes**
Seul Ki Choi[1], Yu Na Lee[1], Yoon Myung[3], Chan Woong Na[3] and Minho Yang[1,2*]
[1]Department of Hydrogen Energy, Dankook University, Cheonan, Korea, [2]Department of Energy Engineering, Dankook University, Cheonan, Korea, [3]Dongnam Regional Division, Korea Institute of Industrial Technology (KITECH), Busan, Korea

Poster Presentation 2 — Tuesday, July 14

▸ Refractory Metals and Ceramic Materials (RCM)

P64 **Effect of Hf, Al, Cr, Y, and B Additions on the Microstructure and Oxidation Behavior of Mechanically Alloyed Nb-Si-Ti Powders**
DeokHyun Han[1,2], Jung-joon Kim[1], Youngkyun Kim[1], Jongmin Byun[3], and Byungmin Ahn[2,4*]
[1]Center for Advanced Materials & Processing, Institute for Advanced Engineering, Yongin, Republic of Korea, [2]Department of Materials Science and Engineering, Ajou University, Suwon, Republic of Korea, [3]Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea, [4]Department of Energy Systems Research, Ajou University, Suwon, Republic of Korea

P65 **Synthesis of homogeneous W-Mo alloy by ultrasonic spray pyrolysis and spark plasma sintering**
Wonyong Kwon, Eui Seon Lee, Ji Young Kim, Jongmin Byun, and Sung-Tag Oh*
Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

P66 **Isothermal carbothermal behaviors and microstructures of HfC and TaC nanoparticles according to the synthesis process conditions**
Minju Son, Eui Seon Lee, Jongmin Byun, and Sung-Tag Oh*
Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea

P67 **Simultaneous enhancement of the thermal conductivity and fracture toughness of AlN ceramics via incorporation of boron nitride nanotubes**
Byeongsoo Park[1,2], Dae-Ho Yoon[1], Sung-Soo Ryu[2*]
[1]Department of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon 16419, Republic of Korea, [2]Engineering Materials Center, Korea Institute of Ceramic Engineering and Technology, Icheon 17303, Republic of Korea

P68 ***Effect of BN particle Size on the Sintering Behavior and Properties of Si3N4 Ceramics***
Na-Young Kim[1,2], Yong-Ho Choa[3], Bo-Ram Lee[2], Sung-Soo Ryu[1*]
[1]Cross-Functional Ceramic R&D Group, Korea Institute of Ceramic Engineering and Technology, Icheon 17303, Republic of Korea, [2]School of Advanced Materials Science and Engineering, SungKyunKwan University, Suwon 16419, Republic of Korea, [3]Department of Materials Sciences & Chemical Engineering, HanYang University, Ansan 15588, Republic of Korea

P69 **Hydrogen Flame-Induced Degradation of Refractories for Glass Melting Furnaces**
Keonhee Cho[1,2*], Junsu Lee[1,3], and Junghun Kim[1*]
[1]Korea Institute of Ceramic Engineering and Technology, [2]Hanyang University, [3]Sungkyunkwan University

P70 **Thermal durability and fracture behavior of YSZ-based thermal barrier coatings in thermal cyclic exposure**
Byoungchul Hwang[1*], Sang-Gyu Kim[1], Hee-Chang Shin[1], Seung-Cheol Yang[2], Junseong Kim[2], Han-Sang Lee[2], Jungkeuk Park[3]
[1]Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea, [2]Department of Materials Convergence and System Engineering, Changwon National University, Changwon 51140, Republic of Korea, [3]Power Generation Laboratory, Korea Electric Power Company Research Institute, Daejeon 34056, Republic of Korea

ISNNM&EKAMP 2026

Plenary Lecture

PL-01

Thermophysical properties of liquid Al-Ti-V alloys

Jürgen Brillo
Institute for Frontier Materials on Earth and in Space, German Aerospace Center (DLR), Cologne, Germany
Juergen.Brillo@dlr.det.

- Education (Degrees and Institutions):
  Diploma, Physics, 1995, Göttingen University
  Ph.-D., Physics, 1998, Free University, Berlin
  Habilitation, Thermophysical Properties of Materials, 2015, RWTH-Aachen University

- Research Expertise & Contributions (or Major Research Achievements):
  - Thermophysical properties of Liquid Metals using Levitation techniques under gravity and micro-gravity

- Selected Awards or Professional Honors:
  - DLR Research semester, 2005, spent at NPL, Teddington
  - ECTP-Netzsch Young Scientist Award (2008)
  - DLR, Senior Scientist (2017)
  - Apl-Professor, RWTH-Aachen (2025)

Thermophysical properties of liquid Al-Ti-V alloys

Jürgen Brillo[1*], Benedikt Reiplinger[2]

[1]*Institute for Frontier Materials on Earth and in Space, German Aerospace Center (DLR), Cologne, Germany)*
[*]*e-mail of Corresponding Author: Juergen.Brillo@dlr.de*

Al-Ti-V alloys play an important role in technical applications. Especially, the liquid phase and its properties are of tremendous importance, as the vast majority of materials is directly made by casting. In order to understand and model those thermophysical properties, and in order to be able to optimize a material, systematic composition dependent measurements are mandatory. However, despite the importance of Al-Ti-V alloys, data is sparse for the binary and ternary systems. One reason for the lack of data is the increased chemical reactivity of liquid Ti at high temperatures. Containerless investigation methods, such as electromagnetic levitation, are therefore inevitable.

The present talk presents data on density and surface tension of binary and ternary Al-Ti-V liquid alloys. For each alloy system, the composition is systematically varied and thermodynamic mixing rules based on the (sub-)regular solution model are discussed.

It is found that Al-Ti and Al-V are highly non-ideal systems with strongly negative excess volumes and positive excess surface tensions. In contrast to this, Ti-V can be approximated by the ideal solution model. The properties of the ternary alloy system are dominated by the Al-Ti subsystem. Mathematically, a large ternary parameter has to be included into the Redlich-Kister equation in order to compensate for the effect that Al-V, should have on the excess properties if binary interactions are considered alone.

In addition, the effect of oxygen on the surface tension is studied in detail for liquid Ti and V. Due to the highly attractive interaction between Oxygen and Vanadium or Titanium, respectively, oxygen is preferable coordinated in the bulk. The surface can be regarded as virtually clean over a broad range of oxygen concentration until the latter is increased above the critical value of 1 at.-%. As a result, surface tension data is almost unaffected by the presence of oxygen, as long as the quantities of oxygen remain moderate.

Keywords: *Al-Ti-V, Liquid alloys, Mixing rules, Oxygen, Thermophysical properties*

PL-02

Sintered steel parts – just shape or also material?

Herbert DANNINGER
Institut für Chemische Technologien und Analytik, Technische Universität Wien, Vienna, Austria
herbert.danninger@tuwien.ac.at

- Education (Degrees and Institutions):
  Technical Chemistry at TU Wien 1974-1979, Dipl.-Ing. degree 1979; PhD study at TU Wien 1979-1980, Dr. techn..1980; Habilitation (venia docendi) at TU Wien 1990. Full professor for Chemical Technology of Inorganic Materials at TU Wien 2003; Dean of Faculty of Technical Chemistry 2011-2019; retired 2021

- Research Expertise & Contributions (or Major Research Achievements):
  Powder metallurgy, sintering phenomena in metallic and composite systems; chemistry of sintering; chemical surface reactions during processing of steel sheet

- Selected Awards or Professional Honors:
  Dr. honoris causa. of TU Cluj-Napoca (RO); Univ. Carlos III de Madrid (ES); Univ. Craiova (RO). Fellow of APMI, Princeton NJ (USA), and EPMA, Brussels (BE). Ivor Jenkins award from IOM3, London (UK); Honorary member of KPMI (KR)

Sintered steel parts – just shape or also material?

H. Danninger*, R. de Oro Calderon, and C. Gierl-Mayer

Technische Universität Wien, Institute of Chemical Technologies and Analytics, Vienna, Austria
**herbert.danninger@tuwien.ac.at*

For many decades, ferrous precision parts have been the main product of powder metallurgy (PM) with regard to tonnage. Applications mainly focused on automotive components, with a high proportion for internal combustion engines and transmissions. With recent trends towards alternative drivetrain systems, such as BEVs, demand for such parts is decreasing. Nevertheless, the material- and energy-saving and cost-effective press-and-sinter route remains attractive whenever complex-shaped precision parts are required in large numbers. Traditionally, the main feature of these parts was their highly complex shape combined with excellent geometrical precision, and in earlier decades, the performance of the material the parts consisted of was regarded less relevant. This was also because the inherent porosity of these parts was a penalty at least with regard to "database" properties. In the present study it is shown that the PM steels on which these precision parts are based are also a group of materials well suited to investigate the peculiarities of powder metallurgy compared to other metallurgical routes. This holds for both the inherent porosity and resulting large specific surface as well as the microstructure of the metallic matrix, in which e.g. the various alloying routes accessible through powder metallurgy offer high flexibility. Furthermore, different sintering regimes can be applied, e.g. solid state, transient or persistent liquid phase, and, depending on the system, dimensional stability or densification can be aimed at. Therefore, the expertise on materials and processing the PM community can derive from ferrous powder metallurgy products is a benefit that improves the understanding of PM as a whole.

Keywords: Powder metallurgy, sintered steels, sintering, alloying, porosity

PL-03

Advanced Powder Metallurgical Techniques and Additive Manufacturing for innovative functional materials

Thomas Weissgaerber

Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany
TUD Dresden University of Technology, Institute of Materials Science, Chair Powder Metallurgy, Dresden, Germany
*Thomas.weissgaerber@ifam-dd.fraunhofer.de

Prof. Dr.-Ing. Thomas Weißgärber is head of the Dresden branch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM and a member of the institute's management. He has held the professorship of Powder Metallurgy at TU Dresden since 01.04.2022. His expertise lies in the areas of powder metallurgy and additive manufacturing. He has worked on various material groups such as metal matrix composites, dispersion-strengthened materials, high-temperature, and lightweight materials and has published more than 200 articles and been involved in more than 18 patent applications. In 2018, he was awarded the “Skaupy Award”, the highest honour in the German-speaking world in the field of powder metallurgy and 2022 he received the EPMA Fellowship award.

Advanced Powder Metallurgical Techniques and Additive Manufacturing for Next-Generation Functional Materials

Thomas Weissgaerber[1,2*], Inge Lindemann[1], Felix Heubner[1], Christian Bernäcker[1], Thomas Studnitzky[1], Kay Reuter[1]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany*
[2]*TUD Dresden University of Technology, Institute of Materials Science, Chair Powder Metallurgy, Dresden, Germany*
[*]*Thomas.weissgaerber@ifam-dd.fraunhofer.de*

The development of advanced functional materials is a key driver for innovation in energy systems, mobility, electronics, and sustainable manufacturing. Powder metallurgy (PM) and additive manufacturing (AM) have emerged as powerful enabling technologies that offer unprecedented control over material composition, microstructure, and component shape. By combining the flexibility of powder-based processing with the design freedom of additive manufacturing, novel materials with tailored properties and multifunctional performance can be realized.

This presentation provides an overview of recent advances in powder metallurgical techniques and additive manufacturing technologies for the development of innovative functional materials at Fraunhofer IFAM Dresden. Special attention is given to the development of novel soft magnetic components using PM and AM techniques. In the context of electrification, soft magnetic materials and parts are becoming increasingly important in electromagnetic components. Loss reduction and miniaturization of these components is required and can be realized by the adjustment of very specific application-dependent properties. Powder metallurgical approaches presented here as an overview enable the resource-saving production of soft magnetic components. In addition, advanced additive manufacturing methods provide greater design freedom. In general, powder metallurgy and additive manufacturing offer a greater variety of soft magnetic materials and properties tuned for the specific application.

In the field of energy technology, hydrogen is considered as an emerging energy carrier but specific challenges for the production and storage of hydrogen must be solved. The presentation will display innovative approaches to manufacture highly efficient electrodes for alkaline electrolysis. The electrodes can be produced with PM or AM techniques and the advantages of porous materials to increase efficiency will be displayed. The storage of hydrogen is another issue, and the presentation will discuss the advantages of PM techniques to store hydrogen in the solid state.

The third part of the talk will focus on thermal management challenges in electronics. Increased power density and miniaturization lead to increased thermal loads. To guarantee a reliable operation of electronic components thermal management becomes increasingly important. Materials like copper with high thermal conductivity are needed. In addition, a tailored coefficient of thermal expansion requires composites and, nevertheless, complex shapes for heat exchanger components are also required. Also in this field, PM and AM offer unique opportunities and will be displayed in the presentation.FormularbeginnFormularende

Keywords: Powder Metallurgy, Additive Manufacturing, Soft Magnetic Materials, Hydrogen Technology, Thermal Management

PL-04

Mechanism-Based Constitutive Modeling of High-Entropy Alloys Across Length Scales

Hyoung Seop Kim
Graduate Institute of Ferrous and Eco Materials Technology (GIFT),
Pohang University of Science and Technology (POSTECH), Korea
hskim@postech.ac.kr

- Education (Degrees and Institutions):
  - Ph.D. in Metallurgical Engineering, Seoul National University (1988.3.1–1992.2.26)
  - Master in Metallurgical Engineering, Seoul National University (1986.3.1–1988.2.26)
  - Bachelor in Metallurgical Engineering, Seoul National University (1982.

- Research Expertise & Contributions (or Major Research Achievements):
  - Mechanical behavior modeling of porous and amorphous materials
  - Severe plastic deformation for nanostructured metallic materials
  - High entropy alloys development and processing
  - Metal additive manufacturing and heterostructure alloy development
  - Computer simulation and artificial intelligence for metal plastic deformation and thermo-mechanical behaviors
  - Extensive publication record including over 1,200 SCI papers
  - Significant academic impact with over 49,000 citations and an h-index of 104 (Google Scholar)

- Selected Awards or Professional Honors:
  - MPMD Distinguished Scientist Award, TMS (2025)
  - POSCO AWARD, Korean Institute of Metals and Materials (2024)
  - Medal of Science and Technology, Korean Government (2023.4)
  - Basic Research Performance Minister Award, Korean Ministry of Science and Technology Information and Communication (2021.12)
  - SeAh Chair Professor, Pohang University of Science and Technology (2021)
  - Foreign Fellow, Indian National Academy of Engineering (INAE)
  - Fellow, National Academy of Engineering, Korea
  - Fellow, Korea Academy of Science and Technology
  - President, Korean Powder Metallurgy Institute (2019), Korean Institute of Metals and Materials (2026)

Mechanism-Based Constitutive Modeling of High-Entropy Alloys Across Length Scales

Hyoung Seop Kim

POSTECH, Republic of Korea
**hskim@postech.ac.kr*

High- and medium-entropy alloys (HEAs and MEAs) exhibit exceptional strength–ductility synergy originating from complex deformation mechanisms activated across multiple length scales. Unlike conventional alloys, their mechanical response is governed by pronounced microstructural heterogeneity, including solute-induced lattice distortion, segregation, deformation twinning (TWIP), transformation-induced plasticity (TRIP), and engineered heterostructures such as harmonic and core–shell architectures. This talk presents a unified, mechanism-based framework that links microstructural heterogeneity to macroscopic deformation behavior through physically informed constitutive modeling. Starting from classical concepts of statistically stored dislocations (SSDs) and geometrically necessary dislocations (GNDs), we demonstrate how solute-induced back stress, strain partitioning, and phase-specific deformation can be explicitly incorporated into constitutive laws. Finite element simulations combined with experimental validation reveal how heterostructured microstructures generate enhanced strain hardening via stress and strain redistribution. Furthermore, constitutive models for TWIP- and TRIP-assisted deformation are introduced, including critical stress-based descriptions of deformation-induced martensitic transformation in metastable MEAs. These models successfully capture multiple stages of strain hardening observed in both wrought and additively manufactured alloys over a wide temperature range. By bridging microstructural design, deformation physics, and constitutive modeling, this work provides a pathway toward predictive alloy design beyond empirical optimization, offering transferable principles for next-generation structural materials.

PL-05

Correlative examination of mass transport at moving high angle boundaries of cellular precipitates

Pawel Zieba
Polish Academy of Sciences, Institute of Metallurgy and Materials Science, Cracow, Poland

Prof. Pawel Zieba - (born 1956) is the former head of the Institute of Metallurgy and Materials Science of the Polish Academy of Sciences (2011-2019). His PhD and DSc he obtained at the Polish Academy of Sciences in 1987 and 1997, respectively. He received full professor scientific title in 2003. In 1991-92 he was British Council Fellow at Manchester Materials Science Centre and then in 1997-2001 Alexander von Humboldt Foundation at Max-Planck Institute für Metallforschung and Institut für Metallkunde der Stuttgart Universität. In the years 2011-2015 he served as the Executive Committee member for the Federation of European Materials Societies. He served as the Editor-in-Chief for the Archives of Metallurgy and Materials (2011-2023). Since 2016 Prof. Zięba is a member of Polish Academy of Sciences and from 2019 the President of the Committee of Materials Engineering and Metallurgy of the Polish Academy of Sciences.

His main scientific interest is related to methods of materials characterization including electron microscopy, mass and charge transport at grain boundaries of metallic and ceramic materials, severe plastic deformation, interconnection and joining of materials, renewable energy sources with special emphasize on silicon solar cells.

For his scientific achievements, Prof. Zięba was awarded (among others) Knight's Cross of Polonia Restituta Order for all the scientific achievements, Diploma and badge of honor of the Ministry of Economy merit incurred for the development of economy of the Republic of Poland.

Correlative examination of mass transport at moving high angle boundaries of cellular precipitates

P. Zieba[1*], J. Opara[2], M. Chronowski[3], M. Faryna[1]

[1] *Polish Academy of Sciences, Institute of Metallurgy and Materials Science, Cracow, Poland*
[2]*Łukasiewicz – Upper Silesian Institute of Technology, Gliwice, Poland*
[3]*Knorr-Bremse Polska Sp. z o.o., Rzeszów, Poland*
[*]*p.zieba@imim.pl*

Mass transport at the moving high-angle boundaries of cellular precipitates is the rate controlling factor in the solid state phase transformation called discontinuous precipitation (DP). As the maximum diffusion distance is a half of the α lamella width and the typical width of the α lamella is typically of order of 100-300 nm, the DP can be considered as a nano-reaction both in terms of resulting products and the diffusion path. Therefore, a proper approach necessary to understand the details of mechanism and kinetics of DP required the use of advanced and sophisticated analytical techniques. In this survey, the so-called correlative use of different tools enhanced by the modelling will be shown successfully to appropriate description of the DP process at the example of Al-22 at.% alloy.

The first step is related to the *in-situ* observation of the nucleation and growth of discontinuous precipitates directly at the heating stage at the scanning electron microscope (SEM) combined with the electron backscatter diffraction (EBSD) analysis at the beginning and after termination of the reaction. Then, in the second stage the transmission electron microscopy (TEM) was applied to reveal the go- and -stop motion of the reaction front of cellular precipitates while an energy-dispersive X-ray spectroscopy (EDS) to determine the discrete changes of Zn-content across the a phase lamellae. As the last step, the modelling of those details of DP which cannot be delivered by the SEM and TEM examination. This modelling step is aimed at visualizing the redistribution of solute atoms within the α -phase lamellae during the go-and-stop motion of the reaction front, especially during the stop periods that cannot be chemically resolved by TEM/EDS. By dividing the moving high-angle boundary into a set of discrete sectors, the model enables simulation of solute accumulation, local stoppering, and subsequent relaxation of the reaction front, thereby linking the experimentally observed go-and-stop motion with changes in the Zn concentration profile behind the front.

This a correlative and also synergic methodology not only leads to better understanding of DP's fundamental aspects but also exemplifies the power of combined analytical techniques in uncovering complex material behaviors. Our findings illustrate the profound implications of correlative electron microscopy in studying nano-reactions, offering invaluable insights into the intricate dynamics of solid-state transformations.

Keywords: correlative electron microscopy, discontinuous precipitation, numerical modeling, Al-Zn alloy

ISNNM&EKAMP 2026

Keynote Lecture

Innovative Aerospace and Space Structures made by Additive Manufacturing

Christoph Leyens

Fraunhofer Institute for Material and Beam Technology IWS

Additive manufacturing of metals is becoming increasingly important in various industrial sectors, including aviation and space. Unlike other manufacturing technologies, AM of high quality parts requires a deep understanding of the close relationship between the AM process, the material, and the resulting component properties.

Based on the material properties and the desired component specifications, special coating heads for coaxial feeding of the material to the laser beam at the working position are available at Fraunhofer IWS, compatible with conventional laser systems and hybrid AM machines. Some nozzles have been optimized for use in extreme conditions or confined spaces, while others are designed for particularly fine structures or for high-grade materials. The Fraunhofer IWS is constantly upgrading this system line and designing complete coating units with integrated optical components to customer specifications. Exemplary components for the aerospace industry will be discussed.

Advanced Plasma and Electron Beam Processing for Next-Generation Clean-Energy Technologies

Elizabeth von Hauff

[1] *Fraunhofer Institute for Electron Beam and Plasma Technology FEP (Dresden, Germany)*
[2] *TU Dresden (Electrical and Computer Engineering, Dresden, Germany)*
[*] *elizabeth.von.hauff@fep.fraunhofer.de*

The Fraunhofer Society's mission is to bridge the gap between fundamental and applied research by partnering with industry to translate laboratory results into real-world applications. The Fraunhofer FEP in Dresden specializes in electron-beam and plasma technologies for large-scale and precision coatings and advanced surface engineering. By integrating process and hardware development, we deliver technical solutions across a broad range of fields, including energy technologies, architectural glazing, semiconductors, optics, sustainable packaging, and environmental and biomedical applications. Our collaboration models span from feasibility studies to pilot-scale production, accelerating knowledge transfer and reducing risk for industry, with a focus on overcoming bottlenecks in cost, reliability, and performance to deliver scalable, robust solutions. In this talk, I present our latest results in precision coatings for optics and power electronics, and in large-scale, flexible coatings for photovoltaic and battery technologies. I will also highlight how tailored hardware platforms and integrated process chains can reduce material usage, lower energy consumption, and eliminate toxic precursors, without compromising performance. The focus is on strategies that combine process design, equipment engineering, and system integration to enable cleaner, more efficient solutions.

Keywords: Electron beam, plasma, vacuum, coating, energy

Resorbable metallic materials: The key to the next generation of advanced medical implants

Georg Poehle[1*], Christian Redlich[1], Thomas Weissgaerber[1,6], Tom Schroeder[2], Lysann Kroschwald[2], Guenter Lauer[2], Michael Wagner[3], Maria-Elisa Prieto Jarabo[3], Sems-Malte Tugtekin[3], Utz Kappert[3], Axel Linke[3], Antje Schauer[4], Volker Adams[4], Ali El-Armouche[4] and Peter Quadbeck[5]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany*
[2]*Department of Oral and Maxillofacial Surgery, University Hospital Carl Gustav Carus, TUD Dresden University of Technology, Dresden, Germany*
[3]*Clinic for Internal Medicine and Cardiology, Heart Center Dresden, TUD Dresden University of Technology, Dresden, Germany*
[4]*TUD Dresden University of Technology, Dresden, Germany*
[5]*Department of Electrical Engineering, Medical Engineering and Computer Science, Offenburg University of Applied Sciences, Offenburg, Germany*
[6]*Chair of Powder Metallurgy, Institute of Materials Science, TUD Dresden University of Technology, Dresden, Germany*
[*]*Georg.poehle@ifam-dd.fraunhofer.de*

Metallic implants are an indispensable part of modern medicine that save lives and enable patients to regain quality of life after accidents, injuries, or diseases. Despite major clinical successes and established clinical gold standards, the highly complex interactions between an implant as a foreign body and the highly adaptive, self-regenerating biological tissue continue to pose major challenges. This results in complications that can lead to implant failure and revision surgery. Even for frequently performed standard procedures, e.g. in orthopedics, double-digit complication and long-term revision rates are reported.

Clinicians and patients expect the next generation of implants to address these limitations. The development of implants based on resorbable metallic materials takes center stage in these efforts. For many applications in orthopedics/trauma surgery, cardiology, or neurology, the supportive function of an implant is only needed temporarily. Once healing is complete, the implant itself may cause complications or impede subsequent interventions. Removal is often invasive, costly and associated with additional risks for the patient, or even fundamentally impossible.

Developing resorbable metallic materials requires us to tune time-dependent mechanical/functional properties, biocompatibility and controlled degradation in the body. Thus, the implant is enabled to reliably fulfill its function during healing and subsequently disappear without a trace. This requires precise tailoring of chemical, structural, mechanical, and functional properties, as well as advanced manufacturing technologies, e.g. based on powder metallurgy or additive manufacturing.

The presentation provides an overview of the most important classes of resorbable metallic materials, including magnesium-, zinc-, iron-, and molybdenum-based materials. Particular emphasis is placed on molybdenum, which has the potential to become the key material for the next generation of load-bearing temporary implants. The current state of research, key challenges in material and process development, and the perspectives of clinical users and industrial stakeholders are discussed. Future research directions and translation paths are outlined to make the vision of patient- and application-specific temporary metallic implants a reality.

Keywords: Medical technology, resorbable metallic materials, implants, additive manufacturing, molybdenum, magnesium

Circular Carbon Technologies – The Potential of Pyrolysis and Gasification in Chemical Recycling

Martin Gräbner*, Jörg Kleeberg

Fraunhofer Institute of Ceramic Technologies and Systems IKTS, Füchsmühlenweg 9D, 09599 Freiberg, Germany
**e-mail of Corresponding Author: martin.grabner@ikts.fraunhofer.de*

The use of renewable electric energy to provide anthropogenic, biogenic, and atmospheric carbon for sustainable chemistry and energy storage is the central focus of the circular carbon technologies research in Freiberg. In this context, chemical recycling plays a key role, as it enables the re-utilization of plastics and waste materials as feedstock for future chemical industry plants [1]. To accomplish this, pyrolysis and gasification technologies can be applied. Bringing these technologies to market requires a systematic scale-up process, from material and laboratory experiments via bench-scale installations to large pilot plant campaigns.

The keynote presentation will address the current linear production of plastics and highlight the role of pyrolysis and gasification within a circular carbon technology concept. Two examples from recent research activities will be presented.

The first example focuses on the pyrolytic depolymerization of polycarbonates (PC) and polyurethanes (PUR) under defined atmospheres and systematically varied operating conditions, with the aim of producing high-value products such as bisphenol A, phenols, or other derivatives [2]. These products can be readily reintroduced as feedstocks into PC and PUR production processes. Latest results from experiments under ammonia atmosphere will be presented, showing significantly enhanced yields of target products.

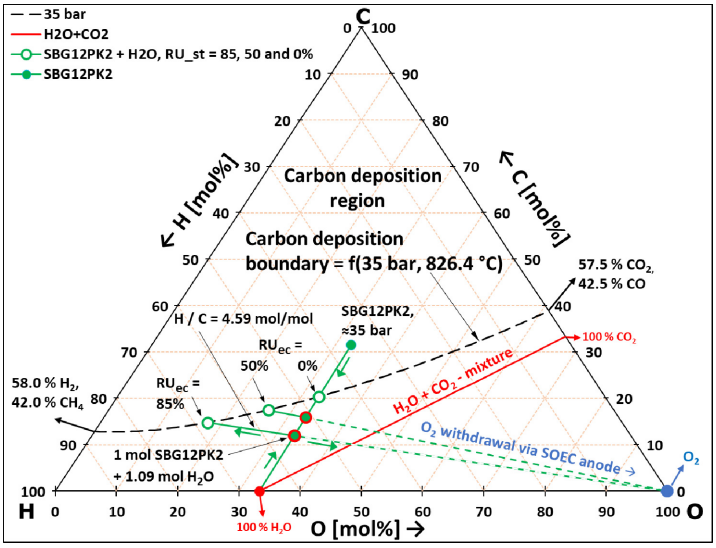


Figure 1 - Thermodynamic study on gas upgrading effects using high-temperature electrolysis

The second example concerns the integration of gasification with high-temperature electrolysis, used as a downstream gas upgrading unit following a conventional gasifier. This configuration enables the conversion of CO_2, steam, and methane—otherwise non-usable fractions of typical biomass- or waste-derived product gases—into valuable syngas (H_2 and CO), which can be directly utilized for methanol or Fischer–Tropsch sytheses. A thermodynamic study (see Fig. 1) on operating conditions and the technical implementation in a pilot unit will be presented in the keynote lecture.

Keywords: Chemical Recycling, Gasification, Depolymerisation, High-Temperature Electrolysis

References

[1] Lee, R.P.; Keller, F.; Gräbner, M. 2023. Beyond Plastics-to-Plastics to Waste-to-Products: Opportunities for Closing the Carbon Cycle via Chemical Recycling, Chemie Ingenieur Technik, Vol. 95 (8), pp. 1228-1232.

[2] Rathsack, P.H.; Scheithauer, D.; Kleeberg, J.; Gräbner, M. 2025. Chemical Recycling of PC/ABS-Blends by Pyrolysis, Journal of Analytical and Applied Pyrolysis, 107047.

Solid State Phase Separation and Precipitation During Additive Manufacturing of Metallic Alloys

Rajarshi Banerjee

Department of Materials Science and Engineering and Center for Agile and Adaptive Additive Manufacturing, University of North Texas, Denton, TX, 76207, USA

While there is an overwhelming worldwide activity on 3D printing or additive manufacturing (AM) of alloys, the efforts have been largely focused on maturing this technology for fabricating near-net shape components. However, the unconventional thermo-kinetics associated with these AM processes can result in precipitation and phase separation within these alloys which may differ from their conventionally melted and thermo-mechanically processed counterparts. Importantly, such precipitation and phase separation impacts their mechanical and functional properties. This talk will attempt to demonstrate these aspects in AM processed metallic systems employing the following examples:

1. Influence of thermo-kinetics associated with laser powder bed fusion (LPBF) on the nature of fine scale omega precipitation and its impact on strain transformability and mechanical properties in titanium alloys.
2. Competing ordering and clustering (phase separation) tendencies in a compositionally graded $AlCo_{1-x}Cr_xFeNi$ high entropy alloy, processed using directed energy deposition (DED), and its impact on magnetic properties.
3. Dislocation cell structure overlaid on compositionally segregated solidification substructure in LPBF processed Nb-base alloy C103 (Nb-10Hf-1Ti) and its impact on tensile yield strength.

These representative examples will also highlight the power of combining TEM, SEM-EBSD-ECCI and APT analysis, towards revealing the micro/nanostructure of AM processed metallic alloys and its influence on mechanical/functional properties.

Application of Particle-Based Simulation Methods in Powder Metallurgical Processes

Yuanbin Deng[1,2*], Ziping Sang[2], Meng Zhou[1], Anke Kaletsch[1,2], and Christoph Broeckmann[1,2]

[1]*Institute for Materials Applications in Mechanical Engineering, Aachen, Germany*
[2]*Institute of Applied Powder Metallurgy and Ceramics (IAPK) at RWTH Aachen e. V., Aachen, Germany*
[*]*y.deng@iwm.rwth-aachen.de*

Particle-based simulation methods have become increasingly important for the understanding and optimization of advanced powder metallurgical manufacturing processes, as they enable the explicit description of particle-scale phenomena such as particle rearrangement, segregation, packing behavior, and local material transport. In this talk, the application of discrete element method (DEM)-based and DEM-coupled multiphysical simulation approaches to different powder metallurgical process chains that include hot isostatic pressing (HIP), metal binder jetting (MBJ), and powder bed fusion–laser beam/metal (PBF-LB/M) is demonstrated and discussed.

For HIP processing with integrated rapid cooling, coupled experimental and numerical investigations were conducted to analyze the influence of pressure and cooling conditions on the microstructural evolution of martensitic and duplex steels during the entire HIP cycle. Finite element (FE) simulations were developed to predict densification behavior, final component geometry, and microstructural evolution during consolidation and subsequent rapid cooling. The developed simulation framework was further extended to include capsule design for possible near-net-shape manufacturing of complex components. The good agreement between experimental observations and numerical predictions demonstrates the capability of the developed methodology to monitor and predict coupled thermomechanical and metallurgical process during HIP manufacturing.

In MBJ, the interaction between powder bed density distribution and binder migration was investigated using a coupled DEM–computational fluid dynamics (CFD) workflow. Powder spreading simulations under varying process conditions were first performed using DEM to generate heterogeneous powder bed structures, which subsequently served as initial conditions for CFD-based binder deposition simulations. The results reveal that local powder bed density significantly influences binder spreading and penetration behavior. Increasing powder bed density initially enhances lateral binder spreading while suppressing vertical penetration, while reduced droplet spacing promotes binder migration during multi-droplet deposition. The developed numerical workflow was validated through dedicated single-layer printing experiments and provided a robust tool for analyzing sequential powder spreading and binder infiltration phenomena in MBJ processes.

Furthermore, DEM-based simulations were also applied to investigate powder demixing phenomena in PBF-LB/M processing of nitrogen-alloyed stainless steels produced from powder mixtures of stainless steel AISI 304L and silicon nitride (Si_3N_4). Maintaining this homogeneous powder mixture during recoating is critical for ensuring a uniform nitrogen content and minimizing defect formation in the final components. Numerical studies were performed to analyze the influence of layer thickness, substrate roughness, and powder characteristics on powder bed homogeneity and local nitrogen distribution. The simulation results were correlated with experimental microstructural characterization and local nitrogen measurements, demonstrating that the developed particle-based models can effectively predict compositional homogeneity and identify optimized process conditions for PBF processing.

Overall, the presented studies demonstrate that coupled particle-based multiphysical simulation methods provide a powerful framework for establishing digital process chains in powder metallurgy. By linking particle-scale behavior with subsequent thermal, mechanical, and metallurgical phenomena, these methods enable enhanced process understanding, simulation-driven process optimization, and advanced control of final component properties.

Keywords: Discrete element method, Powder metallurgy, Modeling, Process digitalization, Simulation-Driven Optimization

Recycled Powder Strategies for Sustainable Metal Additive Manufacturing: From Powder Degradation and Recovery to Final Build Performance

Soon-Jik Hong

Kongju National University, Republic of Korea
**hongsj@kongju.ac.kr*

Additive manufacturing (AM), particularly powder-fed directed energy deposition (DED), has attracted considerable attention as a sustainable manufacturing route because it enables near-net-shape fabrication and production of geometrically complex metallic components. However, despite its material-saving potential, DED does not fully utilize the delivered feedstock. A considerable fraction of the powder stream remains non-deposited owing to limited powder-capture efficiency, powder scattering near the deposition zone, and complex powder–laser–melt-pool interactions. Recovery and reuse of these powders are therefore essential for improving the economic viability and environmental sustainability of metal AM.

This invited talk presents an integrated framework for understanding, assessing, and controlling recycled powders in powder-fed metal AM, using 316L stainless steel as a representative alloy system. Heat-affected recycled powders collected at different distances from the DED deposition region were systematically characterized to clarify the effects of collection location and particle-size fraction on powder degradation and reuse potential. Surface oxidation, microstructural, compositional, crystallographic, and surface analyses revealed distance-dependent degradation, including surface oxidation, internal pore formation, and enrichment of Cr/Fe-rich oxides. Comparison with thermally exposed virgin powders confirmed that oxidation during DED is a major degradation pathway governing recovered-powder quality. The results demonstrate that recyclability is not uniform across the recovered powder population, but depends on thermal history, collection distance, and particle-size distribution.

Further, the influence of these recycled powders on DED build quality, microstructural evolution, mechanical response, and tribological behavior was evaluated and benchmarking them against virgin-powder builds. Recycled-powder builds exhibited increased porosity, higher surface roughness, enlarged oxide inclusions, increased oxide fraction, and coarser grains. Although hardness increased and compressive strength was only marginally affected, ductility decreased significantly because oxide inclusions acted as stress concentrators, deformation barriers, and crack-initiation sites. Transmission electron microscopy and finite-element analysis confirmed that oxide coarsening, dislocation pinning, and local microstructural instability reduced plastic deformation. Tribological characterization showed lower wear rates during early sliding owing to work hardening and protective tribo-oxide layer formation, while long-duration wear resistance remained comparable to virgin-powder specimens.

To move beyond simple powder reuse, a vibration-assisted oxide-separation strategy was applied to selectively remove severely oxidized recycled powders before reprocessing. By optimizing the separation parameters, a maximum separation efficiency of 94.9% was achieved. The oxide-reduced powder fraction was subsequently reused for AM fabrication, and mechanical property evaluation showed no significant difference between specimens fabricated from virgin powders and oxide-removed recycled powders.

Overall, our research establishes a strong relationship between DED powder recovery, oxidation-induced powder degradation during reprocessing, and the resulting microstructure–property trade-off relations. More broadly, sustainable powder recycling in metal AM requires an integrated strategy combining collection-location control, particle-size classification, oxide monitoring, defect mitigation, and build-level performance validation. This approach provides significant scientific basis for closed-loop feedstock-recycling protocols and contributes to sustainable, cost-effective, and reliable metal AM production.

AI-Based Multimodal Sensor Fusion Framework for Quality Prediction in WAAM

Seung Ki Moon*

School of Mechanical and Aerospace Engineering, Nanyang technological University, Singapore, Singapore
**skmoon@ntu.edu.sg*

Wire Arc Additive Manufacturing (WAAM) has emerged as a highly promising technology of the additive manufacturing (AM) methods due to its ability to fabricate complex geometries with high deposition rates, leading to its growing industrial application. However, the high-power electric arcs utilized in WAAM inherently cause severe heat accumulation that can lead to thermal distortion and structural defects, traditionally necessitating time-consuming and costly iterative experiments for process optimization. To overcome the process defects and ensure structural integrity, real-time process monitoring utilizing various sensors has become essential. Currently, individual process monitoring sensor such as a vision camera for analyzing bead geometry and melt pool shape, a thermal imaging camera for monitoring temperature gradients, and an acoustic or ultrasonic sensor for detecting internal flaws like porosity and microcracks are widely employed. While the individual sensor is effective, relying on a single data modality often lacks the comprehensiveness required for precise process control. Consequently, there is an active research trend toward integrating the diverse multi data streams into a single, unified module. In this talk, I'll introduce a comprehensive analysis of the recent trends in multimodal sensor fusion technologies for WAAM. Specifically, it investigates how intelligently integrating multimodal sensor data through Artificial Intelligence (AI) frameworks can effectively analyze complex defect formation mechanisms and thermal behaviors. Through this analysis, the research offers a framework for advanced process control and quality prediction in WAAM and an additive manufacturing industry. Future research directions and limitations in AM technologies with AI will be discussed.

Keywords: Wire Arc Additive Manufacturing, Directed Energy Deposition, Process monitoring, Multimodal sensor fusion, Quality prediction

Design and Development of Ultra-High Temperature Ceramics for Extreme Environments

P. Tatarko[1*], H. Ünsal[1], I. Zhukova[1], A. Kovalčíková[2], Z. Chlup[3], M. Tatarková[1], I. Dlouhý[3]

[1]*Institute of Inorganic Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia*
[2]*Institute of Materials Research, Slovak Academy of Sciences, Košice, Slovakia*
[3]*Institute of Physics of Materials, Czech Academy of Sciences, Brno, Czech Republic*
[*]*peter.tatarko@savba.sk*

Highly pure high-entropy diboride ceramics (HEBs) were produced by two-step spark plasma sintering, consisting of boro/carbothermal reduction of oxides mixtures at 1800°C and pressure-assisted sintering at 1900°C. The aim of this work was to improve the mechanical properties of (Ti-Zr-Hf-Nb-Ta)B_2 diboride system by the addition of different amounts of SiC (5 − 25 vol.%) and formation of new non-equimolar diboride structures in this diboride system.

The first part of the presentation will report on the enhancement of room- and high-temperature mechanical properties of HEB ceramics by the addition of SiC, which continuously increased with the increasing amount of SiC up to 20 vol.%. It was concluded that the (Ti-Zr-Hf-Nb-Ta)B_2 composite sintered with 20 vol.% SiC showed the best combination of room and high temperature mechanical properties.

Based on the $(Ti_{0.2}Zr_{0.2}Hf_{0.2}Nb_{0.2}Ta_{0.2})B_2$ structure, a group of high-entropy diborides with non-equimolar transition metal ratios were theoretically predicted using Density Function Theory implemented in VASP and experimentally investigated. Three most promising non-equimolar diboride structures were selected, considering the formation energy, cohesive energy and mechanical properties of the structures: $(Ta_{0.6}Hf_{0.1}Zr_{0.1}Ti_{0.1}Nb_{0.1})B_2$, $(Ta_{0.6}Hf_{0.25}Zr_{0.05}Ti_{0.05}Nb_{0.05})B_2$, $(Ta_{0.6}Hf_{0.2}Zr_{0.1}Ti_{0.05}Nb_{0.05})B_2$. All of these non-equimolar structures were successfully synthesized to a single phase and sintered to a relative density higher than 96 %. The nanohardness of the individual grains of non-equimolar structures was significantly higher when compared to the equimolar composition. Similarly, the Young's modulus of non-equimolar compositions was slightly higher than that of equimolar one. It was shown that by optimization of the molar ratio of the individual transition metals, the mechanical properties of HEBs were improved.

Acknowledgewment

This work was supported by the Slovak Research and Development Agency under the contract no. APVV-22-0493 and APVV-21-0402. The support of project VEGA 2/0133/26 is also acknowledged.

Keywords: ultra-high temperature ceramics, spark plasma sintering, entropy stabilisation, mechanical properties, ablation resistance

CALPHAD Approach for the Prediction of Density and Surface Tension in Ti-Al-V Alloy Melt

Min-Kyu Paek[1*], Hosea Simanjuntak[1], Benedikt Reiplinger[2], and Jürgen Brillo[2]

[1]*Clausthal University of Technology, Institute of Metallurgy, Clausthal-Zellerfeld, Germany*
[2]*German Aerospace Center, Institute of Material Physics in Space, Cologne, Germany*
[*]*min-kyu.paek@tu-clausthal.de*

Ti-Al-V, especially the Ti-6Al-4V composition, is the workhorse titanium alloy because it combines low density, high specific strength, corrosion resistance, and good biocompatibility, making it valuable for aerospace, biomedical, and other high-performance applications. Its demand in additive manufacturing(AM) is strong because this process can produce complex, lightweight parts that are difficult or expensive to make conventionally, and Ti-6Al-4V is among the most widely used AM titanium alloys. For liquid Ti-Al-V processing, thermophysical properties matter because melt flow, spreading, wetting, and solidification in casting and laser/electron-beam AM depend on them. For the liquid Ti-V side of the ternary system, the molar volume behaves nearly ideally, with no significant excess volume observed, so ideal-solution models are a good first requirement for property estimation. On the other hand, the Ti-Al and V-Al binaries show strong negative deviations, and the volume shrinks in the negatively deviated solution due to the attractive forces among the atoms. The interactions among Ti, Al, and V were predicted based on the pair exchange reaction using the Modified Quasichemical Model(MQM). In this model, the properties of the liquid solution were described by the pair fractions of Ti-V, Ti-Al, and V-Al as functions of melt temperature and composition. By plotting the molar volume of the liquid solution against the calculated pair fraction for each sub-binary system, the specific binary-pair volume can be obtained from the slope. In the ternary system, the pair distributions were calculated using the Toop-interpolation method, with Al set as the asymmetric component. The molar volume of the Ti-Al-V ternary liquid solution was successfully reproduced by merging the specific binary-pair volume determined in the sub-binaries. Using the bulk thermodynamic properties such as chemical potential and molar volume, the surface segregation was predicted in the ternary system.

Keywords: Ti-Al-V alloy, Modified Quasichemical Model, Excess Gibbs Free Energy, Molar volume, Surface tension

Magnetic nanocomposites utilizing bioresources for magnetic hyperthermia and biosensor applications

Edi Suharyadi

Department of Physics, Gadjah Mada University, Yogyakarta, Indonesia

Biosensors-on-chip (BoC), compact and affordable public diagnostic devices, are vital for preventing health crises caused by viral and bacterial mutations, climate change, and poor diets. Clinical, remote, and field use are possible with these devices. BoC is used in food safety, environmental monitoring, and medical diagnosis. Nowadays, the existence of giant magnetoresistance (GMR) and tunnelling magnetoresistance (TMR) based biosensors is interesting, as it promises a portable, fast, and low-cost assay method. The basic principle of this sensor system is relying on the detection of biomolecules through the stray-field generated by the magnetic nanoparticle label that leads to a resistance change of the GMR and TMR sensing element that is processed into a sensor signal. On the other hand, radiotherapy and chemotherapy are conventional cancer therapies that are still widely used, but often cause side effects in the form of damage to healthy tissues. Therefore, magnetic hyperthermia therapy is developed as a more selective follow-up approach, utilizing magnetic nanoparticles that are internalized into cancer cells and heated through alternating magnetic-field exposure. Exploration of magnetic nanoparticle labels for biosensing technology and magnetic hyperthermia agent is very crucial. Large magnetization of dispersed nanoparticles to generate sufficient stray-field and heating are the notable issues. Magnetite-based nanoparticles and nanocomposites is among the most widely studied magnetic nanoparticles for GMR/TMR-based biosensor label and magnetic hyperthermia, though converting magnetic energy into heat remains a significant challenge. Magnetic nanoparticles with good biological compatibility with human are one of crucial issues for the applications. This research explores and investigates the performance of green synthesized magnetic-based nanoparticles and nanocomposites utilizing bioresources such as watermelon peel waste, *Moringa oleifera*, Amaranthus viridis, and *Cerastoderma edule* (common cockle) shell waste for GMR/TMR-based biosensors and magnetic hyperthermia applications.

Keywords: Green synthesis, Biosensor, Magnetic Nanoparticles, Hyperthermia

High-performance Nd-saving hot-deformed permanent magnets

Jung-Goo Lee*, Hee-Ryoung Cha, Su-Min Kim and Tae-Hoon Kim

Nano Materials Research Division, Korea Institute of Materials Science, Changwon, Korea
**jglee36@kims.re.kr*

Current challenge in Nd-Fe-B permanent magnets is to achieve high-performance Na-saving magnets. Nd is expensive and very unstable in supply and demand, but it is essential for realizing the high performance in rare earth permanent magnets. To realize the Nd-saving technology, the content of Nd should be reduced by replacing it with inexpensive Ce. However, until now, it has not been possible to prevent the deterioration of the magnetic properties of the magnet as the Ce content increases due to the inferior intrinsic magnetic properties of $Ce_2Fe_{14}B$ compared to $Nd_2Fe_{14}B$. In addition, it is recently reported that Ce-segregated $ReFe_2$ secondary phases are formed, which significantly deteriorate the microstructure and magnetic properties in the Nd-saving hot-deformed magnet. On the other hand, it has been reported that the deterioration of magnetic properties due to Ce substitution could be largely suppressed by developing a dual main phase structure in Nd-Fe-B sintered magnets. The short-range exchange coupling and long-range magnetostatic interaction induced by the peculiar chemical heterogeneity of dual main phase magnets are believed to be a key factor for improving coercivity and remanence of Nd-Ce-Fe-B sintered magnets. In this study, the limit of the hard magnetic properties of the Ce-substituted magnets was successfully surpassed by the hot-deformation using amorphous precursors that contain no (Nd, Ce)Fe_2 secondary phases. In addition, we also developed the dual main phase Nd-Ce-Fe-B hot-deformed magnets using two different amorphous melt-spun precursors with different compositions.

Keywords: Rare-earth magnets, Nd-saving, amorphous, hot-deformation

ISNNM&EKAMP 2026

KEIT-Supply Chain and Resources

Materials R&D Investment and Global Partnerships in Korea

Min Ha Jung*, Ji In Jung, Dong Geon Ju and Yoon Young Chang

Korea Planning & Evaluation Institute of Industrial Technology (KEIT),
32, Cheomdan-Ro 8-Gil, Dong-Gu, Daegu 41069, Republic of Korea
**mhjung@keit.re.kr*

Carbon neutrality, the restructuring of global supply chains, and digital transformation are emerging as key issues that will shape the competitiveness of future industries. To respond to these changes, it is essential not only to secure advanced materials technologies, but also to promote global cooperation that connects research capabilities across countries. In this context, Korea and Germany are important partners that can jointly lead future industries based on their strengths in manufacturing competitiveness and materials technology. Korea has designated materials research and development (R&D) as a national strategic priority to sustain the competitiveness of its advanced manufacturing industries. The Korea Planning & Evaluation Institute of Industrial Technology (KEIT) plans, evaluates, and manages R&D programs, while supporting collaboration among industry, academia, and research institutions at home and abroad. This presentation introduces Korea's materials R&D investment directions, with a focus on the steel, non-ferrous metals, and ceramics sectors, as well as the Materials and Components Technology Development Program, one of Korea's representative R&D support programs. It also shares case studies of international joint R&D projects involving Germany's Fraunhofer research institutes. In addition, the presentation introduces the technology demand survey system and intellectual property (IP) management principles for international joint R&D, providing practical pathways for overseas research institutions to participate in Korea's R&D programs. This presentation goes beyond introducing Korea's materials R&D policy. It aims to propose new directions and collaboration opportunities for a global partnership through which Korea and Germany can jointly advance innovation in future materials technologies.

Keywords: Steel R&D, Non-Ferrous Metals R&D, Ceramics R&D, Materials R&D Investment, International Joint R&D

The Cooperation Equation: The Role of Interfacialists in Advancing Korea–Germany Global Collaborative R&D through K-FAST

Taeyoung Han

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany

Global research and innovation increasingly depend on international collaboration networks that connect complementary expertise, infrastructure, and funding resources across national boundaries. While technological excellence remains a key success factor, many international R&D initiatives fail to achieve their full potential due to differences in institutional culture, communication styles, decision-making processes, and expectations among stakeholders. These challenges become particularly visible in collaborations between countries with distinct innovation ecosystems, such as the Republic of Korea and Germany.

This paper introduces the concept of the **Interfacialist**, a collaboration-oriented professional who acts as a bridge between organizations, disciplines, cultures, and innovation systems. Unlike traditional project coordinators, Interfacialists focus on reducing collaboration barriers, aligning stakeholder interests, and creating an environment in which multinational research consortia can operate effectively. Their role becomes increasingly important as research partnerships evolve from bilateral projects toward large-scale international consortium-based programs.

The paper further presents **K-FAST (Korea-Fraunhofer Advanced Science and Technology Network)** as a practical model for strengthening Korea–Germany cooperation within the global R&D landscape. Established to facilitate strategic partnerships between Korean and German research institutions, universities, companies, and public organizations, K-FAST supports the development of joint research initiatives, Horizon Europe participation, technology exchange, and international consortium building.

The findings suggest that successful global collaborative R&D requires not only technological capabilities but also dedicated interface functions that enable effective cooperation across organizational and cultural boundaries. The combination of the Interfacialist approach and the K-FAST platform provides a promising framework for expanding Korea–Germany research partnerships and enhancing their contribution to global innovation ecosystems.

Keywords: Global Collaborative R&D, K-FAST, Interfacialist, Korea-Germany Cooperation

Enhancing Public Technology Commercialization Support Systems and International Cooperation: Focusing on Joint TLO Operations and Government Program Linkages

Kyung Won Seo

CODA. Co., Ltd(30, Gangnam-Daero 78-Gil, Gangnam-Gu, Seoul, Republic of Korea, 06243)
**kwseo@codaip.com*

As Korea's public research technology transfer rate declined to 28.9% in 2024, systematic support frameworks are urgently needed to improve transfer efficiency and create commercialization outcomes. This presentation draws on operational experience from the Joint TLO Marketing Office of the National Research Council of Science & Technology (NST) under the Ministry of Science and ICT (MSIT) to discuss: ①full-cycle technology commercialization support systems, ②government program linkage strategies, and ③international cooperation models including Korea-Europe collaboration.

Key achievements include a major overseas technology license from KIMM to global EPC firm KBR, Inc. (USA) for plasma conversion process technology (signed June 2024); leveraging ETRI's music search AI transfer (KRW 90M) to secure a KRW 7.62B AI Global Big Tech Development Program; and a successful re-negotiation that increased technology royalties 12.7-fold at Korea Institute of Fusion Energy.

On the government support side, the presentation covers R&D/R&BD linkages with SMBA and MSIT programs, demand discovery through Kibo (Korea Technology Finance Corporation), and a big-data-driven latent demand pipeline. For international cooperation, the paper proposes a three-stage Korea-Europe framework—opportunity exploration, partner matching, and joint project execution—leveraging Korea's accession as Horizon Europe's first Asian associate member (January 2025).

Keywords: Public Technology Transfer, Technology Commercialization, Joint TLO, Government Support Programs, Korea-Europe Cooperation, Horizon Europe, Overseas Technology Licensing

Development of an Integrated Urban Turquoise Hydrogen via Advanced Biogas Purification, Adsorption Storage, and Microwave-Catalytic Decomposition

Chul Ho Park[1,2]

[1]*Korea Institute of Energy Research (Jeju Center, Hemajihean-ro, 200, 63357, South Korea)*
[2]*University of Science and Technology (Gajeong-ro, Yuseong-gu, Daejeon, 217, 34113, South Korea)*
[*]*chpark@kier.re.kr*

This study presents a comprehensive and highly integrated system for the continuous co-production of turquoise hydrogen and high-value carbon materials from underutilized biogas, aiming to establish a sustainable and carbon-neutral urban energy infrastructure. To achieve a highly efficient, zero-emission process, the proposed system is sequentially structured into three core technological phases: advanced purification, high-density storage, and innovative conversion. In Step 1, raw biogas is efficiently upgraded using next-generation (3rd-generation) separation membranes. This advanced membrane technology ensures the precise separation of impurities, delivering a highly purified and concentrated biomethane stream suitable for continuous processing. In Step 2, the purified gas is securely managed utilizing advanced high-pressure adsorption storage vessels. This adsorption-based approach significantly optimizes gas storage density and operational safety, making the system highly viable for space-constrained urban environments. Finally, in Step 3, the stored biomethane is processed through an innovative urban-type turquoise hydrogen production system that synergistically combines microwave heating technology with advanced catalytic decomposition. This hybrid approach enables the continuous, energy-efficient breakdown of methane into clean, CO_2-free turquoise hydrogen and premium solid carbon materials without direct greenhouse gas emissions. By seamlessly integrating these three state-of-the-art technologies, this project demonstrates a highly scalable, economically viable, and eco-friendly model for distributed clean energy generation. Ultimately, it provides a practical pathway for resource recovery and the realization of a circular hydrogen economy in urban settings.

This work was supported by the Materials & Components Technology Development Program (Project number: 2410002362 and 2410002364) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea)

Keywords: hollow fiber membrane, in-situ outer nanocoating, gas separation, CO_2, N_2, and H_2

ISNNM&EKAMP 2026

EKAMP:
Aerospace Applications

Advanced Surface-Engineered Aluminum Powders for High-Performance Space Propulsion

Kyung Tae Kim

Nano Materials Research Division, Korea Institute of Materials Science, Republic of Korea
**ktkim@kims.re.kr*

The New Space era is characterized by a transition from government-led programs to commercially driven space activities, emphasizing cost reduction and rapid launch capabilities. In parallel, the demand for low-Earth-orbit (LEO) satellites is rapidly increasing to support emerging 6G-enabled autonomous systems. In solid and hybrid propulsion systems, reactive metallic powders play a critical role in determining thrust performance, combustion efficiency, and achievable launch altitude. This talk presents recent advances in metallic powder technologies for compact launch vehicles designed to deploy small and CubeSat-class satellites into low- and medium-Earth orbits. Among various energetic materials, aluminum (Al) remains one of the most attractive fuels because of its high gravimetric energy density and large heat release during oxidation. However, its practical application is limited by the formation of a dense native oxide layer that suppresses ignition and reduces combustion reactivity. To address this challenge, we report recent progress at the Korea Institute of Materials Science (KIMS) in the development of surface-engineered aluminum powders through one-pot surface modification processes. Surface fluorination using PVDF or PTFE generates Al–F-based interfacial compounds that inhibit re-oxidation while promoting efficient combustion through enhanced Al–O reactions. In addition, direct Ni coating and metal–organic framework (MOF)-derived coatings have been shown to improve energetic performance by enhancing interfacial heat transfer and enabling more uniform ignition.

These surface-mediated layers serve dual functions as oxidation barriers and combustion-promoting interfaces, significantly mitigating energy losses associated with surface oxidation. The findings provide new design strategies for advanced energetic powders for next-generation space propulsion systems.

Keywords: Aluminum, Powder, Reactivity, Energetic Applications

Laser Processing of Advanced Material

Dr. Andreas Wetzig, Prof. Frank Brueckner

Fraunhofer IWS

Industrial laser technology is today an integral part of industrial manufacturing. This is particularly true for cutting and joining processes in sheet metal processing, but lasers have also become indispensable in additive manufacturing and surface technology. The presentation will provide on one hand a short overview of the state of the art of laser material processing. On the other hand, by using industrial lasers advanced materials like novel fiber reinforced plastics, dissimilar materials, sophisticated metal alloys and even natural based materials like plywood and paper can be processed. This concerns all manufacturing technologies like joining, additive manufacturing, surface treatment and cutting.

AM of ceramic components for space applications

T. Moritz*, E. Schwarzer-Fischer, U. Scheithauer, L. Gottlieb and J. Abel

Dept. Processes & Components, Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany
tassilo.moritz@ikts.fraunhofer.de

In recent years, additive manufacturing has opened up unprecedented levels of design freedom in component production. There are now many processes to choose from when it comes to near-net-shape manufacturing of components with challenging geometries, and many of these are already suitable for producing medium and large component series. For ceramic components, which are always manufactured using powder-based processes, there is the additional challenge of thermal post-processing, i.e., debinding and sintering, following the additive manufacturing process. However, due to their thermal, mechanical, and corrosion resistance, ceramic materials are also particularly well-suited for aerospace applications, where they can be used as engine components, slide bearings, mirror mounts, or sensors. In addition to high geometric complexity, the functionality of the components also plays a decisive role. The next challenge facing additive manufacturing is the multifunctionalization of components, which can be achieved through so-called hybrid manufacturing methods. Hybridization is a term used in the field of AM to indicate the combination/integration (either in parallel or in series) of different technologies, where at least one is additive, to generate components with features typically not obtainable when using a single approach, or to provide additional manufacturing benefits [1].

The presentation focuses on hybridization achieved, on the one hand, by combining two additive manufacturing processes and, on the other hand, by combining two different materials using an additive manufacturing process. Using the former approach, a low-thrust engine made of aluminum oxide was built to stabilize or alter the trajectory of microsatellites. Vat photopolymerization and fused filament fabrication were used as additive processes for this purpose. The component parts were manufactured in segments and then joined together via a common sintering step. The second approach was used, among other things, to combine electrically insulating ceramic components with electrically conductive components, for example to manufacture ceramic igniters for propellant mixtures. Such multi-material manufacturing is made possible by the multi-material jetting process. This process will be presented in more detail in the lecture using several examples.

References

[1] Gao, W., Zhang, Y., Ramanujan, D. et al. (2015). The status, challenges, and future of additive manufacturing in engineering. *i StartComput. Aided Des.i End* **69**: 65–89. https://doi.org/10.1016/j.cad.2015.04.001.

Keywords: Ceramic Additive Manufacturing, hybridization, space applications, Multi Material Jetting

Innovative coating systems and reliable component cleanliness for high-performance turbines

F.-H. Rögner*, B. Zimmermann, G. Mattausch, St. Saager, F. Fietzke, B. Scheffel

Fraunhofer-Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany
**frank-holm.roegner@fep.fraunhofer.de*

Rising demands for turbine efficiency, lower emissions, higher operating temperatures, and compatibility with sustainable fuels, including hydrogen, require continuous improvement of coating systems that protect components against thermal, mechanical, and chemical loads. In this context, Fraunhofer FEP has developed and transferred key hardware and process solutions that enhance conventional EB-PVD by targeted plasma activation. The combined approach enables high deposition rates while simultaneously improving coating properties, even under challenging conditions such as reduced substrate temperature or elevated process pressure. Plasma activation increases excitation, ionization, and dissociation of vapor and reactive gas species, allowing precise control of particle energy at the substrate surface and thus tailoring coating density, composition, hardness, and microstructure. Demonstrated for yttria-stabilized zirconia, this results in markedly denser layers and increased microhardness. To achieve sufficient ionization in high-rate processes, Fraunhofer FEP employs adapted high-density plasma concepts based on vacuum arc discharges, including hollow cathode arc-assisted deposition (HAD), spotless arc-assisted deposition (SAD), and a tandem hollow cathode system for TBC coaters. In addition, optical plasma emission spectroscopy is used as an advanced process control tool, while dynamic electron beam deflection compensates magnetic field effects in real time. Together, these developments provide a robust platform for next-generation protective coatings with improved performance and industrial applicability.

As important as high-performance coatings is the surface preparation of the components before coating to ensure the required bonding force and interface structures. But typically cleaning processes have a bad image in industry. They cost a lot, need time, energy and staff and often cleaning is a bottleneck in a production chain. Especially at MRO processes but not only there, it is a challenge to remove defective layers and contaminations to enable a repair coating as well as qualified crack testing. On the other hand, the sufficient cleanliness of components is an important requirement for quality insurance, not only in case of coating processes. Fraunhofer FEP developed a process chain integrated cleanliness management approach. Starting with a data-based cleanliness specification for each step along the process chain, the design of measures to minimize contamination, necessary cleaning steps and efforts to keep components clean enough follow traceable rules. These developments led to activities with key industry representatives to standardize the approach. Frank-Holm Rögner is a co-author of this German standard DIN 4878-1, which will be published shortly. It is the basis to optimize cleanliness efforts and change cleaning processes from “necessary evil” to a high-quality production process. Therefore, the development of sufficient, efficient and sustainable cleaning processes play an important role in managing the whole process chain under the strong quality requests. Intelligent process monitoring methods and process integrated cleanliness analysis are further elements to optimize the cleaning effort.

Keywords: Coating, TBC, EB-PVD, Process Chain, Cleaning

Correlative 4D-STEM Characterization of Strain, Structure and Magnetization in Metallic Glasses for Aerospace Applications

Sangjun Kang[1,2*], Wang Di[1], and Christian Kübel[1,2]

[1]*Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany*
[2]*Department of Material- and Geosciences, Technical University of Darmstadt (TUDa), 64287 Darmstadt, Germany*
[*]*sangjun.kang@tu-darmstadt.de*

Metallic glasses are promising candidates for aerospace-relevant structural and functional applications because of their high strength, large elastic limit, good corrosion and wear resistance, and, in Fe-based systems, excellent soft ferromagnetic properties [1]. These properties make them attractive for lightweight mechanical components, magnetic shielding, sensing, and energy efficient electromagnetic devices operating under demanding service conditions. However, their practical use is still limited by catastrophic failure at low plastic strain, which is commonly associated with highly localized shear banding. A nanoscale understanding of how strain, atomic structure, and magnetic configurations evolve around shear bands is therefore essential for improving the reliability of metallic glasses in aerospace environments.

Here, we use advanced 4D-STEM based approaches to characterize a deformed Fe-based metallic glass ribbon [2-3]. First, local elastic strain is quantified from amorphous diffraction rings by fitting their elliptical deviations using an algebraic singular value decomposition based method. This unbiased fitting procedure improves precision and reduces computational cost compared with nonlinear iterative fitting. From the long and short axes of the fitted ellipses, the principal strains are extracted and transformed into the loading coordinates to reconstruct the local strain tensor. Tensor decomposition further separates deviatoric strain, which reflects local distortion, from volumetric strain, which captures local net volume changes associated with hydrostatic stress. In parallel, pair distribution function analysis is performed from the same 4D-STEM dataset to provide local atomic structure information.

To extend this correlative analysis to magnetic functionality, we further employ large-angle Lorentz 4D-STEM, which enables simultaneous mapping of local magnetization, strain, and structural information [3]. By optimizing the STEM optics for large diffraction angle acquisition in Lorentz mode, both unscattered and diffracted electron beams are recorded, allowing magnetic field mapping while preserving interatomic pair information [4-5]. The combined analysis reveals complex residual strain fields near shear bands, including quadrupolar shear strain fields concentrated around inclusions. These strain fields perturb the surrounding amorphous matrix in a vortex-like manner and influence nearby inclusions, contributing to shear band formation. At the same time, anomalous magnetic configurations are observed near shear bands, indicating a competition between magnetoelastic effects and magnetostatic energy.

This work demonstrates that large-angle Lorentz 4D-STEM provides a powerful correlative platform for visualizing nanoscale strain, local atomic structure, and magnetization in amorphous ferromagnets. The approach offers new insight into the deformation and functional response of metallic glasses and supports the development of more reliable metallic glass based materials for aerospace applications.

Keywords: Metallic glass, Aerospace materials, 4D-STEM, Shear banding, Magnetoelastic coupling

References

[1] J. M. Silveyra et al., *Science* 362, 418 (2018).
[2] S. Kang et al., *Advanced Materials* 35, 2212086 (2023).
[3] S. Kang et al., *Nature Communications* 16, 1305 (2025).
[4] S. Kang et al., *Acta Materialia* 269, 119495 (2024).
[5] S. Kang et al., *Ultramicroscopy* 281, 114295 (2026).

Thermodynamic Modeling for High-Temperature Ni-Based Superalloys: From Unary Optimization to Multi-Component Phase Stability

DongEung Kim*

Korea Institute of Industrial Technology, Incheon, Republic of Korea
**canon@kitech.re.kr*

High-temperature alloys, such as Ni-based superalloys used in extreme environments, require accurate thermodynamic data to predict how their phases behave. These databases are built step by step. Pure elements come first, then binary, ternary, and higher-order systems are added on top. This talk reviews how thermodynamic modeling has evolved, with a focus on the CALPHAD (CALculation of PHAse Diagrams) method. It shows how CALPHAD links basic thermodynamics with practical alloy design for high-temperature use. The talk also covers the growth from unary to multi-component systems, made possible by tools like Thermo-Calc and databases such as SGTE. Two case studies illustrate this step-by-step approach, moving from a single element to a complex engineering alloy. The first case uses pure aluminum as a simple unary example. Gibbs energy functions were optimized by fitting heat capacity (Cp), enthalpy, and entropy at the same time, using the PARROT module in Thermo-Calc. This step shows the level of care needed for any reliable multi-component model, no matter which alloy is the final target. The second case builds on this foundation and looks at a multi-component Ni-based superalloy system designed for high-temperature use. Here, the focus is on the phase stability of key strengthening and secondary phases that govern long-term mechanical performance, creep resistance, and microstructural stability under harsh service conditions. Higher-order interaction parameters were assessed to match experimental phase equilibria, yielding a thermodynamic database useful for alloy design and microstructure prediction. Together, these examples show how careful thermodynamic modeling supports the development of next-generation high-temperature Ni-based superalloys, working alongside advances in processing, joining, and additive manufacturing for demanding industrial applications.

Keywords: CALPHAD, Ni-based superalloy, High-temperature phase stability, Multi-component alloy design, Thermodynamic database

Joining of SiC and SiC_f/SiC for Aerospace applications

Dang-Hyok Yoon*, Sebin Park, Jiwoo Jung, Sunghwan Bang, and Inseo Hwang

School of Materials Science and Engineering, Yeungnam University, Gyeongsan, 38541, Republic of Korea
**dhyoon@ynu.ac.kr*

Because SiC possesses excellent properties, such as high mechanical strength, a low coefficient of thermal expansion (CTE), high thermal conductivity, good corrosion resistance, and low induced radioactivity, it has been widely used in various fields, ranging from conventional abrasives to the advanced aerospace and nuclear reactors. However, the strong Si-C covalent bonding and low self-diffusivity make densification extremely difficult, necessitating the use of sintering additives and external pressure application by a mold during sintering. Therefore, the development of reliable joining techniques is essential for fabricating complex-shaped SiC components for practical applications. In this talk, after delivering the overview on various SiC joining techniques developed so far, special attention is paid to the Si-C reaction bonding because it demands relatively lower joining temperature ($\leq$1550℃) and short time ($\leq$1 h), revealing a relatively high joint strength ($\geq$150 MPa). This presentation also discusses long-lasting key questions associated with the Si-C reaction bonding, including the optimal filler composition for minimizing free Si, the effect of surface roughness on the joint strength, the ideal filler thickness for achieving the maximum joint strength, and the typical defects observed at the joint. To examine these questions, SiC is joined using a SiC/C filler tape with varying thicknesses of 10−100 μm, followed by molten Si infiltration at 1430℃ for 20 min under vacuum. Additionally, the surface roughness of the SiC base is adjusted to four levels to evaluate its effect on the joint strength, while common defects are identified too. The results indicate that a finely polished SiC base joined with SiC/C = 70/30 wt.% tape of $\leq$ 50 μm thickness results in a high joint strength of $\geq$250 MPa. Moreover, phase distribution and its amount, microstructural evolution, and the resulting joint strength are also systematically investigated to determine the optimal SiC/C filler composition for SiC joining via Si-C reaction bonding. The phase distribution and amount within the joint is characterized using SEM, TEM, FIB, and EBSD, and is found to strongly depend on the filler tape composition. Thin specimens prepared by FIB enables clearer identification of nanoscale free Si in SEM and EBSD analyses by minimizing signal superimposition. Free Si is detected at the joint for all filler compositions, and its amount increases with increasing SiC content in the filler tape, which is attributed to additional molten Si infiltration caused by volume shrinkage during RBSC formation. In contrast, C segregation is observed only for the SiC/C = 10/90 wt.% filler tape, resulting from capillary channel blockage, which leads to poor joint integrity and a low joint strength of 165 MPa.

Keywords: SiC, Joining, Si-C reaction bonding, MAX phase joining, Joint properties

AM of non-weldable Ni- based superalloys in high temperature applications

Thomas Studnitzky[1*], Thomas Weißgärber[1,2]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden, Germany*
[2]*Technische Universität Dresden, Institute of Materials Science, Dresden, Germany*
[*]*thomas.studnitzky@ifam-dd.fraunhofer.de*

Ni-based superalloys are key materials for high-temperature applications in gas turbines and energy conversion systems, operating typically in the range of 900–1050 °C. Their outstanding creep resistance, oxidation behaviour and high-temperature strength make them the material of choice for turbine blades, vanes and shroud components.

Within the broader landscape of metal additive manufacturing, certain Ni-based alloys have a comparatively long track record. Alloys such as IN625 and IN718 have been processed by laser powder bed fusion (PBF-LB) for many years and are among the best-established materials in that process class. Their moderate γ' content and relatively narrow solidification interval result in acceptable weldability, which is a prerequisite for robust PBF-LB processing (Fig. 1). Both alloys are also well established in sinter-based routes, including conventional metal injection moulding (MIM) as well as newer sinter-based additive manufacturing (SBAM) processes.

The situation is fundamentally different for cast-type superalloys with high γ' volume fractions and wide freezing intervals, such as CM247 and IN713C. These alloys are well known to be prone to hot cracking and segregation under welding conditions. As a result, their processability in PBF-LB remains very limited, and most published work is confined to feasibility studies requiring high preheating temperatures or strongly adapted scan strategies, with narrow and unreliable process windows.

Electron beam melting () represents a relevant intermediate case. Since PBF-EB operates with continuous, high-temperature preheating of the entire powder bed, typically in the range of 800–1000 °C depending on the alloy, thermal gradients and cooling rates are substantially reduced compared to PBF-LB. This significantly lowers the susceptibility to hot cracking and makes PBF-EB a viable candidate for Ni-based superalloys that cannot be reliably processed by PBF-LB. Published work on PBF-EB of high-γ' alloys has demonstrated crack-reduced or crack-free microstructures in several cases, positioning PBF-EB as a complementary fusion-based option for this alloy class.

Sinter-based AM offers a further and fundamentally different approach. Since consolidation is driven by solid-state diffusion and, in some cases, controlled liquid-phase sintering rather than by local melting and resolidification, the root cause of hot cracking is eliminated entirely. CM247 has been successfully processed by multiple SBAM routes, including Metal Binder Jetting and MoldJet, yielding sintered densities of 96–99 %. Tensile testing of Metal Binder Jetting samples at room temperature showed a mean ultimate tensile strength of approximately 1052 MPa, meeting the target range of 1050–1200 MPa. IN713C was likewise successfully manufactured by the MoldJet process, resulting in sound microstructures free of solidification cracks.

Taken together, PBF-EB and SBAM play complementary roles with respect to PBF-LB for this alloy class. This contribution discusses the process-related differences, their consequences for alloy selection, and the current technology readiness of the various routes for high-γ Ni-based superalloys.

Keywords: Sinter-based AM, Nickel-based superalloys, PBF-EB, PBF-LB

ISNNM&EKAMP 2026

EKAMP:
Energy-battery Technologies

Research on the Application of Agent-Based Artificial Intelligence Using Manufacturing Data

Hyoseop Kim*

Korea Institute of Industrial Technology (KITECH)
**hyoseop1231@kitech.re.kr*

Manufacturing sites generate diverse data from equipment sensors, production records, process conditions, quality inspections, and experimental documents. These data can support quality prediction, anomaly detection, process improvement, and engineering decision-making, but they are rarely ready for direct use. In practice, they are dispersed across multiple systems, recorded at different time scales, and affected by missing values, noise, and inconsistent labels. For this reason, applying artificial intelligence to manufacturing data requires more than training a prediction model; it also requires reliable data alignment, process-aware feature preparation, interpretable analysis, and outputs that engineers can review.

This study investigates the application of agent-based artificial intelligence to manufacturing data analysis. The proposed approach organizes the workflow into coordinated agents responsible for data profiling, process-quality alignment, feature generation, quality prediction, anomaly detection, result interpretation, and evidence-based report generation. Each agent performs a specific analytical role while sharing structured outputs with the next stage, allowing raw manufacturing data to be transformed into information that can be used for quality monitoring and process improvement.

The approach is examined through manufacturing data analysis cases involving production, process, and quality data. The cases show that an agent-based workflow can help identify data quality issues, structure relationships between process conditions and quality outcomes, and present prediction or anomaly-detection results in an interpretable form. By connecting analytical outputs with report generation, the workflow also helps translate model results into materials that support engineering review and decision-making.

This study suggests that agent-based artificial intelligence can provide a practical way to automate and organize manufacturing data analysis while maintaining traceability and interpretability. The approach can support more reliable use of artificial intelligence in manufacturing environments and contribute to data-driven quality management and process improvement.

Keywords: Manufacturing Data, Agent-Based Artificial Intelligence, Quality Prediction, Anomaly Detection, Process Analytics

Toward Stable Li/LATP Interfaces Using Polymeric Ionic Liquids

Seul Ki Choi[1], and Minho Yang[1,2,*]

[1]*Department of Hydrogen Energy, Dankook University, Cheonan, Republic of Korea*
[2]*Department of Energy Engineering, Dankook University, Cheonan, Republic of Korea*
[*]*mhyang@dankook.ac.kr*

All-solid-state lithium batteries (ASSLBs) are promising candidates for next-generation energy storage systems owing to their high safety and energy density. However, direct contact between lithium metal and $Li_{1.5}Al_{0.5}Ti_{1.5}(PO_4)_3$ (LATP) solid electrolytes induces Ti^{4+} reduction and interfacial degradation, resulting in increased resistance and poor cycling stability. In this study, a polymeric ionic liquid (PIL) with high ionic conductivity was synthesized via anion exchange and applied onto LATP through a simple dip-coating process. The PIL layer effectively filled grain-boundary gaps and acted as an electron-blocking interlayer, suppressing the reduction of Ti^{4+} while maintaining efficient lithium-ion transport. As a result, the ionic conductivity increased from 7.7×10^{-5} to 1.1×10^{-4} S/cm, and the interfacial resistance was significantly reduced. Li symmetric cells employing PIL-coated LATP exhibited stable lithium stripping/plating behavior for over 300 cycles at 0.5 Ma/cm^2 with low polarization. Furthermore, Li//PIL@LATP//LFP full cells delivered superior rate capability and maintained 83.73% capacity retention after 200 cycles at 1 C. XPS analysis confirmed that the PIL layer effectively mitigated Ti^{4+} reduction and suppressed the formation of resistive interfacial by-products. These findings demonstrate that ion-conductive polymer coatings provide an effective strategy for stabilizing the Li/LATP interface and enhancing the electrochemical performance of oxide-based ASSLBs.

Keywords: Polymeric ionic liquid, NASCION-type electrolytes, LATP, Interface stability, All solid-state batteries

Vacuum-Based Thin Film Technologies for High-Performance Lithium-Ion Batteries

Stefan Saager, Ludwig Decker, Jens-Peter Heinß, Claus Luber, Bert Scheffel, Steffen Straach, Burkhard Zimmermann

Fraunhofer Institute for Electron Beam and Plasma Technology FEP; Winterbergstrasse 28, 01277 Dresden, Germany
**stefan.saager@fep.fraunhofer.de*

There is a growing demand for lithium-ion batteries (LIBs) with high energy density, long service life, and low manufacturing costs. The use of LIBs has also expanded beyond traditional markets such as portable electronics and electric vehicles to applications that require ultra-lightweight and high-performance energy systems. Innovative approaches to battery structure and production processes are needed. Vacuum thin-film technologies offer great potential in this regard: for silicon anodes, lithium anodes, lightweight current collectors, lithium-sulfur batteries.

At Fraunhofer FEP, vacuum-based thin-film technologies are developed not only to improve these materials' cycling stability but also to address weight sensitivity critical for next-generation applications. A notable advancement is the creation of ultra-light metalized polymer-film current collectors, balancing reduced weight with enhanced mechanical and electrochemical stability. For silicon anodes, diverse approaches integrate powder-based processes – where Si particles are functionalized via PECVD carbon coatings – and structured thin-film silicon deposited on textured surfaces via roll-to-roll PVD, featuring columnar structures to mitigate volume fluctuations.

Further innovations include porous silicon anode layers from dealloying processes using silicon-zinc systems, pre-lithiated silicon layers via co-evaporation, and PVD-deposited pure lithium layers with controlled porosity for higher-capacity anodes. Each vacuum-coating method is tailored to ensure compatibility with advanced battery configurations while maintaining scalability, resource efficiency, and operational reliability.

Such technologies underline the versatility and transformative impact of vacuum processes in designing high-performance anodes for LIBs capable of meeting rigorous demands in cutting-edge lightweight energy applications.

Keywords: Vacuum Coating Technology, Silicon Anodes, Lightweight Current Collectors, PVD and PECVD Processes, Next-Generation Lithium-Ion Batteries

Cellular Metals for Battery Applications

O. Andersen[1*], T. Seidl[1], V. Pacheco[1], T. Weißgärber[2]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden, Germany*
[2]*Institute of Materials Science, Chair Powder Metallurgy, Technical University of Dresden, Germany*
[*]*olaf.andersen@ifam-dd.fraunhofer.de*

Metallic materials are commonly denoted as cellular metals when the total volume of pores is larger than the volume of metal contained in a given reference volume. Powder metallurgy is especially well suited for the generation of porous and cellular metallic materials over several orders of magnitude of pore sizes. Hence, this contribution presents examples for the development of different cellular metallic materials for a variety of battery technology related applications at the Fraunhofer Institute for Fabrication and Advanced Materials.

At the nano scale, nanoporous silicon powders with a total pore volume > 70 % were developed by leaching out the aluminum phase of gas atomized AlSi40 alloy particles in order to build and test silicon-rich anodes for lithium-ion batteries. The resulting nanoporous silicon powders show a BET surface area of 21 m^2/g. Literature has it that below a pore size of approx. 300 nm, the volume expansion during the intercalation of the lithium can be suppressed inside the nanostructure. Anodes containing 2.5, 5, 10 and 30 m% Si were built and tested. Tests in half cells showed an initial capacity efficiency around 90 % with a strong degradation after formation. This behaviour was attributed mainly to the quick decomposition of the electrolyte in contact with the very large surface area of the nanoporous silicon which led to the formation of thick solid electrolyte interfaces. A different approach was taken by leaching of commercial CaSi2 powders. The resulting product is polysiloxene with a lamellar structure and a BET surface of 62 m^2/g. It showed stable operation in initial tests with up to 30 m% of polysiloxene. This material is not only suitable for lithium-ion batteries, but also for Zn and Na batteries.

Other developments were carried out in the area of 3D electrodes for lithium-ion batteries based on modified commercial metallic foam materials, i. e. a Sb-coated copper foam. Pore sizes ranged from 450 to 1200 µm. In some cases, the foams were calandered down to a thickness of 50 µm, thus, changing the initial pore size and total porosity significantly. The best results were achieved with an antimony coated copper foam where an initial capacity of 800 mAh/g was reached in a half cell. However, quick degradation was observed as the system could not be optimized within the framework of the respective project.

Besides developments directly targeting the battery cell, thermal management of batteries via cellular metal enhanced phase change materials was investigated for temperature peak-shaving in passive systems. For a combination of sintered aluminum fiber structures with a paraffin-based phase change material, it was shown that a passive operation for the investigated duty cycles even in high-power conditions is possible. However, for mobile applications an additional weight penalty for the system has to be tolerated. Therefore, an application in stationary systems is better suited for this approach.

Keywords: battery, anode, porous, powder metallurgy, thermal management

Online Process Monitoring in Battery Production: From Powder and Slurry Characterization to Electrolyte Wetting Monitoring

H. Heuer

Fraunhofer IKTS, Testing Systems, Dresden, Germany

The transition toward high-performance and sustainable battery manufacturing requires robust, scalable, and intelligent production technologies capable of ensuring consistent electrode quality while minimizing waste, energy consumption, at increasing process variability. This lecture addresses these challenges through the development of a comprehensive, non-invasive process monitoring and feedback control platform for battery electrode production lines. The proposed approach integrates advanced sensing technologies, real-time data acquisition, and adaptive process control strategies across four critical manufacturing stages: material preparation, electrode coating, cell filling, and charging.

The first stage focuses on milling, mixing, and extrusion, where active and passive acoustic sensing technologies will be implemented to monitor material preparation in situ and in real time. Acoustic transducers mounted externally on ball mills and screw extrusion systems will enable non-contact sensing of material behavior during processing. Passive acoustic sensing will analyze spatially resolved broadband sound emissions generated during milling and extrusion, while active acoustic sensing will inject high-power acoustic waves through screws or propellers and evaluate the resulting transfer functions through the processed material. These measurements will provide direct insight into material density, viscosity, agglomerate size, and homogeneity, generating a characteristic process fingerprint for material state evaluation.

The second process stage addresses material transport and feeding to the coating system. Here, inductive electrical impedance spectroscopy combined with broadband ultrasonic spectroscopy will be integrated into a “sensing pipe” positioned within the material delivery line. Non-contact ultrasonic and inductive electrical probes mounted externally on the sensing pipe will continuously evaluate the electrical and acoustic properties of the transported slurry or dry material. This real-time monitoring solution will provide direct information on material consistency immediately prior to deposition, enabling adaptive control of coating parameters and significantly reducing the risk of production waste.

The third process stage focuses on inline electrode area inspection using high-frequency eddy current sensing technology developed by Fraunhofer IKTS. Modular sensor array systems operating at frequencies up to 100 MHz will provide non-contact, spatially resolved measurements of areal loading, conductivity, dielectric properties, solvent content, and topography for both single- and double-sided coated electrodes. By analyzing the complex electrical impedance response, the system will enable micrometer-scale thickness resolution and simultaneous monitoring of conductive and dielectric material characteristics. The modular architecture allows seamless integration into roll-to-roll manufacturing systems of varying widths and supports scalable deployment in industrial battery production.

Based on the local process data generated throughout all manufacturing stages, local and global process feedback strategies will be developed to enable interconnected process optimization across the entire production chain. The consortium, including Fraunhofer IWS, Fraunhofer IPT, Fraunhofer IKTS, and Nanointech from South Korea, combines expertise in sensor development, process engineering, data analytics, industrial automation, and battery manufacturing. Together, the partners aim to create a next-generation digital process control framework that supports industrial scale-up, improves product quality, reduces resource consumption, and strengthens international competitiveness in advanced battery manufacturing technologies.

Keywords: Batter process monitoring, Slurry Monitoring, Powder characterization

ISNNM&EKAMP 2026

EKAMP:
Environmental Technology

Surface Functionalization of open-cell metallic foams by advanced coating processes for energy and environmental applications

F. Neupert[1*], N. Eißmann[1], T. Büttner[1], I. Lindemann[1], A. Tillmann[2], M. Al Aiti[3], G. M. Lange[3], P. Falat[3], G. Cuniberti[3], E. Andreou[4], C. Savaniu[4], J. Irvine[4], T. Weißgärber[1,5]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Dresden Branch, Dresden, Germany*
[2]*Alantum Europe GmbH, Munich, Germany*
[3]*Institute of Materials Science, Chair of Materials Science and Nanotechnology, Faculty of Mechanical Engineering, TU Dresden, Dresden, Germany*
[4]*School of Chemistry, University of St Andrews, St Andrews, United Kingdom*
[5]*Institute of Materials Science, Chair of Powder Metallurgy, Faculty of Mechanical Engineering, TU Dresden, Dresden, Germany*
[*]*felix.neupert@ifam-dd.fraunhofer.de*

Open-cell metallic foams are promising porous substrates due to their high permeability, large accessible surface area, and favorable thermal and electrical conductivity. Their three-dimensional strut architecture enables efficient heat and mass transport at low pressure drop, making them attractive materials for functional cellular systems. However, the performance of such systems strongly depends on suitable surface functionalization strategies that preserve the intrinsic pore structure and transport properties.

Advanced coating processes provide a promising approach for the functionalization of open-cell metallic foams. Achieving homogeneous and conformal coatings across complex three-dimensional strut networks while maintaining effective porosity remains a key challenge. Coating penetration into the porous structure, coating adhesion and stability, and the interaction between coating architecture and substrate microstructure must be carefully controlled in particular.

Homogeneous coating coverage across the foam strut network can be achieved while maintaining open porosity and accessible surface area. Coating architecture and processing conditions thereby govern transport properties and functional performance of the system.

The versatility of this approach is reflected in its applicability across different functional regimes. Functionalized metallic foams can serve as porous electrodes for hydrogen electrolysis through coatings based on exsolvable nanoparticles, as well as photocatalytic systems for flow-through water treatment when incorporating upconversion microcrystals to enhance light utilization. In both cases, tailored surface functionalization enables efficient interaction between reactive interfaces and flowing media.

Overall, conformal coating of complex foam structures can be achieved while preserving transport properties, providing a robust route for integrating functional materials into three-dimensional porous substrates. This work demonstrates transferable coating strategies for the functionalization of complex porous substrates, bridging electrochemical and photocatalytic applications. Coated metallic foams therefore emerge as a versatile platform for energy conversion and environmental applications.

Keywords: Open-cell metallic foams, surface functionalization, coating processes, hydrogen electrolysis, photocatalytic water treatment

IKTS water technologies - from materials to pilot plants

Burkhardt Faßauer[1*], Anja Gerbeth[2]

[1]*Fraunhofer IKTS, Water and Circular Technologies, Winterbergstr. 28, 01277 Dresden*
[2]*Fraunhofer IKTS, Water and Wastewater Systems Engineering, Winterbergstr. 28, 01277 Dresden*
[*]*burkhardt.fassauer@ikts.fraunhofer.de*

As a leading research service provider specialising in high-performance ceramics within the water sector, Fraunhofer IKTS focuses on the efficient treatment of municipal and industrial wastewater. The talk highlights the importance of ceramic innovations at the material and component level for the successful piloting of plant technology in a practical, industrial water technology setting. Key aspects include ceramic membranes and hybrid AO processes for the removal of trace substances. The focus is on photocatalytic membranes, 3D-printed TiO_2 structures, ultrasonic electrodes and plasma-based systems. In addition to water recovery, the aim is the efficient retention or degradation of pollutants in municipal and industrial water treatment. The presentation introduces innovative approaches to water treatment based on ceramic materials: hybrid membrane processes that combine filtration with advanced oxidation processes (AOP) in planar or tubular designs, as well as additive manufacturing via laser powder melting for the production of highly active TiO_2 structures, with the preservation of the anatase phase being of central importance. In addition, electrochemical concepts such as the sono-electrode for accelerated boundary layer reactions and energy-efficient pollutant oxidation, as well as cost-effective ta-C layers as an alternative to BDD electrodes, are being investigated. The spectrum is rounded off by compact, LTCC-based plasma systems (PLASKA), which generate reactive species upon contact with water, degrade pollutants without the use of chemicals and simultaneously disinfect. A proof of concept has been successfully demonstrated for many processes. For example, membrane samples with a 10 µm thick titanium layer exhibited the highest activity in radical formation. The technologies investigated offer high chemical and thermal resistance and enable targeted water flow through compact stack designs. The IKTS is thus positioning itself as a partner for the development of specific components for the 'next generation' of water treatment. The talks also includes some examples for pilot plants developed and established by IKTS.

Keywords: ceramic membranes, advanced oxidation processes, photocatalytic TiO_2, sono-electrode, pilot plants

Coatings for radiation management- a versatile tool for improving sustainability in buildings and devices

Matthias Fahland

Fraunhofer FEP

The radiation management of the incoming sunlight is a crucial tool for improving the sustainability of devices and buildings.

Sunlight can be exploited in different ways. Most prominently, the visual part of the spectrum is important for the light in the interior of buildings. At the same time, the near infrared part of the light can be used for the temperature regulation. It can support the heating system. At the same time, it can increase the necessary energy for air conditioning in warmer climates. The presentation will present surface technologies which are beneficial for the regulation of incoming light in both scenarios. Special attention will be paid to the application options of thermochromic coatings. Thermochromic coatings are one version of the so-called smart coatings which have the ability to adapt their properties according to the special situation, in this case in response to temperature changes of the window. Material characteristics and application scenarios will be discussed.

Another important field of radiation management is the optimization of photovoltaic modules. Light in-coupling systems, transparent electrodes, barriers and back reflectors are optical elements which interact with the absorbing material of the cells. The understanding of the optical characteristics of all elements and their interaction is crucial for improving the power conversion efficiency of the cells. Examples of recent projects are given.

The contribution will include a short introduction into fabrication tools for both piloting and large scale manufacturing of radiation management coatings.

The extruded ceramic membrane support and nanopore coating: Recent developments and prospect

In-Hyuck Song*, Hong Joo Lee, Jang Hoo Ha, Jongman Lee

Nano Materials Research Division, Korea Institute of Materials Science (KIMS), Changwon, Korea
**sih1654@kims.re.kr*

Ceramic membranes have limited applications until now owing to their high processing cost, despite their excellent properties such as long-term durability, high strength, and incredible thermal / chemical resistance compared with polymeric membranes. The filtration efficiency and permeability of ceramic membranes have rapidly increased, and manufacturing costs have continuously decreased due to continuous research. Nowadays, ceramics membrane market starts to open for field of withstanding harsh conditions such as oil, textile, semiconductor and hydrogen separation industry.

In this study, we will present the recent developments and prospect of ceramic membranes for wastewater and gas separation. Also, the research results of the multi-channel ceramic membrane developed by the extrusion process in KIMS were reported. In the case of alumina and zirconia membranes, permeability could be improved through the sol-gel process and surface modification. For silicon carbide membrane, by developing an oxidation bonded SiC membrane, an original excellent membrane could be developed.

Recently, in Korea, research program on the development of large area, high-strength, high-permeability extruded ceramic supports based on nanopores for the production of high-purity, high-flow hydrogen is carried out. We will introduce an extrusion process technology that can manufacture high-strength ceramic supports, control surface roughness, and coating technology that can form nanopores.

Keywords: Ceramic, Membranes, Filter, Pore structure, Extrusion

Study of thermal induced reversible devitrification in Zr-Pt amorphous alloys

Song-Yi Kim and Min-Ha Lee*

Research Institute of Intelligent Manufacturing & Materials Technology, Korea Institute of Industrial Technology, Incheon 21999, Republic of Korea
**mhlee1@kitech.re.kr*

Amorphous phases can be obtained by the liquid quenching technique based on the rapid cooling at a rate which is sufficient to bypass nucleation of crystalline phase. Crystallization due to devitrify of amorphous structure during the thermal annealing is common phenomenon because of the thermodynamic stability. However, it was recently observed that amorphous phase can be formed by a solid state reaction of pure polycrystalline metals under isothermal conditions. In current study, unlike other typical metallic glassy alloys which show annealing induced devitrification, we report the annealing induced vitrification (or reversible devitrification) in amorphous Zr-Pt binary melt spun ribbons with effect of critical cooling rate on the formation of metastable phase. This reversible devitrification is clearly represented in a Zr-Pt alloy which transformed into amorphous structure from metastable nanocrystals due to the decomposition of quenched in metastable crystalline phase by the annealing process.

$Zr_{77}Pt_{23}$ alloys obtained by different cooling rate at 15m/s, 20m/s were analyzed by X-ray diffraction. Zr-Pt alloy prepared at 15m/s is identified as an icosahedral phase. The amorphous phase and icosahedral phase are divided by the critical point (the blue line) under the cooling rate 1×10^4 °C/s. In annealing process, icosahedral phase in Zr-Pt alloy was transformed to amorphous phase at 400°C. Then, amorphous phase consistently changes to icosahedral phase with annealing at 400°C. Eventually, all phase in Zr-Pt alloy were observed icosahedral phases. We observed thermal induced reversible devitrification of $Zr_{77}Pt_{23}$ alloy. By annealed isothermal system at 400°C, Zr-Pt alloys showed reversible devitrification: the distorted icosahedral phase was transformed to stable icosahedral phase through the amorphous phase. Quenched-in nuclei of quasicrystals (i.e., i-phase) have large strain around nuclei due to incoherent interface because those are formed in the non-resist liquid. However, crystallized nuclei of quasicrystals by annealing have semi- or coherent interface to minimize interfacial strain because those are formed in the constraint solid even though amorphous phase. Therefore, to reduce misfit strain or free energy, the quenched-in metastable phase will decide whether it goes to overcome this strain by increasing size of crystal above the critical diameter (growth) or be submitted strain by adjusting interface to surrounding atoms (dissolution).

This reversible devitrification is clearly represented in a ZrPt alloy which transformed into amorphous structure from metastable nanocrystals due to the decomposition of quenched in metastable crystalline phase by the annealing process

Keywords: Amorphous alloy, Metallic glass, Crystallization, Rejuvenation, Quasicrystal

Subsea Laser Processing

Dr. Jan Hauptmann*, Dr. Madlen Borkmann

Department Laser Ablation and Cutting, Fraunhofer IWS, Dresden, Germany
**jan.hauptmann@iws.fraunhofer.de*

Laser technology has become an established tool in numerous areas of materials processing; however, underwater applications remain largely unexplored. The surrounding medium—water—poses fundamental challenges to beam delivery and propagation. Recent advances in high-power, directly emitting diode lasers operating at visible wavelengths (particularly in the kilowatt range) offer new opportunities to overcome these limitations.

In laser cutting, replacing the assist gas—traditionally used to expel molten material from the kerf—with water introduces entirely new process possibilities. Eliminating a compressible gas medium enables independence from water depth, which is a significant constraint in conventional underwater processes. Both theoretical analyses and experimental investigations indicate that water does not constitute a fundamental barrier to laser processing. In particular, blue laser radiation shows negligible attenuation over relevant distances in water, supporting its suitability for submerged applications.

This presentation reports on experimental studies conducted at the Fraunhofer Institute for Material and Beam Technology IWS, demonstrating the feasibility of underwater laser cutting and highlighting its application potential—especially in the context of automation and remote operation. Furthermore, initial exploratory experiments suggest that laser-based joining and cladding processes may also be viable underwater, opening new avenues for laser-assisted manufacturing and repair in submerged environments.

Keywords: Under water, laser cutting, laser material processing, laser cutting, laser cladding

Dry processing: A platform for LiB, SSB and next generation batteries

Stefan Kaskel

Fraunhofer IWS

The development of environmentally friendly battery production techniques is a key requisite for future sustainable battery development. The so-called DRYtraec® process is a solvent-free process developed at Fraunhofer IWS as a viable approach to replace slurry-based binders by fibrous polymers and produce laminated electrodes with a low carbon footprint. It has been demonstrated to work for liquid and solid electrolyte-based batteries.

We demonstrate applications in LIBs and SIBs cathode and anode processing. For lithium sulfur batteries carbon/sulfur composites can be processed without sulfur loss.

In particular in the field of solid state batteries DRYtraec® shows significant advantages. It is ideally suited for electrolyte and composite processing into dense and highly interface optimized electrodes. Free-standing argyrodite separator sheets are accessible with low binder content. For thin film Si-anodes, interface SE-engineering is an enabler for long term cycling. As a generic technique NMC/SE composites as well as sulfur/carbon systems can be produced. Testing on pouch cell level under relevant conditions advancing low pressure operation is an integral part of process evaluation. The presentation highlights recent developments of the DRYtraec® process and its application to LIBs, SIBs, ASSBs, and LiS-batteries.

ISNNM&EKAMP 2026

EKAMP：Life Science

Microphysiological Systems – Engineering and Applications

J. Golde[1,2], C. Dittfeld[3], A. Starcke[1], F. Schmieder[1] and F. Sonntag[1*]

[1]*Fraunhofer Institute for Material and Beam Technology IWS, Dresden, Germany*
[2]*Westsächsische Hochschule Zwickau WHZ, Zwickau, Germany*
[3]*Department of Cardiac Surgery, Faculty of Medicine and University Hospital Carl Gustav Carus, TU Dresden, Heart Centre Dresden, Germany*
[*]*frank.sonntag@iws.fraunhofer.de*

To this day, companies rely on animal testing for the development, testing, and approval of new implant materials, functionalization, and active substances, and in doing so, they face ethical, medical, and economic limitations. Research results obtained in mice or rats, for example, are only partially transferable to humans due to species differences such as variations in body size, the distribution of substances within the organism, and immune system responses. At the same time, animal husbandry and regulatory requirements represent a significant cost factor that offers little potential for optimization given legally mandated numbers of laboratory animals and rising laboratory costs.

Microphysiological systems (MPS) offer a promising alternative – Non-Animal Methods (NAMs), in which cell cultures, organoids, or tissue samples can be maintained in a manner analogous to that of a living organism and incubated under conditions that are as close to physiological as possible for various testing scenarios. Such miniature laboratories, known as organ-on-a-chip (OOAC) or MPS, are highly scalable and are therefore superior to animal testing from both an economic and, above all, an ethical perspective. To further promote the adoption of MPS-based methods and improve the reliability of the results, advanced tissue models with greater physiological relevance are needed. However, their broader adoption is limited by the lack of suitable non-invasive, depth-resolved imaging tools for dynamic three-dimensional monitoring of tissues and implant materials.

A major challenge in this context is the lack of contactless, time-resolved monitoring - for example, of the effect of a new implant material, a new functionalization (coating, texturing), or a new active substance on three-dimensional cell constructs or tissues. Currently, this is difficult to achieve, as established phase-contrast microscopy can only image the surface, and light-sheet fluorescence and confocal multiphoton microscopy are generally limited to penetration depths of up to 100 µm. For non-invasive in vitro imaging, optical methods from biomedical diagnostics are suitable, as they can image structures and changes across several orders of magnitude, from the cellular (~µm) to the tissue level (~mm). Optical Coherence Tomography (OCT) uses near-infrared light for interferometric 3D imaging of biological samples and meets these requirements with a resolution in the micrometer range. The current state of the art involves not only utilizing the backscattered light but also capturing dynamic and optical properties such as temporal speckle variance and polarization. With appropriate image processing, microscopic properties - such as metabolism and cell activity - can be derived from this data even during macroscopic observation - a mesoscopic approach to tissue function and tissue substructure that is particularly suited for non-invasive monitoring in MPS.

We present a modular MPS platform for the dynamic long-term culture of tissues and implant materials, optimized for non-contact, time-resolved 3D monitoring using polarization-sensitive OCT (PS-OCT). By imaging aortic valve and pericardial tissue, we demonstrate that PS-OCT enables the non-invasive, 3D characterization of tissue anatomy and pathology. Physiological features, such as the layered structure, which can be identified by the orientation of the optical axis in birefringent tissue, as well as pathological changes, which are reflected in the depolarization contrast, can thus be observed using PS-OCT.

Keywords: Microphysiological Systems, MPS, NAMs, OCT, PS-OCT

Electron Beam-Driven Engineering for Functional Materials in Life Sciences

N. Gürtler, U. König*

Biocompatible Materials, Fraunhofer Institute for Electron Beam and Plasma Technology FEP, Dresden, Germany
**ulla.koenig@fep.fraunhofer.de*

In life sciences, interface properties mostly dictate the performance of complex systems, from medical technology and biotechnology to pharmaceuticals. Whether cell adhesion on implants, biofouling control in bioreactors, or the inactivation of pathogens, the interface between biological systems and technical materials is often the key challenge for innovation. Conventional wet-chemical modification represents a strategic bottleneck, limited by high solvent consumption, thermal stress on sensitive substrates, and persistent toxic residues. These constraints hinder both the bio-economy and regulatory pathways. Low-energy electron beam technology (ebeam), utilizing accelerating voltages up to 300 keV, provides a transformative solution, a dry, chemical-free paradigm for precise and energy-efficient surface transformation. This methodology allows for the tailoring of biological responses without compromising the functional integrity of the base material. The technical core of ebeam lies in its non-thermal interaction mechanism. By delivering kinetic energy directly to the material's surface, the process induces radical formation, cross-linking, and grafting nearly independent of heat. This "cold" process is crucial for smart materials, intelligent implants as well as living or biohybrid substances. While the surface is (bio)functionalized, the material integrity remains intact, circumventing the damage caused by traditional thermal alternatives. This precision facilitates a critical transition from modifying synthetic interfaces to the complex stabilization of biological matrices.

As a promising electron beam-assisted process, the patented SULEEI (Stabilization by UV and Low-Energy Electron Irradiation) procedure utilizes decellularized tissues as a universal biomatrix for applications such as heart valve prostheses. Moving beyond the glutaraldehyde gold standard, SULEEI employs sequential photo-initiated UV crosslinking followed by low-energy electron irradiation. This dual-modality approach achieves ISO-compliant terminal sterilization and stabilization in a single step. Results demonstrate superior biocompatibility and a significant reduction in late-stage calcification. By preserving the natural extracellular matrix, SULEEI drastically reduces validation costs and time-to-market.

Furthermore, electron beam-induced grafting enables covalent functionalization of synthetic and bio-based polymers, allowing for the durable immobilization of bioactive substances. For instance, immobilizing water-soluble polymers onto film surfaces creates hydrophilic, anti-adhesive interfacial characteristics that prevent biofilm formation without biocides. The targeted, selective crosslinking achieved using low-energy accelerated electrons enables the formation of hydrogel-like interfaces with tunable hydration and biological interactions.

In addition, modifying biobased textiles with natural biocidal substances provides antiviral efficacy by inhibiting viral uptake. This specific electron beam-assisted textile modification fulfills the demand for high-performance, sustainable medical components.

In general, electron beam technology serves as an integrated high-speed development platform linking process design directly to industrial performance and scalability. Electron beam processes take place in seconds, making them highly efficient and easily integrable into industrial production lines (e.g. roll-to-roll). Its key features such as non-thermal processing, preservation of material integrity and adaptability make it a versatile enabler of "green engineering".

Keywords: Low-energy Electron Beam Technology, Surface Engineering, Biofunctionalization, Biomaterials, Sustainability

Pioneering the Future of Nuclear Energy: Advanced Manufacturing & Material Engineering

Suk Hoon Kang[1*], Joowon Suh[1], Wonjong Jeong[2], Seungmun Jung[1] and Ho Jin Ryu[3]

[1]*Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea*
[2]*Korea Institute of Machinery and Materials, Busan, 46744, Republic of Korea*
[3]*Korea Advanced Institute of Science and Technology, Daejeon, 34141, Republic of Korea*
[*]*shkang77@kaeri.re.kr*

Gen IV reactor systems are attracting attention as a key solution to mitigate the impacts of climate change due to global warming and to enable a safer and more stable energy supply. Gen IV reactors are expected to operate in extreme environments, including high temperatures, high radiation, high stress, and high corrosion. Consequently, key structural materials must exhibit high reliability and durability to maintain their integrity over long periods of time. These materials must be scalable beyond laboratory development to commercial scale, while simultaneously meeting both economic and environmental sustainability requirements.

The timely development of high-performance new materials is essential for the realization of advanced reactors. However, the current pace of research and development requires significant time and cost, and the practical application of new structural materials typically takes 10 to 20 years. To overcome these limitations, an integrated approach that integrates cutting-edge technologies and capabilities, such as additive manufacturing, automation and robotics, artificial intelligence (AI), and machine learning (ML), is required. This enables innovation across the entire material lifecycle, from design to manufacturing and performance verification, and is considered a way to dramatically improve the speed and efficiency of next-generation nuclear material development.

As part of this international effort to develop structural materials for Gen IV, materials and manufacturing-related issues are addressed through separate working groups. In May 2018, the Advanced Manufacturing and Materials Engineering (AMME) Task Group was established. It aims to foster cross-functional activities and collaborative projects within GIF countries, thereby accelerating the development of advanced materials and shortening the time required for their manufacture. Currently, the AMME Working Group is operating as a collaborative effort among researchers.

Keywords: Gen IV Reactors, Structural Materials, Advanced Manufacturing, AMME Task Group, Reliability

Cold Sintering processes in application for biomaterials and biomedical devices

A. Sharipova*, M. Fritsch, and M. Ahlhelm

Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden, Germany
**aliya.sharipova@ikts.fraunhofer.de*

Bioceramics based on hydroxyapatite (HAp) are widely used in bone healing applications due to their chemical similarity to bone mineral. However, replicating both the HAp–collagen composition and hierarchical microstructure of natural bone in dense materials remains a significant challenge, as conventional sintering requires high temperatures that induce grain growth and degrade organic components. Cold sintering (CS/CSP) has recently emerged as a promising alternative, enabling densification of ceramic-based materials at near-room temperatures through the application of high external pressure. This approach allows preservation of nanostructure and incorporation of organic phases that are otherwise incompatible with conventional processing.

In this work, we report on the fabrication of HAp–gelatin composites (79 wt% HAp) synthesized via precipitation in a gelatin matrix, followed by consolidation using CS at pressures up to 1000 MPa and temperatures up to 50 °C. The organic modification of HAp resulted in nanocrystalline particles embedded in a gelatin phase, closely mimicking the composition and structure of natural bone. This biomimetic nanostructure was retained after densification, yielding dense composites with ductile mechanical behavior and compressive strength approaching that of cancellous bone (~200 MPa). However, increasing consolidation pressure led to a reduction in mechanical strength, particularly at 1000 MPa, which is attributed to gelatin embrittlement and distortion of HAp nanocrystals. These findings highlight a trade-off between densification and structural integrity.

Beyond structural performance, the low-temperature nature of CS provides a unique opportunity to introduce additional functionalities into bioceramics. In particular, HAp–gelatin composites loaded with vancomycin demonstrated sustained drug release behavior governed by diffusion-controlled kinetics, well described by the Ritger–Peppas model. The release process exhibited an initial swelling-controlled regime, followed by Fickian diffusion after approximately three days. Notably, only ~50–55% of the drug was released over two weeks, indicating partial retention of the drug within the matrix and suggesting potential for prolonged therapeutic functionality.

We also demonstrate a novel approach for integrating metallic functionality into bioceramics through direct CS of multilayered structures. Using HAp–gelatin powders and gold (Au) nanoink-based features, multilayer composites with embedded metallization were fabricated at 1000 MPa and 50 °C without the need for thermal debinding or post-sintering treatments. Densification of the ceramic phase is supported by the plastic flow of the gelatin component, while the metallic phase densifies via plastic deformation of Au nanoparticles under pressure. This simultaneous consolidation enables the formation of dense conductive features within the ceramic-based matrix. The resulting ceramic–metal interfaces exhibit strong integrity without delamination, which is attributed to mechanical interlocking enhanced by interfacial roughness. The embedded metallic structures were successfully characterized using optical coherence tomography (OCT), providing a non-destructive method to assess the continuity and integrity of conductive pathways within the bulk material.

Overall, this work establishes CS as a versatile platform for the fabrication of multifunctional bioceramics that combine bone-mimicking structure, mechanical performance, and integrated electrical functionality. The ability to process ceramic–polymer–metal systems at near-room temperature opens new opportunities for next-generation implantable devices with combined structural, therapeutic, and electronic capabilities.

Keywords: Cold sintering, bioceramics, hydroxyapatite–gelatin, embedded metallization

Metal fiber structures for implants – the perfect match between strong and soft

Christian Redlich[1*], Georg Pöhle[1], Thomas Weissgaerber[1,5], Ulrike Jehring[1], Cris Kostmann[1], Olaf Andersen[1], Matthias Rüger[2], Ansgar Petersen[3], Peter Quadbeck[4]

[1]*Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Branch Lab Dresden, Germany*
[2]*Department of Paediatric Orthopedics and Traumatology, University Children´s Hospital Zurich, Switzerland*
[3]*Berlin Institute of Health at Charité (BIH), BIH Center for Regenerative Therapies (BCRT) and Julius Wolff Institute (JWI), Berlin, Germany*
[4]*Department of Electrical Engineering, Medical Engineering and Computer Science, Offenburg University of Applied Sciences, Offenburg, Germany*
[5]*Chair of Powder Metallurgy, Institute of Materials Science, TUD Dresden University of Technology, Dresden, Germany*
[*]*Christian.redlich@ifam-dd.fraunhofer.de*

Bone is a lightweight, hierarchical hard tissue that transmits complex loads and shows directiondependent mechanical behavior. The elastic modulus of bone can vary by up to 200% in one single bone of the same individual. Conventional bone implants do not have matching flexibility in mechanical properties, which is the reason for early implant failures due to poor mechanical compatibility, stress shielding, limited osseointegration, and aseptic loosening. These complications routinely occur in stems of ankle and elbow arthroplasties, tumor endoprostheses, and vertebral body replacement devices. Natural bone density and remodeling capacity vary strongly between individuals and with age. Thus, a biomimetic loadbearing implant material should (i) match the strengths and stiffnesses of the individual bone, (ii) allow continuous remodeling within and around the implant to adapt to biological changes, and (iii) provide a large surface area for optional biofunctionalization or coatings to further improve osteointegration. To improve anchorage, reduce stress shielding, and limit aseptic loosening, porous titanium structures were developed. Methods like plasma spraying or 3D printing via selective laser melting (SLM) have enabled agile production of complex, highly porous orthopedic implants. However, SLM still has limitations in cost, scalability, precision, quality control, and in matching mechanical behavior to individual bone structures.

A porous metal fiber structure that mimics the architecture and anisotropic mechanics of bone could improve implant survival in regions of high strain or in patients with low bone strength and remodeling capacity, while also reducing manufacturing costs. We developed a material called TiFi which consists of strategically layered and sintered titanium fibers to adjust implant architecture and mechanical properties. Its pore network is suitable for vascularization and bone ingrowth. Thus, the TiFi material is “strong” in terms of load-bearing capability, and “soft” in terms of adaptation to the shape of peri-implant bone region. The concept was extended to resorbable magnesiumalloy fiber structures for bone regeneration applications. The talk will present the manufacturing process, structural composition, mechanical properties, in vitro biocompatibility and cell colonizability, and in vivo osseointegration of both variants of metallic fiber structures.

Keywords: Medical technology, metallic fiber materials, implants, titanium, magnesium

Data-Driven Real-Time Prediction and Process Optimization of Micro/Nanofiber Additive Manufacturing

Dongwoon Shin[1*], Joonphil Choi[1], Yongrae Kim[1], Phil-Ho Lee[1], Minkyo Jung[1], and Jiyoung Chang[2]

[1]*Department of 3D Printing, Korea Institute of Machinery and Materials (KIMM), Daejeon 34103, Republic of Korea*
[2]*Department of Mechanical Engineering, University of Utah, Salt Lake City, UT 84112, USA*
[*]*shindw@kimm.re.kr*

Micro/nanofiber additive manufacturing (AM) enables the freeform fabrication of functional fibers with diameters ranging from the micro- to the nanoscale for tissue engineering, printed and flexible electronics, and sensing. A representative process is electrohydrodynamic direct-writing (EDW), also known as near-field electrospinning, in which electric forces draw a polymer jet into fibers far smaller than the nozzle diameter. However, such processes couple hydrodynamic, capillary, and electrostatic forces with rapid solvent evaporation, so fiber dimensions and deposition patterns are difficult to predict and process development still relies heavily on trial and error. This work presents a data-driven framework that replaces empirical tuning with real-time, model-based prediction and optimization of the printing process. A real-time monitoring system was built to capture in-situ images of the Taylor cone and jet during printing, and image analysis was used to extract jet-profile features across the key process parameters: applied voltage, nozzle-to-collector distance, feed rate, collector speed, and solution concentration. A multilayer perceptron (MLP) multi-output regression model was trained on these data to predict the jet diameter and the jet center position. The model achieved root-mean-square errors of 0.025 for jet diameter and 0.078 for jet center position on unseen data, with an inference time of 0.043 s per prediction. The agreement between predicted and observed jet profiles allowed an operational parameter window for stable, optimal jetting to be mapped without exhaustive experimentation. The millisecond-scale inference time indicates that the model is well suited for embedded, real-time deployment on GPUs or FPGAs, enabling closed-loop monitoring and on-the-fly parameter adjustment during printing. More broadly, the study shows that coupling real-time process imaging with a lightweight predictive model can convert the complex multiphysics of micro/nanofiber AM into fast, accurate predictions, reducing reliance on trial-and-error and advancing toward fully automated, intelligent fiber manufacturing. Ongoing work targets the prediction of jet initiation and the inclusion of additional factors, such as polymer molecular weight, nozzle geometry, and environmental conditions, to broaden the design space.

Keywords: Micro/nanofiber additive manufacturing, Electrohydrodynamic direct-writing, Machine learning, Real-time monitoring, Process optimization

ISNNM&EKAMP 2026

(Special Session)

ISNNM: Additive Manufacturing of Advanced Materials

Enhancing the High-Temperature Mechanical Performance of Additively Manufactured Inconel 718 through HfC Reinforcement

Wonjong Jeong[1], Joowon Suh[2], Suk Hoon Kang[2], Seungmun Jung[2], In-Dcuk Park[1], Ho Jin Ryu[3*]

[1]*Department of Industrial Laser Technology, Korea Institute of Machinery and Materials, Republic of Korea*
[2]*Materials Safety Technology Development Division, Korea Atomic Energy Research Institute, Daejeon 34057, Republic of Korea*
[3]*Department of Materials Science and Engineering, KAIST, Daejeon, Republic of Korea*
[*]*hojinryu@kaist.ac.kr*

Nickel-based superalloy matrix composites fabricated by additive manufacturing have attracted increasing attention as a promising approach to improving the mechanical performance of nickel-based superalloys. However, additively manufactured nickel-based composites often exhibit relatively limited high-temperature mechanical properties compared with those produced by conventional manufacturing processes. In this study, HfC-reinforced Inconel 718 composite powders were applied to a laser powder directed energy deposition process to fabricate composite specimens. The room-temperature and high-temperature tensile properties, as well as creep behavior, were systematically investigated before and after heat treatment. Composite powders containing up to 6 vol.% HfC were prepared using the surface modification and reinforcement transportation process and subsequently deposited by laser powder directed energy deposition. During deposition, the added HfC partially decomposed and contributed to the formation of carbide phases, identified as (Hf, Nb, Ti)C, in the interdendritic regions. In addition, the HfC addition influenced the solidification behavior and promoted columnar grain formation. The specimens containing up to 3 vol.% HfC exhibited more than a 15% increase in room-temperature yield strength compared with the unreinforced Inconel 718 specimens, both before and after heat treatment, while satisfying the AMS 5663 specification. Furthermore, the heat-treated specimen containing 3 vol.% HfC showed remarkable improvements in high-temperature mechanical performance at 650 °C. Compared with the unreinforced specimen, its yield strength and elongation increased by more than 20% and 500%, respectively. The creep elongation and rupture life were also enhanced by approximately 300% and 400%, respectively. These improvements in high-temperature mechanical properties are attributed to the combined effects of secondary carbide phases formed in the interdendritic regions and the development of columnar grain structures, which increased resistance to deformation at elevated temperatures. These results demonstrate that HfC reinforcement is an effective strategy for enhancing the tensile and creep performance of additively manufactured Inconel 718, suggesting the strong potential of HfC-reinforced Inconel 718 composites for high-temperature structural applications.

Keywords: Inconel 718, Hafnium carbide, laser powder directed energy deposition, additive manufacturing, mechanical properties, Creep properties

Acknowledgments

This work was supported by National Research Foundation of Korea (NRF) grants funded by the Ministry of Science and ICT (Grant numbers 2022R1A5A1030054) and Korea Institute of Energy Technology Evaluation and Planning (KETEP) grants funded by the Korea government (20241E00000020).

Novel Sc-free Al-Mg-Si-Zr alloy for laser powder bed fusion

Philip Grimm[1,2], Stefan Martin[2], Jongtae Kim[3], Junhee Han[3], and Julia Kristin Hufenbach[1,2*]

[1]*Institute of Materials Science, Technische Universität Bergakademie Freiberg, Freiberg, Germany*
[2]*Institute for Materials Chemistry, Leibniz Institute for Solid State and Materials Research Dresden, Dresden, Germany*
[3]*Korea Institute for Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[*] *j.k.hufenbach@ifw-dresden.de*

The demand for novel high-performance alloys for laser-based additive manufacturing (AM) has increased significantly over the past decade, as conventional high-strength wrought aluminum alloys are highly susceptible to hot tearing under the rapid solidification conditions inherent to the process. Furthermore, the use of critical alloying elements in Al-based materials, such as scandium, should be minimized to improve sustainability and reduce material costs.

In this study, a customized Al–Mg–Si–Zr alloy for laser powder bed fusion (PBF-LB/M) was developed, combining high strength, sufficient ductility, and excellent processability. Various Al–Mg–Si–Zr compositions were produced using an efficient casting approach to estimate their thermophysical properties, microstructure, and mechanical performance. The most promising alloy was subsequently gas-atomized into powder, processed by PBF-LB/M, and comprehensively characterized.

Highly dense (> 99.5%) and crack-free specimens were successfully manufactured over a wide range of energy densities while exhibiting outstanding mechanical properties, including a yield strength of almost 400 MPa and an elongation to fracture of approximately 14% in the as-built condition. These properties are attributed to the refined microstructure consisting of α-Al grains, an Al-Mg_2Si eutectic network along grain boundaries, and finely dispersed Al_3Zr precipitates acting as grain refiners. The microstructure was analyzed using transmission electron microscopy (TEM), electron backscatter diffraction (EBSD), and X-ray diffraction (XRD).

Overall, the newly developed Al–Mg–Si–Zr alloy demonstrates strong potential as a resource-efficient material tailored for PBF-LB/M applications in the aerospace and automotive industry.

Keywords: Additive manufacturing, laser powder bed fusion, Al-based alloy, mechanical properties, microstructure

Acknowledgement

This work was supported by the German Research Foundation (DFG) within the Research Training Group GRK 2868 D^3 - project number 493401063.

ISNNM&EKAMP 2026

(Special Session)

ISNNM: AI and Simulation based Novel Catalytic Materials Design

Tuning Oxygen Evolution Activity via Water-Induced Interfacial Electronic Effects

Hyeyoung Shin*

Department of Chemistry, College of Science, Kyung Hee University, Seoul, 02447, Republic of Korea

Understanding how interfacial environments influence the oxygen evolution reaction (OER) is critical for the rational design of efficient oxide electrocatalysts. Here, we investigate the role of interfacial water in modulating the electronic structure and reaction energetics of a model oxide system. By incorporating explicit interfacial interactions into first-principles calculations, we find that the presence of water induces a significant redistribution of electronic density at the active site, which in turn alters the nature of key oxygen intermediates and the associated reaction pathway. This interfacial effect facilitates more favorable O–O bond formation while mitigating excessive oxidation of the catalytic center, ultimately leading to improved reaction energetics. Furthermore, extending this framework to chemically modified systems reveals a consistent relationship between interfacial bonding characteristics and catalytic activity. These findings highlight the importance of explicitly considering interfacial environments in electrocatalysis and provide a general design principle for enhancing OER performance through electronic structure tuning.

Active learning approach in designing entropy alloy nanocatalyst

YongJoo Kim*

Department of Materials Science and Engineering, Korea University, Seoul, South Korea
**cjyjee@korea.ac.kr*

Searching for an optimal component and composition of multi-metallic alloy catalysts, comprising two or more elements, is one of the key issues in catalysis research. Due to the exhaustive data requirement of conventional machine-learning (ML) models and the high cost of experimental trials, current approaches rely mainly on the combination of density functional theory and ML techniques. In this study, a significant step is taken toward overcoming limitations by the interplay of experiment and active learning to effectively search for an optimal component and composition of multi-metallic alloy catalysts. The active-learning model is iteratively updated using by examining electrocatalytic performance of fabricated solid-solution nanoparticles for the hydrogen evolution reaction (HER). An optimal metal precursor composition of $Pt_{0.65}Ru_{0.30}Ni_{0.05}$ exhibits an HER overpotential of 54.2 mV, which is superior to that of the pure Pt catalyst. This result indicates the successful construction of the model by only utilizing the precursor mixture composition as input data, thereby improving the overpotential by searching for an optimal catalyst. This method appears to be widely applicable since it is able to determine an optimal component and composition of electrocatalyst without obvious restriction to the types of catalysts to which it can be applied.

Keywords: Active learning, entropy alloy, nanocatalyst, machine learning, hydrogen evolution

Electrocatalyst Design for Next-Generation Hydrogen Production from Efficient Water Oxidation to Energy-Saving Urea Oxidation

Thangavel Saktivel[1], Seyoung Park[1], Yueun Jun[1], Tae Joong Kim[1],
Hyeyoung Shin[2], Yongjoo Kim[3], Sungwook Mhin[1*]

[1]*Department of Energy and Materials Engineering, Dongguk University, 30 Pildong-ro 1-gil, Jung-gu, Seoul, 04620, Republic of Korea*
[2]*Department of Chemistry, College of Science, Kyung Hee University, Seoul, 02447, Republic of Korea*
[3]*Department of Materials Science and Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, Republic of Korea*

Hydrogen is emerging as a central energy vector in the transition toward a sustainable carbon-neutral society, and alkaline electrolysis offers an attractive platform for large-scale production owing to its economic viability and compatibility with earth-abundant materials. Nevertheless, its widespread deployment remains limited by the sluggish oxygen evolution reaction (OER) and the insufficient durability of anodic electrocatalysts. In this presentation, I will discuss our recent efforts to address these challenges through the rational design of LDH-based OER catalysts. Through electronic structure modulation, improved interfacial charge transport, and reinforced structural robustness, these systems enable enhanced catalytic activity and long-term stability under alkaline operating conditions. Extending beyond conventional water oxidation, this presentation also highlights an energy-saving route for hydrogen production based on the urea oxidation reaction (UOR). Distinct from the LDH systems used for OER, the UOR platform is built on a MOF catalyst, where conductivity engineering and dynamic active-site formation promote rapid NiOOH-derived active phase generation, enhanced charge transport, and efficient low-voltage urea-assisted electrolysis. These studies provide an integrated perspective on advanced catalyst design for efficient, durable, and energy-conscious hydrogen production.

A New Paradigm in Materials Research Driven by Data and Artificial Intelligence

Minkyu Park*, Minho Lee

Virtual Lab Inc.
**minkyu.park@matsq.com*

Materials research requires the exploration of vast chemical, structural, and processing spaces, where conventional trial-and-error experiments and rule-based simulations often face limitations in speed, scalability, and efficiency. As the demand for advanced functional materials grows, artificial intelligence (AI) and data-driven approaches are becoming essential for accelerating discovery, improving reproducibility, and guiding more systematic decision-making.

However, applying AI to materials research is not straightforward. Materials data are often fragmented across experiments, simulations, literature, images, spectra, and process records, with inconsistent formats and varying quality. Building reliable AI models also requires data cleaning, structuring, feature extraction, model training, validation, and interpretation, which can be time-consuming and technically demanding for individual researchers.

In this presentation, we introduce D3Square, a data-driven materials discovery platform that enables researchers to access AI-based materials research more quickly and easily. D3Square supports structured data collection, AI-ready data pipelines, automated model training, property prediction, and optimization of materials and processing conditions. It also provides inverse design capabilities to identify promising candidates that satisfy target properties, as well as active learning workflows that iteratively suggest the most informative next experiments or simulations.

Through academic and industrial case studies, this presentation will demonstrate how D3Square lowers the barrier to AI adoption and enhances the speed, scalability, and reliability of materials discovery. Finally, we emphasize the importance of automated materials data acquisition and integrated AI platforms as key foundations for sustainable innovation in materials research.

Keywords: AI, Materials Informatics, Inverse Design, Active Learning, DFT, MD, Platform, D3Square

ISNNM&EKAMP 2026

(Special Session)

ISNNM: Critical Materials and Sustainability

Development of a Novel EA-P Process for Nickel Recovery from Nickel Pig Iron

Jae Hong Shin[1*], Seounguk Bae[1,2] Myungsuk Kim[1,3], Kyoung-Tae Park[1]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Department of Materials Science and Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea*
[3]*Department of Materials Science and Engineering, Korea University, Seoul, 02841, Republic of Korea*
[*] *shinclusion@kitech.re.kr*

Nickel is a critical material in battery and advanced industrial applications, with the growing demand for high-purity nickel compounds driven by the rapid expansion of electric vehicle batteries and energy storage systems. This study presents an innovative refining process that integrates Electrochemically Assisted Powderization (EA-P) and Solvent Extraction techniques for the efficient recovery of high-purity nickel from Nickel Pig Iron (NPI).

The EA-P process converts bulk NPI into nanopowder, dramatically increasing the surface area and enhancing the dissolution efficiency compared to conventional bulk forms. The nanopowder is subsequently dissolved in sulfuric acid, followed by a solvent extraction process to selectively remove impurities such as iron (Fe) and chromium (Cr). Optimal extractants and process conditions were determined to achieve the efficient production of high-purity nickel sulfate ($NiSO_4$), which is essential for battery manufacturing.

Additionally, a pyrometallurgical refining process utilizing the carbonyl process was developed. The carbonylation reaction selectively separates nickel from iron by forming nickel tetracarbonyl gas, which is then purified and thermally decomposed to obtain high-purity nickel powder. Thermodynamic analysis identified the optimal temperature and pressure conditions to maximize reaction efficiency while minimizing energy consumption.

The proposed EA-P and solvent extraction-based refining process offers significant advantages over conventional high-pressure acid leaching (HPAL) methods, including reduced energy consumption, lower environmental impact, and enhanced nickel recovery efficiency. Future research will focus on scaling up the process from the laboratory to a semi-pilot scale, paving the way for industrial application and contributing to the establishment of a stable and sustainable nickel supply chain.

Keywords: Nickel Pig Iron, Nickel, EA-P, Solvent Extraction, Cabonyl process

Securing High-Purity Nickel for the Green Energy Era through Carbonyl Metallurgy

Youngjae Kim*

Department of Materials Science and Engineering, Inha University, Incheon, Korea
**youngjae@inha.ac.kr*

The Mond process, which exploits the reversible reaction between nickel and carbon monoxide to form volatile nickel tetracarbonyl ($Ni(CO)_4$), offers a promising route for producing high-purity Class 1 nickel ($\geq$99.8%) required for cathode active materials in lithium-ion batteries. Its kinetic behavior under industrially relevant conditions, however, remains insufficiently understood. In this study, the effects of temperature (373–541 K), CO pressure (20–70 bar), and particle size on the carbonylation kinetics of metallic nickel were systematically investigated using both pellet and powder specimens.

The carbonyl conversion rate increased linearly with pressure from 20 to 60 bar, whereas a non-linear enhancement was observed at 70 bar. With respect to temperature, the maximum conversion was achieved near 443 K. Pressure was found to exert a more dominant influence on the overall reaction than temperature. SEM analysis of reacted pellet surfaces revealed step-like morphologies analogous to those described by the Burton–Cabrera–Frank (BCF) crystal growth mechanism. The carbonylation reaction is therefore interpreted as the reverse of the BCF growth process, wherein Ni atoms detach preferentially from step and kink sites defined by the Terrace-Ledge-Kink (TLK) model. At 70 bar, etch pits were observed on the surface, suggesting the existence of a critical driving force between 60 and 70 bar that triggers a transition from step-flow dissolution to a step-wave mechanism, thereby accounting for the non-linear conversion behavior. EBSD analysis confirmed that annealing at 643 K and 773 K progressively reduced the geometrically necessary dislocation (GND) density, which in turn diminished the carbonyl conversion rate, supporting the conclusion that dislocation-sourced steps are essential for sustaining the surface reaction.

For powder specimens, since $Ni(CO)_4$ exists as a liquid phase under typical Mond process operating conditions, a porous ceramic disk was employed for in-situ solid–liquid separation to prevent the powder samples from being submerged in the liquid-phase product. With this configuration, the conversion of 45 μm powder reached approximately 98% within 3 hours.

Keywords: Nickel carbonyl, Mond process, BCF mechanism, TLK model, carbonylation kinetics, Nickel recycling

Pyrometallurgical Recovery of Lithium from Waste Secondary Batteries Using Molten Carbonate Electrolytes and Self-Propagating High-Temperature Synthesis

Seok-Jun Seo, and Kyoung-Tae Park*

Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea
**ktpark@kitech.re.kr*

The increasing demand for lithium-ion batteries (LIBs) in electric vehicles and portable electronic devices has led to growing interest in efficient recycling technologies for recovering valuable lithium resources from spent batteries. Conventional recycling processes are primarily focused on the recovery of transition metals, while efficient lithium recovery remains a significant challenge. In this study, pyrometallurgical processes based on self-propagating high-temperature synthesis (SHS) and molten carbonate electrolyte systems were investigated for lithium recovery from waste secondary battery materials. SHS treatment was employed to induce phase transformation and facilitate lithium concentration into recoverable compounds, while molten carbonate electrolyte processing was applied to selectively recover lithium through high-temperature electrochemical reactions. The proposed processes enable lithium recovery without extensive chemical leaching steps and offer potential advantages in terms of process simplicity and resource efficiency. Experimental results demonstrate the feasibility of recovering lithium from spent LIB materials through pyrometallurgical approaches and suggest that SHS and molten carbonate electrolyte technologies can serve as promising alternatives for sustainable lithium resource recycling.

Keywords: Lithium-ion Battery Recycling, Molten Salt Reaction, Self-propagation High-temperature Synthesis, Lithium Recovery

ISNNM&EKAMP 2026

(Special Session)

ISNNM: Industrial Technology

From Research to Industry: Applications and latest Developments in the field of FAST/SPS-Sintering

Jens Huber*

Dr. Fritsch Sondermaschinen GmbH, Fellbach, Germany
**jenshuber@dr-fritsch.de*

Spark Plasma Sintering, also known as Field Assisted Sintering (FAST/SPS), is the answer to many issues industries and researchers around the world are dealing with. It allows to sinter materials with exactly pre-defined characteristics and combines this precision with a very fast and energy-efficient manufacturing process. The development of new materials can be accelerated significantly compared to traditional hot-pressing techniques. In fact, the sinter quality and achievable density comes close or is on par with Hot-Isostatic-Pressing (HIP) but at a fraction of the cost and time, furthermore with much less grain growth.

The basic idea of sintering with electric current is relatively old. The resistance heating of hard metal powders was patented as early as 1933 by the American inventor George F. Taylor[1]. Since then, the technique has evolved and is known by many different names. SPS, Spark Plasma Sintering, is the most commonly used name, but from a technical point of view it is not correct. There is no proof of the existence of a spark or a plasma. Therefore, for some years now, the term FAST has often been prefixed, which is technically a more appropriate description of how it works.

Most users are already familiar with traditional hot pressing methods before they get into contact with FAST/SPS sintering. Traditional hot pressing is one of the most widely used methods for consolidating cold-pressed or loose powders. However, hot pressing is often associated with long sintering cycles and low flexibility.

FAST/SPS sintering follows a different approach. FAST stands for “Field Assisted Sintering Technique”, SPS for “Spark Plasma Sintering”. The terms are used synonymously and refer to sintering by means of joule heating. Current is passed directly through the mold. The resistance of the mold material and the powder part or green compact generate the heat directly in the powder or mold. Unlike the conventional furnace, neither the sintering chamber nor the atmosphere inside the chamber is actively heated. The heat is generated directly where it is needed - in the sintered material or in the mold surrounding the sintered material.

This leads to very high heating rates and additionally to a significant increase in the sintering activity of fine metal powder aggregates. Depending on the part size, sinter cycles of only a few minutes can be achieved. Furthermore, this process lowers the sintering temperature and the sintering pressure compared to conventional sintering processes.

FAST/SPS sintering of metallic materials has long been state of the art. Major applications are the diamond tool and friction materials industries. However, the main application for FAST/SPS is sintering ceramics. FAST/SPS applications for ceramic materials range from defense to sputtering targets, jewelry and semiconductors. Typical sizes are ceramic plates with diameters of up to 400mm and in near future even larger parts.

A key for producing such large geometries and for high productivity are FAST/SPS machines and automation systems which are able to handle the required production volumes and weights.

Keywords: Sintering, Field Assisted Sintering, Spark Plasma Sintering, Advanced Materials

Reference

[1] *Taylor G.F.* U.S. Patent 1896854, “Apparatus for Making Hard Metal Compositions”, granted February 7, 1933.

On HIP In-Situ High Pressure Gas Quenching

Anders Magnusson[1*], Joohyun Jeon[2], Mustafa Turkoglu[3], James Shipley[1]

[1]*Quintus Technologies (Global BD, Västerås, Sweden)*
[2]*Quintus Technologies (Area Sales, Seoul, Korea)*
[3]*Quintus Technologies (Area Sales, Stuttgart, Germany)*
[*]*anders.magnusson@quintusteam.com*

Development of the Hot Isostatic Pressing, HIP, process equipment has now reached a point where most traditional heat treatment processes can be integrated as part of the HIP densification step, offering the possibility to reduce energy, time at temperature and capital equipment investments. However, processing at high temperature and high-pressures offers some interesting metallurgical and thermodynamics aspects, although historically mostly explored for the GPa pressure range. This as the pressure component in Gibbs free energy calculation and the diffusion equations starts yielding major contributions only at the GPa pressures. However, several investigations conducted in the last decade show that also the MPa pressure range will offer some interesting metallurgical features for both academia and industry, especially when it comes to the high-pressure gas quenching operation. This presentation aims to show a compilation of work done up until today on the effects of MPa gas pressure quenching, what parameters it is affecting, and what potential this can bring for research in academia and applications for the industry as demonstrated by the latest work on understanding the integration of the T6 (solutionizing, quenching and ageing) heat treatment for AlSi7Mg in different size HIP and batch loading.

Keywords: Hot isostatic pressing, high-pressure gas quenching

ISNNM&EKAMP 2026

(Special Session)

ISNNM: Nanomaterial-based Next-generation Energy

Development of in-situ operando microscale reverse electrodialysis as an energy harvesting platform

Inhee Cho*

Korea Institute of Industrial Technology(KITECH), Korea National Institute of Rare Metals(KORAM)
**cdcih@kitech.re.kr*

Reverse electrodialysis (RED) is an important electrochemical energy conversion system since it directly converts the salinity gradient between high- and low-concentration solutions into electrical energy through ion-selective membranes. However, conventional RED systems are generally evaluated by macroscopic electrical outputs, such as voltage, current density, and power density, which makes it difficult to directly observe how electrode reactions and ion fluxes are generated and varied during operation. Although these measurements provide reliable performance information, they do not easily allow for in-time visualization of local ion evolution, especially near the electrode region where water dissociation and charge compensation reactions occur.

In this work, we developed a microscale reverse electrodialysis system for visualizing electrode reaction behavior. The microscale RED platform was designed to monitor flow behavior and ion flux in real time under controlled salinity-gradient conditions. In particular, the cathode region was selected as the main visualization area because the ionic current passing through the cathode can trigger electrode reactions by separating water molecules into hydrogen ions and hydroxide ions. To track the local hydrogen ion evolution, a fluorescent dye, Alexa 488, was introduced into the system. During operation, the green fluorescence near the cathode became darkened, indicating hydrogen ion generation and local pH variation.

With our system, we confirmed that the hydrogen ion profile was highly dependent on the salinity gradient and the corresponding ionic current in the RED system. The microscale platform generated a controllable salinity gradient by modulating two inflows on demand. Furthermore, the slow-run flow condition induced a larger boundary layer from the cathode, which enabled more effective capture of hydrogen ion evolution through fluorescence imaging. The visualization platform also allowed us to quantify the boundary-layer length associated with hydrogen ion evolution. The collapsed length and the corresponding ionic current showed a linear relationship, which was in line with previous theoretical and experimental results.

This work would pave the way for the possibility not only for directly visualizing electrode reactions in reverse electrodialysis systems, but also for integrating electrochemical performance analysis with real-time ion-flux monitoring. Furthermore, this microscale visualization strategy could provide a useful platform for understanding local reaction dynamics in salinity-gradient energy systems and for digitalizing electrochemical process analysis with additional image-based data acquisition systems.

Keywords: Reverse Electrodialysis, ion-selective membranes, in-situ monitoring, hydrogen production, energy harvesting

Understanding ion dynamics in electric double-layer for chemo-mechanical energy harvesting

Seongjae Oh[1], Keon Jung Kim[2], and Shi Hyeong Kim[1*]

[1]*Textile Innovation R&D Department, Korea Institute of Industrial Technology, Ansan, Republic of Korea*
[2]*User Convenience Technology R&D Department, Korea Institute of Industrial Technology, Ansan, Republic of Korea*
[*]*shk@kitech.re.kr*

Chemo-mechanical energy harvesters based on twisted carbon nanotube (CNT) yarns convert mechanical energy into electrical energy through capacitance changes in the electric double layer (EDL) formed at the electrode–electrolyte interface. Although this capacitance-change framework has served as the prevailing explanation, the atomic-scale ion dynamics governing EDL formation, charge storage, and energy conversion during mechanical deformation have remained largely unresolved. This study presents a comprehensive investigation of the piezoionic mechanisms underpinning chemo-mechanical energy harvesting, integrating in situ Raman spectroscopy, piezoelectrochemical impedance spectroscopy (PIS), electrochemical impedance spectroscopy (EIS), and multiscale molecular dynamics (MD) simulations.

The EDL of CNT yarn harvesters is structured according to the Gouy–Chapman–Stern model, wherein cations and anions occupy distinct inner and outer Helmholtz planes (IHP and OHP). Within this architecture, the two ionic species play fundamentally different roles in energy conversion. Cations function as adhesive ions that stabilize the polarization layer at the IHP. The structural mechanics of the hydration shell—specifically ligand bond strength and interligand repulsion—determine adsorption kinetics: hydrated K+ clusters, possessing flexible shells with low interligand repulsion, exhibit superior mobility and sensitivity to electrostatic potential changes at the EDL, explaining the experimentally observed performance trend of KCl > NaCl > LiCl. In HCl electrolyte, H3O+ exploits its asymmetric C3v structure to densely populate the IHP without complete ligand loss, forming a strongly polarized inner layer that amplifies open-circuit voltage. In contrast, anions—particularly Cl-—are the primary drivers of piezoionic energy generation. Cl- adsorbs at the OHP through an electronically isolated orbital configuration that is incompatible with the spx hybridized orbitals of CNTs, establishing a strong electrostatic potential at the electrode surface. In situ Raman analysis confirmed that mechanical stretching causes a reversible leftward G-band shift, directly evidencing Cl- desorption from the CNT bundle into the electrolyte. This anion depletion process, termed unipolarization, constitutes the principal mechanism by which mechanical deformation energy is transduced into an electrical potential difference.

The dynamic interplay between cation and anion layers is governed by both mechanical and electrical operating conditions. Under cross-sectional compression, the OHP collapses preferentially before the IHP, releasing Cl- while the H3O+-stabilized IHP is transiently preserved, thereby sustaining a net EDL polarity that drives electron transport. PIS and EIS analyses further revealed that this piezoionic behavior is frequency-dependent: at low stretching frequencies, mass transport and Stern-layer ion exchange dominate, whereas charge-transfer resistance of the electrolyte controls harvesting performance at high frequencies. These findings collectively redefine the design criteria for chemo-mechanical energy harvesters, establishing ion mobility, hydration shell flexibility, and EDL structural asymmetry as the key parameters for maximizing energy output across diverse aqueous environments.

Keywords: Energy harvesting, Piezoionic, Carbon nanotube yarn, Electric double layer, Ion dynamics

One-dimensional Nanostructures for Energy Conversion and Storage

Kihyun Cho[1,2]

[1]*Department of Energy Engineering, Dankook University, Cheonan 31116, Republic of Korea*
[2]*Department of Hydrogen Energy, Dankook University, Cheonan 31116, Republic of Korea*

One-dimensional nanostructures provide a versatile platform for energy conversion and storage by enabling directional transport, enlarged active surface area, and nanoscale control over carrier and ion migration. This presentation discusses two representative examples in which one-dimensional architectures improve energy-related functions through size effects and continuous transport pathways. First, vertically grown semiconductor nanowire thin films are developed as heterostructured photoelectrodes for energy conversion. The nanowire geometry increases the active surface area, while the nanoscale diameter shortens the radial transport distance for photogenerated holes, promoting their transfer to the surface before recombination. This design improves charge separation and surface reaction kinetics in photoelectrochemical energy-conversion systems. Second, chalcogenide nanowires are used as solid ion-conducting nanostructures, where radial nanoscale confinement facilitates ion migration and axially continuous pathways suppress junction-limited transport. These examples demonstrate that one-dimensional nanostructure design is an effective strategy for controlling charge and ion transport in energy conversion and storage materials.

Earth-Abundant Nanocatalysts for Solar Hydrogen Production and Plastic Waste Valorization

Kwang Leong Choy

The Environmental Research Center, Division of Natural and Applied Sciences, Duke Kunshan University, Kunshan, Jiangsu, China
**kwang.choy@duke.edu*

This presentation highlights the transformative role of advanced nanostructured materials in addressing global energy challenges, with a central focus on next-generation renewable energy systems. We present the rational design of novel, earth-abundant nanomaterials engineered for sustainability—specifically targeting solar-driven hydrogen production. A cornerstone of this work is the establishment of robust structure–property correlations in nanoscale architectures derived from non-toxic, abundant precursors, enabling precise performance optimization for energy conversion applications.

A key advancement is the development of eco-friendly nanocatalysts based on doped chalcogenides for photocatalytic reforming of plastics to produce green hydrogen. These nanostructured catalysts achieve exceptional H_2 evolution rates by synergistically enhancing three critical functions: visible-light absorption, charge separation kinetics, and surface redox activity. A key demonstration is the dual-function performance: non-recyclable plastic waste is valorized alongside clean hydrogen generation. This integrated strategy addresses the twin crises of plastic pollution and carbon-intensive fuel production. The presentation elucidates catalyst design principles, mechanistic pathways of plastic photoreforming, and nanoscale engineering strategies. Ultimately, this work establishes a transformative pathway for circular economy solutions: converting waste hydrocarbons into sustainable hydrogen energy using sunlight and earth-abundant, nanostructured materials.

Keywords: Nanostructured materials, Earth-abundant photocatalysts, Solar-driven hydrogen production, Photocatalytic reforming, Plastic waste valorization

Improving Lithium–Sulfur Batteries Using 2D Material-Based Strategies

Seulgi Kim*

Resources Utilization Research Center, Korea Institute of Geoscience and Mineral Resources, Daejeon 34132, Republic of Korea
**seulgikim@kigam.re.kr*

Lithium–sulfur (Li–S) batteries have attracted considerable attention as next-generation energy-storage systems owing to their high theoretical energy density and cost-effectiveness. However, their practical application remains limited by several critical challenges, including the polysulfide shuttle effect, sluggish sulfur redox kinetics, and the instability of lithium-metal anodes. These issues lead to severe capacity fading, poor cycling stability, and limited rate performance. Recently, two-dimensional (2D) materials have emerged as promising platforms for addressing these limitations because of their large surface area, tunable surface functionalities, excellent electrical conductivity, and unique ion-transport characteristics. In particular, 2D material-based interfacial engineering strategies can effectively regulate polysulfide behavior, enhance charge-transfer kinetics, and stabilize lithium deposition during battery operation. This presentation introduces recent advances in multifunctional interfacial strategies utilizing 2D materials for high-performance Li–S batteries, with a focus on improving electrochemical reversibility, rate capability, and long-term cycling stability. The findings highlight the significant potential of 2D materials in the development of durable and high-energy-density Li–S battery systems.

Acknowledgment

This research was supported by the National Research Council of Science & Technology (NST) Grant by the Korea government (MSIT) (No.CAP22075-000)

ISNNM&EKAMP 2026

(Special Session)

ISNNM: Next-generation on Magnetic Materials

Resource-Efficient Grain Boundary Diffusion Strategies for High-Performance Nd-Fe-B Magnets with Reduced HRE Usage

Vitalii Galkin[1,2*], Hyeonjong Jeong[1], Dong Hyun Lee[1,2], Seong Chan Kim[1], Juyoung Baek[1], Tae-Young Yun[1], Jong Tae Kim[1], Seok-Hwan Chung[1], Kyoung-Hoon Bae[3] Sang Hyub Lee[3], Donghwan Kim[3], Jongwook Roh[2], Dong Hwan Kim[1*], Jeongmin Kim[1*]

[1]*Division of Nanotechnology, Daegu Gyeongbuk Institute of Science and Technology, Daegu, Republic of Korea*
[2]*Department of Hydrogen and Renewable Energy, Kyungpook National University, Daegu, Republic of Korea*
[3]*R&D Center, Star Group, Daegu, Republic of Korea*
galkin@knu.ac.kr (V. Galkin), kimdhwan@dgist.ac.kr (D. H. Kim), jkim@dgist.ac.kr (J. Kim)

Nd-Fe-B sintered magnets demonstrate the highest performance among permanent magnetic materials. Since their discovery in the 1980s, these rare-earth magnets have become indispensable components in a wide range of high-technology applications, including high-capacity HDDs, MRI systems, wind power generators, and high-efficiency motors, particularly for electric and hybrid vehicles. The recent rapid expansion of eco-friendly transportation systems has significantly accelerated global demand. Accordingly, the production volume of Nd-Fe-B magnets is expected to more than double by 2030 compared with 2020, reaching approximately 450,000 tons.

Despite their superior room-temperature performance, Nd-Fe-B magnets suffer from limited thermal stability, exhibiting significant degradation of coercivity at elevated temperatures. Consequently, reliable operation under the service conditions of eco-friendly electric vehicle applications (~200 °C) becomes challenging. To address this limitation and enhance coercivity, 6−10 wt.% heavy rare-earth (HRE) elements such as Dy and Tb are commonly introduced into the alloy. However, their practical application is restricted by low natural abundance, unstable supply, high cost, and antiferromagnetic coupling with Fe in the $Nd_2Fe_{14}B$ phase, which reduces remanence.

Grain boundary diffusion (GBD) processes employing HRE elements have been extensively applied to overcome this limitation. Nevertheless, conventional HRE-based diffusion strategies are inherently constrained by limited diffusion efficiency arising from the high melting point of HRE elements, excessive intergranular diffusion, and insufficient diffusion depth.

In this work, we propose GBD-based strategies to minimize HRE usage while achieving high coercivity in Nd-Fe-B magnets. By optimizing diffusion conditions and GBD-source design, the distribution of HRE elements was effectively controlled, enabling fabrication of core/shell structures with a thin HRE-rich shell, thereby suppressing reverse domain nucleation. As a result, high-performance Nd-Fe-B magnets with significantly reduced HRE usage were fabricated, while maintaining coercivity and thermal stability comparable to conventionally doped systems. This study establishes a resource-efficient pathway for advanced permanent magnet development and enables reduced HRE usage for next-generation eco-friendly transportation systems.

Keywords: Nd-Fe-B magnets, Grain boundary diffusion, Core/shell structure, Coercivity, Heavy rare-earth elements

Simultaneous Enhancement of Coercivity and Electrical Resistivity in Thick Nd–Fe–B Magnets via Sandwich-Structured Grain Boundary Diffusion

Sumin Kim*

Nano Materials Research Division, Korea Institute of Materials Science (KIMS), Changwon 51508, Republic of Korea

The grain boundary diffusion process (GBDP) is widely used to enhance the coercivity (μ0Hc) of Nd–Fe–B magnets while reducing heavy rare-earth (HRE) consumption. However, conventional HRE-based diffusion alloys suffer from shallow diffusion depths because of their high melting temperatures, leading to a substantial decrease in coercivity enhancement in thick magnets. Although low-melting-point Pr-based diffusion alloys exhibit deeper diffusion behavior, the coercivity enhancement remains severely limited when the magnet thickness exceeds approximately 10 mm.

In this study, a sandwich-structured grain boundary diffusion strategy using a low-melting Pr70Cu15Al10Ga5 (PCAG) alloy was developed to overcome this thickness limitation. PCAG diffusion layers were introduced not only at the outer surfaces but also at the internal bonding interfaces of stacked 5 mm-thick Nd–Fe–B magnets. Using this multilayer diffusion-bonding structure, a 15 mm-thick magnet achieved a μ0Hc of 1.85 T with a coercivity enhancement of approximately 0.5 T, comparable to that obtained in a conventional 5 mm-thick single GBD-treated magnet. Microstructural analyses revealed the formation of Pr-rich shells and continuous grain-boundary phases throughout the bonded magnet, which effectively suppressed reverse-domain nucleation and intergranular exchange coupling.

In addition, the diffusion-bonded interfaces exhibited significantly increased electrical resistivity, which reduced eddy-current-induced heating under alternating magnetic fields. These results demonstrate that the proposed sandwich-structured GBDP provides an effective and scalable route for fabricating thick, high-coercivity Nd–Fe–B magnets suitable for next-generation high-power and high-frequency motor applications.

Interfacial spin orbit coupling driven magnetization switching at all oxide interface

Mi-Jin Jin[1*], Doo-Seung Um[2], and Jason W.A. Robinson[3]

[1]*Center for Multidimensional Carbon Materials (CMCM), Institute for Basic Science (IBS), Ulsan 44919, Republic of Korea*
[2]*Department of Electronic Engineering, Jeju National University (JNU), Jeju-do 63243, Korea*
[3]*Department of Materials Science & Metallurgy, University of Cambridge, 27 Charles Babbage Road, Cambridge CB3 0FS, United Kingdom*
[*]*mijin8276@gmail.com*

Spin-orbit torque (SOT)-driven magnetization switching has the potential to enable ultrafast operation and low power consumption in memory and logic technologies. SOT devices generally involve metal-based heterostructures, but oxide materials are competitive, offering highly tuneable electronic properties including interfacial spin–orbit coupling (SOC) and the Rashba–Edelstein effect. In this work, we demonstrate field-free magnetization switching enabled by enhanced interfacial SOC at a quasi two-dimentional (quasi-2D) electron gas interface between $La1_{-x}Ca_xMnO3$ (LCMO) and SrTiO3 (STO). The quasi-2D interface is generated by controlled-creation of oxygen vacancies at the STO surface, which tune the interfacial SOC. The SOC-driven magnetization switching shows a strong polarity-dependence on magnetic field. i.e. the magnetization switching is coherently clockwise or anticlockwise depending on the direction of the external magnetic field above Bcoervicity. These findings demonstrate that quasi-2D electron gases in oxide materials systems are tunable platforms for the development of SOT memory and logic.

Keywords: Spin-Orbit Torque, Spin orbit Coupling, Oxide Interface, in-plane magnetization, Field-free Magnetization switching

ISNNM&EKAMP 2026

(General Session)

ISNNM: Additive Manufacturing and Printing Technology (AMT)

Jet Impingement Cooling Plates for High Density AI Data Centers by LPBF(Laser Powder Bed Fusion) Technique using Gas Atomized Cu Powder

Young Ik Seo[1*], Daeyong Kim[2], Hyun Ho Jo[1], Min Hyung Lee[1], Kyoung-Ju Seo[1], and Jinwoo Oh[2*]

[1]*Arum Dentistry (Metal 3D Printer Team, R&D Center, Daejeon, Republic of Korea)*
[2]*Chungnam National University (School of Mechanical Engineering, Daejeon, Republic of Korea)*
[*]*yiseo8721@arumdetistry.com and jwoh@cnu.ac.kr*

The rapid growth of artificial intelligence (AI) technologies has significantly increased the power density of modern AI data center servers. State-of-the-art high-performance GPUs generate extremely high heat fluxes, making conventional air-cooling systems insufficient for future high-density server environments. Accordingly, advanced liquid cooling technologies capable of managing localized hotspots and high thermal loads are becoming increasingly important. In this study, a jet impingement cooling plate for high-density AI data centers is designed and analyzed using computational fluid dynamics (CFD). The proposed design adopts a unibody structure that integrates the pin plate and heat spreader into a single component, thereby eliminating the thermal interface material (TIM2) layer, reducing thermal resistance, and simplifying assembly processes. The cooling plate is designed for fabrication via laser powder bed fusion (LPBF) using gas-atomized pure Cu powder with high thermal conductivity. Compared with conventional manufacturing methods, LPBF enables the fabrication of complex internal flow channels and optimized jet structures suitable for localized hotspot cooling. The proposed design incorporates jet arrays and pin-fin structures to enhance heat transfer performance and improve coolant distribution uniformity. The results demonstrate that the proposed cooling structure effectively mitigates hotspot concentration and produces a relatively uniform temperature distribution. In the inlet channel, coolant flow is evenly distributed through the nozzles, while characteristic impingement stagnation zones and secondary stagnation zones are clearly observed. Although the initial simulation predicted relatively high surface temperatures under a heat flux of 175 W/cm^2 with a coolant inlet temperature of 45°C, the results remain promising in view of energy efficiency and waste heat recovery requirements. Based on the simulation results, experimental fabrication of the Cu-based cooling plate using LPBF is planned for future work. The present study demonstrates the feasibility of realizing advanced jet impingement cooling plates through metal additive manufacturing for next-generation AI data center thermal management applications.

Keywords: AI Data Center, Jet Impingement, Cooling Plate, Laser Powder Bed Fusion, Additive Manufacturing

Additive Manufacturing Approaches for Automotive Thermal Management: A Ni-Based High-Entropy Alloy and an AlSi10Mg TPMS Heat Exchanger

Hyomoon Joo*

Materials Processing Technology Development Team, Hyundai Motor Group, Gyeonggi-do, Republic of Korea
**Joo.hyomoon@hyundai.com*

Additive manufacturing is opening new pathways for automotive thermal management by simultaneously expanding the design space of structural materials and enabling geometrically complex thermal components. In future mobility platforms, including electric vehicles and robotics-integrated systems, thermal and mechanical demands are becoming increasingly severe because components must operate reliably under broad temperature variations while also meeting stringent requirements for weight reduction, durability, packaging efficiency, and system integration. These trends are driving the need for solutions that do more than improve individual material properties; they must also enable system-level optimization through new structural concepts and manufacturing freedom. Against this background, the present work introduces an AM-centered strategy for automotive thermal management from both material and structural perspectives.

A Ni-based high-entropy alloy was developed as a candidate structural material for thermally demanding mobility applications. Unlike conventional alloys that often undergo significant reductions in strength or ductility under extreme thermal conditions, the proposed HEA was designed to maintain stable tensile behavior over a broad temperature range. This temperature-insensitive response is attributed to microstructural stability, compositional homogeneity, and controlled grain-boundary characteristics, which together help sustain mechanical robustness under variable service environments. The alloy design also aims to suppress thermally induced property fluctuations that can compromise dimensional stability and structural reliability during repeated operation. As a result, the material shows strong potential for applications requiring both strength retention and durability, such as e-powertrain structures, thermally exposed support parts, and safety-relevant mobility components.

In parallel, an AlSi10Mg heat exchanger based on a triply periodic minimal surface (TPMS) architecture was developed to investigate the structural advantages offered by additive manufacturing for thermal-management hardware. The TPMS concept provides an attractive route to lightweight, high-surface-area heat exchangers that cannot be readily fabricated by conventional manufacturing methods. By using AM, complex internal flow passages and continuous surface networks can be realized with high geometric flexibility, enabling compact designs tailored to severe packaging constraints. Such architectures are expected to improve thermal utilization while supporting mass reduction and functional integration. For automotive systems, these characteristics are particularly important in applications where efficient heat rejection, compact packaging, and manufacturable geometric complexity must be balanced simultaneously. The AlSi10Mg platform further highlights the practicality of combining a well-established AM alloy with advanced lattice-like thermal architectures to address real component-level design challenges.

Taken together, this work highlights how additive manufacturing can contribute to automotive thermal management not only through the development of advanced heat-resistant alloys, but also through the realization of architected thermal components optimized for weight, surface area, and design freedom. The combination of temperature-stable Ni-based HEAs and AlSi10Mg TPMS heat exchangers demonstrates the broader potential of AM as a key enabling technology for future mobility systems, supporting improved durability, design flexibility, thermomechanical reliability, and overall system performance. More broadly, the study suggests that future progress in mobility thermal management will depend on the parallel advancement of materials, geometry, and process integration rather than on conventional material substitution alone.

Keywords: Future Mobility, Laser Powder Bed Fusion, High-Entropy Alloy, Triply Periodic Minimal Surface, Heat Exchanger

Control of PBF Defects and Evaluation of Microstructure and Mechanical Properties of D2 Tool Steel through Ni Addition

Joon-Suh Park, Hyun-Su Kim, Su-Gwan Lee, Dinh Van Cong, Jeong-Woo Kim, Jin-Chun Kim*, Sang-yong Shin

University of Ulsan, Ulsan, Republic of Korea
jckimpml@ulsan.ac.kr

As the industrial demand for high-performance metal parts is increasing, research on the application of additive manufacturing (AM) processes is being actively conducted to tool steel materials with excellent hardness and wear resistance. In particular, D2 tool steel exhibits superior hardness and wear resistance owing to its high carbon and chromium contents. However, when D2 tool steel is processed by Powder Bed Fusion (PBF), cracking and delamination can occur due to the formation of brittle microstructures and high residual stresses during rapid melting and solidification process. Therefore, design strategies are required to control defects generated during the build process and improve the printability of D2 tool steel.

In this study, the printability of D2 tool steel was evaluated using the PBF process, and Ni was selectively added to mitigate cracking and delamination. To investigate the effect of Ni addition on the build behavior of high-carbon steel, Ni powder was added using an ex-situ method, and specimens were fabricated under different process conditions by varying the laser power and scan speed. Subsequently, build defects were quantitatively evaluated through porosity analysis using optical microscopy (OM). The microstructural characteristics were observed using scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD), and the mechanical properties resulting from Ni addition were compared through Vickers hardness measurements.

Keywords: D2 tool steel, Nickel, PBF, Microstructure, Process parameter

Acknowledgements

This work was supported by the Competency Development Program for Industry Specialists of the Korea Government (MOTIE), operated by Korea Planning&Evaluation Institute of Industrial Technology (KEIT). (No.20024344, ‘Development of AI-based high carbon steel alloy design and sintering-based additive manufacturing technology for 7.0 L/Hr-level high-speed production of powertrain components with tensile strength over 1.0 GPa in the next-generation mobility’)

Microstructure-Informed Process Window Refinement of LPBF AlSi10Mg via Integrated Defect and Matrix/Texture Response Mapping

Taehyeob Im[1,2], Seungyeop Chun[3], and Seung Ki Moon[1,2*]

[1]*Hyundai-NTU-A*STAR Corporate Lab, Nanyang Technological University, Singapore*
[2]*School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore*
[3]*Additive Manufacturing Solution Team, Hyundai Motor Group, South Korea*
skmoon@ntu.edu.sg

Laser powder bed fusion (LPBF) of AlSi10Mg is highly sensitive to process parameters because melt-pool stability, defect formation, and microstructural evolution occur simultaneously during rapid solidification. Conventional process-window development often relies on macroscopic quality indicators such as porosity and hardness, which are useful for screening acceptable conditions but do not fully explain why certain conditions are more reliable from a defect perspective or mechanically favorable. Therefore, a more microstructure-informed process optimization strategy is needed to connect process parameters with both defect characteristics and the microstructural origins of mechanical response.

In this study, AlSi10Mg specimens were fabricated under systematically varied laser power, scan speed, and hatch spacing conditions. Porosity and Vickers hardness were first used to establish the primary process–quality relationship through response-surface modeling. This step provided an initial process landscape and identified candidate conditions satisfying the basic quality requirements.

The initial process window was then refined using pore-regime information. Instead of treating all low-porosity conditions as equivalent, the pore population within each condition was examined to identify whether the remaining defects were mainly gas-like or showed stronger lack-of-fusion-like or keyhole-like tendencies. Principal component analysis (PCA) and Gaussian mixture modeling (GMM) were used as visualization tools to examine the morphology space of the detected pores, while the final regime interpretation followed morphology-guided criteria. This step allowed the low-porosity window to be further narrowed toward gas-pore-dominant conditions, providing a more microstructurally informed basis for process condition selection.

In parallel, hardness was used to represent the mechanical response associated with matrix and texture evolution. XRD-derived information was introduced to examine whether hardness variations could be explained more effectively when crystallographic and microstructural changes were considered together with process parameters. Through an ablation-style comparison, the analysis evaluated how the process–hardness relationship changed as microstructural descriptors and advanced regression models were progressively added. This comparison clarified the contribution of matrix/texture descriptors to the process–hardness relationship and established hardness as a microstructure-informed mechanical-response axis for subsequent process optimization.

Finally, the refined response definitions provide a basis for Gaussian process surrogate modeling, quality prediction, and multi-objective process optimization. Overall, this work presents a process optimization paradigm that connects process parameters, defect regime, matrix/texture response, and mechanical performance. The proposed approach supports robust LPBF AlSi10Mg process-window refinement and future AI-enabled quality prediction.

Keywords: LPBF, AlSi10Mg, Process window refinement, Pore regime, XRD–hardness modeling

Acknowledgements

This research is supported by the RIE2025 Industry Alignment Fund – Industry Collaboration Projects (IAF-ICP) (Award I251E0048), as well as supported by Hyundai Motor Group Innovation Center Singapore, NTU Singapore, and the Agency for Science, Technology and Research (A*STAR) through Hyundai-NTU-A*STAR Corporate Lab.

Nickel-Mediated Regulation of δ-Ferrite Fraction and Morphology and Its Effect on Microstructure–Property Relationships in Binder-Jetted 17-4PH Stainless Steel

Minjae Kang[1], Yuanjiu Huang[1], Hoseong Jeon[2], Kee-Ahn Lee[1*]

[1]*Department of Materials Science and Engineering, Inha University, Incheon 22212, Republic of Korea*
[2]*Jive Solutions, Gyeonggi-Do 18471, Republic of Korea*
[*]*keeahn@inha.ac.kr*

Binder-jetted 17-4PH stainless steel often requires high-temperature sintering to achieve sufficient densification; however, such thermal exposure can promote the formation of δ -ferrite, which strongly affects subsequent microstructural evolution and mechanical response. In this study, the effect of Ni addition on δ -ferrite formation, morphology, and related mechanical behavior was investigated in binder-jetted 17-4PH stainless steel subjected to sintering, hot isostatic pressing, and H900 heat treatment. For comparison, a conventionally manufactured 17-4PH stainless steel subjected to the same H900 heat treatment was also evaluated. The Ni-alloyed binder-jetted specimen was designed by adding 2.5 wt.% Ni to the conventional 17-4PH composition. Thermodynamic calculation and microstructural characterization showed that Ni addition increased γ -phase stability and reduced the tendency for δ -ferrite formation during high-temperature processing. After HIP and H900 treatment, the binder-jetted specimen exhibited a multiphase microstructure consisting of lath martensite, retained γ austenite, and a small amount of δ -ferrite. Importantly, δ -ferrite was not observed as a continuous network but was mainly distributed as isolated island-like regions within the martensitic matrix. EBSD and EDS analyses indicated that these δ -ferrite regions were characterized by low local misorientation and Cr enrichment. The δ -ferrite fraction was estimated to be approximately 3.4%, while about 15.1% γ austenite was retained after heat treatment. Compared with the conventionally manufactured specimen, the binder-jetted specimen showed refined martensitic laths and a higher fraction of high-angle grain boundaries. The different microstructural characteristics led to clearly different mechanical responses. The binder-jetted specimen exhibited a yield strength of 1095.8 ± 14.5 MPa and an ultimate tensile strength of 1227.6 ± 3.0 MPa, which were lower than those of the conventionally manufactured specimen, 1246.2 ± 18.6 MPa and 1390.3 ± 8.2 MPa, respectively. However, the elongation increased from 9.8 ± 0.52% for the conventionally manufactured specimen to 20.89 ± 2.09% for the binder-jetted specimen. In addition, the miniaturized Charpy absorbed energy increased markedly from 0.75 ± 0.2 J to 15.7 ± 1.6 J. EBSD analyses after tensile and impact deformation further revealed deformation-induced $\gamma \rightarrow \alpha'$ transformation in the binder-jetted specimen, indicating that retained austenite contributed to sustained work hardening and additional energy absorption during deformation. These results suggest that the mechanical response of binder-jetted 17-4PH stainless steel is governed not only by the δ -ferrite fraction but also by its morphology and spatial distribution, together with the stability of retained austenite.

Keywords: Binder jet printing, 17-4PH stainless steel, Heat treatment, Phase composition evolution, Mechanical Properties

Cr-controlled ordering and strain-hardening pathways in additively manufactured γ' -strengthened Ni-Co-Cr alloys

Avinash Chavan[1], Muhammad Akmal[1], Cheol Hyeon Lee[1], Ho Jin Ryu[1,2*]

[1]*Department of Nuclear and Quantum Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea*
[2]*Department of Materials Science and Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea*
[*]*hojinryu@kaist.ac.kr*

Cracking susceptibility and limited strain hardening remain critical challenges in additively manufactured precipitation-strengthened Ni-based superalloys. In this work, a CALPHAD-guided alloy design strategy is employed to develop γ' -strengthened Ni-Co-Cr-Al-Ti-Ta alloys with controlled printability and enhanced strain hardening response as a function of Cr content. Cr-dependent modification of the solidification pathway suppresses Laves phase formation in the as-built condition while stabilizing ~30 vol.% coherent $L1_2$ γ' precipitates following a two-step heat treatment. Increasing Cr content results in pronounced γ' refinement (~150 to ~50 nm), driven by a reduction in γ/γ' lattice misfit (~0.78% to ~0.48%), thereby promoting a dense and stable precipitate distribution. First-principles calculations reveal a systematic increase in the anti-phase boundary energy (γ _APB) with Cr content. This trend is consistent with TEM-EDS observations indicating preferential Cr partitioning to the γ' phase, suggesting enhanced chemical ordering within the γ' precipitates. Transmission electron microscopy further reveals thermally activated superlattice intrinsic stacking faults (SISFs) within γ' precipitates in the heat-treated condition. During deformation, dislocation shearing of γ' generates APB ribbons, while pre-existing SISFs likely acted as preferential slip-assisted regions, collectively promoting planar slip behaviour. The resulting planar deformation mode suppressed cross-slip, constrained dynamic recovery, and promoted sustained dislocation accumulation, contributing to enhanced strain-hardening capability. Consequently, Cr-rich alloys exhibit reduced strain localization and improved strength-ductility synergy. These findings establish a mechanistic framework linking alloy chemistry, ordering-related planar defects, and strain hardening, providing a pathway for the design of additively manufacturable γ' -strengthened superalloys with enhanced mechanical performance.

Keywords: Additive manufacturing, γ' -strengthened Ni-based superalloys, Alloy design, Strain hardening mechanism, Transmission Electron Microscopy

Texture-by-Scan path Design in PBF-LB/M Inconel 625: From EBSD-Validated Architectures to Tensile Testing and Crystal Plasticity FE Modeling

Oumayma Elmaalouf[1,2*], Patrice Peyre[1], Stefan Dietrich[2], Corinne Dupuy[1], and Justin Dirrenberger[1,3]

[1]*Laboratoire PIMM, Arts et Métiers Institute of Technology, CNRS, CNAM, 151 boulevard de l'Hôpital, 75013 Paris, France*
[2]*Institute of Applied Materials (IAM-WK), Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany*
[3]*Institut Universitaire de France (IUF)*
[*]*oumayma.elmaalouf@ensam.eu*

Laser powder bed fusion (PBF-LB/M) enables not only near-net-shape manufacturing but also **intentional microstructure and texture design** through local thermal history control [1]. In this work, we demonstrate a process–structure–property–modeling framework to **program crystallographic texture in Inconel 625 (IN625)** and quantify its mechanical implications. In the first part, PBF-LB/M parameter/scan-strategy tuning is used to promote **site-specific preferred orientations** (e.g., ⟨100⟩ type versus ⟨111⟩ type tendencies) by modifying melt-pool stability and heat accumulation, and the resulting microstructures are assessed by metallography and EBSD-based texture analysis. Building on these experimentally observed texture states, we then investigate how **architecturally textured arrangements** can be leveraged to tailor mechanical response [2].

To connect texture architecture to macroscopic response and local heterogeneity, a **crystal plasticity finite element (CPFE)** framework is implemented in Z-set for a periodic, polycrystalline representative volume element (RVE) containing 270 grains generated with a periodic Laguerre–Voronoï tessellation. The RVE is designed as a **three-band texture architecture** aligned with the loading direction: ⟨100⟩ (bottom) – ⟨111⟩ (middle) – ⟨100⟩ (top). Each grain is assigned an orientation sampled from band-specific datasets, and periodic boundary conditions are enforced via multi-point constraints under strain-controlled loading. The constitutive description combines cubic single-crystal elasticity with slip-based viscoplasticity (octahedral and cubic slip families with nonlinear isotropic/kinematic hardening).

The simulations reveal strong **grain-scale dispersion** and **band-wise mechanical partitioning**: the ⟨111⟩ band tends to carry higher stress while ⟨100⟩ bands accommodate more deformation, producing localization near grain boundaries and, importantly, near **band interfaces**. Ongoing work combines these predictions with **tensile testing** (and local micro-indentation) on PBF-LB/M-textured regions to calibrate parameters and validate the predicted partitioning and localization trends through DIC study. The overall outcome is a route toward **texture-by-scanpath design** of IN625 with mechanically meaningful, model-guided microstructure architectures.

Keywords: PBF-LB/M, Inconel 625, crystallographic texture, architectured microstructure, crystal plasticity FEM.

References

[1] K.A. Sofinowski, S. Raman, X. Wang, B. Gaskey, M. Seita. Layer-wise engineering of grain orientation (LEGO) in laser powder bed fusion of stainless steel 316L. AM 38 (2021) 101809.
[2] V. A. Popovich, E. V. Borisov, A. A. Popovich, V. S. Sufiiarov, D. V. Masaylo, L. Alzina. Functionally graded Inconel 718 processed by additive manufacturing: Crystallographic texture, anisotropy of microstructure and mechanical properties Mater. Des. 2017, 114, 441.

ISNNM&EKAMP 2026

(General Session)

ISNNM: Advanced Materials Processing and Powder Metallurgy (MPPM)

Microstructure and Properties of Nb_2AlC MAX Phase-Reinforced Aluminum Matrix Composites Fabricated by Pressureless Sintering

Hyeonseo Hwang[1], Hyeonyoung Choi[1], Seyeop Lee[1] and Jongmin Byun[1,2*]

[1]*Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea*
[2]*The Institute of Powder Technology, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea*
[*]*byun@seoultech.ac.kr*

Aluminum (Al) is widely utilized as a key material in the aerospace and automotive industries owing to its low density, excellent workability, and superior thermal and electrical conductivity. In particular, Aluminum Matrix Composites (AMCs) reinforced with ceramic particles such as SiC, Al_2O_3, and B_4C have been extensively studied to improve mechanical properties. However, these ceramic reinforcements often cause a significant reduction in the intrinsic electrical and thermal conductivity of the aluminum matrix. To overcome this limitation, considerable efforts have been devoted to incorporating low-dimensional nanomaterials such as carbon nanotubes (CNTs) and graphene, which possess outstanding mechanical, thermal, and electrical properties. Nevertheless, challenges associated with uniform dispersion and interfacial reaction control still remain.

Recently, MAX phases have attracted increasing attention as promising reinforcement materials. MAX phases are ternary layered compounds represented by the general formula $M_{n+1}AX_n$ (n = 1, 2, 3), where M denotes an early transition metal such as Ti, V, Mo, or Nb, A represents a group 13 or 14 element such as Al or Si, and X corresponds to carbon or nitrogen. Structurally, MAX phases consist of alternating M–X layers and A atomic layers arranged in a nanolaminated structure. The strong covalent M–X bonds provide ceramic-like high strength and thermal stability, whereas the relatively weak M–A bonds contribute metallic conductivity and excellent machinability.

To date, several studies have investigated the application of MAX phases as reinforcements for AMCs; however, most studies have primarily focused on Ti-based MAX phases, while research on Nb-based MAX phases remains relatively limited. In particular, Nb_2AlC has been reported to exhibit a thermal conductivity of approximately 22 W/m·K and an electrical conductivity of 3.45×10^6 S/m, indicating strong potential as an AMC reinforcement capable of minimizing conductivity degradation compared with conventional ceramic reinforcements.

In this study, Al–Nb_2AlC composites containing 10 vol% Nb_2AlC were fabricated to alleviate the deterioration in conductivity commonly associated with conventional ceramic reinforcements while simultaneously enhancing mechanical properties. The microstructure, density, hardness, thermal conductivity, and electrical conductivity of the fabricated Al–Nb_2AlC composites were systematically investigated.

Keywords: Aluminum matrix composites (AMCs), MAX phase, Nb_2AlC, Powder metallurgy, Plessureless Sintering

Microstructural and Mechanical Characterization of Ti Grade12–TiN/Nb_2O_5 Specimens Fabricated via Spark Plasma Sintering

Hyun-Su Kim[1], Su-Gwan Lee[1], Dinh Van Cong[1], Jun-Seo Park[1], Jin-Chun Kim[1*], Seung-Ick Lee[2]

[1]*Department of Materials Science and Engineering, University of Ulsan, Ulsan, Republic of Korea*
[2]*KPC Corporation, Daegu, Republic of Korea*
[*] *jckimpml@ulsan.ac.kr*

Titanium alloys are widely used in the aerospace, chemical, and medical industries owing to their excellent corrosion resistance, biocompatibility, and lightweight characteristics. In particular, Ti Grade.12 is an alloy containing elements such as Ni and Mo, and has long been used as a piping material in chemical processing facilities due to its superior corrosion resistance and stable mechanical properties. However, when exposed to repeated and prolonged service environments, problems such as wear and corrosion may occur. That why we need for research aimed at improving surface properties.

TiN is a ceramic material with excellent wear resistance and high-temperature stability, and has attracted attention as a coating material for surface modification of Ti.Grade12. In this study, specimens were fabricated on the surface of a Ti.Grade12 substrate using TiN/Nb_2O_3 mixed powders and the Spark Plasma Sintering process. The TiN/Nb_2O_3 coating layer formed on the Ti.Grade12 surface directly affects durability and mechanical properties depending on the microstructure and phases formed at the bonding interface or within the coating layer.

Therefore this study focused on analyzing the changes in the coating layer formed on the Ti.Grade12 substrate surface according to the Nb_2O_3 content. The fabricated specimens were characterized using optical microscopy (OM), scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDS), and electron backscatter diffraction (EBSD) to analyze the microstructure and phases of the bonding interface and coating layer. In addition, the mechanical properties were evaluated through Micro Vickers hardness testing. The results of this study are expected to serve as a reference for determining the appropriate TiN and Nb_2O_3 content ratios in future applications of the laser cladding process.

Keywords: Spark Plasma Sintering, Ti.Grade12, TiN, Nb_2O_3, Microstructure

Acknowledgements

This work was supported by the Competency Development Program for Industry Specialists of the Korea Government (MOTIE), operated by Korea Planning&Evaluation Institute of Industrial Technology (KEIT) (RS-2024-00448195, ‘Development of Manufacturing and Process Technology of Hardened Laser Cladding Composite Powder for Ti-Gr.12 Ball Valve Application’) and Korea Institute for Advancement of Technology (KIAT), (RS-2024-00406598, HRD program, Professional Manpower Education & Training for 3D Printing Industries).

Correlation between Microstrcuture and Hardness of D2 Steel with Different Cr, Mo, and V Contents

Jeong Woo Kim, Su-Gwan Lee, Hyun Su Kim, Jun Seo Park, Sang Yong Shin, Jin-Chun Kim*

School of Material Science and Engineering, University of Ulsan, Ulsan, Republic of Korea
**jckimpml@ulsan.ac.kr, *sshin@ulsan.ac.kr*

As environmental regulations become increasingly stringent, the automotive industry requires lightweight and high-strength components to reduce CO_2 emissions and improve fuel efficiency. In particular, power transmission components such as gears and bearings are subjected to repeated friction and continuous loading during service, and therefore require high hardness and wear resistance. Although conventional low-carbon carburizing steels provide high surface hardness, they have limitations such as long processing times and relatively low core hardness. Therefore, the development of alternative high-strength steels for automotive power transmission components is required.

AISI D2 steel is a high-carbon, high-chromium alloy steel with excellent hardness. However, coarse Cr-rich carbides formed during solidification and heat treatment can act as stress concentration sites and promote crack initiation and propagation. In this study, five types of D2 steel specimens with controlled C, Cr, Mo, and V contents were fabricated using vacuum plasma melting (VPM) based on the standard D2 steel composition. The C content was increased to 2 wt%, while the Cr content was reduced to 8–9 wt% to suppress the formation of coarse Cr-rich carbides. Mo and V were added at 0.5–0.7 wt% and 0.1 wt%, respectively, to investigate the effect of minor alloying elements on carbide precipitation and microstructural evolution.

The fabricated specimens were austenitized at 1200 ℃ for 2 h and then water quenched. Subsequently, the specimens were held at 900 ℃ for 1 h, furnace-cooled to 650 ℃ at a cooling rate of 22 ℃/h, and finally air-cooled. The microstructure will be analyzed using optical microscopy (OM), scanning electron microscopy (SEM), and electron backscatter diffraction (EBSD) to evaluate the matrix structure, carbide morphology, carbide size, carbide fraction, grain size, and local deformation behavior. Mechanical properties will be evaluated using Vickers hardness tests. Based on these analyses, the correlation between carbide precipitation behavior, microstructural evolution, and hardness characteristics will be discussed. This study is expected to provide fundamental data for alloy composition optimization of high-carbon, high-chromium D2 steel for automotive power transmission components.

Acknowlegement

This work was supported by the Competency Development Program for Industry Specialists of the Korea Government (MOTIE), operated by Korea Planning&Evaluation Institute of Industrial Technology (KEIT). (No.20024344, ‘Development of AI-based high carbon steel alloy design and sintering-based additive manufacturing technology for 7.0 L/Hr-level high-speed production of powertrain components with tensile strength over 1.0 GPa in the next-generation mobility’)

Keywords: D2 steel, carbide precipitation, microstructure, hardness

Multi-functional Metal Matrix Composite Wire via Axially Continuous Graphene Integration

Wonjune Choi[1*] and Jongmin Byun[2]

[1]*Department of Materials Science and Engineering, Dankook University, Cheonan-Si, Republic of Korea*
[2]*Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea*
[*]*Wonjune.Choi@dankook.ac.kr*

Next-generation applications in aerospace, electric vehicles, and defense urgently demand advanced materials that simultaneously deliver exceptional mechanical strength, high electrical conductivity, and superior thermal stability. However, conventional metal matrix composites (MMCs) fundamentally struggle with two critical bottlenecks: the classic strength-ductility trade-off and severe high-temperature electrical degradation caused by oxidation and intermetallic diffusion. To overcome these limitations, this study introduces a novel architectural design for MMCs by integrating axially continuous graphene (ACG) between functional metallic layers. By leveraging this unique configuration, our fabricated ACG-Ni wires successfully break the conventional strength-ductility trade-off, achieving a remarkable 71.76% increase in ultimate tensile strength along with a 58.24% enhancement in failure strain compared to pure nickel. Furthermore, the developed Ni-G-Cu composite exhibits a 307.6% higher electrical conductivity and a 61.2% higher current density limit compared to conventional Ni-coated copper, even after high-temperature annealing at 650°C. Demonstrating extreme thermal resilience, the advanced Ni-Ag-G-Cu multi-layered structure maintains its electrical integrity up to 850°C. These findings establish graphene-embedded architecture as a highly scalable and powerful platform for engineering multifunctional materials capable of surviving extreme structural and thermal loads.

Keywords: Graphene, Metal Matrix Composites (MMCs), Wire, Mechanical Properties, Electrical Properties

High cryogenic strength and low thermal expansion in $Fe_{43.2}Co_{33}Ni_{10.3}Cr_{3.8}Mo_{9.7}$ alloy via annealing-induced μ-phase precipitation and microstructural heterogeneity

Taehyung Kim[1], Jae Hyuk Lee[1], Jae Wung Bae[2], Hyoung Seop Kim[3], Jongun Moon[4], Sungwook Kim[5], Soo-Hyun Joo[1*]

[1]*Department of Materials Science and Engineering, Dankook University, Cheonan, 31116, Republic of Korea*
[2]*Department of Metallurgical Engineering, Pukyong National University, Busan, 48513, Republic of Korea*
[3]*Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH), Pohang, 37673, Republic of Korea*
[4]*Division of Advanced Materials Engineering, Center for Advanced Powder Materials and Parts, Kongju National University, Cheonan, 31080, Republic of Korea*
[5]*Industrial Materials Research Group, RIST (Research Institute of Industrial Science and Technology), Pohang, 37673, Republic of Korea*
[*]*jjsh83@dankook.ac.kr*

Although commercial Invar alloys exhibit excellent dimensional stability at cryogenic temperatures, their low yield strength has limited their use in load-bearing structural applications. Here, we report a $Fe_{43.2}Co_{33}Ni_{10.3}Cr_{3.8}Mo_{9.7}$ (at.%) compositionally complex alloy designed to combine high cryogenic strength with Invar-like low thermal expansion through annealing-induced μ-phase precipitation and microstructural heterogeneity. The as-cast alloy was homogenized and then was cold-rolled to a 50% thickness reduction and annealed at 550, 750, and 950 °C for 1 h, producing distinct microstructural states associated with recovery, partial recrystallization, and precipitation. Fine Mo-rich μ-phase precipitates formed preferentially along defect-rich deformation bands and delayed recrystallization through Zener pinning, thereby retaining heterogeneous microstructures over a wide range of annealing temperatures.

At 77 K, the 550 °C annealed specimen exhibited the highest strength, with a yield strength of 1367 MPa and an ultimate tensile strength of 1775 MPa, while maintaining an elongation of 19.4%. The 750 °C annealed specimen achieved the most favorable strength-ductility balance, showing a yield strength of 1198 MPa, an ultimate tensile strength of 1459 MPa, and an elongation of 30.5%. This behavior was attributed to the synergistic effects of μ-phase precipitation strengthening, heterogeneous deformation, hetero-deformation-induced strengthening, and a gradual transformation-i nduced plasticity effect. The 950 °C annealed specimen also maintained high strength, with a yield strength of 1095 MPa, an ultimate tensile strength of 1404 MPa, and an elongation of 24.3%, while reducing the average coefficient of thermal expansion over 90–200 K to 3.4 x 10^{-6} K^{-1}. The reduced thermal expansion resulted from progressive Mo-rich mu-phase precipitation, which depleted Mo from the face-centered cubic matrix, enhanced the magnetic response, and promoted spontaneous volume magnetostriction. These findings demonstrate that tailoring annealing-induced precipitation and matrix chemistry provide an effective route for developing high-strength, low-thermal-expansion alloys for cryogenic structural applications.

Keywords: compositionally complex alloy, cryogenic mechanical properties, low thermal expansion, μ-phase precipitation, heterogeneous microstructure

Microstructural evolution of liquid metal dealloying-induced 3D porous interfacial architectures in Ti–6Al–4V for dissimilar-material joining

Hyeok Min Kwon[1], Jihye Seong[1], Jae Hyuk Lee[1], Hidemi Kato[2], Takeshi Wada[2], Jae Woong Bae[3], Sung Hyuk Park[4], and Soo-Hyun Joo[1*]

[1]*Department of Material Science and Engineering, Dankook University, Cheonan, Korea*
[2]*Institute of Materials Research, Tohoku University, Sendai, Japan*
[3]*Department of Metallurgical Engineering, Pukyong National University, Busan, Korea*
[4]*Department of Materials Science and Metallurgical Engineering, Kyunpook National University, Daegu, Korea*
[*]*jjsh83@dankook.ac.kr*

The dissimilar joining of carbon fiber-reinforced plastics (CFRP) and titanium alloys is important for lightweight structures used in aerospace and liquid hydrogen storage systems. However, reliable joining remains challenging because of the chemical inertness of CFRP and the coefficient of thermal expansion (CTE) mismatch between CFRP and titanium alloys. In this study, liquid metal dealloying (LMD) was applied as a metallurgical surface engineering strategy to modify the Ti–6Al–4V (Ti64) surface. The aim was to form a 3D interconnected porous architecture that can enhance mechanical interlocking and improve interfacial bonding reliability.

Ti64 substrates were immersed in molten Mg to induce selective dissolution and interdiffusion at the surface. Residual Mg was then removed by chemical etching in a nitric acid solution. To establish the relationship between processing conditions and surface microstructure, the LMD temperature and holding time were systematically varied from 700 to 900 ℃ and from 10 to 80 min, respectively. The resulting surface layers were characterized by SEM, EDS, EBSD, and XRD. The microstructural observations indicated that the LMD temperature and holding time played key roles in the development of the porous ligament network. Higher temperatures and longer holding times promoted ligament coarsening and pore enlargement. Among the investigated conditions, LMD at 900 ℃ for 40 min produced the most uniform open-pore morphology. Single-lap shear tests were then conducted on LMD-processed Ti64/CFRP joints fabricated using a structural epoxy adhesive (3M 2216 B/A). The results demonstrate that LMD is an effective surface engineering route for improving the interfacial joint performance of Ti64/CFRP dissimilar-material joints.

Keywords: Liquid Metal Dealloying, Dissimilar Joining, Surface engineering, 3D Porous Architecture, Ti-6Al-4V

Probing temperature gradients for materials characterization

Stephanie Lippmann

Friedrich Schiller University Jena

Experimental data on phase diagrams, chemical and thermal diffusion and interfacial energies are required for reliable alloy and database development, the prediction of microstructural evolution and materials properties. Considering the number of alloy systems and alloying elements, efficient experimental methods are needed to characterize metallic materials. Experiments with concentration gradients offer a high throughput. Widely known are methods with diffusion couples and multiples or thin films. Less common are methods that combine temperature and concentration gradients.

At the university of Jena, methods for effectively obtaining thermodynamic, kinetic, and thermal data have been developed over the past 20 years. The early methods are related to directional solidification, where temperature gradients are used to adjust microstructures. In sample regions where solid and liquid phase co-exist, locally separated, temperature-dependent phase equilibria are formed and accessible to subsequent characterization. In this way, large sections of solidus, solvus and liquidus lines in binary alloys or paths in multicomponent systems can be determined with a highly reduces experimental effort. The concept also allows for the synthesis of pure intermetallic phases as bulk materials for measuring and modelling heat capacities. Recently, the method development focused on analyzing non-equilibrium or transient states. The efficient characterization of thermal properties is one application, another is the measurement of interfacial energies of alloys from metastable microstructures. The poster gives an overview of the methods and introduces basic concepts.

Optimized stress-relief window for hot-rolled pure tungsten: Elucidating the interplay between prior deformation strain and annealing parameters

Nuri Choi[1*], Jun Young Park[2], Ki-bong Kim[1], Young-Taek Seo[1], and Sangsun Yang[1]

[1]*Nano-materials Research Division, Korea Institute of Materials Science, Republic of Korea*
[2]*Nuclear Safety Research Division, Korea Institute of Materials Science, Republic of Korea*
[*]*choin@kims.re.kr*

Tungsten is a premier high-temperature material, characterized by an exceptionally high melting temperature of 3422℃ and high thermal conductivity. Its ability to retain great mechanical properties at elevated temperatures makes it an attractive candidate for extreme environment applications, such as plasma-facing components (PFCs) in nuclear fusion reactors, aerospace propulsion nozzles, X-ray targets, and advanced radiation shielding.

Hot-rolling of tungsten can be employed to develop a pronounced crystallographic texture and a highly aligned microstructure, contributing to a favorable strengthductility combination. However, the high density of dislocations and residual stresses introduced during rolling act as strong driving forces for premature and abnormal grain growth during subsequent thermal exposure. Crucially, abnormal grain growth elevates the ductilebrittle transition temperature (DBTT) and degrades mechanical performance. Consequently, postdeformation annealing becomes essential to relieve internal stresses while retaining the advantageous texture and mechanical properties of the rolled tungsten.

In service, fusionreactor PFCs must withstand operating temperatures of 10001300℃, which overlap with the typical recrystallization threshold of pure tungsten (1200℃). If deformation-induced defects are not properly mitigated beforehand, uncontrolled microstructural evolution during service leads to property degradation. Despite extensive studies on the recrystallization and grain growth behavior of rolled tungsten, systematic investigations establishing a comprehensive processing window for defect-level-dependent stress relaxation treatments remain scarce.

Motivated by this necessity, we systematically quantify the defect density accumulated at various rolling reductions (ranging from 49 to 85% total reduction) and evaluate the subsequent stressrelaxation kinetics over an extensive matrix of temperature–time conditions (8001100 °C, ≤2 h). The microstructural and mechanical evolutions are comprehensively evaluated using Xray diffraction (XRD), Williamson–Hall analysis, Electron backscatter diffraction (EBSD), and microVickers hardness measurements. XRD is utilized for $\sin^2\Psi$-based residual stress measurements Williamson-Hall plots yield crystallite size and micro-strain to estimate dislocation density. EBSD supplies orientation maps, grain size distribution and kernel average misorientation (KAM) maps to track the recovery behavior. Ultimately, this work aims to elucidate the fundamental correlation between prior rolling strain and annealing parameters, thereby proposing an optimized heat-treatment matrix to extend the service life of tungsten-based PFCs under extreme environments.

Keywords: Tungsten, Relaxation, Residual stress, Annealing, Rolling

Impact of severe plastic deformation via high-pressure torsion on interdiffusion in the Cu-Ni system

Neelamegan Esakkiraja[1*], Jasper Berndt[2], Stephan Klemme[2], Gerhard Wilde[1], Sergiy. V. Divinski[1]

[1]*Institute of Materials Physics, University of Münster, Münster – 48149 Germany*
[2]*Institute of Mineralogy, University of Münster, Münster – 48149 Germany*
[*]*eneelame@uni-muenster.de*

In coarse-grained polycrystalline Cu–Ni alloys, interdiffusion has been extensively studied, and the composition-dependent interdiffusion coefficients are known to decrease with increasing Ni content. The present study investigates how the microstructural state of the end members influences interdiffusion behaviour, with a particular focus on the effects of severe plastic deformation introduced via high-pressure torsion. Composition-dependent tracer diffusion coefficients of Ni were determined using the augmented tracer–interdiffusion couple approach. Cu tracer diffusivities were indirectly estimated by applying the Darken–Manning formalism. A comparative analysis between undeformed (coarse-grained) and deformed (ultrafine-grained) samples reveals distinct interdiffusion characteristics. Notably, an anomalous temperature dependence of diffusion behaviour was observed in the deformed state. This comprehensive investigation provides new insights into the role of plastic deformation in governing interdiffusion processes in binary alloy systems.

Keywords: Severe Plastic Deformation, diffusion, Nanograin Structure, HPT

Development of Dense Se-Free n-Type $Bi_{1.8}Sb_{0.2}Te_3$ Thermoelectrics Through Ultralow-Temperature Cold Sintering Processing

Pathan Sharief[1,2*], Ninad B. Velhal[2], Ah-Hyeon Park[2], Ha-Jin Gu[2], Young-Jae Kim[2], Muhammad Uzair[2], Sang-Chae Jeon[1,2*]

[1]*Global Institute for Advanced Nanoscience & Technology, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea*
[2]*School of Materials Science and Engineering, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea*
[*]*sharief@changwon.ac.kr*

Near-room-temperature thermoelectric materials are attractive for direct solid-state energy conversion. However, their large-scale implementation is hindered by conventional high-temperature and energy-intensive fabrication processes. In this work, we report the successful application of the cold sintering process (CSP) for the low-temperature densification of Se-free n-type Bi1.8Sb0.2Te3 (BST) thermoelectric materials. Unlike traditional consolidation techniques such as hot pressing and spark plasma sintering which typically require processing temperatures above 400 °C, CSP enabled effective densification at remarkably low temperatures of 100 and 160 °C. The obtained samples exhibited high relative densities of 95.45% and 98.28%, respectively, confirming the capability of CSP to produce dense thermoelectric bulks under substantially reduced temperatures. Microstructural investigations revealed highly compact and preferentially aligned grains with limited grain growth, which contributed to enhanced phonon scattering without significantly deteriorating electronic transport. Electrical transport measurements showed that the carrier concentration remained nearly unchanged, whereas carrier mobility increased progressively with sintering temperature, leading to improved electrical conductivity while maintaining a relatively stable Seebeck coefficient. Furthermore, the sample sintered at 100 °C exhibited an ultralow thermal conductivity of 0.58 W m^{-1} K^{-1} at 300 K. As a result, a maximum thermoelectric figure of merit (ZT) of 0.27 was achieved comparable to values reported for conventionally processed n-type BST materials. The present study demonstrates that CSP is a promising energy-efficient and sustainable approach for fabricating Bi2Te3-based thermoelectric materials at significantly reduced processing temperatures.

Keywords: Cold sintering process (CSP), Thermoelectrics, Low-temperature densification, Green processing

Significant improvement of strain hardening through massive interfaces in heterogeneous lamellar structured complex-concentrated alloys

T.J. Jang[1,2], Y.N. Lee[1], J. Baek[1], S. Oh[3], Y.T. Choi[3], B. Lee[3], H.S. Kim[4], A. Zargaran[4], S.S. Sohn[1*]

[1]*Korea University (Department of Materials Science and Engineering, Seoul, South Korea)*
[2]*Korea Institute of Materials Science (Extreme Materials Research Institute, Changwon, South Korea)*
[3]*Pohang University of Science and Technology (Department of Materials Science and Engineering, Pohang, South Korea)*
[4]*Pohang University of Science and Technology (Graduate Institute of Ferrous and Energy Materials Technology, Pohang, South Korea)*
[*]*sssohn@korea.ac.kr*

Overcoming the strength-ductility trade-off in ultra-fine-grained (UFG) metallic materials remains a central challenge. This study presents a microstructural engineering strategy utilizing UFG CoNiMo alloys with varying Mo contents to achieve a highly dense interfacial architecture. A specific processing route was employed: cold-rolling, severe plastic deformation via high-pressure torsion (HPT), and a thermodynamically guided short-time annealing treatment to exploit the face-centered cubic (FCC) and hexagonal close-packed (HCP) dual-phase region.

This processing resulted in a recrystallized UFG structure characterized by an intricate intra-granular lamellar morphology. While lower Mo alloys maintain a single FCC phase, higher Mo additions induce an HCP phase that partially orders into a $D0_{19}$ structure. This creates massive coherent twin boundaries and highly coherent FCC-HCP phase boundaries with a Shoji-Nishiyama orientation relationship, significantly refining the lamellar interspacing.

This architectural heterogeneity fundamentally alters deformation mechanisms. The dense coherent boundaries act as effective dislocation barriers, while the strength disparity between the softer FCC matrix and harder HCP layers triggers pronounced heterogeneous deformation and strain partitioning. The resulting synergy of effective dislocation storage and extra back-stress hardening delays plastic instability, yielding an exceptional combination of high tensile strength and uniform elongation.

Keywords: Complex-concentrated alloy, Strain hardening, Ultra-fine grain, Heterogeneous deformation, High-pressure torsion

Laser Surface Cleaning of Corroded 304L Stainless Steel for Chromium-Depleted Layer Removal and Corrosion Resistance Recovery

Hyun Jong Yoo[1], Changkyoo Park[2], and JeoungHan Kim[3*]

[1]*Department of Materials Science and Engineering, Hanbat National University, Daejeon, 34158, Republic of Korea*
[2] *Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea*
[3]*Department of Materials Science and Engineering, Hanbat National University, Daejeon, 34158, Republic of Korea*
[*]*Jh.kim@hanbat.ac.kr*

304L stainless steel is widely used in chemical, marine, and energy-related industries because of its excellent mechanical properties, weldability, and corrosion resistance. However, prolonged exposure to chloride-containing environments can cause surface corrosion and local degradation, reducing material reliability and service life. In particular, corrosion-induced surface damage can destabilize the passive film and accelerate further degradation. Therefore, an effective surface restoration process is required to remove corrosion products and recover the corrosion resistance of degraded stainless steel surfaces. In this study, laser surface cleaning was applied to corroded 304L stainless steel to remove corrosion products and investigate the formation behavior of chromium-depleted and oxide layers during laser processing. Corroded specimens were prepared under severe chloride exposure, and laser cleaning was performed under different scanning conditions. The treated surfaces were analyzed in terms of surface morphology, elemental distribution, microstructure, hardness, and electrochemical corrosion behavior, with particular attention to Cr distribution near the surface because Cr is essential for passive film formation and stability. The results confirmed that laser surface cleaning effectively removed corrosion products and produced a cleaner surface compared with the corroded specimen. However, the surface condition, elemental distribution, and corrosion resistance strongly depended on the laser scanning condition. Although the initial cleaning condition produced a visually clean surface, elemental analysis revealed an inhomogeneous surface composition and a Cr-depleted region near the surface. This Cr-depleted region could reduce passive film stability and increase susceptibility to re-corrosion, indicating that visual removal of corrosion products alone is insufficient for complete surface restoration. To further improve the cleaned surface, an additional laser processing condition was applied to reduce the remaining Cr-depleted region and recover a more uniform surface composition. As a result, the Cr-depleted region was effectively reduced, and Fe and Cr distributions near the treated surface became more homogeneous. Microstructural analysis showed that laser surface cleaning did not induce significant phase transformation, while grain refinement and subgrain formation occurred near the treated surface. These microstructural changes were attributed to high strain introduced during laser processing and contributed to increased surface hardness. Electrochemical corrosion tests showed that the additionally processed condition exhibited the best corrosion resistance among the laser-cleaned specimens, with a corrosion rate close to that of the base metal. These findings indicate that laser surface cleaning is an effective restoration technique for corroded 304L stainless steel when the process is properly controlled to remove corrosion products, reduce Cr-depleted regions, and recover a favorable surface composition for passive film formation.

Keywords: Laser cleaning, corrosion, 304L stainless steel

Effect of mechanical milling on microstructure and mechanical properties of CrMnFeCoNi high-entropy alloy fabricated via spark plasma sintering

Seonghyun Park[1], and Jae-Gil Jung[1,2*]

[1]*Division of Advanced Materials Engineering, Jeonbuk National University, Jeonju, Republic of Korea*
[2]*Research Center for Advanced Materials Development, Jeonbuk National University, Jeonju, Republic of Korea*
[*]*jgjung@jbnu.ac.kr*

High-entropy alloys, originally proposed by Yeh and Cantor, are composed of five or more principal elements in equiatomic or near-equiatomic proportions. Among them, equiatomic CrMnFeCoNi is a representative face-centered cubic high-entropy alloy and has attracted considerable attention because of its excellent ductility and outstanding cryogenic properties. However, its relatively low yield strength at room temperature limits its application in extreme environments, and therefore effective strengthening strategies are required. To improve its strength, various approaches such as precipitation strengthening, transformation-induced plasticity (TRIP), twinning-induced plasticity (TWIP), and grain refinement have been explored. In particular, mechanical milling is considered an effective powder-processing route because it introduces severe plastic deformation, lattice defects, and grain refinement into powders. Nevertheless, impurity incorporation during milling, including carbon and oxygen contamination, and the resulting formation of secondary phases such as oxides and carbides require further quantitative understanding because they can significantly affect the microstructure and mechanical properties.

In this study, gas-atomized CrMnFeCoNi powders were mechanically milled and subsequently sintered by spark plasma sintering (SPS) to produce bulk compacts with dimensions of Φ20×6 mm. The effect of mechanical milling on the microstructure and mechanical properties of the SPSed alloy was systematically investigated. Phase evolution was examined by X-ray diffraction (XRD). The matrix microstructure and grain boundary characteristics, especially the formation of low-angle grain boundaries, were analyzed using scanning electron microscopy (SEM) and electron backscatter diffraction (EBSD). In addition, transmission electron microscopy (TEM) was used to identify secondary phases such as oxides and carbides, while small-angle neutron scattering (SANS) was employed to quantify their size distribution and volume fraction. Mechanical properties were evaluated by compression testing, and yield strength modeling was performed using quantitative parameters obtained from EBSD and SANS analyses.

Keywords: High-entropy alloy, Mechanical milling, Spark plasma sintering, Transmission electron microscopy, Small-angle neutron scattering

ISNNM&EKAMP 2026

(General Session)

ISNNM: Computer-aided Materials Engineering (CME)

Density-based Thermodynamics and Kinetics of Microstructure Defects: A new path to CALPHAD-integrated Material Design

Reza Darvishi Kamachali[1,2*]

[1]*Federal Institute of Materials Research and Testing (BAM), Unter den Eichen 87, 12205 Berlin, Germany*
[2]*Institute of Materials Physics, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster*
[*]*reza.kamachali@bam.de*

Microstructure defects such as grain boundaries, phase boundaries, dislocations, stacking faults, and free surfaces govern many of the most critical processes in engineering materials, including segregation, embrittlement, recrystallization, precipitation, and damage initiation. Despite this central role, defects are still commonly treated as geometric imperfections, kinetic sinks, or phenomenological modifiers rather than as thermodynamic states with their own stability, composition, mobility, and transformation pathways. This creates a fundamental gap between CALPHAD-based bulk thermodynamics and the defect-mediated evolution of real microstructures.

In this contribution, I present density-based thermodynamics and kinetics as a framework for bringing microstructure defects into the language of phase stability, transport, and microstructure evolution. The central idea is to describe defect regions through representative field variables, in particular atomic density and related structural descriptors, which allow grain boundaries and other defects to be represented by continuous free energy functionals compatible with CALPHAD thermodynamics. In this formulation, defects are no longer passive interfaces between bulk phases, but active thermodynamic environments in which segregation, structural relaxation, elastic effects, and local phase transformations can be described within a unified framework.

This approach opens a new path toward CALPHAD-integrated design by extending free-energy descriptions from homogeneous bulk phases to heterogeneous defect states. It enables the construction of defect phase diagrams, segregation-transition maps, and, ultimately, microstructure phase maps that link composition, temperature, defect structure, and kinetic pathways. Recent applications to grain boundary segregation, liquid metal embrittlement, hydrogen-assisted degradation, and density-based phase-field modeling demonstrate how defect thermodynamics can be connected to mesoscale microstructure evolution and materials performance.

By combining CALPHAD, atomistic simulations, and phase-field modeling, density-based thermodynamics and kinetics provide a route toward predictive, defect-aware materials design. The resulting perspective shifts defects from secondary microstructural features to active thermodynamic degrees of freedom, offering a conceptual and computational bridge between phase diagrams and microstructures.

Keywords: Computational Thermodynamics, Materials Design, Microstructure Design, CALPHAD

AI-Accelerated Multiscale Modeling for Alloy Design and Processing

Jin Hyun Chang[1,2*]

[1]*Department of Energy Conversion and Storage, Technical University of Denmark (DTU), Kgs. Lyngby, Denmark*
[2]*PhaseTree ApS, Søborg, Denmark*
[*]*jchang@dtu.dk*

Designing metallic alloys and their processing routes remains a slow and largely empirical undertaking, with development cycles that can extend over many years. Growing demand for high-performance, sustainable, and supply-secure materials, together with the rapid uptake of metal additive manufacturing, is driving a shift toward predictive, simulation-led design. This talk presents an integrated multiscale modeling approach, accelerated by machine learning, that shortens alloy development by linking composition and processing directly to microstructure and properties.

The approach links models spanning atomistic to component length scales within a single workflow, so that fundamental physics informs predictions of phase stability, microstructure evolution, and properties under realistic processing conditions. Machine learning accelerates the workflow and helps navigate large composition and process spaces toward targeted property profiles, while a physics-based foundation keeps predictions reliable and transferable beyond the available data.

Representative applications span the alloy value chain. For alloy development, the framework supports composition design that balances performance against cost and reduces reliance on scarce or critical elements. For heat treatment and post-processing, it relates thermal histories to microstructure and resulting mechanical properties. For additive manufacturing, it connects process parameters to local microstructure and performance, helping navigate the broad and strongly coupled process windows characteristic of metal AM.

I will show how these capabilities are being assembled into an accessible materials-design platform, which integrates multiscale simulation, AI-based optimization, and experimental validation in one environment, developed through academic and industrial collaborations across Europe. By coupling computational workflows with targeted experiments, this approach offers a practical route to faster and more sustainable alloy development.

Keywords: Multiscale modeling, alloy design, computational materials design, process–structure–property mapping, additive manufacturing

Convolutional neural network-based prediction of mechanical properties in Ti6Al4V alloy porous material from micro-CT images

Sungjin Kim, Junho Lee, Seunghyeok Choi, Seok-Jae Lee

Jeonbuk National University, Republic of Korea
**seokjaelee@jbnu.ac.kr*

Deep learning approaches have recently gained attention for predicting the mechanical behavior of porous materials. In this study, a convolutional neural network (CNN) was applied to estimate the mechanical properties of Ti6Al4V alloy foam from micro-CT images. Training datasets were constructed using compressive YS (yield strength) values associated with porosities ranging from 40% to 70%. Micro-CT images were combined with porosity and compressive YS data, and the two parameters were trained separately. The developed model demonstrated accurate and efficient prediction of both porosity and compressive YS, with determination coefficients reaching 0.9707 and 0.9818, respectively. To validate the model, Ti6Al4V alloy foam specimens with porosities of 44%, 55%, and 66% were manufactured and subsequently subjected to micro-CT scanning and compression testing. The trained model was then used to estimate the porosity and compressive YS of these fabricated foam specimens. The results confirmed that both porosity and compressive YS could be predicted with high accuracy using only micro-CT images as input. In addition, the Grad-CAM technique was applied to visualize the decision-making process of the network, offering interpretability regarding how the CNN estimates the compressive YS of Ti6Al4V alloy foam. This study demonstrates the feasibility of evaluating mechanical properties without conducting compression experiments.

Keywords: Convolutional neural network, Ti6Al4V alloy porous material, Micro-CT images, Compressive YS

Random Forest-Guided Design of Al–BN Composites with Enhanced Strength and Thermal Conductivity

Hyojeong Lee[1], Jiyeon Koo[2], Eunsu Park[2], and Hyunjoo Choi[1*]

[1]*Department of Advanced Materials Science and Engineering, Kookmin University, Seoul 02707, Republic of Korea*
[2]*Eloi Materials Co., Ltd., 409, Ace Gwanggyo Tower 3, 77, Changnyong-daero 256beon-gil, Yeongtong-gu, Suwon-si, Gyeonggi-do 16229, Republic of Korea*
[*]*hyunjoo@kookmin.ac.kr*

Addressing the fundamental trade-off between mechanical robustness and thermal transport in Al-matrix composites is pivotal for advanced thermal management in high-performance electronics and aerospace systems. This study introduces a data-driven framework integrating ensemble machine learning with nanostructural engineering to navigate the complex design space of metal matrix composites (MMCs). A Random Forest (RF) regression model was trained on a literature-compiled MMC property dataset comprising reinforcement type, volume fraction, particle size, and processing route as input features, with Vickers hardness and thermal conductivity as target outputs. Feature importance analysis from the RF model identified Boron Nitride (BN) variants as the most promising reinforcement class for simultaneously enhancing both properties, guiding the selection of cubic BN (cBN) particles and Boron Nitride Nanobarbs (BNNB) as experimental candidates.

Both reinforcements were incorporated at 3 vol% into an Al matrix via sequential planetary and attrition milling followed by hot rolling, enabling direct comparison of their microstructural and property responses. The Al-cBN system exhibited a 70–80% enhancement in Vickers hardness relative to pure Al, driven by significant grain refinement to approximately 108 nm through strong interfacial pinning, alongside the formation of an AlN interfacial reaction layer that promotes load transfer. However, the Al/AlN/cBN trilayer structure introduced substantial phonon mismatch due to the acoustic impedance and lattice structure incompatibility of wurtzite AlN with both Al and cBN, increasing interfacial thermal resistance and limiting the thermal conductivity improvement to approximately 25% over pure Al.

In contrast, the Al-BNNB system exhibited a markedly superior thermal response. High-resolution TEM analysis confirmed that the Al-BNNB interface at 3 vol% remained clean and amorphous, with no secondary reaction phases such as AlN or AlB_2, in stark contrast to the Al-cBN system. The unique three-dimensional barbed morphology of BNNB promotes intimate mechanical interlocking with the Al matrix without triggering interfacial chemical reactions, thereby preserving phonon transport pathways. As a result, the Al-BNNB composite achieved an experimental thermal conductivity approximately 78% above the Rule-of-Mixtures theoretical prediction and substantially higher than that of Al-cBN, demonstrating that the absence of a thermally resistive reaction layer is critical for thermal performance. While the coarser average grain size of approximately 174 nm in Al-BNNB, attributed to the porous aggregate morphology limiting grain boundary pinning efficiency, resulted in a comparatively modest 40–50% hardness increase, the nanobarb geometry uniquely enables superior thermal conductivity without sacrificing meaningful mechanical reinforcement.

These results demonstrate that the thermally clean interface of BNNB, enabled by its distinctive nanobarb structure, represents a decisive advantage over cBN for thermal management applications. The two BN reinforcements operate via fundamentally distinct interfacial mechanisms, and RF-guided materials design provides an effective framework for predicting and selecting reinforcement candidates tailored to specific mechanical or thermal performance targets in Al-matrix composites.

Keywords: Aluminum matrix composite, Boron Nitride Nanobarb, Random Forest, Thermal conductivity, Interfacial reaction layer

Rapid Prediction of Precipitate Microstructures in 7000-Series Aluminum Alloys Using DSC–TEM Correlation and Gaussian Process Regression

W.Y. Lee[1], S.Y. Jeon[1], K.H. Lee[1], I.J. Ro[2], S.H. Kim[2], Y.H. Cho[3], K.J. Euh[4], H.J. Choi[1*]

[1]*Department of Materials Science and Engineering, Kookmin University, Seoul, Republic of Korea*
[2]*Department of Materials Science and Engineering, Korea University, Seoul, Republic of Korea*
[3]*Mobility Metals Research Center, Korea Institute of Materials Science (KIMS), Changwon, Republic of Korea*
[4]*Department of Materials Processing, Korea Institute of Materials Science (KIMS), Changwon, Republic of Korea*
[*]*hyunjoo@kookmin.ac.kr*

Precipitation-hardened 7000-series aluminum alloys (Al–Zn–Mg–Cu) are widely used in automotive, aerospace, and defense applications owing to their high specific strength. The mechanical properties of these alloys are governed by the type, size, and volume fraction of precipitates (GP zones → η'→ η ($MgZn_2$)) formed during artificial aging. Accurate characterization of precipitate microstructures is therefore essential for alloy optimization. However, conventional TEM-based analysis requires several days per specimen for sample preparation, imaging, and manual precipitate quantification, creating a critical bottleneck for data-driven alloy design.

In this study, we propose a rapid microstructure prediction methodology combining DSC (Differential Scanning Calorimetry) thermal analysis with Gaussian Process Regression (GPR) to predict precipitate characteristics without extensive TEM measurements. A literature-based TEM database comprising 46 entries was constructed, incorporating precipitate area fraction (%), average size (nm²), alloy composition (Zn, Mg, Cu in wt.%), and aging conditions (temperature, time) collected from both in-house experiments and published studies on 7075, 7050, 7068, and Low Cu 7075 alloys.

DSC data were processed using a physics-based normalization formula: Normalized DSC = $(Q_{SST} - Q_{aged}) / \Delta H_{formation}(MgZn_2)$, where Q_{SST} represents the total potential heat of the solution-treated specimen and Q_{aged} represents the remaining heat after aging. This formula generates a quantitative descriptor proportional to the amount of precipitate formation. The GP zone dissolution endothermic peak was excluded from the integration, and only the η'/η formation exothermic region (~150–320 °C) was considered, as this region directly corresponds to $MgZn_2$ formation.

An ARD (Automatic Relevance Determination) Matérn ν = 5/2 kernel-based GPR model was trained using the scikit-learn framework with five input features: Zn/Mg ratio, aging temperature, aging time, precipitate area fraction, and precipitate average size. The optimizer was restarted 20 times to ensure global convergence of the kernel hyperparameters. Leave-One-Out Cross-Validation (LOOCV) yielded R^2 = 0.774 and RMSE = 0.602, confirming a meaningful quantitative correlation between DSC and TEM data. ARD analysis revealed that the Zn/Mg ratio is the most dominant variable governing DSC prediction, which is consistent with its well-known role in determining the η'/η phase selection and precipitation driving force in 7xxx alloys.

Uncertainty quantification inherent to the GPR framework was utilized to identify high-uncertainty composition and aging conditions across all 46 data entries. This uncertainty map establishes a foundation for active learning-based experimental prioritization, where DSC rapid analysis can guide the selection of subsequent experiments, minimizing costly TEM measurements while systematically improving model accuracy. The proposed DSC–GPR methodology demonstrates the feasibility of replacing time-intensive TEM analysis with rapid thermal analysis for microstructure screening, providing a data-efficient pathway toward accelerated alloy development in 7000-series aluminum alloys.

Keywords: 7000-series aluminum alloys, Differential Scanning Calorimetry, Gaussian Process Regression, Precipitate microstructure, Active learning

ISNNM&EKAMP 2026

(General Session)

ISNNM: Energy and Environmental Materials (EEM)

01

Enhanced Thermal Conductivity and Moisture Stability of AlN/Epoxy Composites via Surface Modification and Trimodal Filler Packing

Minseob Lim[1], Hyung Jin Mun[1], Tae Woong Yun[2], Hoseong Son[2], Kyoungmin Shim[2], Jongryoul Kim[2], Hong-Baek Cho[2], Yong-Ho Choa[1,2*]

[1]*Hanyang Institute of Environmental & Energy Technology, Hanyang University, Ansan 15588, Republic of Korea*
[2]*Department of Materials Science & Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea*
[*]*choa15@hanyang.ac.kr*

As electronic devices continue to shrink in size while operating at higher power densities, localized heat accumulation has become a critical issue that directly affects device performance and reliability. Polymer-based thermal interface materials (TIMs) filled with ceramic particles are commonly employed to address this issue; however, their thermal performance is constrained by high filler–matrix interfacial thermal resistance, poor filler packing, and the moisture-induced degradation of the fillers. Among ceramic fillers, aluminum nitride (AlN) stands out for its high intrinsic thermal conductivity combined with electrical insulation, but these interfacial and stability issues still limit its performance in composite systems. In this study, GPTMS (3-glycidoxypropyltrimethoxysilane) surface modification of AlN was adopted as the core approach, generating a chemically bonded interfacial layer that simultaneously lowers interfacial thermal resistance, improves AlN–epoxy compatibility, and suppresses hydration of the filler. Based on this surface-engineered filler, a trimodal particle-size design—optimized through a machine-learning-based composition search—was implemented to maximize packing density and establish continuous thermal conduction networks. As a result, the fabricated composite showed a markedly higher thermal conductivity than that based on unmodified AlN, while the GPTMS-derived interfacial layer additionally enhanced moisture stability and mechanical hardness.

Keywords: AlN/epoxy composite, Surface modification, Thermal interface materials

Banana Peel-Derived Hierarchical Porous Carbon/MWCNT Hybrid Scaffold for Shape-Stabilized Composite Phase Change Materials with Enhanced Thermal Energy Storage and Management

Hyung Jin Mun[1], Minseob Lim[1], Hoseong Son[2], Hyunji Kang[2], Jongryoul Kim[2], Yong-Ho Choa[1,2*]

[1]*Hanyang Institute of Environmental & Energy Technology, Hanyang University, Ansan 15588, Republic of Korea*
[2]*Department of Materials Science & Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea*
[*]*choa15@hanyang.ac.kr*

Current energy crisis necessitates advancements in photothermal energy storage and the mitigation of thermal abuse in electronic devices, hence driving the development of composite phase change materials with low cost, good thermal stability and excellent shape stability. Therefore, a novel hierarchical porous activated carbon scaffold derived from cheap banana peel waste was developed by pyrolysis process. Shape-stabilized phase change materials for thermal energy storage were then prepared based on activated BP with multi-walled carbon nanotubes (MWCNTs) and paraffin wax (PW). The result composites indicate that through-plane and in-plane thermal conductivity are improved up to 1.98 and 2.29 W m^{-1} K^{-1} respectively due to harmonious effect between carbonaceous skeleton and MWCNTs, and the latent heat attains over 150 J $g^{-1.}$ Moreover, capillary effect and van der Waals force resulting from the highly porous carbon structure and MWCNTs assists excellent shape stability, which hinders the leakage of PW during solid-liquid phase transition at elevated temperature. Consequently, the composite prepared in this work possesses extensive potential in thermal management and sustainable energy storage applications.

Keywords: Phase change materials, Banana peel waste, Multi-walled carbon nanotube, Thermal energy conversion, Thermal interface materials

Eco-Friendly Electrodeposition of Cobalt–Nickel Sulfide Electrodes for Supercapacitor Applications

Ninad B. Velhal[1*], Pathan Sharief[1,2], Muhammad Uzair[2], Sang-Chae Jeon[1,2*]

[1]*School of Materials Science and Engineering, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea*

[2]*Global Institute for Advanced Nanoscience & Technology, Changwon National University, 20 Changwondaehak-ro, Changwon, Gyeongsangnam-do 51140, Republic of Korea*

[*]*ninadvelhal@gmail.com*

The growing demand for efficient and sustainable energy storage systems has significantly increased interest in high-performance supercapacitors due to their high-power density, rapid charge–discharge capability, and long cycling stability. However, the development of advanced electrode materials with enhanced electrochemical performance remains a major challenge. Among various candidates, transition metal sulfides have emerged as promising electrode materials because of their superior electrical conductivity, multiple oxidation states, and rich redox-active sites compared to their oxide counterparts. In this work, cobalt–nickel sulfide (Co–Ni–S) nanostructures were directly grown on nickel foam through a facile and environmentally friendly electrodeposition method without any high-temperature annealing treatment. The influence of Co precursor ratio on the electrochemical behavior of the deposited electrodes was systematically investigated. The as-prepared binder-free electrodes are expected to provide improved ion transport and charge-transfer characteristics due to their porous nanostructured morphology and conductive nickel foam substrate. Structural and morphological characterization will be carried out using X-ray diffraction, FT-Raman and field-emission scanning electron microscopy, while electrochemical performance will be evaluated through cyclic voltammetry, galvanostatic charge–discharge, and electrochemical impedance spectroscopy in alkaline electrolyte. The proposed low-cost and low-energy synthesis strategy demonstrates the potential of cobalt–nickel sulfide electrodes for next-generation supercapacitor applications.

Keywords: Supercapacitor, Cobalt–nickel sulfide, electrodeposition, nanosheets, electrochemical performance

Improving Zn Anode Reversibility Using Water-in-Salt Electrolytes

Ziyauddin Khan*

Laboratory of Organic Electronics, Department of Science and Technology, Linköping University, Sweden
**Ziyauddin.khan@liu.se*

Rechargeable aqueous zinc batteries are emerging as promising candidates for safe and low-cost energy storage. However, their practical deployment is hindered by challenges associated with Zn metal anodes, including dendritic growth, hydrogen evolution, corrosion, and interfacial instability. This talk highlights the water-in-salt electrolyte (WiSE) concept as an effective strategy to overcome these limitations. By employing highly concentrated salt solutions, WiSE electrolytes fundamentally modify the Zn^{2+} solvation environment, suppress free water activity, and broaden the electrochemical stability window. These changes mitigate parasitic side reactions and promote more uniform and reversible Zn deposition. The presentation will discuss recent advances in understanding how WiSE systems stabilize the Zn/electrolyte interface and improve cycling performance. In addition, the talk will address key challenges associated with WiSE electrolytes, such as high cost, increased viscosity, and ion transport limitations, while outlining future directions for electrolyte engineering toward practical and sustainable aqueous zinc battery technologies.

Keywords: Zn battery, Electrolyte, Aqueous, Water-in-salt, Reversibility

Design of a Tb-MOF Advanced Material for Selective Sensing of Flotation Collectors and Sequential Hg^{2+} Detection

Helen P. Toledo-Jaldín[1*], Cristian L. Pinzón-Vanegas[2], Delia M. Ávila-Márquez[1], Alien Blanco-Flores[1], Alejandro Dorazco-González[2]

[1]*National Technological Institute of Mexico (TecNM), Technological Superior Studies Tianguistenco, Santiago Tianguistenco, Mexico*
[2]*Institute of Chemistry, National Autonomous University of Mexico, Mexico City, Mexico*
[*]*helen_mecanica@test.edu.mx*

Thiocarbamates are widely used as flotation collectors in mining; however, their environmental impact remains underexplored compared to their well-documented use as pesticides. These compounds can contribute to water contamination, posing risks to ecosystems. In parallel, mercury (Hg^{2+}) is one of the most hazardous environmental pollutants due to its high toxicity, persistence, and potential for bioaccumulation. The development of sensitive and reliable detection strategies for both species is therefore essential for environmental monitoring and mitigation.

In this work, a new terbium-based metal–organic framework (MOF), formulated as $[Tb(Hbtec)\cdot H_2O]\cdot 2H_2O$ (1), was synthesized via a solvothermal method using a terbium salt and pyromellitic acid. The obtained material was structurally characterized and evaluated as a luminescent sensor for detecting the thiocarbamate collector (AP-5100) and Hg^{2+} ions.

Material 1 exhibits strong green luminescence and functions as a dual-mode sensor in methanol. A "turn-off" response was observed in the presence of AP-5100, attributed to an absorption competition quenching (ACQ) mechanism, while a "turn-on" response occurred upon subsequent addition of Hg^{2+} ions. The luminescence enhancement is attributed to the formation of a complex between AP-5100 and Hg^{2+}, thereby enabling a cascade sensing system.

The detection limits were determined to be 0.77 μM for AP-5100 and 0.078 μM for Hg^{2+}. Although direct comparison of AP-5100 is limited due to scarce literature, the sensor shows competitive performance in mercury detection relative to other luminescent systems. The cascade sensing approach demonstrated a relative error of 1.2% compared to conventional UV–Vis spectroscopy, confirming its reliability.

Furthermore, the applicability of material 1 was validated in a microflotation system using sphalerite as a model mineral, thereby enabling quantification of AP-5100 under conditions closer to real-world mining processes. This highlights the potential of the developed MOF as a practical tool for monitoring flotation reagents and toxic metal ions in complex environments.

Overall, this work demonstrates the design of a multifunctional luminescent MOF capable of selectively and sequentially detecting mining-related pollutants, contributing to the development of advanced materials for environmental sensing and process monitoring.

Keywords: Metal–Organic Frameworks (MOFs), Luminescent Sensing, Thiocarbamate Collectors, Mercury Detection (Hg^{2+}), Environmental Monitoring

MgO-Filled Epoxy Adhesive with Bimodal Particle Packing as an Alternative to Vacuum Brazing for EV Battery Cold Plate Top–Bottom Plate Joining

Hoseong Son, Tae Hoon Kim, Jimin Kim, Hyung Jin Mun, Minseob Lim, and Yong-Ho Choa*

Department of Materials Science and Chemical Engineering, Hanyang Univeristy, Republic of Korea
**choa15@hayang.ac.kr*

Cold plates for indirect liquid cooling of EV battery modules are conventionally manufactured by vacuum brazing of stamped or extruded aluminum top and bottom plates. While this process is mature and provides hermetic sealing, it imposes two independent limitations on the resulting assembly. The first concerns process-induced damage: standard brazing chemistry restricts the base alloy to a narrow range, excluding most heat-treatable aluminum systems favored for lightweighting and structural integration, and the high-temperature brazing cycle dissolves the strengthening precipitates of such alloys, leading to a substantial loss of base-metal strength. The second concerns joint chemistry-induced damage: species derived from the brazing filler diffuse along grain boundaries and render the joint susceptible to intergranular corrosion, on which the acidic degradation products of ethylene glycol–water coolant impose a cumulative chemical load during long-term service.

This study evaluates the feasibility of replacing the brazed joint with a structural adhesive bond based on MgO-filled epoxy, an approach that simultaneously addresses the process-induced limitations and removes the filler-diffusion pathway of joint corrosion. MgO is selected as the thermally conductive ceramic filler because it combines high intrinsic thermal conductivity, isotropic conduction, and high electrical resistivity, thereby avoiding the principal weaknesses of competing ceramic fillers. To maximize the effective thermal conductivity of the cured composite, a bimodal MgO particle size distribution is adopted, in which fine particles occupy the interstices between coarse particles to raise the packing density beyond the monomodal limit and promote the formation of a continuous thermal pathway through the adhesive layer. The main intrinsic limitation of MgO — thermodynamically spontaneous hydration — proceeds through a dissolution–precipitation mechanism whose surface step is kinetically addressable by silane coupling treatment. The study explicitly recognizes that this approach does not eliminate the chemical burden borne by the joint but transforms it, with epoxy hydrothermal aging and ceramic-filler hydration emerging as new failure pathways that constitute the central scope of the work.

The investigation characterizes the trade-off between thermal conductivity and lap shear strength as a function of MgO loading, bimodal size ratio, and surface treatment condition, the retention of mechanical and sealing performance under accelerated EG–water immersion aging and thermal cycling, and the cold-plate-level performance of the adhesive joint relative to a brazed reference in thermal management, base-metal strength preservation, and joint corrosion stability.

Keywords: EV battery cold plate, MgO-filled epoxy, bimodal particle packing, vacuum brazing alternative, ethylene glycol aging

ISNNM&EKAMP 2026

(General Session)

ISNNM: Rare Metals and Recycling (RMR)

Enhanced Separation of Zirconium from Hafnium via Synergistic Solvent Extraction with Cyanex 272 and tributyl phosphate (TBP) in Nitric Acid Solutions

Haroon Kamal[1,2], Jae Hong Shin[1,2], Dong-Hyun Kim[1], Kyoung-Tae Park[1,2*]

[1]Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea
[2]Convergence Manufacturing System Engineering, KITECH School, University of Science and Technology, Daejeon, Republic of Korea
[*]ktpark@kitech.re.kr

The selective separation of zirconium (Zr) from hafnium (Hf) remains one of the most challenging processes in hydrometallurgy due to the nearly identical physical and chemical properties and closely related ionic characteristics of these two elements. Zirconium and Hafnium commonly occur together in nature in the form of Zircon ($ZrSiO_4$) and baddeleyite (ZrO_2), where hafnium typically ranging from 0.5 to 3 wt.%. They are broadly used in the chemical, aerospace, advanced materials, military, and nuclear industries for their superior mechanical strength, outstanding corrosion resistance, points favorable physicochemical properties, and high melting points. The production of nuclear grade zirconium requires the efficient removal of hafnium, Because Zr based alloys are broadly utilized as fuel cladding and structural materials in water cooled nuclear reactors. On the other hand, Hafnium possesses a thermal neutron absorption cross section approximately 600 to 640 times greater than zirconium which can adversely affect reactor performance. Due to their remarkably similar physicochemical properties and chemical behavior the separation of zirconium from hafnium is very difficult.

Therefore, in this study, a synergistic solvent extraction system composed of Cyanex 272 and tributyl phosphate (TBP) diluted in kerosene is being investigated for the selective extraction and separation of zirconium from nitric acid media. Zirconyl chloride octahydrate is being used as the feed material for preparing the aqueous phase, and batch solvent extraction experiments are being conducted. The research focuses on systematically evaluating the influence of important operational parameters, including contact time, nitric acid concentration, Cyanex-272 concentration, and TBP concentration, to determine the optimum extraction conditions for efficient zirconium separation. The synergistic interaction between Cyanex-272, which acts as an acidic cation-exchange extractant, and TBP, functioning as a neutral solvating agent, is being examined to understand its role in enhancing the extraction behavior and stabilization of zirconium nitrato complexes in the organic phase. In summary, the optimal extraction conditions identified in this work are discussed in relation to their influence on zirconium extraction, zirconium and hafnium separation, and the achievement of high selectivity toward zirconium under moderate nitric acid conditions. Furthermore, the application of a synergistic extractant system offers a promising alternative to conventional zirconium purification routes by potentially reducing process complexity while maintaining high selectivity. The results provide a basis for the development of an efficient and practical solvent extraction process for zirconium purification.

Keywords: Solvent Extraction, Cyanex272, Tributyl phosphate, Zirconium, Hafnium

Selective Fe/Ni Separation from Nickel Pig Iron Leachate through Saponification-Controlled Solvent Extraction

Burhan Febrinawarta[1,2], Myungsuk Kim[1,3], Haroon Kamal[1,2], Kyoung-Tae Park[1,2], Jae Hong Shin[1,2*]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Convergence Manufacturing System Engineering, KITECH School, University of Science and Technology, Daejeon, Republic of Korea*
[3]*Department of Materials Science and Engineering, Korea University, Seoul, Republic of Korea*
[*]*shinclusion@kitech.re.kr*

The increasing global demand for high-purity nickel, particularly for lithium-ion battery cathode materials and advanced energy storage technologies, has accelerated the transition of nickel production from conventional ferronickel and stainless-steel markets toward battery-grade chemical products. Nickel pig iron (NPI), traditionally utilized as a low-cost feedstock for stainless steel manufacturing, has recently emerged as a promising intermediate resource for the production of high-purity nickel sulfate through hydrometallurgical processing routes such as high-pressure acid leaching (HPAL). However, NPI-derived leachates commonly contain substantial concentrations of residual iron and impurity metals, even after conventional precipitation treatment, which complicate downstream purification and reduce the purity of nickel sulfate products. Moreover, further iron removal through aggressive pH adjustment often promotes hydrolysis and secondary precipitation, resulting in operational instability, excessive reagent consumption, and potential nickel loss. Consequently, the development of a selective and controllable separation strategy is essential to enable efficient Fe/Ni separation while minimizing hydrolysis-dependent purification steps in integrated NPI-to-battery-material processing flowsheets.

This study proposes a two-stage solvent extraction-based purification strategy for selective iron removal and nickel recovery from NPI leachate toward the production of battery-grade nickel sulfate. In the first stage, selective iron extraction was investigated using Cyanex 272 under controlled saponification conditions. The results revealed that increasing the saponification degree substantially enhanced iron extraction, achieving near-complete Fe removal at 25–30% saponification, while nickel co-extraction remained below 15% under moderate extraction conditions. McCabe–Thiele analysis further demonstrated that efficient iron removal could be achieved using a relatively low organic-to-aqueous ratio, indicating favorable extraction equilibrium and process scalability. These findings confirm the existence of a selective Fe/Ni extraction window governed primarily by saponification-controlled extractant behavior and phase equilibrium. In the second stage, nickel recovery from the iron-depleted raffinate was evaluated using Versatic Acid 10 systems. Nickel extraction efficiency increased markedly with increasing extractant concentration and operating pH, with 1.0 M Versatic Acid 10 at 40% saponification achieving greater than 90% Ni extraction. The influences of extractant concentration, equilibrium pH, saponification degree, and organic-to-aqueous phase ratio were systematically assessed through extraction efficiency, distribution ratio, and separation factor analyses.

Keywords: Nickel Pig Iron, Nickel Recovery, Solvent Extraction, Iron Removal, Hydrometallurgy

ISNNM&EKAMP 2026

(General Session)

ISNNM: Refractory Metals and Ceramic Materials (RCM)

Mechanical Properties and Oxidation Behavior of Niobium-based Refractory Alloys Fabricated by DED and SPS

Sheng Yu[1], Cheolhyeon Lee[1], Muhammad Akmal[1], Wonjong Jeong[2], and Ho Jin Ryu[1,3*]

[1]*Department of Nuclear and Quantum Engineering, KAIST, Daejeon, Republic of Korea*
[2]*Department of Industrial Laser Technology, Korea Institute of Materials and Machinery, Busan, Republic of Korea*
[3]*Department of Materials Science and Engineering, KAIST, Daejeon, Republic of Korea*
[*]*hojinryu@kaist.ac.kr*

Niobium-based refractory alloys are of interest for high-temperature structural applications because of their high melting points and potential strength retention at elevated temperatures. Their use in oxidizing environments, however, is restricted by rapid oxidation and associated degradation. In this study, niobium alloys were fabricated using different advanced processing routes, and their microstructure, mechanical properties, and high-temperature oxidation behavior were examined. C103 alloy specimens were produced by wire laser directed energy deposition to assess the applicability of this process to refractory niobium alloys. Nb521 alloy specimens were also fabricated by spark plasma sintering, allowing the effect of rapid powder consolidation on the resulting microstructure and mechanical response to be evaluated. In addition, ceramic reinforcement particles were introduced into Nb521 alloys for laser powder directed energy deposition, with the aim of examining their influence on processability, microstructural development, and room-temperature mechanical properties. Room-temperature tensile tests were carried out to compare tensile strength, ductility, and fracture behavior of the fabricated alloys. High-temperature oxidation tests were performed using thermogravimetric analysis, and the resulting mass-gain curves were compared to evaluate oxidation susceptibility under elevated temperature exposure at 750°C. The combined results show that the processing route strongly affects the microstructural features and mechanical response of niobium alloys. The oxidation data also confirm that alloy composition and microstructures influence the extent of oxidation degradation. These results provide useful information for selecting and optimizing manufacturing routes for niobium-based refractory alloys, demonstrating the feasibility of applying additive manufacturing and spark plasma sintering to niobium alloy components.

Keywords: Niobium alloys, laser wire directed energy deposition, laser powder directed energy deposition, spark plasma sintering, mechanical properties, oxidation resistance

Acknowledgments

This work was supported by the National Research Council of Science & Technology (NST) grant by the Korea government (MSIT) [grant number CAP23041-000]

Thermal and mechanical properties of high-entropy ultra-high temperature ceramics depending on the atomic homogeneity

Eui Seon Lee, Minju Son, Jongmin Byun, and Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea
**stoh@seoultech.ac.kr*

Owing to the growing interest in extreme-environment applications, innovative strategies to enhance oxidation and wear resistance, as well as high-temperature strength, have been explored at temperatures above 2000℃. Particularly, in the aerospace, aviation, and military industries, ultra-high temperature ceramic (UHTC) materials have been widely utilized for hypersonic and atmospheric re-entry vehicles, which are exposed to severe thermal shock, wear, oxidation, and ultra-high-temperature environments. However, because of their extremely high melting points exceeding 3000℃ and inherently poor fracture toughness, there have been many attempts to fabricate dense bodies at relatively low consolidation temperatures and improve fracture resistance by controlling the microstructures and employing either enhancements or multi-component design. Especially, as multi-component UHTCs, high-entropy UHTC (HE-UHTC) materials have recently been investigated because they are expected to exhibit improved fracture toughness and enhanced mechanical and chemical properties over a wide temperature range. Meanwhile, there was a lack of studies on their thermal and mechanical properties because achieving homogeneous dense HE-UHTC bodies requires ultra-high temperatures with prolonged sintering time due to the intrinsically low self- and inter-diffusivities of the constituents. Thus, in this study, the thermal and mechanical properties of an elementally homogeneous dense HE-UHTC were investigated using $(Ti_{0.2}Zr_{0.2}Nb_{0.2}Hf_{0.2}Ta_{0.2})C$ nanoparticles. The $(Ti_{0.2}Zr_{0.2}Nb_{0.2}Hf_{0.2}Ta_{0.2})C$ nano-powders were synthesized at 1900℃ for 60 min under high vacuum from the combination of metal hydrides, metal oxides, and activated charcoal. Then, they were spark plasma sintered (SPS) at 1950-2000℃ for 10-30 min under a pressure of 80 MPa. The compositional homogeneity, impurity levels, density, and grain size were evaluated. As the consolidation temperature and holding time increased, atomic homogeneity improved significantly, and remarkable grain coarsening was not observed. Finally, the oxidation and ablation behaviors as a function of the atomic homogeneity were investigated. This study provides a prominent investigation of the dependence of atomic homogeneity on thermal and mechanical properties and suggests an innovative method for synthesis of $(Ti_{0.2}Zr_{0.2}Nb_{0.2}Hf_{0.2}Ta_{0.2})C$ nanoparticles and consolidation strategies.

Keywords: High-entropy ultra-high temperature ceramics, Mechanical properties, Thermal properties, Fracture toughness, Spark plasma sintering

Sintering Behavior and Microstructural Revolution of Stellite 6–WC Composites Fabricated by Hot Pressing Process

Seyeop Lee[1], Hyeonyoung Choi[1], Hyeonseo Hwang[1] and Jongmin Byun[1,2*]

[1]*Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea*
[2]*The Institute of Powder Technology, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea*
[*]*byun@seoultech.ac.kr*

Stellite 6 is a Co-based alloy widely used in various applications such as gas turbines due to its excellent wear resistance, oxidation resistance, and mechanical properties. In particular, its wear resistance originates from the hard carbide phases dispersed within the Co–Cr alloy matrix. Recently, the introduction of WC particles with high hardness as a reinforcement has attracted considerable attention in order to further improve the mechanical properties and wear resistance of Stellite 6.

The performance of Stellite 6–WC composites is strongly influenced by the densification behavior and microstructural evolution during sintering. Therefore, the development of an appropriate fabrication process is essential to achieve a dense microstructure and strong interfacial bonding between the matrix and reinforcement phases.

Most previous studies on Stellite 6–WC composites have focused on laser cladding and additive manufacturing processes, whereas studies on bulk composites fabricated through conventional powder metallurgy routes remain limited. The fabrication of dense Stellite 6–WC composites by conventional powder metallurgy is challenging because both Stellite 6 and WC powders exhibit high hardness and limited compressibility. Furthermore, pressureless sintering often requires prolonged holding times, which may result in grain growth and carbide coarsening, while differences in diffusion rates between the matrix and reinforcement phases can lead to residual interfacial porosity. Therefore, pressure-assisted sintering has attracted considerable attention as an alternative processing route. The application of external pressure can enhance particle rearrangement and densification, reduce residual pores at the matrix–reinforcement interface, and promote the development of improved mechanical properties. Among various pressure-assisted sintering techniques, the hot pressing process is particularly attractive because simultaneous application of temperature and uniaxial pressure enables effective densification while suppressing excessive grain growth. Consequently, improved microstructural uniformity and enhanced mechanical properties can be expected in Stellite 6–WC composites fabricated by hot pressing process.

In this study, the sintering behavior and microstructural evolution of the Stellite 6–WC alloy during hot pressing process were systematically investigated. The experimental variables included sintering temperature and holding time as processing parameters, and WC powder content and particle size as compositional parameters. In particular, the effects of process variables on the sintering behavior, phases, microstructure, and mechanical properties of the powders were comprehensively investigated.

Keywords: Stellite 6, WC, Hot pressing process, Densification, Microstructure

Effects of LaB_6 Addition on Microstructure and Mechanical Properties of Nb-Si Based Alloys Fabricated by Spark Plasma Sintering

Hyeonyoung Choi[1], Hyeonseo Hwang[1], Seyeop Lee[1] and Jongmin byun[1,2*]

[1]*Department of Materials Science & Engineering, Seoul National University of Science & Technology, Seoul 01811, Republic of Korea*
[2]*The Institute of Powder Technology Seoul National University of Science and Technology, Seoul 01811, Republic of Korea*
[*]*byun@seoultech.ac.kr*

Nickel based superalloys are currently the most extensively studied and commercially deployed high-temperature structural materials. However, they are not suitable for the most demanding applications in space launch vehicles, where the nozzle expansion of liquid rocket engines is required to operate between 1427 ℃ and 1627 ℃, which well above the maximum service temperature of Ni-based superalloys (~1100 ℃). Accordingly, refractory metals have emerged as promising candidates for next-generation ultra-high-temperature alloys to replace Ni-based superalloys.

Among the refractory metals, defined as those with melting points above approximately 2000 °C, Nb is regarded as one of the most promising alternatives owing to its high melting point (~2468 ℃), superior ductility and workability, and relatively low density (~8.57 g/cm^3) compared with that of Ni-based superalloys (~8.908 g/cm^3).

However, Nb based alloys are known to suffer from continuous and catastrophic oxidation at temperatures above 600 °C. In high-temperature oxidizing environments, the non-protective Nb_2O_5 phase forms and tends to volatilize above ~1000 ℃, thereby severely deteriorating both the high-temperature mechanical properties and oxidation resistance of the alloys. To overcome these limitations, Nb-Si based alloys have been developed to form a protective SiO_2 scale under high-temperature oxidation environments.

Recent research has focused on tailoring the microstructure and enhancing the mechanical properties of Nb-Si based alloys through the addition of alloying elements and compounds. Among them, rare-earth elements are known to preferentially form rare-earth oxides upon addition to Nb-Si based alloys, thereby suppressing internal oxidation of the matrix. In the case of boron, it has been reported to either promote the formation of Nb_5Si_3 or accelerate the decomposition of Nb_3Si.

Previous studies have indicated that the addition of borides such as TaB_2 to Nb-Si based alloys results in their decomposition into Ta and B during sintering, with each element subsequently influencing the microstructure and mechanical properties of the alloy. However, the effect of rare-earth borides on Nb-Si based alloys remains largely unexplored. Therefore, it is necessary to investigate the feasibility of rare-earth borides as additives in Nb-Si based alloys.

In this study, LaB_6 was selected as a rare-earth boride additive. Nb-Si based alloy powder and LaB_6 powder were uniformly mixed using high-energy ball milling, and the mixed powders were subsequently consolidated by a spark plasma sintering (SPS) system. The phase constitution, microstructure, and mechanical properties of the resulting alloys were then systematically analyzed to reveal the role of LaB_6 in Nb-Si based alloys.

Keywords: Nb-Si based alloy, Rare-earth borides, Spark Plasma Sintering, Dispersion strengthening, Solid solution strengthening

ISNNM&EKAMP 2026

Poster Presentation

P-01

Standardization of Compressive and Shear Test Methods for Evaluating Agglomerate Properties of Fine Ceramic Powders

Boram Jeon*, Hyeji Kim

Material Technology Cente, Korea Testing Laboratory, Seoul, Korea
*brjeon@ktl.re.kr

Advanced ceramic powders used in semiconductor and secondary battery applications are becoming increasingly fine, resulting in strong interparticle interactions and pronounced agglomeration behavior. Conventional gravity-driven flowability evaluation methods, such as funnel flow tests specified in ISO 14629, are often not applicable to these cohesive powders because arching and bridging phenomena can prevent powder discharge. To address these limitations, a new multi-part ISO standard series, ISO 25685, is being developed within ISO/TC 206 WG2 for evaluating the agglomerate properties of ceramic powders using mechanical testing approaches.

Part 1 specifies a compressive test method in which ceramic powders are compacted under a controlled pressure to form a stable compact, followed by measurement of compressive strength. The ratio between compaction pressure and compressive strength is used to comparatively evaluate agglomerate characteristics. This method is applicable to powders capable of forming stable compacts under uniaxial compression.

Part 2 specifies a shear test method based on yield locus analysis and Mohr stress circle interpretation. A powder specimen is consolidated under a specified normal stress and subjected to pre-shear to establish a steady-state condition. The specimen is subsequently sheared under reduced normal stresses to determine the unconfined yield strength and major principal stress. These parameters are used to evaluate flow resistance and relative agglomerate strength of cohesive powders, including materials that cannot form stable compacts.

The proposed ISO 25685 series provides standardized methodologies for evaluating agglomerate properties of fine ceramic powders over a broad range of consolidation and flow conditions. The standards are expected to support improved characterization and quality control of advanced ceramic powders in high-technology industries.

Keywords: Fine ceramics, Yield strength, Agglomeration, Compresion strength, Shear test

P-02

No lightweight construction without vibration damping!

Ulrike Jehring[1*], Philipp Breyl[1], Georg Pöhle[1], T. Weißgärber[2]

[1]Fraunhofer IFAM-Dresden, Cellular metallic materials, Dresden, Germany
[2]Dresden University of Technology, Chair of Powder Metallurgy, Fraunhofer IFAM-Dresden, Cellular metallic materials, Dresden, Germany

Lightweight, highly rigid structures transmit vibration energy almost completely, resulting in large vibration amplitudes in lightweight assemblies. These limit precision and cycle rates, shorten the service life of tools and machines, and cause discomfort and even health problems. However, lightweight construction is necessary in order to be able to execute increasingly faster movements precisely and to enable lower drive power. Minimizing drive power is the biggest lever for saving energy and reducing CO_2 emissions in machine tools. That is why lightweight construction only makes sense in combination with vibration damping! One way of implementing this is through particle damping. The presentation will outline the current state of development, from metrological and numerical analysis to the simulative design of reference assemblies and the construction of semi-finished products and prototypical applications.

Keywords: Vibration damping, lightweight construction, extending life cycles, reducing health risks

P-03

Phase Evolution and Mechanical Performance of SPS-Consolidated WMoCoTiCr High-Entropy Alloy

Ammad Ali[1,2], Kee-Ryung Park[1], Muhammad Aneeq Haq[3], Yoseb Song[1,2], Da-Woon Jeong[1,4], Bum Sung Kim[1,2*]

[1]*National Korea Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Industrial Technology and Smart Manufacturing, University of Science and Technology, Daejeon, Republic of Korea*
[3]*School of Chemical and Materials Engineering, National University of Science and Technology (NUST), Islamabad, Pakistan*
[4]*School of Mechanical Engineering, Chung-Ang University, Seoul, Republic of Korea*
[*]*bskim15@kitech.re.kr*

An equimolar WMoCoTiCr high-entropy alloy was synthesized by high-energy ball milling followed by spark plasma sintering to investigate the relationship between mechanically alloyed powder characteristics, sintering-induced phase evolution, and mechanical performance. After 48 h of milling, the elemental powder mixture transformed into a dominant body-centered cubic solid-solution phase, indicating the successful formation of a mechanically alloyed high-entropy alloy powder. The development of a BCC phase after prolonged milling is consistent with the strong refractory-metal contribution of W, Mo, Cr, and Ti, since refractory-rich high-entropy alloys commonly favor BCC-type solid solutions and exhibit high strength and hardness.

The milled powders were subsequently consolidated by spark plasma sintering at 1100, 1150, 1200, 1250, and 1300 °C under 50 MPa in vacuum. During SPS, the initially milled BCC structure evolved into mixed FCC and BCC phase constituents, suggesting that thermal activation promoted partial phase redistribution, elemental partitioning, and possible stabilization of Co-rich FCC regions together with refractory-rich BCC regions. Similar mechanically alloyed and SPS-processed HEA systems have shown that sintering temperature can strongly affect phase constitution, densification behavior, microstructural refinement, and the resulting hardness response.

The coexistence of FCC and BCC phases provides a useful framework for interpreting the mechanical behavior of the WMoCoTiCr alloy. In general, FCC phases in HEAs are associated with improved plastic accommodation and crack blunting, whereas BCC phases contribute to higher hardness and strength but may increase brittleness when present as a dominant or poorly distributed phase. Therefore, the SPS temperature is expected to control the balance between hardness and fracture toughness by modifying the relative fraction, distribution, and continuity of the FCC and BCC phases. Dual-phase FCC/BCC HEA design has been widely discussed as an effective strategy to combine the strength of BCC structures with the damage tolerance of FCC structures.

In this study, the WMoCoTiCr system is presented as a powder-metallurgy-based dual-phase HEA in which mechanical alloying establishes a metastable BCC precursor, while SPS enables controlled phase evolution and densification. The expected mechanical response is governed by the combined effects of solid-solution strengthening, refractory-element hardening, grain refinement from mechanical alloying, and temperature-dependent FCC/BCC phase redistribution. The results provide a basis for understanding how SPS temperature can be used to tune the hardness–fracture toughness relationship in W–Mo–Cr–Ti–Co-based high-entropy alloys for structural and wear-resistant applications.

Keywords: High-entropy alloy, WMoCoTiCr, mechanical alloying, spark plasma sintering, phase evolution, mechanical properties

P-04

Enhanced densification of pure tungsten through multimodal particle packing during spark plasma sintering

Nuri Choi*, Ki-bong Kim, Young-Taek Seo, and Sangsun Yang

Nano-materials Research Division, Korea Institute of Materials Science, Republic of Korea
*choin@kims.re.kr

Powder metallurgy is an attractive processing route for refractory metals such as tungsten owing to its high material utilization and near-net-shape capability. However, achieving full densification remains challenging because residual porosity is difficult to eliminate during sintering. Activated sintering using transition metal additives such as Ni, Fe, and Co has been widely employed to enhance densification by promoting mass transport. Nevertheless, the presence of additive elements may lead to grain boundary segregation or secondary phase formation, which can comprise the high temperature mechanical performance of tungsten.

An alternative strategy for enhancing densification for tungsten is the adjustment of particle packing through optimized particle size distributions. The packing theory introduces fine particles into the voids between coarse particles and increases the packing density and green density of the powder compact. It reduces the pore volume that must be eliminated during sintering. In addition, nanoscale particles provide a large specific surface area and high surface energy, thereby increasing the thermodynamic driving force for sintering and promoting diffusion kinetics.

Here, we investigate the influence of multimodal particle size distributions on the densification behavior of pure tungsten during spark plasma sintering (SPS). Tungsten powders with mean particle sizes of 2❍m, 400nm, and 100nm were mixed to prepare bimodal and trimodal particle size distributions. The powder mixtures were homogenized by planetary ball milling and subsequently consolidated by SPS under vacuum. The effects of particle size distribution on densification and microstructural evolution were evaluated by relative density and grain size of final sintered parts. The role of nanoscale powder fractions in improving packing efficiency was also examined. The results reveal a correlation between particle packing and densification mechanisms and demonstrate an effective approach for producing highly dense pure tungsten without the use of sintering additives.

Keywords: Densification, Tungsten, Powder consolidation, Sintering

P-05

Thermal Properties of Unidirectional Mo-Cu Composites Fabricated via Freeze Casting and Spontaneous Melt Infiltration

Youngmin Kim, Eui Seon Lee, Ji Young Kim, Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea
**stoh@seoultech.ac.kr*

Mo-Cu composites, as one of the prominent thermal management materials, are widely applied as base plates or spacers in power modules due to their favorable workability, high thermal conductivity, and tunable CTE. In general, Mo-Cu composites serve a crucial dual function: mitigating interfacial stresses between the semiconductor chip and the heat sink while transferring heat in the Z-direction towards the heat sink. Among the various configurations of Mo-Cu composites—including liquid-phase sintered bodies, melt-infiltrated structures, and Cu-Mo-Cu (CMC) laminates—the CMC structure is the most predominantly utilized in commercial applications. Widely used CMC laminates, however, suffer from an inherent structural limitation, where the low-thermal-conductivity Mo core acts as a bottleneck for heat transfer in the Z-direction. To circumvent the structural bottleneck, we introduced freeze casting to produce a Mo preform. Freeze casting is a versatile method to produce macroporous materials with directional pore channels by directionally solidifying a suspension, followed by sublimating the solvent and sintering, thereby allowing precise control over the resulting pore size, shape, orientation, and total porosity. In this study, an Mo preform featuring unidirectional pore channels was fabricated via water-based freeze casting, followed by spontaneous Cu-melt infiltration to produce a unidirectional Mo-Cu composite. We investigated the effects of the suspension's solid loading (10–30 vol%) and sintering temperature (1100–1400 °C) on the microstructural evolution of the porous Mo preform and, in turn, on the thermal properties of the resulting unidirectional Mo-Cu composite. Specifically, the continuous Cu network aligned in the Z-direction provides an uninterrupted pathway for highly efficient vertical heat dissipation, while the interconnected Mo skeleton ensures structural stability and CTE matching. This study offers a structural design strategy to overcome the thermal management bottleneck in advanced power electronics.

Keywords: Mo-Cu composite, Unidirectional composite, Freeze casting, Thermal conductivity, Coefficient of thermal expansion

P-06

Effect of nonionic/cationic dispersants on the dispersion stability of water-based WO_3 slurries for freeze casting

Ji Young Kim, Eui Seon Lee, Youngmin Kim and Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea
**stoh@seoultech.ac.kr*

Porous materials, due to their large surface area and high porosity, are widely used in many fields, such as catalyst supports, separation materials, and absorbents. Common porous material fabrication methods, including powder metallurgy approaches, lead to equiaxed pores with an isotropic distribution over the whole specimen. Consequently, it is difficult to control pore structures such as porosity, pore size, and orientation. In contrast, the freeze casting method can produce materials with controllable pore structures. The freeze casting process involves preparing a slurry by mixing a freezing vehicle with the powders and polymeric additives, which is subsequently frozen and sublimated to remove the freezing vehicle. During solidification, the freezing vehicle grows and expels the particles, forming crystals whose morphology is replicated as the pore channels after sublimation. For this reason, freezing vehicles playing a vital role in the process. They require an appropriate melting point to freeze near room temperature and a high vapor pressure for easy sublimation. Thus, water, camphene, and tert-butyl alcohol (TBA) are frequently used. Among them, water is widely used in freeze casting owing to its non-toxicity and environmentally friendly characteristics. Water-based freeze casting has been widely investigated. By controlling parameters such as solid loading, freezing, and sintering conditions, the pore structure can be easily tailored. To attain a homogeneous green body, the slurry properties and stability are essential. The dispersion stability of the slurry is primarily determined by electrostatic, van der Waals, and steric interactions between organic additives and powders. To enhance dispersion stability, this study utilizes non-ionic and cationic polymeric dispersants. The influences of dispersant molecular weight and charge characteristics on slurry stability were evaluated via zeta potential, viscosity, and Turbiscan analyses. This research not only optimizes the processing for a specific suspension system but also proposes a generalized methodology to improve particle dispersion stability in water-based slurries.

Keywords: Dispersion stability, Water-based slurries, Freeze casting, Porous W

P-07

Effect of Zr Addition on the Microstructure and Oxidation Behavior of HIP-Processed Cr-Al Sputtering Targets for ATF Cladding Applications

Jae Hong Kim[1], Jae-Hyeok Sim[1], Dae-Hyeon Kim[1], Seung-Hye Jeong[1], Min-Ho Shin[1], Junkoo Lee[2], Sangha Park[3], and Soon-Jik Hong[1*]

[1]*Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea.*
[2]*HANCAP, Cheonan, Republic of Korea*
[3]*Daegu Mechatronics & Materials Institute (DMI), Daegu, Republic of Korea*
[*]*hongsj@kongju.ac.kr*

Following the 2011 Fukushima Daiichi nuclear disaster, there has been an urgent demand for cladding materials that can maintain structural integrity under loss-of-coolant accident (LOCA) scenarios, thereby securing additional time for emergency response. This has driven active development of Accident Tolerant Fuel (ATF) coating technologies to address the rapid oxidation of conventional Zr-based cladding in high-temperature steam environments. Among various candidates, Cr–Al-based alloys are considered a promising class of sputtering target materials due to their ability to form protective Cr_2O_3 and Al_2O_3 oxide scales at elevated temperatures.

In this study, a small amount of Zr was added as a reactive element to the Cr–Al alloy system, and its effects on microstructural evolution and high-temperature oxidation resistance were investigated. Cr–Al and Cr–Al–Zr alloy ingots were fabricated by vacuum induction melting (VIM), followed by ball milling and classification to minimize particle size differences between the two powders. Powder characterization showed that the D90 values of the Cr–Al and Cr–Al–Zr powders were 61.8 and 59.5 μm, respectively, indicating comparable size distributions. The oxygen content for both compositions was approximately 1,933 ppm with no significant difference. The apparent densities (2.44 and 2.42 g/cm^3) and tap densities (3.47 and 3.46 g/cm^3) were also nearly identical, effectively eliminating powder-related variables. The controlled powders were then consolidated into 3-inch sputtering targets by hot isostatic pressing (HIP).

XRD, SEM, and EBSD analyses confirmed that both alloys retained a BCC single-phase structure with Al dissolved in the Cr matrix after HIP consolidation. The Cr–Al–Zr alloy exhibited markedly refined grains, with localized Zr segregation observed along grain boundaries. In terms of densification, the Zr-containing target reached near-full density under identical processing conditions, whereas the Cr–Al target fell short of this level. No phase transformation was detected in either alloy.

High-temperature oxidation tests using TGA revealed that the Cr–Al–Zr alloy exhibited approximately five times greater oxidation resistance than the Cr–Al alloy. Post-oxidation surface analysis confirmed the formation of Cr_2O_3 and Al_2O_3 oxide layers on both alloy surfaces. The superior oxidation performance of Cr–Al–Zr is attributed to the reactive element effect of Zr, which segregates at grain boundaries, enhancing oxide scale adhesion and suppressing outward cation diffusion. These findings confirm that the addition of a small amount of Zr to the Cr–Al system is an effective strategy for developing high-performance sputtering targets for ATF cladding applications.

Keywords: Accident Tolerant Fuel (ATF), Hot Isostatic Pressing (HIP), Cr–Al–Zr alloy, Oxidation resistance, Reactive element effect

P-08

Wear Properties of Laser-Cladded STS316L/WC Coatings on Gray Cast Iron Brake Discs

Jae Hong Kim[1], Eun-Ha Go[2], and Soon-Jik Hong[1*]

[1] *Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea.*
[2]*InssTek., 154 Shinsung-ro Yuseong-gu, Daejeon, Republic of Korea*
[*]*hongsj@kongju.ac.kr*

Growing concerns regarding air pollution and fine particulate matter have accelerated global environmental regulations. In particular, the European "Euro 7" regulation expands emission control targets beyond conventional exhaust gases to include non-exhaust particulate emissions generated from the wear of brake discs and tires. Conventional brake discs are primarily manufactured from gray cast iron (GCI) because of its excellent thermal conductivity and heat dissipation characteristics. However, its relatively poor wear resistance results in significant wear-particle generation during braking. Therefore, the development of brake-disc materials with enhanced wear resistance and reduced particulate emissions has become increasingly important.

Stainless steel 316L (STS316L) offers excellent corrosion resistance, ductility, and formability, making it a promising coating material for improving the mechanical performance of conventional brake-disc substrates. In addition, laser cladding enables precise control of coating thickness and microstructure while enhancing wear resistance through rapid solidification and work-hardening effects. Furthermore, the incorporation of tungsten carbide (WC) hard particles into the STS316L matrix can improve hardness and wear resistance through effective load sharing and partial dissolution of WC during high-temperature processing.

In this study, STS316L–WC composite coatings were deposited on GCI substrates using a laser-cladding process, and their wear behavior was evaluated using a ball-on-disc linear wear test. The specific wear rate of the uncoated GCI specimen was 10.71×10^{-6} $mm^3/N \cdot m$, whereas those of the 100 μm and 300 μm coated specimens were 3.41×10^{-6} and 4.33×10^{-6} $mm^3/N \cdot m$, respectively. The 100 μm coating exhibited approximately 68% lower wear than the GCI substrate and approximately 20% lower wear than the 300 μm coating. The superior wear resistance of the 100 μm coating was attributed to effective load sharing by WC particles distributed near the wear surface. In contrast, the relatively lower wear resistance of the 300 μm coating was associated with the sedimentation of WC particles toward the lower region of the coating layer, which reduced their contribution to surface load bearing during sliding.

These results demonstrate that coating thickness plays a critical role in determining the wear performance of laser-cladded STS316L–WC composite coatings and suggest their strong potential for application in environmentally friendly brake discs with improved wear resistance and reduced particulate emissions.

Keywords: Wear test, Wear rate, Wear resistance, Wear properties, Brake Discs

P-09

Gas Atomization Process Optimization of Ni-Co-Cr Alloy Powders and Effects of Alloying Elements on Powder Characteristics

Seunghye Jeong[1], Dae-Hyeon Kim[1], Jae-Hyeok Sim[1], Chaewon Han[1], Youngtae Kim[1], Ankhbayar Odonkhuu[1], Ji-Woon Lee[1], Ho Jin Ryu[2], and Soon-Jik Hong[1*]

[1]*Division of Advanced Materials Engineering and Center for Advanced Materials and Parts of Powder (CAMP2), Kongju National University, Budae-dong, Cheonan City, Chungcheongnam-do, 330-717, Republic of Korea.*
[2]*Department of Nuclear and Quantum Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-701, Republic of Korea*
*hongsj@kongju.ac.kr

Ni-based heat-resistant alloys for space launch vehicles must exhibit excellent high-temperature mechanical properties, oxidation resistance, and ignition resistance under extreme thermal environments. Launch vehicle engines and high-temperature structural components are repeatedly exposed to high-temperature and high-pressure conditions; therefore, thermal stability and oxidation suppression are critical factors for ensuring component reliability and service life. Accordingly, Ni-Co-Cr-based heat-resistant alloys containing Co for enhanced high-temperature stability and Cr for improved oxidation resistance have attracted considerable attention as high-performance aerospace materials. Recently, alloy design and powder manufacturing technologies for applying these alloys to additive manufacturing (AM) have been actively investigated.

Metal powders for additive manufacturing are commonly produced by the gas atomization (GA) process. GA is a process in which molten metal is disintegrated into spherical powders using high-pressure gas, and it directly affects key powder characteristics such as particle size distribution, sphericity, satellite formation, oxygen content, and microstructure. For the application of Ni-Co-Cr alloy powders to the AM process, both excellent flowability for stable powder feeding and low oxygen content for suppressing defect formation during deposition are required. Poor powder flowability can cause non-uniform powder feeding during AM, leading to reduced dimensional accuracy, density, and mechanical properties of the deposited parts. In addition, increased surface oxidation of powders may promote the formation of oxide inclusions in the melt pool and increase the possibility of interfacial defects.

Therefore, to reliably manufacture Ni-Co-Cr powders for additive manufacturing, it is essential to control process instabilities during GA, including nozzle clogging, back pressure, melt oxidation, and unstable atomization behavior. GA process parameters influence the particle size, sphericity, cooling rate, and solidification microstructure of powders, while alloying elements strongly affect their microstructure, mechanical properties, oxidation resistance, and the performance of the final deposited materials. However, simultaneously optimizing process conditions and alloy composition, while also clarifying their effects on the properties of the final deposited parts, requires extensive time and experimental validation. Studies that quantitatively evaluate powder characteristics before additive manufacturing and separately interpret the effects of GA process conditions and alloy composition remain limited.

In this study, the effects of GA process parameters on the characteristics of Ni-Co-Cr alloy powders for additive manufacturing were systematically investigated. Particle size distribution, sphericity, secondary dendrite arm spacing (SDAS), flowability, and oxygen content were selected as key evaluation factors, and changes in powder quality according to GA process conditions were quantitatively compared. In addition, the effects of alloying elements on the mechanical properties and oxidation resistance of the powders were analyzed to determine suitable powder manufacturing conditions and alloy compositions for additive manufacturing. This study aims to systematically elucidate the characteristics of Ni-Co-Cr alloy powders prior to AM processing and to establish a basis for process optimization and alloy design of Ni-based heat-resistant alloy powders for space launch vehicle applications.

Keywords: Gas atomization, Powder Characteristics, Ni-Co-Cr alloy, Additive manufacturing

P–10

The Stability of Copper Nanoparticles in Polyethersulfone Membranes and Their Impact on the Macromolecular Structure

Axel Kretschmer*, Qiaodan Chen, Steffen Witzleben

Institute of Technology, Resource and Energy-efficient Engineering, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany
axel.kretschmer@h-brs.de

Modern water purification processes involve multiple treatment steps to remove a wide range of undesirable contaminants. In addition to chemical or physical disinfection, membrane-based filtration processes fulfil an important role in the removal of suspended organic compounds or dissolved ions.

.Due to their cost-effectiveness and flexible fabrication options, polymeric membranes are commonly used in industrial water treatment. Among these materials, polyethersulfone (PES) is widely applied because of its excellent chemical, thermal and mechanical stability while being polar and highly water-permeable. Due to these features PES is used as material in desalination processes, as a support material for reverse osmosis membranes, and as a base polymer for microfiltration and nanofiltration membranes. However, membrane fouling caused by biological and chemical contaminants remains a major challenge, resulting in increased cleaning frequency which is causing process interruptions and a reduced membrane lifetime.

The incorporation of copper nanoparticles (CuNPs) in PES membranes has been identified as a promising strategy to reduce fouling, owing to their antimicrobial and catalytic properties of. This approach is advantageous as CuNPs are more economical and readily available than silver nanoparticles which are common used as antimicrobial substance.

Although the application of CuNPs in membrane systems has been reported in the literature, there is limited information available on their influence on membrane, the ability to retain different substances, long-term stability and leaching within the polymer matrix.

This study investigates effects of elemental copper and different copper species in the form of NPs with focus on their distribution in the final membrane and the leaching during usage by using microscopic and spectroscopic techniques. Depending on the polymer solution's composition, the elemental composition of the particles, and the preparation method, different distributions and stabilities of the nanoparticles in the final membranes were observed. Following our analysis of the findings it is possible to adjust the parameters in order to manufacture membranes in a more targeted manner. This makes it possible to stabilize the nanoparticles contained in the matrix and prevent leaching while maintaining membrane functionality for water treatment applications. We are going to present results regarding the leaching and stabilization of the CuNPs in a PES matrix.

Keywords: Polyethersulfone (PES) membranes, Copper nanoparticles (CuNPs), leaching, water purification

Reference

[1] García et al., 2021 [2] Liu et al., 2024 [3] Ozay et al., 2016 [4] Nasrollahi et al., 2019

P-11

Withdrawn

P–12

Fabrication of Flake-Shaped Co-Ni Alloy Powders by Mechanical Milling and Their Application to rSOC Current Collectors

Jung-Yeul Yun*, Min-Jeong Lee, and Hyeon-Ju Kim

Nano Materials Research Division, Korea Institute of Materials Science, Changwon, Republic of Korea
**yjy1706@kims.re.kr*

With increasing interest in the expansion of renewable energy and the establishment of hydrogen-based energy systems, reversible Solid Oxide Cells (rSOCs) have attracted significant attention as next-generation high-efficiency energy conversion and storage technologies. The performance and long-term stability of rSOC stacks are strongly influenced by the structure and electrical properties of current collectors. However, conventionally used metal foam-based current collectors suffer from limited structural controllability and restricted electrode contact area, resulting in degraded electrical conductivity. To address these limitations, spherical CoNi alloy powders (Co:Ni = 5:5 and 9:1) were mechanically transformed into flake morphologies through high-energy ball milling. The effects of milling time (1–8 h) on particle morphology and size distribution were systematically analyzed, and the deformation behavior was compared between alloy compositions.

The results showed that CoNi (5:5) powders were effectively transformed from spherical to flake shape after 8 h of milling, whereas CoNi (9:1) powders exhibited limited flake formation under the same conditions. This indicates that alloy composition significantly influences mechanical deformation behavior and flake formation efficiency. These findings demonstrate that precise control of milling parameters and alloy composition can enable the fabrication of Co-Ni-based flake-type current collectors, providing a fundamental basis for the design and optimization of current collectors aimed at enhancing rSOC performance.

Keywords: CoNi alloy powder, High-energy ball milling, flake, alloy composition

P-13

Phase Stabilization Behavior of Rapidly Solidified SUS316L Micro-Wires Fabricated by the Taylor-Ulitovsky Method

Junghyun Noh, Seungjae An, Hoseong Rhee, Moonsik Song

R&D Center, Secufibre Co., Ltd., Incheon, Republic of Korea
**noah@secufibre.com*

Rapidly solidified metallic micro-wires have attracted increasing attention due to their non-equilibrium microstructures and potential functional applications. In this study, the phase stability and heat-treatment behavior of ultra-fine STS316L glass coated micro-wires for metallic gas filter layer applications were investigated. To achieve wire dimensions below 5 μm, comparable to conventional metal powder sizes, ultra-fine STS316L micro-wires were fabricated using the Taylor-Ulitovsky process, which involves rapid solidification during fabrication.

Although conventional STS316L generally exhibits a fully FCC austenitic phase, OM, SEM, and EBSD analyses revealed that the as-fabricated micro-wires contained partially formed ferritic phases together with the FCC austenitic structure. The formation of these ferritic phases is presumed to originate from the non-equilibrium solidification behavior induced by the rapid cooling conditions of the Taylor-Ulitovsky process.

To restore phase stability, heat-treatment processes were performed under various temperature conditions in order to induce transformation of the ferritic phases into a stable austenitic phase. The resulting phase evolution and microstructural behavior were systematically analyzed using SEM and EBSD techniques.

The experimental results demonstrated that the phase transformation behavior of the micro-wire samples differed from that of conventional bulk STS316L materials. In particular, thinner wire samples exhibited enhanced phase stabilization behavior and distinct microstructural evolution due to their high surface-to-volume ratio and rapid thermal diffusion characteristics. Furthermore, heat-treatment-dependent reductions in ferritic phase fraction were observed together with corresponding variations in tensile properties.

These findings indicate that rapid solidification and micro-wire geometry significantly influence the phase stability and mechanical properties of STS316L micro-wires. The present study provides fundamental insights into the heat-treatment-induced phase stabilization behavior of ultra-fine STS316L micro-wires and may contribute to the optimization of metallic filter layer materials for advanced gas filter applications.

Keywords: SUS316L glass coated Micro-Wire, Taylor-Ulitovsky Process, Rapid Solidification, Phase Evolution, Ferritic Phase Formation

P-14

Effect of Latent-Curing Behavior on Ag Neck Formation in Ag Sintering

So-Jeong Lee*, Je-Yong Jeong, Jun-Ki Kim, Min-Su Kim

Advanced Packaging Integration Center, Korea Institute of Industrial Technology, Incheon, Republic of Korea
flthwha27@kitech.re.kr

Ag sintering has been widely studied as a die attach technology for wide-bandgap power semiconductor packaging because of its high thermal/electrical conductivity and high melting point. However, in practical packaging processes, the sintering temperature is usually limited below 300 °C due to thermal damage and warpage issues. Under low-temperature sintering conditions, residual pores remain within the sintered layer and densification becomes limited. In epoxy-containing Ag paste systems, premature epoxy curing during sintering causes a rapid increase in viscosity, restricting Ag particle rearrangement and neck formation.

In this study, a latent-curing epoxy system was applied to delay epoxy curing during Ag sintering. A hybrid Ag paste containing Ag flakes and Ag nanoparticles was prepared. Delayed gelation maintained a low-viscosity state during the initial sintering stage and allowed particle rearrangement and diffusion-driven neck formation before gelation. Epoxy curing behavior was analyzed by DSC and isothermal viscosity measurements, and microstructures of the sintered joints were observed by SEM.

The specimen processed at 225 °C showed continuous Ag networks and well-developed necking. In contrast, premature curing at 250 °C caused epoxy entrapment between Ag particles and discontinuous necking. These results indicate that delayed gelation during sintering affects Ag neck formation and densification.

Keywords: Ag sintering, latent-curing epoxy, Ag neck formation, hybrid Ag paste, densification

P-15

A strong and ductile nano/micro titanium carbide reinforced austenitic steel at 4.2 K

Young-Kyun Kim* and Young-Sang Na

Korea Institute of Material Science (KIMS), Changwon 51508, Republic of Korea

Traditionally, incoherent precipitates and intergranular particles have been considered detrimental to mechanical properties at cryogenic temperatures. Here, we present a novel TiC-reinforced metastable austenitic steel (TiC-MAS) exhibiting exceptional performance at 4.2 K. The TiC-MAS shows a face-centered cubic (FCC) structure with intragranular nanoscale TiC and intergranular microscale TiC particles. In this regard, present alloy features an exceptional ultimate tensile strength near ~1.4 GPa, coupled with high ductility exceeding ~78% at 4.2 K. Notably, deformation-induced martensitic transformation to a body-centered cubic (BCC) phase occurred preferentially at crack tips near TiC carbides, strongly impeding crack growth and associated failure under cryogenic conditions. This study proposes a new alloy design concept of combining metastability with dual-scale TiC particles as a promising strategy for strong-and ductile metallic materials at extremely low temperatures

Keywords: Extremely low temperature, Liquid helium, TiC precipitate, Austenitic steel, Mechanical property

P-16

Evaluation of Thin Film Properties Deposited Using Al Alloy Targets for Hillock Suppression and Electrical Property Improvement

Jung-joon Kim, Youngkyun Kim*

Center for Advanced Materials & Processing, Institute for Advanced Engineering, Gyeonggi-do, Republic of Korea
**kyk@iae.re.kr*

Al and Al alloy thin films are widely used as main interconnection materials for TFT electrodes in the formation of backplane interconnects and barrier layers, which are essential components of display devices. Al thin films deposited by sputtering require high purity and low electrical resistivity to ensure stable device performance. However, pure Al thin films are susceptible to reliability issues such as hillock formation, electromigration (EM), and splash defects, which can degrade interconnect stability and cause electrical failure during display manufacturing processes. Among these defects, hillock formation is particularly important because it is closely associated with thermal stress generated by the difference in the coefficient of thermal expansion between the substrate and the deposited thin film. Hillocks can grow during subsequent thermal treatment processes and may lead to short circuits or deterioration of device reliability.

To address these issues, Al alloy thin films containing selected alloying elements have been studied as alternatives to pure Al films. In this study, high-purity Al targets, commercial Al alloy targets, and newly fabricated Al-Sc and Al-Y alloy targets were prepared to investigate the effects of alloy composition on hillock suppression and electrical properties. Thin films were deposited using a 2-inch sputtering system, followed by vacuum annealing at 460°C for 30 min to simulate thermal exposure during display fabrication. The surface morphology, microstructure, and hillock growth behavior of the deposited films were characterized using scanning electron microscopy (SEM) and atomic force microscopy (AFM). Electrical resistivity was evaluated using a 4-point probe method combined with thickness measurements obtained by an Alpha-Step profiler.

The results are expected to clarify the relationship between alloying elements, microstructural evolution, hillock formation behavior, and electrical performance of Al-based thin films. In particular, the addition of Sc and Y is considered to influence grain refinement and internal stress relaxation, thereby contributing to improved thermal stability and interconnect reliability. This study provides useful guidelines for the design of high-purity Al alloy sputtering targets applicable to advanced display backplane interconnects.

Keywords: Al alloy target, Thin film, Hillock, Electrical properties

P-17

Impact of Sulfate Recrystallization on the Morphological Development of Gd_2O_2S

Kee-Ryung Park[1], Ammad Ali[1,2], Yoseb Song[1,2], Da-Woon Jeong[1,3] and Bum Sung Kim[1,2*]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Industrial Materials and Smart Manufacturing Engineering, University of Science and Technology, Daejeon, Republic of Korea*
[3]*School of Mechanical Engineering, Chung-ang University, Seoul, Republic of Korea*
[*]*bskim15@kitech.re.kr*

This study investigates the phase-evolution pathway of Gd_2O_2S synthesized from $Gd_2(SO_4)_3 \cdot 8H_2O$, utilizing a three-stage heat-treatment process: dehydration, intermediate air heat treatment, and hydrogen reduction. Through systematic analysis via XRD, SEM, and TG–DSC, we elucidated the precise reaction mechanisms involved.

The findings reveal that the hydrated precursor dehydrates into anhydrous $Gd_2(SO_4)_3$ at 300 °C. Crucially, the subsequent heat treatment at 400–700 °C triggers a structural rearrangement and recrystallization, which serves as a definitive precursor-conditioning stage rather than a mere continuation of dehydration. During the final hydrogen reduction at 800 °C, this recrystallized precursor follows a stepwise reduction pathway, transforming first into an oxysulfate intermediate ($Gd_2O_2SO_4$) and ultimately into hexagonal Gd_2O_2S.

This research confirms that the formation of Gd_2O_2S is governed by a recrystallization-mediated multistep process. These insights provide a mechanistic framework for sulfate-derived synthesis, offering a practical foundation for achieving enhanced reproducibility and precise phase control in the production of rare-earth oxysulfide powders.

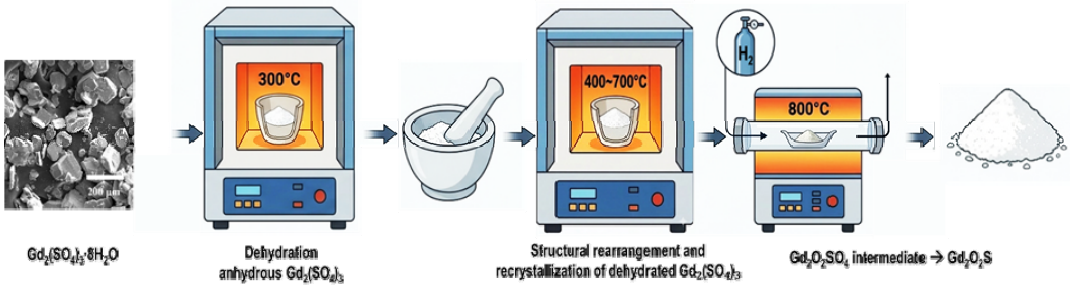


Figure. Schematic illustration of the synthesis pathway and phase evolution from $Gd_2(SO_4)_3 \cdot 8H_2O$ to Gd_2O_2S. The hydrated precursor was dehydrated at 300 °C to form anhydrous $Gd_2(SO_4)_3$, followed by mortar grinding and subsequent heat treatment in air to induce structural rearrangement, polymorphic transformation, and recrystallization. The recrystallized sulfate precursor was then hydrogen-reduced at 800 °C through a $Gd_2O_2SO_4$ intermediate to yield Gd_2O_2S.

Keywords: Gd_2O_2S, $Gd_2O_2SO_4$ intermediate, Recrystallization, Phase evolution, Hydrogen reduction

P-18

Fine $Tb_{70}Cu_{30}$ Eutectic Alloy Diffusion Sources Prepared by Reduction-Diffusion for Uniform Grain-Boundary Diffusion in Nd-Fe-B Magnets

Hyeon Seong Kim[1], Jeong Hyun Kim[1], Kyung Shik Yoon[1], Yu Na Kim[1], Hee Yeon Jeon[1], Park Jae Min[1], and Young-In Lee[1,2*]

[1]*Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea*
[2]*The Institute of Powder Technology, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea*
[*]*youngin@seoultech.ac.kr*

In the grain-boundary diffusion process (GBDP) for Nd-Fe-B sintered magnets, an ideal microstructure requires deep penetration of the heavy rare-earth diffusant along grain boundaries while limiting excessive diffusion into the grain interior. This enables the formation of a thin and homogeneous Tb-rich shell around $Ne_2Fe_{14}B$ grains, thereby enhancing coercivity with minimal loss of remanence. Eutectic diffusion sources such as $Tb_{70}Cu_{30}$ are effective for GBDP because they promote liquid-assisted grain-boundary diffusion. However, conventional melt-spun ribbon sources are difficult to convert into fine powders without oxidation, contamination, or severe agglomeration, which limits the formation of a uniform coating layer on the magnet surface.

In this study, fine $Tb_{70}Cu_{30}$ diffusion-source powders were directly synthesized by a reduction-diffusion (RD) process, in which Tb oxide was reduced and subsequently reacted with Cu to form a Tb-Cu eutectic alloy powder. A melt-spun ribbon with the same nominal composition was also prepared as a reference source. By optimizing the RD conditions, a fine powder with a D_{50} of 4.92 μm was obtained without an additional pulverization step. Confocal microscopy and surface observations confirmed that the RD-derived powder provided more uniform coverage over the magnet surface than the ribbon source at the same loading of 1wt%. Further improvement in coating uniformity was achieved by dispensing a suspension containing the RD powder.

After GBDP both diffusion sources produced comparable coercivity enhancement. However, the RD-derived powder led to higher remanence and improved loop squareness, indicating reduced magnetic deterioration during diffusion. Microstructural analysis revealed that the RD powder-treated magnet developed a thinner and more homogeneous Tb-rich shell, which is attributed to the uniform pre-coating and controlled supply of the Tb-Cu liquid phase. These results demonstrate that RD process is an effective route for directly preparing fine eutectic alloy GBD sources and offers a promising strategy for improving coating uniformity and diffusion controllability in high-performance Nd-Fe-B magnets.

Keywords: $Nd_2Fe_{14}B$ magnet, grain boundary diffusion process, reduction-diffusion, fine powder, eutectic alloy

P-19

Effect of Reduction-Diffusion Conditions on the Synthesis of Fine Ti-Stabilized $SmFe_{12}$-Based Powders and Their Spark Plasma Sintering Behavior

Kyung-Shik Yoon[1*], Jeong Hyun Kim[1], Hyeong Seong Kim[1], Yu na Kim[1],
Hee Yeon Jeon[1], Jae Min Park[1], and Young-In Lee[1,2*]

[1]*Department of Material science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea*
[2]*The Institute of Powder Technology, Seoul National University of Science and Technology, Seoul, Republic of Korea*

The increasing demand for Nd-based permanent magnets has stimulated interest in rare-earth-lean magnetic materials with reduced dependence on critical rare-earth resources. Among them, Ti-stabilized $SmFe_{12}$-based compounds are considered promising candidates because of their low rare-earth content and intrinsic uniaxial magnetic anisotropy. However, the fabrication of dense bulk forms remains challenging because the 1:12 phase is thermally unstable during high-temperature processing, where Sm volatilization, secondary phase formation, and grain growth can occur. Therefore, the synthesis of fine and homogeneous precursor powders is a critical step for improving the subsequent consolidation behavior of $SmFe_{12}$-based materials.

In this study, $SmFe_{11}Ti$ was selected as a representative Ti-stabilized $SmFe_{12}$-based composition, and fine powders were synthesized by the reduction-diffusion process using Sm_2O_3 and Fe-based raw materials. The amount of Sm_2O_3 was controlled to compensate for Sm loss during reduction-diffusion and to promote the formation of the target 1:12 phase. In addition, the reduction-diffusion temperature, holding time, and heating rate were systematically varied. These parameters were investigated based on the hypothesis that nucleation and growth during reduction and interdiffusion strongly affect the particle size, morphology, and agglomeration behavior of the resulting powders. The synthesized powders were characterized in terms of phase formation, particle morphology, and size distribution.

The reduction-diffusion-derived powders were subsequently consolidated by spark plasma sintering to evaluate their densification behavior and microstructural stability under rapid sintering conditions. The effects of sintering temperature and applied pressure on relative density, grain growth, and phase stability were examined. The results provide insight into how reduction-diffusion powder synthesis conditions influence the sintering response of Ti-stabilized $SmFe_{12}$-based powders. This study suggests that controlling the powder synthesis stage is essential for developing fine-grained $SmFe_{12}$-based bulk materials through rapid consolidation.

Keywords: $SmFe_{11}Ti$, Rare-earth lean magnets, Reduction-Diffusion process, Spark Plasma Sintering

P-20

Comparative Study of Gas-Atomized Powder and Melt-Spun Ribbon as Dy-Al-Cu Diffusion Sources for Grain Boundary Diffusion in Nd-Fe-B Sintered Magnets

Serin Jeong[1,2], Myungsuk Song[1], Dae-Kyeom Kim[1], Kee-Ahn Lee[2], Seung-Yeon Park[1,2*], Kyoung-Mook Lim[1**]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Department of Materials Science and Engineering, Inha University, Incheon, Republic of Korea*
**ssica418@kitech.re.kr,*mook@kitech.re.kr*

The growing demand for high-efficiency traction motors in electric vehicles has increased the importance of Nd-Fe-B sintered magnets with high coercivity and improved thermal stability. However, conventional approaches for improving high-temperature magnetic performance often rely on the excessive addition of heavy rare earth elements such as Dy, which can reduce remanence and increase material cost. Grain boundary diffusion processing (GBDP) has therefore attracted attention as an effective approach for enhancing coercivity while reducing the overall consumption of critical heavy rare earth elements. Although the alloy composition of diffusion sources has been extensively investigated, the effects of the physical state, fabrication process, and phase constitution of the diffusion source on GBD characteristics have not been fully clarified.

In this study, $Dy_{70}Al_{20}Cu_{10}$ at.% diffusion sources were prepared as gas-atomized powder and melt-spun ribbon to examine how differences in fabrication process, phase constitution, and melting behavior affect Dy supply characteristics during GBDP. Phase constitutions and microstructures of diffusion sources were characterized using XRD and SEM-BSE, and thermal behaviors were examined by DSC. The gas-atomized powder exhibited a crystalline multiphase structure containing AlCuDy, AlDy-based phases, $CuAlO_2$, and Dy_2O_3. This multiphase structure was associated with multiple endothermic peaks and sequential melting behavior. In contrast, the melt-spun ribbon showed a relatively homogeneous nanocrystalline structure predominantly consisting of the AlCuDy phase, with a single major endothermic peak near 703 °C and liquid-phase formation within a narrow temperature range. These differences were reflected in the post-GBDP Dy distribution behavior along the depth direction, as analyzed by EPMA and EDS. In the powder-treated sample, pronounced Dy accumulation was observed near the surface region, whereas the ribbon-treated sample formed a more gradual and deeper Dy concentration gradient with depth. Compared with the pristine magnet with a coercivity of approximately 13 kOe, both diffusion sources enhanced the coercivity with increasing coating amount from 0.5 to 3.0 wt.%, reaching approximately 19 kOe at a 3.0 wt.% coating amount. These results suggest that even with the same nominal composition, the solidification route, phase constitution, and melting behavior of Dy-Al-Cu diffusion sources can affect Dy infiltration and supply characteristics during GBDP, thereby influencing the resulting magnetic properties of Nd-Fe-B sintered magnets.

Keywords: Permanent magnet, Nd-Fe-B sintered magnet, Grain boundary diffusion process, Heavy rare earth, Diffusion source

P–21

Optimization of a DNA-conjugated magnetoplasmonic nanosensor for mutation detection

N. Ausoni[1*], L. Friedemann[1], M.-C. T. Nguyen[2], J. Lee[2], and M. B. Williams[1]

[1]*Institute for Safety and Security Research, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany*
[2]*Department of Chemistry, Chungnam National University, Daejeon 34134, Republic of Korea*
[*]*nadia.ausoni@h-brs.de*

Early detection of genetic mutations is crucial for effectively treating various diseases, including cancer. While traditional diagnostic methods are often time-consuming, nanosensors offer a rapid and cost-effective alternative. Aptamer-based sensors, in particular, utilise the high binding specificity of oligonucleotides to provide sensitive detection.

The aim of this study was to optimise a magnetoplasmonic nanosensor designed specifically to detect a two-base insert mutation in DNA. The objective was to improve the binding efficiency, stability and detection performance of the nanoparticle hybridisation assay. The sensor system utilizes two types of nanoparticles: Gold Nanoparticles and Silver-Magnetite core-shell nanoparticles ($Ag@Fe_3O_4$). This combines the plasmonic sensitivity of noble metals with the magnetic separation capabilities of magnetite.As seen in Fig. 1 the signal DNA-AuNP conjugate binds to the target only if it is mutated, completing the sandwich hybridization assay and inducing a measurable plasmonic shift. For wild-type targets, steric hindrance from unpaired bases at the end of the capture DNA prevents sDNA binding.

The $Ag@Fe_3O_4$ underwent a multi-step surface modification: silica coating for stability, amine functionalization, conversion to carboxylic acid groups (succinic anhydride), and finally streptavidin conjugation via EDC/NHS chemistry. These magnetic particles were then conjugated with biotinylated capture DNA. The successful completion of each step was verified using various analytical techniques, including UV-Vis spectroscopy, SEM, DLS, zeta potential measurements, protein assays and FT-IR.

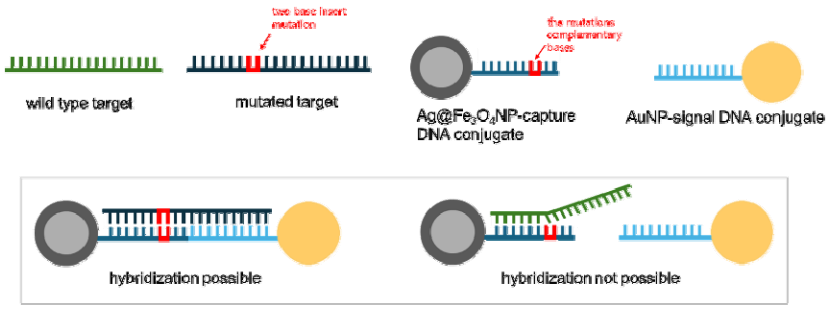


Fig. 1. This scheme shows the biosensor used in this study and its components. Sandwich hybridization with the target is only possible if the target is mutated.

Optimization of the AuNP-aptamer conjugation achieved a maximum efficiency of 54.1% by identifying 200 nM as the optimal DNA concentration. Stability tests confirmed that the DNA-functionalized AuNPs maintained colloidal stability for at least 72 hours. For the $Ag@Fe_3O_4$ particles, surface modifications were tracked through significant zeta potential shifts and a 22 nm increase in hydrodynamic diameter after protein conjugation. Additionally, the binding efficiency of streptavidin to the functionalised $Ag@Fe_3O_4$ particles was found to be 49%, as determined by a Bradford assay.

In the final sandwich hybridization assay, the sensor successfully differentiated between mutated and wild-type DNA. The presence of the mutated target induced a visible colorimetric change and a clear UV-Vis spectral redshift. SEM imaging provided visual confirmation, showing AuNPs bound to the surface of the magnetic nanoparticles only in the presence of the mutated target. Testing with longer DNA sequences confirmed the system's robustness, though signal intensity decreased due to increased steric hindrance.

This work demonstrates the successful development of a functional magnetoplasmonic nanosensor for mutation detection. The optimized system shows promise for medical diagnostics and clinical screenings of genetic conditions.

Keywords: Genetic mutation detection, Magnetoplasmonic nanoparticles, Aptamer-functionalized nanoparticles, Sandwich hybridization assay, Biosensors

P–22

Tiny Tools, Big Impact: Nanoparticle-Aptamer Sensors for Water Pathogen Detection

L. Friedemann[1*], K. Kosciow[2], and M. B. Williams[1]

[1]*Institute for Safety and Security Research, Hochschule Bonn-Rhein-Sieg, Rheinbach, Germany*
[2]*Institute for the Protection of Terrestrial Infrastructures, German Aerospace Center, Rheinbach, Germany*
[*]*Luise.Friedemann@h-brs.de*

Monitoring drinking water contaminants is becoming increasingly important due to climate change and rising demands on water infrastructure.[1] The aim of the project is to develops a rapid, visual detection system for water-borne pathogens using an aptamer-based approach. These short DNA oligomers are selected to bind to specific targets by systematic evolution of ligands by exponential enrichment (SELEX). [2] Their binding selectivity and affinity can be enhanced by chemical modification with functional groups, yielding Clickmers®. These oligomers can be attached to surfaces, lateral flow assay patches, or nanomaterials without losing their functionality. While they are already faster to identify and cheaper to produce than the traditionally used antibodies,[3] this study also focuses on optimizing the yield of bound oligomers.

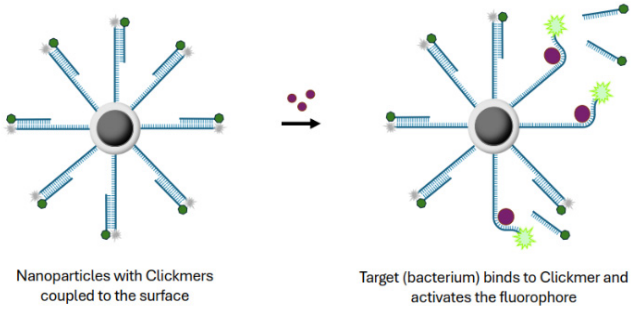


Fig 1. Schematic representation of a functionalized nanoparticle and its coupling with a Clickmer®/Aptamer for bacteria recognition via affinity-induced complementary strand suppression

The system uses a fluorescence-based detection mechanism with a theoretical detection limit as low as 2 nM in a standard fluorescence spectrometer. The fluorophore 6-carboxyfluorescein is attached to the binding end of the aptamer (see Fig.1), while a black hole quencher linked to a complementary strand suppresses fluorescence in the absence of a target. Upon target binding, the quencher strand is displaced, activating the fluorescence signal.

To enhance usability and sensitivity, the system utilizes the magnetic properties of the nanoparticle. After binding to the pathogen, a magnet can be used to concentrate the sensor particles in the detection area of the sensor and enables easy separation from the sample matrix. This step not only facilitates sample processing and enrichment but also improves the detection limit by amplifying the sensor signal.

We present results regarding the yield optimization, comparing the yield of different conjugation strategies reported in the literature (thiol-ene Michael addition, disulfide bridge formation and streptavidin–biotin binding) via different quantification strategies such as digestion of surface-bound aptamers followed by HPLC analysis, direct qPCR and fluorescence measurements of fluorophore-labeled aptamers. Furthermore, the fluorescence switching mechanism of the sensor was successfully demonstrated using lysozyme as a placeholder target.

This method shows promise for field-deployable, low-cost pathogen monitoring and could be adapted for a wide range of microbial contaminants. By addressing these aspects, the project aims to contribute a scalable, environmentally friendly tool for real-time water quality surveillance—ultimately supporting global efforts to ensure safe drinking water access in a changing climate.

References

[1] J. Walker, Perspect Public Health 138, 282 (2018)
[2] C. K. L. Gordon, ACS Chem. Biol. 14, 2652-2662 (2019)
[3] F. Pfeiffer and G. Mayer, Front. Chem. 4:25 (2016)

Keywords: Waterborne pathogen detection, Clickmers, Aptamer-functionalized nanoparticles, Aptamer immobilization, Biosensors

P-23

Electromechanical Behavior of Auxetic Electrode-Based FPCB for Stretchable Devices under Repeated Stretching

Sangwoong Baek, Hyojin Bang, Chan-Jae Lee*

Display research center, Korea Electronics Technology Institute, Seeongnam, Korea
**chanjael@keti.re.kr*

Flexible and stretchable electronic devices require mechanically robust interconnect structures capable of maintaining stable electrical performance under repeated tensile deformation. However, conventional electrode geometries often suffer from localized strain concentration and irreversible dimensional distortion during stretching, resulting in electrical instability and mechanical failure. In this study, flexible printed circuit board (FPCB) structures with conventional hexagonal (positive Poisson's ratio, PPR) and auxetic double-arrowhead (negative Poisson's ratio, NPR) geometries were designed and systematically evaluated to investigate their mechanical deformation behavior and electromechanical reliability under uniaxial tensile loading. The electrode patterns, composed of a Cu/adhesive/PI stacked layer, were fabricated on a 50 μm-thick polyimide (PI) substrate laminated with 0.5 oz and 1 oz copper foils, and their geometric parameters were systematically varied. Uniaxial tensile strain up to 10% was applied along the y-axis, and the resulting dimensional changes, including width, height, rib length, and internal angle were experimentally tracked using in-situ optical microscopy to quantitatively evaluate the effective Poisson's ratio. The experimental results revealed distinct deformation characteristics depending on the structural topology and copper thickness. The hexagonal structures exhibited stable lateral contraction, whereas the double-arrowhead structures showed suppressed transverse deformation, demonstrating geometry-sensitive auxetic responses. Crucially, the 0.5 oz copper samples demonstrated superior structural compliance and cyclic durability up to 10% strain, whereas the 1 oz samples under 10% strain suffered from intermittent open-circuit failures and signal overflow due to excessively high bending stiffness. Electrical characterization during 100-cycle fatigue testing further highlighted the electromechanical differences between the geometries. The auxetic double-arrowhead structures exhibited a significantly lower initial electrical resistance (~0.213 Ω) compared to the hexagonal structures (~0.575 Ω) due to their optimized conductive pathways. Under cyclic deformation, both 0.5 oz structures maintained stable operations at 5% strain. Interestingly, a mechanical annealing effect was observed, where the baseline resistance decreased by approximately 5.2% for the hexagonal and 2.8% for the auxetic structures after 100 cycles, signifying micro-stress relaxation within the thin copper layer. To further investigate the underlying mechanisms, finite element analysis (FEA) was conducted using Abaqus with geometries identical to the fabricated samples. The simulated stress distributions and deformation patterns showed good agreement with the experimentally observed dimensional changes and failure modes, validating the structural design boundaries. This study provides practical design guidelines for optimizing stretchable electrode architectures, demonstrating that controlling copper thickness (0.5 oz) and structural topology is paramount for securing electromechanical reliability in next-generation deformable electronic systems.

P-24

Optically Programmed Interlocked Elastomer Dielectrics for Four-Regime Broad-Range Capacitive Pressure Sensing and Wearable Voice Interfaces

Min Soo Baek[1], Roun Lee[2], Yeonwook Jeong[2], Su Bin Choi[3,4], Han-Ki Kim[1], Chan-Jae Lee[5], Youngmin Kim[5], and Jong-Woong Kim[2*]

[1]*Department of Display Engineering, Sungkyunkwan University, Suwon 16419, Korea*
[2]*Department of Semiconductor Convergence Engineering, Sungkyunkwan University, Suwon 16419, Korea*
[3]*Department of Electrical and Computer Engineering, University of Virginia, Charlottesville, VA 22904, USA*
[4]*Department of Electrical and Electronic Engineering, Yonsei University, Seoul 03722, Korea*
[5]*Display Research Center, Korea Electronics Technology Institute, Seongnam 13509, Korea*
[*]*wyjd@skku.edu*

Pressure sensors for wearable and interactive electronics must operate across a highly demanding mechanical window, where extremely weak stimuli such as subtle touch, airflow, and laryngeal vibration need to be detected without sacrificing reliable performance under much larger compressive loads. However, this combination remains difficult to realize in conventional capacitive systems because soft dielectric structures that amplify low-pressure signals often undergo early saturation, structural collapse, or limited dynamic range. Here, we present a broad-range capacitive pressure sensor enabled by a photopatternable urethane–acrylate dual-network elastomer (UA-DNE) and an optical interfacial patterning strategy that programs hierarchical dielectric architectures through reflection-assisted curing at a liquid-metal-particle interface.

The UA-DNE was designed not only as a deformable dielectric medium, but also as an optically processable and mechanically resilient material platform. By coupling its near-UV photocurability with reflected and scattered light from the underlying liquid-metal-particle layer, we achieved deterministic formation of interlocked hierarchical structures composed of dome-shaped upper microfeatures, spiral-patterned lower features, and a process-defined peripheral spacer region. This architecture is significant because it spatially separates highly compliant deformation sites from mechanically stable load-bearing domains, thereby allowing the sensor response to evolve progressively with increasing pressure rather than collapsing into a single deformation mode.

Multiphysics analysis and experimental measurements consistently showed that this interlocked dielectric architecture produces a four-regime electromechanical response governed by sequential redistribution of deformation and load transfer. In the lowest-pressure region, deformation is concentrated in compliant air-gap domains and generates large capacitance changes. As the applied pressure increases, the deformation extends to wider interfacial regions and gradually engages the tougher UA-DNE framework, which delays saturation and preserves sensing functionality under much larger loads. As a result, the device continuously operates from 0.0097 to 200 kPa and exhibits sensitivities of 17.7714, 5.7320, 0.5321, and 0.1527 kPa^{-1} across four distinct pressure regimes. The sensor further delivers fast response and recovery times of 22 and 23 ms, respectively, together with stable operation over 5000 loading–unloading cycles.

In practical low-pressure tests, the device experimentally resolved pressures as low as 9.7 Pa, while signal-to-noise-ratio analysis indicated a theoretical limit of detection of 0.0515 Pa. Beyond pressure transduction itself, the mechanically stable and information-rich outputs of the sensor enabled multiple wearable functions, including motion monitoring, grip-force discrimination, finger-bending recognition, and laryngeal signal acquisition. Notably, when combined with a one-dimensional convolutional neural network, laryngeal pressure waveforms recorded from the device enabled voice-command classification with an accuracy of 97.6%. These results demonstrate that optically programmed hierarchical dielectrics can provide a scalable route toward capacitive pressure sensors that simultaneously achieve ultralow-pressure sensitivity, broad operating range, rapid dynamic response, and intelligent wearable interface capability within a single material–device platform.

Keywords: Photopatternable dual-network elastomer, Hierarchical interlocked dielectric, Broad-range capacitive pressure sensor, Four-regime pressure transduction, Wearable voice interface

P-25

Wet-Chemical Morphology Engineering of Nickel Nanoparticles through Polymer-Mediated Stabilization and Reduction Control

C. G. Kim[1,2], Y. G. Lee[1,3], J. J Sim[1*]

[1]*Korea Institute of Industrial Technology (Korea National Institute of Rare Metals, Incheon, Republic of Korea)*
[2] *Inha University (Department of Materials Science and Engineering, Incheon, Republic of Korea)*
[3]*Korea University (Department of Materials Science and Engineering, Seoul, Republic of Korea)*
[*]*simjae@kitech.re.kr*

Nickel nanoparticles are widely used as functional metallic powders in electronic, electrochemical, and catalytic fields due to their electrical conductivity, chemical durability, and morphology-sensitive properties. For multilayer ceramic capacitor (MLCC) electrodes, spherical particles with narrow size distribution are required to ensure packing uniformity and reliable electrode formation. In contrast, particles with rough or anisotropic surfaces can provide more active sites, making them suitable for catalytic and energy-related applications. Despite their ability to produce high-purity powders, conventional gas-phase routes often involve high processing costs and insufficient flexibility for morphology design.

In this study, nickel nanoparticles were prepared by a solution-based reduction process, with particular emphasis on controlling particle shape through dispersant chemistry and reduction kinetics. Nickel chloride was selected as the metal precursor, and hydrazine was used as the reducing agent. By varying the hydrazine concentration, the balance between nucleation and subsequent particle growth was adjusted. In parallel, polyvinyl alcohol (PVA) and polyvinylpyrrolidone (PVP) with different molecular weights were introduced to examine how polymer structure, functional groups, and chain length affect particle dispersion, surface stabilization, and morphological development during wet synthesis.

The resulting nickel powders exhibited distinct morphology depending on the type of polymeric dispersant and reduction condition. PVA-assisted synthesis produced well-dispersed, nearly spherical nickel nanoparticles with an average particle size of about 100 nm, and the optimized condition achieved a particle size of approximately 97 nm, satisfying the target criterion for sub-100 nm nickel nanopowders. In contrast, the use of PVP resulted in broader particle-size distribution and promoted anisotropic surface growth, leading to spiky or irregular surface features. These morphological differences became more pronounced with changes in PVP molecular weight and hydrazine concentration. Characterization by SEM, DLS, XRD, ICP-OES, and carbon/sulfur analysis confirmed that the synthesized powders possessed controlled particle size characteristics, crystalline nickel phase, and high compositional purity, with a nickel purity of 99.56%. Overall, the results suggest that polymer-mediated stabilization and reduction-rate control are key factors governing nickel nanoparticle morphology, providing a practical strategy for designing nickel nanopowders tailored to MLCC, catalytic, and electrochemical applications.

Keywords: Nickel nanoparticles, Wet chemical reduction, Polymer dispersants, Morphology control

P-26

Nickel Carbonylation as a Selective Route for Sustainable Nickel Recovery

Sanghyun Jeon, Youngjae Kim*

Material Science and Engineering, Inha University, Incheon, Korea
**youngjae@inha.ac.kr*

Nickel is classified as a critical raw material owing to its essential role in stainless steel, batteries, and high-performance alloys, yet its supply remains vulnerable and its conventional refining is energy-intensive and generates considerable chemical waste. Developing selective, low-waste routes for nickel recovery is therefore essential for establishing a more sustainable metal supply chain. The carbonyl process offers a distinctive approach: metallic nickel reacts with carbon monoxide under a controlled atmosphere to form volatile nickel tetracarbonyl, $Ni(CO)_4$, which can be separated in the gas phase and subsequently decomposed to high-purity nickel. This selectivity arises because only a limited number of metals can form volatile carbonyl species under practical reaction conditions.

In this study, the carbonylation behavior of metallic nickel samples was investigated as a selective route for sustainable nickel recovery. Nickel pellets were used to evaluate the effects of temperature, CO pressure, and surface pretreatment, while nickel powders were used to examine time-dependent conversion behavior and the influence of particle size. With increasing temperature, nickel carbonylation became kinetically more favorable, while the thermodynamic driving force for $Ni(CO)_4$ formation decreased; consequently, the conversion reached a maximum near 443 K. Elevated CO pressure enhanced carbonylation. SEM images obtained after carbonylation and EBSD analyses suggested that the dominant factors varied with feed form and particle size: dislocations were more influential in pellets, both surface area and dislocation contributed in 250 μm powders, and the increased surface-area-to-volume ratio became dominant in 45 μm powders. These results demonstrate that the extent of nickel carbonylation can be regulated by adjusting temperature, CO pressure, and feed characteristics, establishing carbonylation as a selective and reagent-lean route for sustainable nickel recovery. In addition, CO gas can be regenerated during the decomposition of $Ni(CO)_4$ and recycled within the process, further reducing reagent consumption and waste generation.

Keywords: Nickel Carbonylation, Mond process, Selective recovery, Sustainable nickel recovery

P-27

Effects of Pressure and Temperature on the Kinetics and Mechanisms of Ni Carbonylation

Seoung Uk Bae[1,2], Kyoung-Tae Park[1], Seok-Jun Seo[1], Jae Hong Shin[1*]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon 21655, Republic of Korea*
[2]*Department of Materials Science and Chemical Engineering, Hanyang University, Ansan 15588, Republic of Korea*
[*]*shinclusion@kitech.re.kr*

Nickel carbonylation is the only pyrometallurgy refining process capable of producing high-purity nickel powder without hydrometallurgy. However, its kinetics under high-pressure conditions and the role of particle microstructural evolution remain insufficiently understood. In this study, a closed reaction system was employed to investigate the effects of temperature and pressure on nickel carbonylation kinetics during the carbonylation process. High-purity nickel powder was carbonylated at 150-250 ℃ and 20-70 atm, and reaction behavior was evaluated using mass loss, particle size distribution, and microstructural analysis. Carbonylation preferentially initiated at finer particles owing to their higher chemical potential. As the reaction progressed, exothermic heat release induced localized temperature rise, promoting partial thermal decomposition and re-deposition of $Ni(CO)_4$. With further reaction, the process accompanied by particle collapse and shrinking, which increased effective reaction surface area and accelerated the reaction rate. An empirical nickel consumption rate incorporating mass loss and particle size evolution demonstrated that carbonylation proceeds as a dynamic process with an increasing reaction rate as the reaction progresses. Kinetic analysis based on the kinetic–diffusion model demonstrated that the reaction is governed by both temperature and pressure. Increasing both parameters enhanced the apparent rate constant and reaction order. A carbonylation conversion of 94% was achieved during 1 h at 250 ℃ and 70 atm.

P-28

Enhancing Energy Management in Electron Beam Smelting of Molybdenum: A Finite Element Analysis Approach

Addisu Boshe Botto[1,2], Ui-jun Ko[1,3], Seok-jun Seo[1], Kyoung-tae Park[1], Jae-jin Sim[1*]

[1]*Korea Institute for Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Convergence Manufacturing System Engineering, University of Science and Technology, Daejeon, Republic of Korea*
[3]*Department of Materials science and engineering, Korea University, Soul, Republic of Korea*
[*]*simjae@kitech.re.kr*

High-grade molybdenum is valued for its extreme melting point ~2,896K, elastic shear modulus of 126GPa, resistance to corrosion and low thermal expansion (~$5.4\times10^{-6}K^{-1}$ @20~1000°C). Hence, it is used in semiconductor manufacturing, precision heating, x-ray tube targets, and aerospace components such as nozzles, thrust chambers, exhaust vanes, and satellite structures. Pyrometallurgical processing of molybdenum ingots removes impurities through preferential evaporation, achieving >99% purity. Plasma Arc Melting offers a cost-effective way for recycling scrap but has limited impurity separation due to the inert gas atmosphere. Conversely, Vacuum Arc Melting improves purity but requires complex preparation of raw materials through compaction, sintering, and welding. With power consumption comparable to PAM and VAM, Electron Beam Melting offers enhanced purification in high vacuum and direct feeding of raw materials. However, EBM is constrained by the need to use low intensity beam and melt-pool instability. Low beam power reduces loss of metal by co-evaporation/ splattering, but it suffers from premature freezing of the melt due to energy loss through the cold crucible system.

This study explores a simulation-guided approach to enhance thermal efficiency and purification performance during the electron beam smelting of molybdenum. Multiphysics simulation was computed using COMSOL to analyze electron beam particle distribution, heat flux, temperature profiles, and melt-pool evolution, aiming to optimize heat management during the refining process. Two key mechanisms of energy loss were examined: electron deflection and conduction loss through the cold crucible system. The simulation revealed that electron deflection predominantly occurs at the primary focusing lens and increases with decreasing beam diameter setting an upper limit on electron beam power intensity. Conduction loss, influenced by temperature gradients, sets the lower threshold for beam power. Two techniques employed to minimize conductive loss were: reducing the effective contact area and reciprocating the bottom crucible in and out of the water-chilled mold, intermittently isolating the hot region. Energy distribution was managed by adopting beam pattern comparison results from previous research checking by simulation.

Conduction loss accounted for ~68% of the total energy flowing through the specimen. As a result, a continuous gap was required between the seed and the mold to achieve any melting. This reduced the loss to 1/4th and sustained a stable melt-pool. Further 10-fold reduction and subsequently, wider melt-pool was achieved by minimizing the contact area to ~1.1% of the seed cross-section. Melt-depth, refining-time, and purification-rate were recorded as control parameters to validate the simulation. Experimentally, melting began after approximately 6 minutes, and the melt-pool expanded with increasing beam current 400-600mA at 35kV. Observation of the cross section of the melt after it solidifies revealed 0.5-1cm depth. A 99.9% pure molybdenum was obtained after the principal impurities were removed to undetectable levels. Simulation of the composition showed that 3N grade molybdenum could be achieved after 17 minutes refining. Further analysis considering multi-beam operation show that remelting at 50% more power could upgrade it to 4N in 10 minutes. With <0.011% Fe detected, the findings also highlight the importance of further exploration into the peculiar disparities observed.

Keywords: Electron-beam furnace, Energy efficiency, Finite element analysis, Refractory metals, Vacuum smelting

P-29

Conversion of Fe-Al Sludge from Secondary Battery Recycling into Calcium Aluminate via Phase Transformation

Hana Lim, Seungyun Han, Yong Hwan Kim*

Korea Institute of Industrial Technology (KITECH), Incheon, 21999, Republic of Korea
yhkim@kitech.re.kr

With the exponential growth of secondary battery utilization, the volume of spent batteries is rapidly increasing, leading to the expansion of battery recycling processes. Various metal-bearing byproducts are generated during these processes; in particular, Fe-Al sludge is mostly discarded as simple waste despite containing significant amounts of iron and aluminum. Because Fe-Al sludge exists in a hydroxide form, it possesses low structural stability, limiting its direct application as a material. Therefore, converting this sludge into a functional material through phase transformation, aimed at structural stabilization and reactivity control, is highly required.

In this study, Fe-Al sludge was dried, pulverized, and subjected to heat treatment to transition the hydroxide phase into an oxide phase, followed by a reaction with calcium to induce calcium aluminate formation. The phase transformation behavior with respect to heat treatment temperature was investigated via XRD and thermal analysis. The results confirmed a trend where the hydroxide decomposed and the oxide phase formed as the temperature increased. Additionally, the formation of the calcium aluminate phase along with the separation of impurity phases was identified under specific temperature conditions.

These phase transformation characteristics play a critical role in establishing optimal conditions for calcium aluminate synthesis and can be utilized as foundational data for designing continuous calcination processes. This approach is expected to contribute to building a resource circulation system within the battery industry by upcycling waste sludge from recycling processes into high-performance raw materials for cement quick-setting agents.

Keywords: Secondary battery recycling, Fe-Al sludge, Calcium aluminate, Cement quick-setting agent

P-30

The Recovery of Molybdenum from Inorganic Acids Generated as Industrial Waste using Tributyl Phosphate

Hee-Nam Kang[1], Benyamin Shakib[1,2], Rajesh Kumar Jyothi[3], Tae-Hyuk Lee[1], Jin-Young Lee[1,2*]

[1]*Resources Utilization Research Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), 124 Gwahak-ro, Yuseong-gu, Daejeon, 34132, Republic of Korea*
[2]*Department of Resources Engineering, Korea University of Science and Technology (UST), 217 Gajeong-ro, Yuseong-gu, Daejeon, 34113, Republic of Korea*
[3]*CSIRO Mineral Resources (CMR), Australian Mineral Research Center (AMRC), 7 Conlon St. Waterford WA 6102, Perth, Australia*

This study explores the recovery and optimization of molybdenum (Mo) from inorganic acids derived from semiconductor industry waste streams with tributyl phosphate (TBP) by implementing machine learning (ML) models. A series of tests were conducted to assess the impact of various operational variables on the effectiveness of Mo extraction and stripping. The SVR-SFLA model yielded the most meticulous predictions, identifying optimal extraction conditions with a TBP concentration, mixing time, temperature, and O/A ratio of 50%, 30 min, 25°C, and 1, respectively, achieving 77.8% efficiency. When viewed in conjunction with the McCabe-Theil diagram, the derived results indicated the necessity of a four-stage counter-current extraction process required to achieve a yield exceeding 99%. In the stripping process, the hybrid model indicated optimal conditions with 3 M NH_4OH and an A/O ratio of 0.5 at 50°C during 20 min, requiring two counter-current stages for nearly complete stripping.

Keywords: molybdenum, inorganic acid, liquid–liquid extraction, tributyl phosphate, machine learning

P-31

Sustainable Vanadium Pentoxide Production from Spent Sulfuric Acid Catalysts via an Integrated Hydrometallurgical Approach

Nityanand Singh[1,2], Tae-Hyuk Lee[1], Hee-Nam Kang[1], Jin-Young Lee[1,2*]

[1]*Convergence Research Center for Development of Mineral Resources (DMR), Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon 34132, Korea*
[2]*Department of Resource Engineering, Korea University of Science and Technology (UST), Daejeon 34113, Korea*

Industrial waste generated from sulfuric acid production, particularly spent catalysts, represents both a significant environmental liability and an untapped secondary source for critical metals. To address these ecological concerns and promote circular economy principles, this research proposes a highly optimized hydrometallurgical circuit, integrating acid leaching and solvent extraction, to effectively reclaim vanadium (V(V)) from these discarded materials. Prior to chemical treatment, the catalytic waste underwent mechanical homogenization via a rod mill for 20 minutes. Subsequent ambient-temperature leaching using a 5% v/v sulfuric acid (H_2SO_4) solution at a pulp density of 200 g/L achieved a remarkable 96.0% dissolution rate of V(V) in just 10 minutes. The resulting pregnant leach solution was then subjected to liquid-liquid separation. Utilizing an organic phase composed of 50% v/v Aliquat 336 and 3% v/v iso-decanal in a D-80 diluent, 99.9% of the vanadium was successfully extracted. Optimal extraction parameters were identified as an aqueous pH of 2.0, an organic-to-aqueous (O/A) phase ratio of 1:1, and a contact time of 10 minutes. The loaded organic phase was efficiently stripped using sodium hydroxide (NaOH), generating a highly concentrated and pure V(V) stream. Precipitation was carried out by introducing NH_4Cl at a carefully controlled pH of 7.5 to yield ammonium metavanadate (NH_4VO_3). A final calcination step at 400 °C for 2 hours successfully converted the precursor salt into high-purity vanadium pentoxide (V_2O_5). The findings validate this sequential leaching, extraction, and thermal conversion process as a viable and sustainable framework for upcycling hazardous industrial residues.

Keywords: Sulfuric acid catalysts, Vanadium pentoxide, Hydrometallurgy, Liquid-liquid extraction, Resource recycling

P-32

The Effect of Electromagnetic Stirring on the Mechanical Properties of Ti-6Al-4V Alloys

Tae-Hyuk Lee*

Resources Utilization Division, Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea
**t.lee@kigam.re.kr*

In this study, the effect of electromagnetic stirring (EMS) on the microstructure and mechanical properties of the titanium (Ti) − 6 aluminum (Al) − 4 vanadium (V) alloy fabricated by a vacuum arc remelting (VAR) process was investigated. The analytical results of macro and microstructure showed that the EMS was effective to refine the grains of Ti − 6 Al − 4 V alloy. However, the EMS did not affect the formation of the chill layer of alloy because the solidification rate was too fast for the Lorentz force to affect solidification. The yield strength and the ultimate tensile strength of Ti − 6 Al − 4 V alloy were increased from 700.4 MPa and 726.8 MPa to 748.5 MPa and 768.2 MPa, respectively. On the other hand, the elongation was decreased from 11.3 % to 6.4 %. These results are the effect of grain refinement of Ti − 6 Al − 4 V alloy by EMS process.

Keywords: Ti-6Al-4V alloy, vacuum arc remelting (VAR), electromagnetic stirring (EMS), microstructure, tensile strengh

P-33

Effect of Al Doping on the Sintering and Ionic Conductivity of $Li_7La_3Zr_2O_{12}$ via Sol-Gel Process

Sung Gue Heo[1*], Seok-Jun Seo[2], Sang-Hoon Choi[1], Yun Ji So[1], HoByung Kim[1]

[1]*Non-Ferrous Metal/Alloy Research Center, Institute for Advanced Engineering, Yongin, Korea*
[2]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Korea*
[*]*sgheo@iae.re.kr*

In this study, $Li_7La_3Zr_2O_{12}$ electrolytes doped with different amounts of Al were prepared by a polymerized complex Sol-gel process. The influence of aluminum on the structure and conductivity of $Li_7La_3Zr_2O_{12}$ were investigated by X-ray diffraction (XRD), impedance spectroscopy, scanning electron microscopy (SEM), and thermal analysis (TG/DTA). It was found that even a small amount of Al added to $Li_7La_3Zr_2O_{12}$ can greatly accelerate densification during the sintering process, and SEM results showed that this was due to the existence of a liquid phase introduced by Al additions which led to the enhanced sintering rate. Moreover, the addition of Al stabilized the higher conductivity cubic form of $Li_7La_3Zr_2O_{12}$ rather than the less conductive tetragonal form. The combination of these two beneficial effects of Al enabled a great reduction in calcination time for the preparation of highly conductive $Li_7La_3Zr_2O_{12}$ electrolyte. Furthermore, the conductivity of $Li_7La_3Zr_2O_{12}$ electrolytes prepared by microwave and conventional sintering processes were compared in order to investigate the effect of different sintering methods on the electrochemical properties of the electrolyte.

Keywords: $Li_7La_3Zr_2O_{12}$, Solid electrolyte, Sol-gel process, Ion conductivity

P-34

Mechanical Response of Pure Ta under Elevated-Temperature Hydrogen Environments

Hyojoo Lee, and Hoon-Hwe Cho*

Depetment of Materials Science and Engineering, Hanbat National University, 125 Dongseodaero, Yuseong-gu, Daejeon 34158, Republic of Korea
hhcho@hanbat.ac.kr

To investigate the effects of hydrogen at elevated temperatures on pure tantalum (Ta), specimens are exposed to hydrogen at 10 torr over a temperature range of 400–1000 °C, and the mechanical response to hydrogen exposure is investigated. The Vickers hardness value of the hydrogen-exposed specimens reaches a maximum at 600 °C, and thermal desorption spectroscopy (TDS) analysis confirms a correlation between temperature and hydrogen uptake. X-ray diffraction (XRD) analysis reveals lattice expansion associated with hydrogen incorporation, while scanning Kelvin probe microscopy (SKPM) analysis reveals a decrease in surface work function associated with hydrogen dissolution. These results suggest that the observed hardening is primarily governed by interstitial hydrogen. Tensile testing further demonstrates that specimens exposed to hydrogen at 600 °C exhibit increased ultimate tensile strength but reduced ductility, accompanied by brittle fracture behavior, indicating the occurrence of hydrogen embrittlement.

Keywords: Tantalum (Ta), mechanical response, interstitial hydrogen, hydrogen embrittlement

P-35

Development of Mg-CaO Composite Coating Technology Using Magnesium Process By-products for Hot Metal Desulfurization

Jaeyun Jeong, Yubin Kang and Hongjun Chae*

Materials Science and Chemical Engineering Center, Institute for Advanced Engineering, Yongin, South Korea
**hjchae@iae.re.kr*

The steelmaking industry is actively seeking environmentally sustainable refining technologies to reduce carbon emissions and recycle industrial by-products. In this study, magnesium (Mg) process by-products were utilized to develop Mg-CaO composite desulfurization materials with enhanced thermal stability and sulfur removal efficiency for hot metal treatment. The research focused on the surface coating behavior of CaO on Mg-based by-product powders through a dry mechanical milling process.

Four different types of Mg process by-products, including discolored powder, coarse powder, fine powder, and slag powder, were characterized using XRF, ICP, SEM-EDS, and XRD analyses. The results confirmed that most by-products contained high Mg purity above 98 wt.%, while oxidation-induced discoloration was observed during storage. Mechanical coating experiments were performed using a planetary mill under various Mg:CaO mixing ratios (9:1, 7:3, 5:5, and 3:7) and milling times (10 min to 6 h).

SEM-EDS analysis demonstrated that uniform CaO coating layers were successfully formed on Mg particle surfaces under most conditions. Increasing CaO content generally increased coating thickness; however, excessive CaO ratios caused local agglomeration, surface non-uniformity, and coating delamination. Among the investigated conditions, the Mg:CaO ratio of 9:1 exhibited the most stable and homogeneous coating morphology. Milling time also significantly affected coating characteristics. Milling for approximately 1 h produced relatively uniform coating layers with thicknesses ranging from 10 to 25 μm, while prolonged milling induced excessive energy transfer, resulting in jar damage and powder adhesion issues.

The results indicate that Mg process by-products can be effectively recycled as Mg-based desulfurization materials through optimized Mg-CaO composite coating technology. The developed composite powders are expected to improve desulfurization efficiency and thermal stability in steel refining processes while contributing to carbon reduction and industrial waste valorization.

Keywords: Mechanical milling, Desulfurization, Steel refining, Recycling, Mg-CaO composite

P-36

Microstructure, Tensile Properties, and Fatigue Behavior of Bulk Hastelloy C276 Fabricated by Wire Arc Additive Manufacturing

Ui-Jong Lee[1], So-Yeon Park[1], Hyungwoo Park[2], Kee-Ahn Lee[1*]

[1]*Department of Materials Science and Engineering, Inha University, Incheon 22212, Republic of Korea*
[2]*B.A.T Partners Inc, Daejeon 34129, Republic of Korea*
[*]*keeahn@inha.ac.kr*

Hastelloy C276 is a Ni-based heat- and corrosion-resistant alloy that combines excellent high-temperature strength with outstanding corrosion resistance, making it widely used for structural components operating in extreme environments. Wire arc additive manufacturing (WAAM) is a metal additive manufacturing process in which wire feedstock is melted and deposited using an arc heat source. Owing to its high deposition rate, WAAM is considered a promising technology for the fabrication of large-scale metallic components. However, although the thermal history can vary with increasing component size, thereby affecting the microstructure and mechanical properties, most studies on WAAM Hastelloy C276 have focused on thin-wall structures with thicknesses below 10 mm. Consequently, investigations under conditions closer to practical bulk components remain limited.

In this study, bulk Hastelloy C276 specimens were fabricated using WAAM, and their microstructure, tensile properties, and fatigue behavior were investigated. The fabricated specimens exhibited a well-developed dendritic structure grown along the building direction (BD), with some micro-scale precipitates observed in interdendritic regions. Direction-dependent tensile testing showed average yield strengths of 356.6 MPa and 374.6 MPa along the building direction (BD) and transverse direction (TD), respectively, while the corresponding average ultimate tensile strengths were 649.2 MPa and 699.4 MPa. The elongations were measured to be 63% in the BD and 65% in the TD. These results confirm that the WAAM-fabricated material exhibits a strength–ductility combination comparable to the property range of Hastelloy C276 produced by conventional manufacturing processes. Fractographic analysis revealed predominantly ductile fracture characteristics regardless of loading direction, with deformation accommodated by slip within the dendritic regions.

In addition, high-cycle fatigue tests were conducted for both directions at R = 0.1 and 10 Hz. A fatigue limit was identified in both directions: the BD specimens exhibited a fatigue limit exceeding the yield strength, while the TD specimens showed a fatigue limit below the yield strength, yet still reaching approximately 93% of its yield strength, indicating high fatigue resistance. Contrary to the tensile properties, the BD specimens exhibited superior fatigue performance, which is considered to be associated with differences in the crack propagation stage. Fatigue fracture surfaces showed ridges and facets with various orientations near the crack initiation region. Voids attributed to the detachment of dendrites or interdendritic precipitates were also observed, together with slip bands between striations.

Based on these results, this study elucidates the tensile and fatigue deformation mechanisms of WAAM-fabricated Hastelloy C276 alloy and discusses its potential applicability to structural components used in extreme environments.

Keywords: Wire arc additive manufacturing, Hastelloy C276, Microstructure, Tensile, High cycle fatigue

P-37

Process Evaluation of 7075 Aluminium Alloy Manufactured by Laser Powder Bed Fusion

Yujin Rhee*, Sehun Kim, Tae hu Kang, Jongik Lee, Sanghee Jeong and Bin Lee*

Department of Advanced Materials Engineering, Kyung Hee University, Youngin, Republic of Korea
**yujrhee@khu.ac.kr, leebin@khu.ac.kr*

Laser powder bed fusion (LPBF) has been widely used to produce aluminium components with complex geometries; however, 7075 aluminium alloy remains difficult to process because of its high cracking susceptibility and narrow processing window. In addition, aluminium alloys have high laser reflectivity, which can limit energy absorption during LPBF and affect the densification of the built material. Therefore, the processing conditions need to be carefully examined to reduce defects and improve the quality of LPBF-built 7075 aluminium alloy. In this study, 7075 aluminium alloy specimens were manufactured by LPBF under a wide range of laser power conditions from 100 to 450 W to understand its influence on the build quality. After the LPBF build process, the samples were prepared for density measurement, hardness testing, and microstructural observation. The density was measured to check the degree of densification and to identify possible defects such as pores and lack-of-fusion regions. Vickers hardness testing was carried out on the as-built samples to evaluate their basic mechanical response and scanning electron microscopy (SEM) was used to examine the melt-pool morphology, defect distribution, and microstructural features formed during the LPBF process. To compasate for the high reflectivity of aluminium, a double-scan strategy was applied instead of a single-scan process to improve the density of the LPBF-built samples. The double-scan condition showed a tendency to increase the density of the built samples. However, when the second scan was applied with the same energy input as the first scan, excessive energy input and remelting appeared to affect the build quality. Therefore, the energy input of the second scan was reduced to control the additional laser irradiation and to examine its effect on densification and defect formation. Based on these measurements and observations, the effects of laser power and the controlled double-scan strategy on LPBF-built 7075 aluminium alloy were evaluated in terms of densification, hardness, and microstructural characteristics. The results will serve as a reference for subsequent optimization of LPBF process parameters and post-processing studies for high-strength 7075 aluminium alloy.

Keywords: 7075 aluminium alloy, Laser powder bed fusion, Additive manufacturing, Cracking susceptibility, Double scan

P-38

Irradiation-induced hardening and defect characterization in additive manufactured Inconel 718 alloy

Joowon Suh[1], Wonjong Jeong[2], Sun-Young Park[1], Hyung-Ha Jin[1], Hyun Woo Seo[1], Seunghyun Lee[3], Dong Won Lee[3], and Suk Hoon Kang[1*]

[1]*Materials Safety Technology Development Division, Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea*
[2]*Department of Industrial Laser Technology, Korea Institute of Machinery & Materials, Busan, 46744, Republic of Korea*
[3]*Nuclear Physics Application Research Division, Korea Atomic Energy Research Institute, Daejeon, 34057, Republic of Korea*
[*] *shkang77@kaeri.re.kr*

An irradiation hardening of Inconel 718 produced by the additive manufacturing was studied based on the microstructural observation and nano-indentation. In this study, ion irradiation was employed to emulate neutron irradiation damage because of its advantages, including low radioactivity, short experimental time, and reduced cost. Additive manufactured Inconel 718 alloy was irradiated with Fe^{+} ions with 5 dpa, and 20 dpa at 300 °C. The hardness of the irradiated samples was measured by nanoindentation as a function of depth. The depth distributions of implanted Fe ions and dpa were calculated using the Monte Carlo SRIM (Stopping and Range of Ions in Matter) 2013 code. The correlation between hardness and irradiation damage along the depth was analyzed. Transmission electron microscopy was used to characterize irradiation-induced defects and to identify the boundary between irradiated and unirradiated regions, confirming the SRIM-predicted damage profile.

Keywords: Additive manufacturing, Inconel 718 alloy, Ion-irradiation, Nano-Indentation, Transmission Electron Microscopy (TEM)

P-39

Oxidation and Ignition Resistance of DED-Fabricated Inconel 718 with Haynes 214 Surface Layers Prepared by DED and Plasma Spray Coating

Minho Shin, Daehyun Kim, Jaehong Kim, Seunghye Jeong, Soon-Jik Hong*

Center for Advanced Powder Materials and Parts, Kongju National University, Cheonan, Republic of Korea
**hongsj@kongju.ac.kr*

Inconel 718 is widely used in aerospace and energy-related components due to its exceptional mechanical strength, high-temperature performance, and good processability. However, prolonged exposure to high-temperature oxidizing or ignition-prone environments can promote degradation of the surface oxide scale and localized oxidation damage, thereby reducing the long-term reliability of Inconel 718 components. In contrast, Haynes 214, a Ni-based alloy with relatively high Al and Cr contents, is known to form a stable and adherent Al_2O_3-based protective oxide scale at elevated temperatures, resulting in superior resistance to high-temperature oxidation-related degradation. Therefore, applying Haynes 214 as a surface layer on Inconel 718 is considered an effective strategy for enhancing surface oxidation resistance while retaining the mechanical advantages of the Inconel 718 substrate.

In this study, Inconel 718 substrates were first fabricated by directed energy deposition (DED) using powders with a particle size range of 53−150 μm. Subsequently, Haynes 214 was applied onto the surface of the DED-fabricated Inconel 718 substrates using two different coating processes: DED coating and plasma spray coating. For the DED coating process, Haynes 214 powders with a particle size range of 53−150 μm were used, whereas finer Haynes 214 powders with a particle size range of 20−53 μm were employed for the plasma spray process. Three types of specimens were prepared and systematically compared such as as-built Inconel 718, Inconel 718 with a DED-deposited Haynes 214 layer, and Inconel 718 with a plasma-sprayed Haynes 214 coating. Prior to fabrication, the feedstock suitability of the Inconel 718 and Haynes 214 powders was evaluated by analyzing powder morphology, particle size analysis (PSA), flowability, dynamic flow testing, and chemical composition, respectively. The fabricated specimens were characterized by relative density measurements and X-ray diffraction (XRD) analysis to evaluate densification behavior, defect formation, and the major crystalline phases. Thermogravimetric analysis (TGA) and high-temperature oxidation tests were then conducted to compare the mass change per unit surface area and oxidation kinetics of the different specimens. After high temperature oxidation testing, SEM combined with energy-dispersive X-ray spectroscopy (EDS) was used to examine the oxide scale morphology, elemental distribution, coating/substrate interfacial characteristics, and microstructural evolution. The objective of this study is to clarify the role of Haynes 214 surface layers in improving the high-temperature oxidation resistance of DED-fabricated Inconel 718 and to compare the differences in surface layer formation, interfacial characteristics, and oxidation behavior between DED coating and plasma spray coating. These findings are expected to provide fundamental insight into the design of hybrid superalloy structures that integrate the high mechanical performance of an Inconel 718 substrates with the superior oxidation resistance of Haynes 214 surface layers.

Keywords: Inconel 718, Haynes 214, Directed Energy Deposition, Plasma Spray Coating, Oxidation Resistance

P-40

LPBF Process of Al-4Fe Matrix Composites Reinforced with ZrB_2 Particles

Jungho Choe, Kyung Tae Kim, and Ji Hun Yu*

Nanomaterials research Division, Korea Institute of Materials Science, Republic of Korea
**jhyu01@kims.re.kr*

The demand for high-performance lightweight materials in aerospace and automotive industries has intensified the search for aluminum alloys that maintain structural integrity under extreme thermal fluctuations. Although conventional Al-Si and Al-Zn alloys offer excellent ambient-strength, they suffer from rapid softening above 200 °C due to the coarsening of strengthening precipitates. To address these limitations, Al-Fe alloy systems have emerged as promising candidates, utilizing thermally stable intermetallic phases (e.g., Al_6Fe) to inhibit dislocation motion and grain boundary sliding at elevated temperatures. However, conventional casting of Al-Fe alloys often results in brittle, coarse microstructures. This study employs laser powder bed fusion (LPBF), leveraging its ultra-high cooling rates (10^5-10^6 K/s), to refine these intermetallic phases and optimize the Al-4Fe matrix. To further push the performance boundaries, this research investigates the incorporation of ZrB_2 ceramic particles as a reinforcement agent. ZrB_2 was selected for its exceptional thermal stability (melting point >3000 °C), chemical inertness, and high hardness, ensuring compatibility with the rapid thermal cycling of the LPBF process. Unlike TiB_2, ZrB_2 possesses a larger lattice misfit with the Al matrix, which minimizes deleterious interfacial reactions and allows for a clearer evaluation of intrinsic strengthening effects. Microstructural analysis confirmed that the addition of ZrB_2 particles triggered significant grain refinement, reducing the average grain size of the Al-4Fe matrix from 54.5 μm to 17.9 μm. Mechanical testing demonstrated that the ZrB_2/Al-4Fe composites achieved a simultaneous improvement in both strength and ductility compared to unreinforced Al-4Fe alloys, maintaining this superiority from room temperature up to 400 °C. The strengthening mechanisms were systematically identified as grain refinement, effective load transfer, and enhanced dislocation density arising from the coefficient of thermal expansion (CTE) mismatch between the matrix and ZrB_2. Interestingly, the enhancement in ductility was attributed to promoted void nucleation and coalescence near Zr-rich regions. These findings provide critical insights into the design of heat-resistant, high-strength Al-matrix composites, highlighting the potential of ZrB_2-reinforced Al-Fe systems for next-generation structural applications in demanding environments.

Keywords: Additive Manufacturing, Laser Powder Bed Fusion, Aluminum, Aluminum Alloys Matrix Composite, Elevated Temperature

P-41

DEM- and Machine Learning-Based Prediction of Powder Packing Behavior for Powder Process Design

Jung-joon Kim, Hongjun Chae, Youngkyun Kim*

Center for Advanced Materials & Processing, Institute for Advanced Engineering, Gyeonggi-do, Republic of Korea
**kyk@iae.re.kr*

Powder packing behavior is a key factor that determines the quality and reliability of various powder-based manufacturing processes, including hot isostatic pressing (HIP), sintering, heat treatment, and powder compaction. In particular, in powder systems with different particle size distributions, the packing structure and packing density can vary significantly depending on the mixing ratio and particle arrangement. Therefore, a systematic understanding of powder packing behavior is essential for optimizing powder process design. However, experimental optimization alone requires considerable time and effort because various powder combinations and process conditions must be evaluated.

In this study, a combined approach using the discrete element method (DEM) and machine learning was applied to predict and optimize the packing behavior of soft magnetic powder systems. DEM simulations were conducted for powder mixtures with different particle size distributions and mixing ratios to analyze changes in packing density and particle arrangement. The simulation data were then used to construct a machine learning-based prediction model, and the optimal mixing condition for improved packing behavior was derived.

To validate the prediction results, experimental verification was performed using the powder mixture condition suggested by the DEM–machine learning approach. The experimentally obtained packing behavior showed good agreement with the predicted tendency, confirming that the proposed approach can be effectively used to estimate suitable powder mixing conditions. These results indicate that DEM simulation combined with machine learning can serve as a useful computational framework for reducing experimental trial-and-error and supporting powder process design.

Keywords: DEM, Powder Packing, Machine Learning, Soft Magnetic Powder, Process Design

P-42

Co/Beta Zeolite Catalyst for Efficient N_2O Decomposition in Oxygen-Containing Gas Streams

Sanghyeok Seo[1], Myeung-Jin Lee[1], Bora Jeong[1], Donghyeok Kim[1], Nahea Kim[2], Dahye Park[1], Hong-Dae Kim[1*]

[1]*Ulsan Technology Application Division, Korea Institute of Industrial Technology Ulsan, Republic of Korea*
[2]*Low-carborn energy group, Korea Institute of Industrial Technology Ulsan, Republic of Korea*
[*]*hdkim@kitech.re.kr*

Nitrous oxide (N_2O), a potent greenhouse gas emitted during semiconductor and display manufacturing, requires efficient catalytic abatement under practical exhaust conditions. In this study, cobalt oxide catalysts supported on Beta zeolite, CeO_2, and TiO_2, along with unsupported Co_3O_4, were prepared and evaluated for the direct decomposition of N_2O under O_2-rich atmospheres. Unlike previous studies that mainly examined catalyst performance under N_2O-rich conditions, this work focuses on catalytic activity and O_2 tolerance in oxygen-containing gas streams relevant to industrial exhaust treatment. Among the tested catalysts, Co/Beta exhibited the highest N_2O decomposition activity and excellent O_2 tolerance, achieving over 95% conversion at 450 °C in the presence of 5% O_2 and complete conversion at 500 °C with 15% O_2. The enhanced performance is attributed to highly dispersed Co species on Beta zeolite, a high Co^{2+} ratio, abundant chemisorbed oxygen species, improved low-temperature reducibility, and enhanced oxygen mobility. These properties facilitate N_2O activation and surface oxygen removal, thereby suppressing O_2-induced activity loss. Overall, Co/Beta is a promising catalyst for N_2O abatement in semiconductor and display exhaust gas treatment.

Keywords: N_2O decomposition, Cobalt oxide catalyst, Beta zeolite, Oxygen-rich atmosphere, O_2 tolerance

P-43

Mesoporous Silica-Carbon Composites as Anode Materials for Enhanced Stability in Lithium-Ion Batteries

Yehui Kim[1,2*], Dong-Hyun Kim[1*]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology, Incheon, Republic of Korea*
[2]*Department of Material Science and Engineering, Korea University, Seoul, Republic of Korea*
[*]*kdh0516@kitech.re.kr*

Lithium-ion batteries (LIBs) are widely used in electric vehicles, energy storage systems, and portable electronics because of their high energy density and long cycle life. However, commercial graphite anodes have a limited theoretical capacity, while silicon-based anodes suffer from low electrical conductivity and severe volume changes during cycling. To address these limitations, mesoporous silica–carbon (M-SiO_2@C) composite anode materials were prepared by retaining spherical mesoporous SiO_2 within the final composite and introducing water-soluble carbon precursors to enhance structural stability and electrical connectivity.

Spherical SiO_2 was synthesized through a CTAB-assisted sol–gel process, and its structural properties were optimized through thermal treatment. Based on TGA, XRD, BET, and FE-SEM analyses, SiO_2 treated at 750 °C exhibited a high specific surface area, large pore volume, and well-maintained spherical morphology, and was therefore selected as the framework material.

Methyl cellulose (MC), sucrose, and mixed MC/sucrose precursors were coated onto the selected 750-SiO_2 using a D.I. water-based process, followed by carbonization under an Ar atmosphere. Structural characterization confirmed that the SiO_2 framework remained largely amorphous after carbonization, while the carbonaceous phase was predominantly disordered or amorphous in nature. FE-SEM and EDS analyses indicated that both precursor composition and carbonization temperature significantly influenced the morphology and carbon distribution of the composites.

Electrochemical performance was evaluated using CR2032 half-cells. Among the prepared samples, the 1200-Mix-0.4-0.1 electrode exhibited the best performance, delivering a discharge capacity of 202.1 mAh g^{-1} with a Coulombic efficiency of 98.1% after 100 cycles. The improved performance is attributed to the MC-rich precursor composition and the well-preserved spherical morphology after high-temperature carbonization.

These results demonstrate the feasibility of preparing M-SiO_2@C composite anodes using water-soluble carbon precursors and highlight the importance of precursor composition and carbonization conditions in determining the structural and electrochemical properties of mesoporous silica–carbon composite anodes.

Keywords: Lithium-Ion Battery, Anode, Mesoporous, Silica-Carbon

P-44

Fabrication and Characterization of Powder Sintered Ti PTL (Porous Transport Layer) for PEM Water Electrolysis

Young-yo Yoon[1*], Young-min Jin[1], Jung-yeul Yun[2], Man-ho Park[1*]

[1]*ENERICH Co. Ltd. (Gyeonggido, Korea)*
[2]*Korea Institute of Materials Science (KIMS, Changwon, Korea)*
[*]*ho.park@enerichs.com*

Among various green hydrogen production technologies, Proton Exchange Membrane Water Electrolysis (PEMWE) has attracted significant attention due to its capability for dynamic operation and hydrogen production at high current densities. The Porous Transport Layer (PTL), one of the key components in PEMWE, plays multiple roles including water supply, product gas removal, electron transport, and mechanical support.

Conventional Ti felt-based PTLs may undergo compression-induced deformation due to their fibrous structure, and the protruding titanium fibers can potentially cause localized damage at the interface with the membrane electrode assembly (MEA).

In this study, a Ti PTL with a uniform porous structure was fabricated using a powder-sintering process. Green sheets were first prepared by tape casting a slurry composed of titanium powder and binder, followed by debinding and sintering processes to obtain the Ti PTL. The fabricated PTLs exhibited controllable porosity in the range of 30–60% and thicknesses ranging from 0.1 to 0.5 mm. In addition, Pt coating was applied to the PTL surface to enhance electrical properties and durability.

Electrochemical performance was evaluated in a PEM water electrolysis single cell with an active area of 25 cm^2. Polarization (I–V) characteristics were measured over a current density range of 0–3 A cm^{-2}. The fabricated PTL achieved a cell voltage of 1.82 V at 3 A cm^{-2} and demonstrated stable performance in the high-current-density region. This improved performance is attributed to reduced mass transport resistance resulting from enhanced water supply and gas removal through the uniform porous structure, as well as decreased interfacial contact resistance between the catalyst layer and PTL owing to the low surface roughness of the powder-sintered PTL.

Keywords: Titanium powder, Porous metal, Tape casting, Proton electrolysis membrane, Water electrolysis

P-45

Wettability-Modified Hydrovoltaic Modules for Self-Powered Direct Lithium Extraction

So Hyun Baek[1,2], Seung-Hwan Lee[1], Yu-Na Lee[1], Yewon Do[1], Yongbum Kwon[1], Taeseok Oh[1], Kanghyuk Lee[1], Yoseb Song[1], Bum Sung Kim[1], Yong-Ho Choa[2*], Da-Woon Jeong[1,3*]

[1]*Korea National Institute of Rare Metals, Korea Institute of Industrial Technology*
[2]*Department of Materials Science and Chemical Engineering, Hanyang University*
[3]*School of Mechanical Engineering, Chung-Ang University*
[*]*dwjeong@kitech.re.kr*

Hydrovoltaic power generation harvests electricity from water movement and evaporation without external power input and offers a promising route for sustainable self-powered systems. However, when one end of a hydrovoltaic generator is immersed in an aqueous electrolyte, capillary driven over wetting can cause the electrolyte to spread throughout the entire device. This weakens the moisture gradient required for hydrovoltaic power generation and decreases the output voltage, limiting its practical use in electrolyte immersed applications. In this work, we fabricated and evaluated a cellulose sponge based hydrovoltaic generator designed for operation in a saline electrolyte environment. The porous cellulose sponge substrate provides interconnected pathways for spontaneous electrolyte uptake, capillary transport, and evaporation induced ion transport. Electrical conductivity was introduced by dip coating the sponge with a carbon black suspension, followed by drying to form a continuous conductive network along the porous framework. A seawater-like 0.5 M NaCl aqueous solution was used as the saline electrolyte. Although the cellulose sponge effectively absorbs the electrolyte, excessive wetting of the entire structure reduces the moisture gradient and lowers the generated voltage. To mitigate this issue, a selective wettability modification strategy was applied to suppress excessive electrolyte spreading while maintaining sufficient water supply from the immersed region. Specifically, a fluorinated polymer coating was introduced at one end of the generator to form a hydrophobic region that delays excessive electrolyte propagation without fully blocking electrolyte transport. The fabricated single device delivered an output of approximately 0.45 V and 150 μA in 0.5 M NaCl, demonstrating that the cellulose sponge-based structure can generate hydrovoltaic electricity under seawater relevant electrolyte conditions. Finally, the hydrovoltaic generator was coupled with a direct lithium extraction system. The coupled system confirmed that lithium extraction can be achieved using only the electricity generated by the hydrovoltaic module, demonstrating the potential of a low carbon, self-powered lithium recovery platform based on hydrovoltaic energy harvesting.

Keywords: Hydrovoltaic, Wettability modification, Self-powered system

P-46

Effect of Mixed Metal Oxide Composition on Organic Additives Decomposition and Lifetime of the Dimensionally Stable Anodes for PCB Copper Electroplating

Sung Cheol Park, Jin Man Jang, Wonsik Lee and Seong Ho Son*

Industrial Components R&D Department, Korea Institute of industrial Technology, Incheon, Republic of Korea
**shson@kitech.re.kr*

The dimensionally stable anode (DSA) has been widely used as an insoluble anode in various electrochemical processes because of the stable electrode shape, excellent electrochemical properties, and long-term durability. In the copper electroplating process for printed circuit boards (PCBs), stable anodic reactions are required to maintain uniform current distribution and reliable operation during long-term electrolysis. In addition, the reduction of anodic potential is important because the cell voltage is directly related to the electrical energy consumption of the electroplating process. Organic additives such as suppressor, brightener, and leveler are added to the electroplating bath to control the surface morphology, throwing power, and uniformity of electrodeposited copper. However, these organic additives can be decomposed by anodic oxidation during electrolysis, and the decomposition may affect the stability of the electroplating bath and the quality of copper deposition. However, these organic additives can be decomposed by anodic oxidation during electrolysis, and the decomposition can affect the stability of the electroplating bath and the quality of copper electrodeposition. Therefore, the electrochemical properties, lifetime, and organic additive decomposition behavior of the DSA should be evaluated under PCB copper electroplating conditions.

In this study, mixed metal oxide-based DSAs with different composition ratios were prepared on titanium substrates. Ir-, Ru-, Pt-, and Ta-containing oxide coatings were formed by precursor coating and thermal decomposition after surface pre-treatment of the titanium substrate. The electrochemical characteristics and organic additive decomposition behavior of the prepared DSAs were evaluated under PCB copper electroplating conditions. The decomposition behavior of suppressor, brightener, and leveler was analyzed by cyclic voltammetric stripping (CVS) after electrolysis in a $CuSO_4$-H_2SO_4-Cl^- electrolyte containing organic additives. The lifetime of the DSAs were evaluated by an accelerated lifetime test under high-current-density conditions. The surface morphologies of the prepared electrodes before and after the accelerated lifetime test were characterized by field-emission scanning electron microscopy (FE-SEM). The decomposition behavior of organic additives was affected by the composition of the metal oxide coating layer. Suppressor decomposition was relatively small, whereas brightener and leveler decomposition depended on the coating composition. In the accelerated lifetime test, the Ir-Ta based DSA showed the longest lifetime compared with the other prepared DSAs. After the test, degradation and loss of the metal oxide coating layer were observed on the electrode surface. These results show that the composition ratio of the metal oxide coating layer is a factor affecting organic additive decomposition, applied potential and lifetime of the DSA for PCB copper electroplating applications.

Keywords: Dimensionally Stable Anode, PCB Copper Electroplating, Mixed Metal Oxide, Organic Additive Decomposition, Accelerated Lifetime Test

P-47

Effects of Cr and Mo on Elongation of Structural Materials for Molten Salt Reactor Applications

Ji-Hyun Yoon[1*], Sang-Yeob Lim[1], Jaeseong An[2], Jung-Min Kim[3], Chaewon Kim[1], Daejong Kim[1]

[1]*Materials Technology Research Division, Korea Atomic Energy Research Institute, Daejeon, South Korea*
[2]*Department of New Materials Engineering, Chungnam National University, Daejeon, South Korea*
[3]*Department of Nuclear Science and Technology, University of Science and Technology, Daejeon, South Korea*
[*]*jhyoon4@kaeri.re.kr*

Structural components in next-generation Generation IV Molten Salt Reactors (MSRs) are strictly required to endure aggressive chloride-based fuel and coolant salts at elevated temperatures up to 700°C. Advanced nickel-based alloys are developed in this study to replace conventional Hastelloy N, which is fundamentally limited by insufficient high-temperature strength and catastrophic intergranular tellurium (Te) embrittlement.

Specific additions of Niobium (Nb) and Hafnium (Hf) are incorporated into the alloy design to promote the discrete precipitation of stable, multi-scale carbides. These precipitates are utilized as sacrificial trapping sites for fission products, whereby the hazardous segregation of tellurium at grain boundaries is successfully prevented. A remarkable divergence in high-temperature mechanical response was discovered between two candidate alloys that both satisfied the baseline corrosion resistance benchmarks. The modified alloy featuring increased levels of Chromium (Cr) and Molybdenum (Mo) demonstrated a paradoxical and highly desirable synergistic enhancement in both yield strength and ductility. Most notably, a dramatic surge in elongation was achieved by this specific 10Cr-6Mo formulation during the post-necking stage at 700°C, establishing a unique combination of strength and plasticity that transcends traditional metallurgical trade-offs.

Comprehensive microstructural investigations utilizing Electron Backscatter Diffraction (EBSD) and Kernel Average Misorientation (KAM) mapping were conducted to premium the underlying atomistic mechanisms. The Stacking Fault Energy (SFE) of the FCC nickel matrix is fundamentally lowered by the elevated concentrations of Cr and Mo via the local stabilization of the HCP phase. Perfect dislocations are consequently forced to dissociate into widely separated partial dislocations, whereby an insurmountable physical barrier to cross-slip and climbing processes is established. The dominant high-temperature softening mechanism is thus transitioned from conventional dynamic recovery (DRV) to prolific dynamic recrystallization (DRX). Dislocations are confined within specific planes due to the suppressed DRV kinetics, inducing rapid planar slip and severe dislocation pile-ups. These planar bands are actively blocked by the uniformly distributed, tens-of-nanometers-scale precipitates that act as impenetrable barriers. Extensive localized lattice curvature is generated by this spatial interaction, through which Particle-Stimulated Nucleation (PSN) and the subsequent nucleation of fresh, strain-free grain boundaries are accelerated throughout the matrix. This microstructural refreshment is substantiated by EBSD analysis, where a substantial expansion of the low-energy $\Sigma 3$ Coincident Site Lattice (CSL) boundary network up to 46.4% is captured within the necked region. Efficient dislocation consumption is also confirmed by heavily diminished KAM values. Premature strain localization and intergranular decohesion are effectively prevented by this continuous self-healing loop, allowing vast plastic energy to be absorbed during necking.

Keywords: MSR, Cr, Mo, Elongation, Recrystallization

P-48

Ultrathin TiO_x Nanosheet-Mediated Interface Design for Durable Microsized Silicon Anodes

Jeong Yun Hwang*, Sol Han, and Kyu Hyung Lee*

Department of Materials Science and Engineering, Yonsei University, Seoul 03722, Republic of Korea
**jyhawng@yonsei.ac.kr, khlee2018@yonsei.ac.kr*

Microsized silicon (micro-Si) is an attractive anode material for high-energy-density lithium-ion batteries because of its high theoretical capacity, low cost, and scalable processability. However, repeated lithiation/delithiation causes large volume changes, particle pulverization, unstable solid–electrolyte interphase (SEI) formation, and rapid capacity fading. Conventional surface coatings and carbon-based matrices can reduce electrolyte decomposition, but they often provide limited control over the mechanically unstable Si/electrolyte interface. Here, we present an ultrathin TiO_x nanosheet-mediated interface design for stabilizing micro-Si anodes. TiO_x nanosheets with an average thickness of approximately 1 nm wrap the micro-Si particles and form a chemically coupled Si–O–Ti interfacial network. This nanosheet-based interface relieves local strain, reduces direct electrolyte decomposition on the Si surface, and promotes more uniform lithiation/delithiation during cycling. After 100 cycles at 0.3 C, the Si@TiO_x anode retains 1306 mAh g^{-1}, whereas pristine micro-Si decreases to 768 mAh g^{-1}. Cross-sectional SEM shows that electrode thickness expansion is reduced from 271% for pristine micro-Si to 171% for Si@TiO_x after cycling, confirming suppressed electrode-level structural degradation. The NMC811-based full-cell test also shows better capacity retention for Si@TiO_x than for pristine micro-Si, indicating that the TiO_x nanosheet layer remains effective in a full-cell configuration. These results suggest that ultrathin TiO_x nanosheets can be used as active interface layers for durable micro-Si anodes.

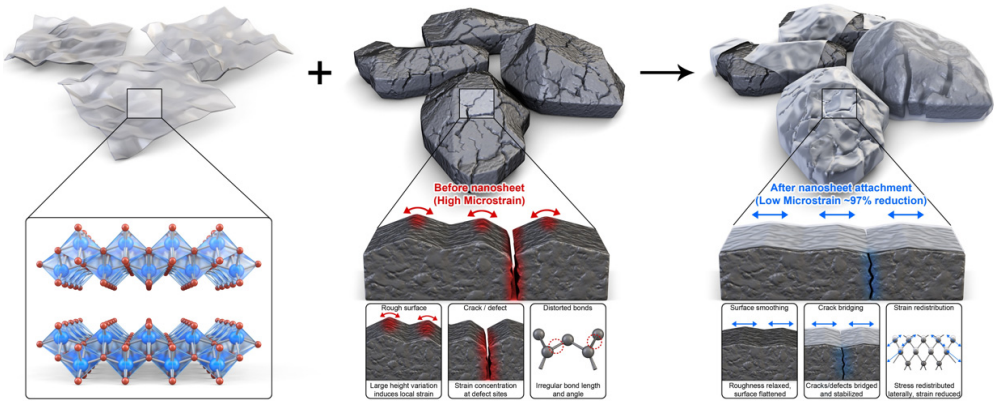


Figure. Schematic representation of microstrain relaxation in TiO_x nanosheet-attached micro-Si particles.

Keywords: Microsized silicon anode, TiOx nanosheet, Interfacial engineering, Microstrain relaxation, Lithium-ion batteries

P-49

Eco-friendly Direct Lithium Extraction via LLTO Membrane Driven by Hydrovoltaic Energy

Seung-Hwan Lee[1,2], So Hyun Baek[1], Yongbum Kwon[1], Kanghyuk Lee[1], Kee-Ryung Park[1], Yoseb Song[1], Bum Sung Kim[1], Yong-Ho Choa[2*], Da-Woon Jeong[1,3*]

[1]*Korea Institute of Industrial Technology*
[2]*Hanyang University Erica*
[3]*Chung-Ang University*
[*]*dwjeong@kitech.re.kr*

The rapid proliferation of mobile electronics and the Internet of Things is intensifying demand for ultralow power sources. Accordingly, ambient energy harvesting has been actively pursued to complement or replace batteries in distributed and maintenance limited devices. Water is a continuously replenished resource and converting capillary driven moisture transport and evaporation into electricity represents a growing hydrovoltaic route toward self-sustaining power. Here, we demonstrate a cellulose sponge based hydrovoltaic power generator (CHPG) activated by a small volume of seawater and apply the harvested electricity to operate a direct lithium extraction (DLE) system. A single CHPG (4.0 × 1.0 × 1.0 cm^3) is triggered by depositing 300 μL of seawater on one end, producing an open circuit voltage of approximately 0.41 V and a short circuit current of approximately 150 μA. To satisfy the electrical requirement of the DLE unit, an array was configured by connecting five generators in series and six such series modules in parallel. The resulting 30 units CHPG array delivered 1.7 V and 200 μA, enabling direct electrical coupling to the DLE system. During operation, the DLE cell was driven at 1.4 V with a steady current of 160 μA, confirming sufficient output for continuous electrochemical extraction. After 20 h of continuous operation using seawater as the feed solution, selective lithium extraction was achieved, yielding a lithium concentration of 17.7 mg/L while suppressing co transport of major competing ions, with sodium and magnesium measured at 2.7 mg/L and 0.1 mg/L, respectively. These results validate that seawater activated hydrovoltaic modules can be scaled via series parallel integration to supply application level voltage and current, and can directly power lithium selective extraction without external electricity. Overall, this study demonstrates that hydrovoltaic electricity can provide sufficient power to drive resource recovery, highlighting potential for further development of self-powered extraction systems.

P-50

Oxidation State Engineering of IrO_2 through Strategic Doping for Durable Oxygen Evolution Catalysis

Youngtae Park[1*], and Changsoo Lee[2]

[1]*Department of Materials Science and Engineering, Kumoh National Institute of Technology, Gumi, Gyeongbuk 39177, Republic of Korea*

[2]*Department of Chemical Engineering Education, Chungnam National University, 99 Daehak-ro, Daejeon 34134, Republic of Korea*

[*]*cs.lee@cnu.ac.kr*

The development of efficient and durable oxygen evolution reaction (OER) catalysts is crucial for advancing proton exchange membrane water electrolysis (PEMWE). In this study, a doped IrO_2-based catalyst is developed to simultaneously improve catalytic activity and long-term stability under acidic OER conditions. Through a combination of electrochemical measurements, spectroscopic characterization, and first-principles calculations, we demonstrate that selected post-transition metal dopants play a dual role in IrO_2 by stabilizing the oxidation state of Ir species and suppressing oxygen vacancy formation. These effects effectively mitigate catalyst degradation and enhance durability during acidic OER operation.

The improved structural and electronic stability of the catalyst leads to significantly enhanced performance retention compared with undoped IrO_2 under both half-cell and practical PEMWE operating conditions. Furthermore, spectroscopic observations and theoretical investigations reveal that dopant incorporation promotes lattice oxygen retention, contributing to the preservation of the catalyst framework during extended operation. The synergistic modulation of the electronic structure and defect chemistry provides a promising strategy for improving both the activity and durability of IrO_2-based OER catalysts. These findings offer valuable insights into the rational design of next-generation electrocatalysts for acidic water electrolysis systems.

Keywords: Proton Exchange Membrane Water Electrolysis (PEMWE), Oxygen Evolution Reaction (OER), Iridium Oxide (IrO_2), Oxidation State Modulation

P-51

Investigation of the crystallization behavior of NbCoSn amorphous alloy

Chanwon Jung*

Department of Materials Science and Engineering, Pukyong National University Busan, Korea
**c.jung@pknu.ac.kr*

NbCoSn half-Heusler compounds are promising thermoelectric materials for the mid-temperature range of 500-800 °C due to their excellent electrical properties, including a high Seebeck coefficient and electrical conductivity, as well as good mechanical stability. However, their relatively high thermal conductivity limits further improvement in thermoelectric figure of merit. To reduce thermal conductivity, nanocrystalline structures have been widely employed. Conventional fabrication methods for nanocrystalline materials, such as ball milling followed by powder sintering, generally require long processing times and provide limited control over the resulting microstructure. In contrast, nanocrystallization from an amorphous precursor offers a more efficient approach for tailoring nanostructures through controlled annealing conditions. In this study, the crystallization behavior of amorphous NbCoSn alloys was investigated using a correlative approach combining atom probe tomography (APT) and transmission electron microscopy (TEM). APT provided three-dimensional atomic-scale information on elemental distribution and segregation behavior, while TEM revealed structural features such as crystal structure and grain size. The combined analysis provides a comprehensive understanding of the crystallization process and offers insights for designing advanced thermoelectric materials through the controlled nanocrystallization of amorphous alloys.

Keywords: NbCoSn, Half-Heusler, Crystallization behavior, Atom probe tomography, Transmission electron microscopy

P–52

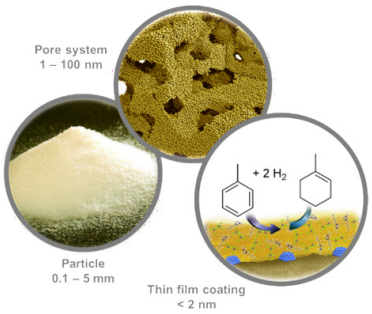
SCILL Catalyst systems for the selective hydrogenation of aromatics and unsaturated hydrocarbons

M.B. Williams[1], T. Retzer[2], M. Haumann[2]

[1]*Angewandte Naturwissenschaften, Hochschule Bonn-Rhein-Sieg*
[2]*Universität Erlangen-Nürnberg, Lehrstuhl für Chemische Reaktionstechnik*
[3]*Interface Research and Catalysis, ECRC, Universität Erlangen-Nürnberg*
[*]*Marc.Williams@h-brs.de*

Selective partial hydrogenation of aromatic and unsaturated hydrocarbons is an important step in the production of industrial intermediates and fine chemicals. However, continuous gas-phase hydrogenation remains challenging because substrates tend to undergo complete hydrogenation under conventional reaction conditions. In this work, we investigate solid catalysts with ionic liquid layers (SCILL systems) based on supported noble metal catalysts for the selective gas-phase hydrogenation of aromatic and alkyne substrates.

Different ionic liquids were applied as thin films on porous supported catalysts to improve selectivity toward partially hydrogenated intermediates. In addition, the influence of inorganic additives and organic feed additives was studied. Catalyst structure and surface chemistry were analysed using diffuse reflectance infrared Fourier transform spectroscopy with CO as probe molecule (CO-DRIFTS).



Compared to the uncoated catalysts, SCILL systems showed significantly enhanced selectivity toward partially hydrogenated products, albeit at lower overall conversion. Yield Increases of up to factor 50 were achieved compared to commercial catalysts. The catalyst performance strongly depended on the nature of the ionic liquid, indicating a complex interplay of substrate solubility, hydrogen availability, diffusion, and surface interactions within the ionic liquid layer.

CO-DRIFTS experiments revealed pronounced differences between coated and uncoated catalysts. While the bare catalysts showed signs of oxidative disruption and restructuring under reaction-relevant atmospheres, the ionic liquid-coated systems predominantly preserved metallic surface sites, indicating enhanced stabilization of the noble metal nanoparticles by the ionic liquid layer. Furthermore, characteristic spectral shifts confirmed the presence of local electric fields generated by the ionic liquid environment.

The addition of inorganic salts to the ionic liquid layer generally did not improve catalytic performance under gas-phase conditions. In contrast, small amounts of oxygenated organic additives in the feed significantly enhanced the yield of partially hydrogenated products. Combining organic additives with SCILL catalysis resulted in strongly improved intermediate yields compared to both the uncoated catalysts and the corresponding SCILL systems without additives.

In situ spectroscopic investigations suggest that the organic additives modify adsorption processes at the catalyst surface and influence the transport properties of the ionic liquid layer. Competitive adsorption effects as well as altered reactant permeability are proposed to contribute to the improved selectivity patterns observed for the SCILL systems.

Overall, the results demonstrate that combining ionic liquid-coated noble metal catalysts with suitable organic additives is a promising strategy to improve selectivity in continuous gas-phase partial hydrogenation reactions. The concepts presented here may provide a foundation for the further development of selective catalytic processes for industrial hydrogenation chemistry.

Keywords: Heterogeneous Catalysis, Ionic Liquids, Selective Hydrogenation, DRIFTS, Hydrogenation

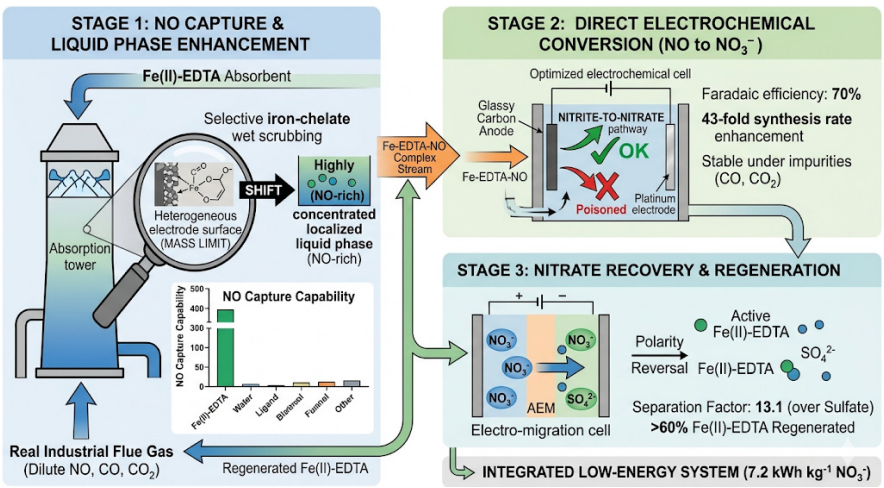
P–53

Electrochemically-mediated Reactive Separation of Nitric Oxide into Nitrate Using Iron Chelate

DongYeon Kim*, Beomseo Kim, Taeyoul Han, Taeil Kim

Blueone, Research Institute, 70, Hannam-ro, Daedeok-gu, Daejeon, 34430, Korea
**coolkdy11@gmail.com*

Electrochemical oxidation of nitric oxide (NO) into nitrate (NO_3^-) offers a sustainable closed-loop approach for mitigating air pollution while decentralized producing high-value chemical feedstocks. However, conventional electrocatalytic systems suffer from severe mass transport barriers driven by the extremely low aqueous solubility of NO and struggle with the dilute nature and complex impurities of real industrial flue gases. To overcome these challenges, this study demonstrates a novel reactive separation platform that seamlessly couples selective iron-chelate wet scrubbing with an electrochemical conversion process. Among various screened ligands, iron(II)-ethylenediaminetetraacetic acid (Fe(II)-EDTA) exhibited the most outstanding gas-phase NO capture capability, shifting the reaction environment from a limited heterogeneous electrode surface to a highly concentrated, localized liquid phase. Direct electrochemical oxidation of the resulting Fe-EDTA-NO complex was optimized using a glassy carbon electrode, which displayed superior catalytic activity and mass-transfer-controlled kinetics for the key nitrite-to-nitrate intermediate pathway compared to platinum electrodes that suffer from surface oxide poisoning. Under optimal conditions of 200 mM Fe-EDTA-NO at pH 7 and an operating potential of 2.2 V vs. RHE, the system achieved a maximum partial current density of 30.1 mA cm-2 and a stable Faradaic efficiency of 70% toward nitrate, yielding a 43-fold enhancement in synthesis rate (23 mg cm-2 h-1) over simple aqueous purging without a selective absorbent. Furthermore, gaseous impurities like CO and CO2 did not severely impair the highly selective capture and Faradaic efficiency of the process. Following electrooxidation, the synthesized nitrate was successfully recovered through a secondary electro-migration stage with simple polarity reversal, utilizing an anion-exchange membrane (AEM) to achieve a separation factor of 13.1 over background sulfate counterions while concurrently reducing and regenerating more than 60% of the active Fe(II)-EDTA absorbent for continuous recycling. Ultimately, this integrated, low-energy system (7.2 kWh kg-1 NO3−) presents a robust, highly efficient blueprint for the concurrent remediation and valorization of diluted nitrogenous waste streams.



Keywords: NO oxidation, Nitrate production, Iron-chelate scrubbing, Electrochemical oxidation, Mass-transfer enhancement

Acknowledgement

This work was partly supported by the Technology development Program of MSS [RS-2025-02222138] and the Korea Environmental Industry & Technology Institute (KEITI) through the 'Field-Driven Environmental Technology Commercialization R&D Program' (RS-2026-25505447), funded by the Ministry of Climate, Energy and Environment of the Republic of Korea.

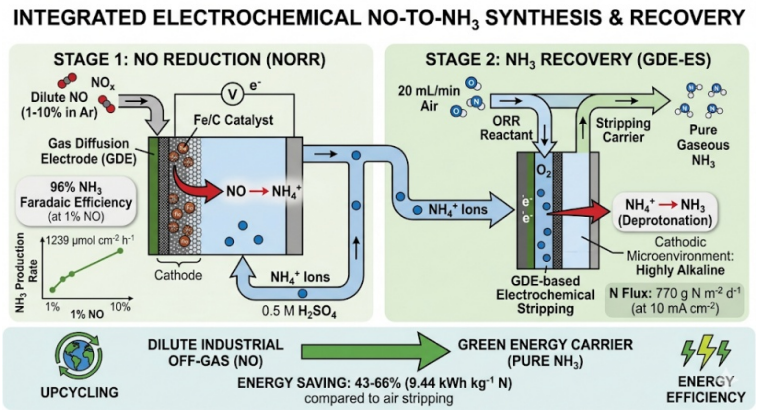
P-54

Integrated Gas Diffusion Electrode System for Sustainable Ammonia Synthesis from Dilute Nitric Oxide and Direct Gaseous Recovery

DongYeon Kim*, Beomseo Kim, Taeyoul Han, Taeil Kim

Blueone, Research Institute, 70, Hannam-ro, Daedeok-gu, Daejeon, 34430, Republic of Korea
coolkdy11@gmail.com

Electrochemical upcycling of nitrogenous air pollutants into value-added chemicals presents a promising alternative to the energy-intensive Haber-Bosch process. Specifically, the electrochemical nitric oxide reduction reaction (NORR) has emerged as a thermodynamically favorable pathway for ammonia synthesis. However, conventional aqueous-phase NORR remains strictly limited by the poor solubility of NO, and the synthesized product typically exists as dissolved ammonium ions (NH_4^+), necessitating an additional high-cost separation process for pure nitrogen recovery. To overcome these limitations, this study proposes an integrated, energy-efficient dual-gas diffusion electrode (GDE) system that achieves both high-rate NH_4^+ synthesis from dilute NO (1–10%) and its concurrent recovery into gaseous ammonia (NH_3). By utilizing a GDE loaded with nanoscale zero-valent iron supported on carbon black (Fe/C), the NORR stage effectively overcame mass transport restrictions, yielding an exceptional NH_3 Faradaic efficiency of 96% with a 1% NO feed. Under an optimized proton-rich environment (0.5 M H_2SO_4), the net NH_3 production rate reached a maximum of 1239 μmol cm^{-2} h^{-1} using a 10% NO gas mix, while density functional theory (DFT) calculations verified that the Fe/C catalyst selectively facilitates the cleavage of the N–O bond in the H_2NO^* intermediate. The generated NH_4^+ stream was subsequently routed into a GDE-based electrochemical stripping (GDE-ES) cell, where a structurally confined, narrow cathodic compartment maintained a highly alkaline microenvironment to enable instantaneous deprotonation of NH_4^+ into NH_3. Driven by a continuous air flow of 20 mL/min which served a dual function as an effective stripping carrier and an oxygen reduction reaction (ORR) reactant the integrated recovery system successfully achieved a superior nitrogen flux of 770 g N/m^2 d at a low current density of 10 mA/cm^2. Due to the therapeutic energy reduction from the cathodic ORR, the net electrochemical energy requirement was restricted to 9.44 kWh/kg N, representing a significant energy saving of 43% to 66% compared to conventional chemical-air stripping systems. Ultimately, this study successfully demonstrates an innovative, closed-loop electrochemical platform that bridges gas-phase pollutant reduction with direct chemical resource recovery, providing a robust, highly competitive, and energy-efficient blueprint for converting diluted industrial off-gases into green energy carriers.



Keywords: NORR, Ammonia synthesis, Gas diffusion electrode, Iron catalyst, Resource recovery

Acknowledgement

This work was partly supported by the Technology development Program of MSS [RS-2025-02222138] and the Korea Environmental Industry & Technology Institute (KEITI) through the 'Field-Driven Environmental Technology Commercialization R&D Program' (RS-2026-25505447), funded by the Ministry of Climate, Energy and Environment of the Republic of Korea.

P-55

Balancing Activity and Durability: Iridium-Assisted Calcium-Doped Manganese Oxybromide for Acidic PEM Water Electrolysis

Taeyoul Han[2], Donggyun Yoo[1], DongYeon Kim[2], HyukSu Han[1*]

[1]*Hanyang University (Division of Materials Science and Engineering, Seoul, Republic of Korea)*
[2]*Blueone (Research Institute, Daejeon, Republic of Korea)*
[*]*hyuksuhan@hanyang.ac.kr*

Electrochemical oxidation of nitric oxide (NO) into nitrate (NO_3^-) offers a sustainable closed-loop approach for mitigating air pollution while decentralized producing high-value chemical feedstocks. However, conventional electrocatalytic systems suffer from severe mass transport barriers driven by the extremely low aqueous solubility of NO and struggle with the dilute nature and complex impurities of real industrial flue gases. To overcome these challenges, this study demonstrates a novel reactive separation platform that seamlessly couples selective iron-chelate wet scrubbing with an electrochemical conversion process. Among various screened ligands, iron(II)-ethylenediaminetetraacetic acid (Fe(II)-EDTA) exhibited the most outstanding gas-phase NO capture capability, shifting the reaction environment from a limited heterogeneous electrode surface to a highly concentrated, localized liquid phase. Direct electrochemical oxidation of the resulting Fe-EDTA-NO complex was optimized using a glassy carbon electrode, which displayed superior catalytic activity and mass-transfer-controlled kinetics for the key nitrite-to-nitrate intermediate pathway compared to platinum electrodes that suffer from surface oxide poisoning. Under optimal conditions of 200 mM Fe-EDTA-NO at pH 7 and an operating potential of 2.2 V vs. RHE, the system achieved a maximum partial current density of 30.1 mA cm^{-2} and a stable Faradaic efficiency of 70% toward nitrate, yielding a 43-fold enhancement in synthesis rate (23 mg cm^{-2} h^{-1}) over simple aqueous purging without a selective absorbent. Furthermore, gaseous impurities like CO and CO_2 did not severely impair the highly selective capture and Faradaic efficiency of the process. Following electrooxidation, the synthesized nitrate was successfully recovered through a secondary electro-migration stage with simple polarity reversal, utilizing an anion-exchange membrane (AEM) to achieve a separation factor of 13.1 over background sulfate counterions while concurrently reducing and regenerating more than 60% of the active Fe(II)-EDTA absorbent for continuous recycling. Ultimately, this integrated, low-energy system (7.2 kWh kg^{-1} NO_3^-) presents a robust, highly efficient blueprint for the concurrent remediation and valorization of diluted nitrogenous waste streams.

Acknowledgement

This work was supported by the Technology development Program [RS-2025-25438906] funded by the Ministry of SMEs and Startups(MSS, Korea)

Keywords: Electrochemical NO Oxidation, Fe(II)-EDTA, Reactive Separation, Nitrate Electrosynthesis, Flue Gas Treatment

P-56

Highly Selective Electrochemical Ammonia Production from Flue-Gas-Level NO using Redox-Engineered Fe-MOF-74

Taeyoul Han[1], Seonjeong Cheon[2], Siranuysh Badalyan[3], DongYeon Kim[1*], Kyubock Lee[3*]

[1]*Blueone (Research Institute, Daejeon, Republic of Korea)*
[2]*University of Seoul (Department of Environmental Engineering, Seoul, Republic of Korea)*
[3]*Chungnam National University (Graduate School of Energy Science and Technology, Daejeon, Republic of Korea)*
[*]*dy0907@blue-tech.co.kr, kblee@cnu.ac.kr*

The electrochemical nitric oxide reduction reaction (NORR) to ammonia (NH3) presents an attractive alternative for both environmental remediation and sustainable chemical synthesis. However, achieving high selectivity and activity under dilute flue gas conditions remains a significant challenge due to competing reactions and the mass transport limitation of low-concentration gaseous reactants. In this work, we report a redox-tuned iron-based metal-organic framework (Fe-MOF-74) catalyst meticulously optimized for highly selective NO-to-NH3 electroreduction under dilute NO gas feed. By systematically controlling the oxidation state and local coordination environment of the Fe active centers, we demonstrate a profound enhancement in the adsorption energetics and activation pathways of dilute NO molecules. Advanced characterization techniques, including synchrotron X-ray absorption spectroscopy (XAS) and Mössbauer spectroscopy, reveal that the deliberately modulated Fe(II)/Fe(III) redox properties suppress the competitive hydrogen evolution reaction (HER) while dramatically accelerating the multi-proton electron transfer steps toward NH_3 production. Electrocatalytic evaluations confirm that the redox-tuned Fe-MOF-74 achieves an outstanding Faradaic efficiency for NH3 and an exceptional yield rate, even when subjected to realistic, highly dilute NO concentrations. This study highlights the power of structural and electronic tuning within metal-organic frameworks, offering fresh design principles for durable and selective electrocatalysts tailored for gas-phase nitrogen upcycling.

Acknowledgement

This work was partly supported by the Technology development Program of MSS [RS-2025-02222138] and the Korea Environmental Industry & Technology Institute (KEITI) through the 'Field-Driven Environmental Technology Commercialization R&D Program' [RS-2026-25505447], funded by the Ministry of Climate, Energy and Environment of the Republic of Korea.

Keywords: NORR, Fe-MOF-74, Redox Tuning, Ammonia Electrosynthesis, Dilute No Conversion

P-57

Potential-Induced Morphological Evolution of Copper Nanoparticles during Electrochemical Nitric Oxide Reduction to Ammonia

Beomseo Kim[1], Seonjeong Cheon[2], and DongYeon Kim[1*]

[1]*Blueone, (Research Institute, Daejeon, Korea)*
[2]*University of Seoul (Department of Environmental Engineering, Seoul, Korea)*
[*]*coolkdy11@gmail.com*

The electrochemical nitric oxide reduction reaction (NORR) to ammonia (NH_3) offers a sustainable pathway for clean energy and chemical production, with Copper (Cu) serving as a premier catalyst due to its high selectivity. However, the dynamic behavior of Cu under NORR conditions remains poorly understood. In this study, we investigate the potential-dependent morphological evolution of Cu nanoparticle catalysts using a flow-through electrochemical cell. Our results demonstrate that applying high overpotentials (-0.7 V RHE to -0.9 V RHE) triggers a dramatic transformation of spherical Cu nanoparticles into a distinctive bundled nanowire structure. This structural rearrangement leads to a nearly twofold increase in double-layer capacitance (CDL), driving a progressive rise in total current density over time. Comprehensive characterizations (SEM, XRD, XPS) reveal that this adaptive nanostructure propagates via a dynamic dissolution-redeposition mechanism, uniquely facilitated by the strong chemical interactions between Cu and NO or its reactive intermediate, hydroxylamine (NH_2OH). Crucially, long-term stability tests up to 24 hours prove that despite these dynamic morphological changes, the exceptional Faradaic efficiency for NH_3 is robustly sustained, maintaining up to 95% at -0.6 V RHE and achieving a maximum partial current density of 263 mA cm^{-2}. This work provides critical mechanistic insights into the self-adaptive behaviors of Cu-based catalysts, offering a key foundation for designing highly efficient electrocatalysts for nitrogen upcycling.

Keywords: Nitric oxide, NO reduction, Ammonia, Cu nanoparticle, Morphological Evolution

Acknowledgement

This work was partly supported by the Technology development Program of MSS [RS-2025-02222138] and the Korea Environmental Industry & Technology Institute (KEITI) through the 'Field-Driven Environmental Technology Commercialization R&D Program' (RS-2026-25505447), funded by the Ministry of Climate, Energy and Environment of the Republic of Korea.

P-58

Sustainable NO_X/SO_X Removal Utilizing a Large-Area Water Electrolysis Electrode System: Focusing on Fe(II)EDTA Regeneration Control

Beomseo Kim, Taeyoul Han, Taeil Kim, and DongYeon Kim*

Blueone, (Research Institute, Daejeon, Korea)
**coolkdy11@gmail.com*

Ferrous ethylenediaminetetraacetate (Fe(II)EDTA) has been widely investigated as an effective absorbent for simultaneous NO_X and SO_X removal because it can instantaneously capture NO with low solubility in water through the formation of Fe(II)EDTA-NO complexes. However, its practical application is limited by oxidative deactivation, where Fe(II)EDTA is converted to inactive Fe(III)EDTA by O_2, as well as by the reverse release of NO from Fe(II)EDTA-NO. Accordingly, continuous absorbent regeneration is essential for sustaining NO_X removal performance in wet scrubbing process.

In this study, we identify the the Fe(II)EDTA-NO/Fe(II)EDTA ratio as a governing parameter for $DeNO_X$ performance in Fe(II)EDTA-based absorption systems. Furthermore, to control this parameter, two strategies were suggested: a large-area water-electrolysis electrode system for the electrochemical reduction, chemical regeneration mediated by sulfite ions (SO_3^{2-}) captured during the $DeSO_X$ process. The electrochemical system effectively maintained the active Fe(II)EDTA concentration, and the reduction reaction was enhanced at higher Fe(III)EDTA concentrations. In addition, sulfite selectively reacted with Fe(II)EDTA-NO, suppressing NO release and promoting regeneration of the absorbent.

The combination of electrochemical and Sulfite-mediated regeneration processes showed a synergistic effect in lowering the Fe(II)EDTA-NO/Fe(II)EDTA ratio. During 5 h of operation, the integrated system achieved stable simultaneous removal with $DeNO_X$ · SO_X efficiencies of 90.7% and 99.9%, respectively. These results suggest that Fe(II)EDTA regeneration control based on the Fe(II)EDTA-NO/Fe(II)EDTA ratio is a promising strategy for sustainable NO_X · SO_X removal.

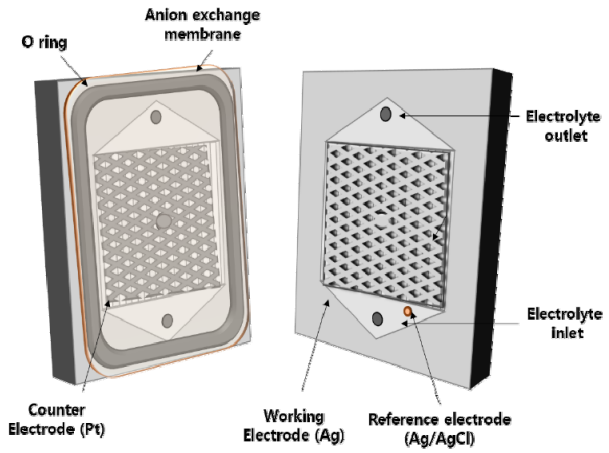


Figure 1. zero-gap water electrolysis cell

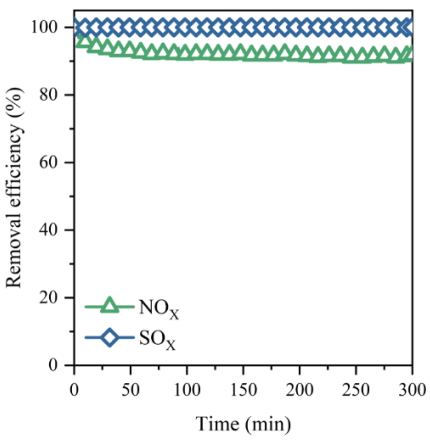


Figure 2. $DeNO_X/SO_X$ removal efficiency of Combination regeneration system

Keywords: Fe(II)EDTA, Electrolysis Electrode System, Simultenious-DeNO_X · SO_X, Wet-scrubbing, Absorbent regeneration

Acknowledgement

This work was supported by the Technology development Program [RS-2025-25438906] funded by the Ministry of SMEs and Startups(MSS, Korea)

P-59

Analysis between Flow-Accelerated Corrosion Surface Morphology and Hydrodynamic Parameter in SA106 Pipes with Elbows

J. Y. Lee*, S. I. Moon, D. J. Kim, J. J. Park, S. W. Kim.

Materials Safety Technology Research Division, Korea Atomic Energy Research Institute, Daejeon, Republic of Korea

In the secondary system of a nuclear power plant, pipe wall thinning due to flow-accelerated corrosion (FAC) has caused rupture accidents, resulting in economic losses and human injuries. Despite extensive research, the correlation between wall thinning and hydrodynamic parameters remains unclear. This study investigates the hydrodynamic parameters influencing FAC in elbow sections to identify high-risk locations. The experiment was designed to isolate the effect of hydrodynamic parameters on FAC by keeping other variables—such as temperature, water chemistry, and material composition—constant. While thermal and chemical factors tend to affect the internal pipe wall uniformly throughout the flow system, hydrodynamic parameters are strongly influenced by local geometry, particularly in elbows where non-uniform velocity profiles and turbulence dominate. Therefore, elbow regions are ideal for assessing how local flow conditions contribute to FAC development. Two experimental runs were conducted, each lasting 2000 hours under consistent operating conditions: flow velocity of 7 m/s, temperature of 150 °C, pressure of 10 atm, pH 7, and dissolved oxygen concentration below 5 ppb. Wall thinning due to FAC was measured before and after each test using a commercial ultrasonic thickness gauge (Olympus 38DL Plus, resolution = 10 μm) under room temperature conditions. This study investigated FAC-induced wall thinning in elbow sections through long-duration flow tests and surface morphology analysis using scanning electron microscopy (SEM). Under controlled chemical and thermal conditions, the experiment revealed that localized surface damage was significantly affected by both circumferential and axial velocity.

Acknowledgment

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Climate, Energy & Environment (MCEE) of the Republic of Korea (No. RS-2025-16065835).

Keywords: Flow-accelerated Corrosion, Surface Morphology, Hydrodynamic Parameters, Elbow

P-60

A study of Electrochemical Characterization of PolyvinylAlcohol(PVA)/Malonic Acid(MA) Cross-linked Aqueous Binders for Silicon Anodes

Jun-Gwon Lee, Tae-Hee Lee, and Kwon-Koo Cho*

Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea
**kkcho66@gnu.ac.kr*

Silicon is considered one of the most promising next-generation anode materials capable of replacing graphite in lithium-ion batteries (LIBs) because of its high theoretical capacity, high energy density, and low cost. However, silicon suffers from severe volume expansion during charge-discharge processes, which causes pulverization of the silicon active material and consequently deteriorates the electrochemical performance of the electrode. In this study, silicon electrodes employing a crosslinked water-soluble polymer binder composed of polyvinyl alcohol (PVA) and malonic acid (MA) were fabricated, and their electrochemical and mechanical properties were evaluated. The PVA-MA binder effectively suppressed the volume expansion of silicon and improved the mechanical stability of the electrode, resulting in enhanced cycling performance of the silicon-based electrode. The silicon electrode using PVA-10 wt.% MA exhibited and initial capacity of 3558 mAh/g at a 0.3 C-rate and maintained a high reversible capacity of 2267 mAh/g after 100 cycles, demonstrating excellent capacity retention.

Keywords: Lithium-ion batteries, Silicon, Cross-linked, Polyvinyl alcohol, Malonic acid

P-61

Design of high-loading sulfur electrode with interlayer formed by vacuum heat treatment and performance improvement of lithium-sulfur batteries

Mi-Ji Kim, and Kwon-Koo Cho*

Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea
**kkcho66@gnu.ac.kr*

Lithium-sulfur (Li-S) batteries have emerged as a promising next-generation energy storage system due to their high theoretical capacity (1675 mAh/g), energy density (2600 Wh/kg), and the abundance and low cost of sulfur. Despite these advantages, practical applications of Li-S batteries are hindered by challenges such as the low electrical conductivity of sulfur, significant volume changes during cycling, and the shuttle effect caused by the dissolution of lithium polysulfides (Li_2S_n) into the electrolyte. To address these issues, this study proposes a vacuum heat treatment process to create a porous desulfurization layer on the surface of sulfur electrodes, which acts as an interlayer to improve electrochemical performance.

The desulfurization layer, formed through the sublimation of sulfur during heat treatment, exhibited a thickness increase from 10 to 33 μm with increasing heating time. Electrochemical characterization revealed that the porous desulfurization layer significantly enhanced lithium-ion diffusion, with diffusion coefficients increasing by 100 to 1000 times compared to untreated electrodes. Additionally, the treated electrodes demonstrated higher initial capacities, with an 80min heat-treated electrode achieving 1006 mAh/g, indicating a substantial improvement in redox reaction kinetics.

This porous layer not only suppressed the dissolution of polysulfides but also facilitated electron transport and enhanced sulfur utilization, leading to improved electrochemical stability. The findings of this study highlight the potential of vacuum heat treatment as a simple yet effective strategy for designing high-performance sulfur electrodes, providing a practical pathway toward the commercialization of Li-S batteries.

Keywords: Lithium–sulfur battery, Vacuum heat treatment, Porous structure, Interlayer, Next-generation secondary batteries.

P-62

Electrochemically deposited sulfur electrode on stainless-steel current collector for lithium–sulfur battery applications

Da-woon Jeong[1], Gyu-Bong Cho[2], and Kwon-Koo Cho[1*]

[1] *Department of Materials Engineering and Convergence Technology, Gyeongsang National University, Jinju52828, Republic of Korea*
[2]*Research Institute for Green Energy Convergence Technology, Gyeongsang National University, Jinju 52828, Republic of Korea*
[*] *kkcho66@gnu.ac.kr*

Lithium–sulfur (Li–S) batteries have attracted significant attention as next-generation energy storage systems due to their high theoretical energy density (2600 Wh/kg) and theoretical capacity (1675 mAh/g), as well as the low cost and environmentally friendly nature of sulfur. However, their practical commercialization is hindered by several critical issues, including the low electrical conductivity of sulfur and the dissolution of lithium polysulfides during charge–discharge cycling, which leads to the shuttle effect. To address these problems, various approaches such as porous carbon structures, carbon interlayers, and polymer coatings have been extensively investigated. Nevertheless, these strategies are still limited by complex fabrication processes and relatively low sulfur contents (<60 wt%).

In this study, solid sulfur was electrochemically deposited onto a stainless-steel (STS) current collector to fabricate a sulfur electrode without binders or conductive additives. The sulfur growth behavior was systematically investigated as a function of deposition time (5, 15, 30, and 60 min). During the initial deposition stage, irregularly shaped fine particles were formed, whereas after 30 min of deposition, the particles gradually evolved into spherical structures. After 60 min, spherical sulfur particles with an average diameter of 5.2 μm completely covered the surface of the current collector.

Although the deposited sulfur electrode exhibited unstable discharge behavior due to weak adhesion between the sulfur layer and the current collector, the introduction of a conductive carbonized PAN (CPAN) interlayer enabled stable electrochemical reactions during charge–discharge cycling. Furthermore, to enhance cell performance, a glass fiber (GF) separator was applied together with the CPAN interlayer, and its electrochemical properties were compared with those of a commercial polypropylene (PP) separator. The GF-based cell demonstrated superior electrochemical performance compared to the PP-based cell, delivering a higher discharge capacity (1120 vs. 993 mAh/g at 0.1 C) and improved capacity retention (86.6% vs. 45.2% after 200 cycles at 0.2 C). From these results, the feasibility of utilizing this process for the fabrication of spherical sulfur powder and for the development of stable electrochemically deposited sulfur electrodes has been demonstrated.

Keywords: Electrochemical deposition, Spherical sulfur, Stainless steel, Li-S battery

P-63

Influence of Chelating Agents on the Microstructure and Electrochemical Performance of LATP Solid Electrolytes

Seul Ki Choi[1], Yu Na Lee[1], Yoon Myung[3], Chan Woong Na[3] and Minho Yang[1,2*]

[1]*Department of Hydrogen Energy, Dankook University, Cheonan, Korea*
[2]*Department of Energy Engineering, Dankook University, Cheonan, Korea*
[3]*Dongnam Regional Division, Korea Institute of Industrial Technology (KITECH), Busan, Korea*
[*]*mhyang@dankook.ac.kr*

NASICON-type $Li_{1.5}Al_{0.5}Ti_{1.5}(PO_4)_3$ (LATP) has attracted considerable attention as an oxide solid electrolyte due to its high ionic conductivity and excellent structural stability. In this study, the effects of different chelating agents, including citric acid (CA), acetylacetone (AcAc), and EDTA, on sol–gel synthesized LATP were systematically investigated. The chelating agents significantly influenced the crystallization behavior, microstructure, and electrochemical properties of LATP. Among the samples, citric acid-derived LATP (c-LATP) exhibited the highest density (2.8 g cm^{-3}), a uniform microstructure with ~2 μm grain size, and the highest ionic conductivity of 1.03 mS/cm. Symmetric Li/c-LATP/Li cells showed the lowest polarization and the most stable cycling behavior. Furthermore, Li/c-LATP/$LiFePO_4$ cells delivered superior electrochemical performance with 81% capacity retention after 100 cycles. These results demonstrate that chelating-agent selection is a key factor in optimizing LATP solid electrolytes for high-performance all-solid-state batteries.

Acknowledgement

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2022R1C1C1006536)

P-64

Effect of Hf, Al, Cr, Y, and B Additions on the Microstructure and Oxidation Behavior of Mechanically Alloyed Nb-Si-Ti Powders

DeokHyun Han[1,2], Jung-joon Kim[1], Youngkyun Kim[1], Jongmin Byun[3], and Byungmin Ahn[2,4*]

[1]*Center for Advanced Materials & Processing, Institute for Advanced Engineering, Yongin, Republic of Korea*
[2]*Department of Materials Science and Engineering, Ajou University, Suwon, Republic of Korea*
[3]*Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul, Republic of Korea*
[4]*Department of Energy Systems Research, Ajou University, Suwon, Republic of Korea*
[*]*byungmin@ajou.ac.kr*

Nb-Si-Ti-based alloys have attracted considerable attention as promising high-temperature structural materials for aerospace and power generation applications owing to their high melting point and excellent high-temperature strength. However, their practical application is still limited by insufficient fracture toughness and poor oxidation resistance under severe thermal exposure conditions. Therefore, alloy design through minor element addition and microstructural control is required to improve their mechanical and environmental stability.

In this study, Nb-Si-Ti alloy powders with different alloying designs were prepared by mechanical alloying using high-energy ball milling, and the effects of Hf, Al, Cr, Y, and B additions were investigated. The alloying behavior and phase evolution of the mechanically alloyed powders were analyzed using X-ray diffraction (XRD), X-ray fluorescence spectroscopy (XRF), and microstructural observations. The effects of minor alloying elements on crystallite refinement, phase constitution, powder morphology, and microstructural homogeneity were also examined.

The influence of Hf, Al, Cr, Y, and B additions on the formation of Nb solid solution and silicide phases, including Nb_5Si_3, was analyzed in relation to microstructural refinement and hardness variation. Oxidation tests were performed to compare oxidation resistance depending on alloy composition, and the microstructure after oxidation was examined to investigate oxide scale formation and oxidation-induced microstructural changes.

This study aims to clarify the relationship between minor alloying element addition, phase evolution, microstructure, hardness, and oxidation behavior in mechanically alloyed Nb-Si-Ti powders. The findings are expected to provide useful guidelines for designing advanced Nb-based high-temperature alloy powders with improved mechanical stability and oxidation resistance.

Keywords: Nb-Si-Ti alloy, Mechanical alloying, Minor alloying elements, Microstructure, Oxidation resistance

P-65

Synthesis of homogeneous W-Mo alloy by ultrasonic spray pyrolysis and spark plasma sintering

Wonyong Kwon, Eui Seon Lee, Ji Young Kim, Jongmin Byun, and Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea
**stoh@seoultech.ac.kr*

Tungsten-molybdenum (W-Mo) alloys have attracted considerable attention as structural materials for extreme environments, including nuclear reactors, aerospace, and high-voltage/current electrical applications, owing to their high melting point, low coefficient of thermal expansion, and excellent high-temperature strength. However, due to the high melting point and ductile-brittle transition temperature (DBTT), the application of powder metallurgy technology is required to manufacture W-Mo alloys with uniform composition and complex shapes. In particular, to obtain fully densified W-Mo alloys, the synthesis of homogeneous alloy powders with nanoscale and pressure-assisted sintering is required. In this regard, W-Mo alloy powders have typically been fabricated via mechanical alloying methods and sol-gel techniques combined with hydrogen reduction, but these methods were susceptible to contamination, process complexity, and elemental heterogeneity. Hence, the solution-based ultrasonic spray pyrolysis (USP) method has recently been introduced due to its significant advantages, such as a variety of precursors, atomic homogeneity, easily controllable particle sizes, and the capability for continuous production. Thus, in this study, we aimed to synthesize homogeneous W-Mo alloy nano-spheres via USP combined with a subsequent hydrogen reduction process and tried to densify the W-Mo alloys with various sintering methods. As precursors, the ammonium metatungstate hydrate and ammonium molybdate tetrahydrate were utilized and dissolved in deionized water to a target concentration of 25 mM. The solution was nebulized into microdroplets with a frequency of 1.7 MHz. The microdroplets were then dried at 200°C and pyrolyzed at 500°C continuously, following a nitrogen carrier gas flow rate of 2 L/min. The as-synthesized W-Mo-O microspheres were post-annealed at 500°C for 1 h in an air atmosphere to obtain a high-crystalline $W_{0.5}Mo_{0.5}O_3$ phase. Finally, the W-Mo alloy powder was prepared after hydrogen reduction at 750°C for 1 h. The as-prepared W-Mo alloy powders were densified using spark plasma sintering and conventional sintering processes. The morphology and phase of powders were analyzed by SEM, TEM, XRD, XPS, and TG-DTA. The density and hardness of the sintered bodies were measured by Archimedes' principle and the Vickers' hardness test. This study suggests a promising way for synthesizing elementally homogeneous W-Mo alloy powders and fabricating dense W-Mo bodies.

Keywords: W-Mo alloy, ultrasonic spray pyrolysis, hydrogen reduction, spark plasma sintering

P-66

Isothermal carbothermal behaviors and microstructures of HfC and TaC nanoparticles according to the synthesis process conditions

Minju Son, Eui Seon Lee, Jongmin Byun, and Sung-Tag Oh*

Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea
**stoh@seoultech.ac.kr*

Ultra-high temperature ceramics (UHTCs), composed of transition metal carbides and borides from groups Ⅳ to Ⅵ of the periodic table, have attracted considerable attention as structural materials for extreme environments due to their extremely high melting points (> 3000 ℃) and superior high-temperature properties. In particular, HfC and TaC have been suggested as promising materials for hypersonic vehicles and atmospheric re-entry systems owing to their extremely high melting points (> 3900 ℃), excellent wear and chemical resistances, and good phase stability over wide temperature ranges. Meanwhile, they were generally synthesized via powder metallurgy routes followed by ultra-high-temperature sintering. One of the powder fabrication methods, the carbothermal reduction (CTR) process under atmospheric pressure, has been widely employed to synthesize HfC and TaC micron powders due to its simplicity, efficiency, and cost-effectiveness. However, conventional CTR processes require ultra-high temperatures for long periods, which can lead to severe particle coarsening. In this regard, an innovative method for synthesizing UHTC nanoparticles with low impurity levels at low temperatures has been recently introduced, utilizing a rapid thermal cycle with a high-vacuum atmosphere CTR process in a pressure-free spark plasma sintering (SPS) system. This approach could decrease CTR temperatures thermodynamically and promote mass transfer through pulsed electric current, thereby suppressing particle growth and shortening processing time. Meanwhile, the CTR behavior under a vacuum has not been kinetically demonstrated. Therefore, in this study, to investigate the effect of atmosphere on CTR kinetics and powder synthesis behavior, we tried to synthesize HfC and TaC nano-powders under vacuum and Ar atmospheres. For that, HfO_2 and Ta_2O_5 were homogeneously mixed with activated charcoal and synthesized into HfC at 1300-1500 ℃ and TaC at 1100-1300 ℃ under isothermal conditions. The effect of the vacuum atmosphere was evaluated from XRD results, and the morphology and size of the as-synthesized powders were analyzed. As a result, the decrease in CTR temperatures and particle size dependence as a function of synthesis atmospheres were demonstrated. In addition, SEM and elemental analyses revealed a significant suppression of particle growth, resulting in reduced particle sizes and impurity levels. This study provides reaction kinetics and synthesis behavior of high-purity UHTC nanoparticles, as well as the effect of working parameters on the CTR kinetics.

Keywords: Ultra-high temperature ceramics, Carbothermal reduction, Synthesis behavior, Reduction kinetics, Nano-powder

P-67

Simultaneous enhancement of the thermal conductivity and fracture toughness of AlN ceramics via incorporation of boron nitride nanotubes

Byeongsoo Park[1,2], Dae-Ho Yoon[1], Sung-Soo Ryu[2*]

[1]*Department of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon 16419, Republic of Korea*
[2]*Engineering Materials Center, Korea Institute of Ceramic Engineering and Technology, Icheon 17303, Republic of Korea*
[*]*ssryu@kicet.re.kr*

Aluminum nitride (AlN) ceramics are widely used as substrates for electronic packaging owing to their high thermal conductivity and electrical insulating properties; however, their limited structural reliability constrains their range of applications. Although the incorporation of plate-like hexagonal boron nitride (h-BN) improves mechanical properties, the accompanying development of *c*-axis preferred orientation reduces thermal conductivity and introduces directional dependence in fracture toughness. In this study, h-BN, nanosized BN (nano-BN), and boron nitride nanotubes (BNNTs) were each introduced into an AlN matrix at an identical content of 5 wt%, and the effects of the initial BN morphology on microstructure formation and thermomechanical properties were investigated. After tape casting, the h-BN and nano-BN specimens exhibited *c*-axis preferred orientation, with orientation preference indices (I_{OP}) of 37.31 and 4.20, respectively, whereas the BNNT specimen retained an isotropic distribution (I_{OP} = 0.98). During sintering, the BNNTs transformed into the h-BN crystalline phase via oxidative unzipping, and in this process, grain-boundary oxygen in the vicinity of the BN was locally consumed. Consequently, the through-plane thermal conductivity of the h-BN and nano-BN specimens decreased by 22–36% relative to that of BN-free AlN (149 $W \cdot m^{-1} \cdot K^{-1}$), and the difference in fracture toughness between the casting plane and the cross-section reached 0.76–1.20 $MPa \cdot m^{1/2}$. In contrast, the BNNT specimen maintained a through-plane thermal conductivity of 151 $W \cdot m^{-1} \cdot K^{-1}$ and exhibited fracture toughness of 5.28 and 5.26 $MPa \cdot m^{1/2}$ on the casting plane and the cross-section, respectively, corresponding to an isotropic enhancement of approximately 65% relative to BN-free AlN. These results demonstrate that BNNT incorporation simultaneously avoids the *c*-axis preferred orientation and grain-boundary oxygen retention inherent to plate-like BN, thereby providing a processing route that resolves the trade-off between the reduction in thermal conductivity and the directional dependence of fracture toughness.

Keywords: Aluminum nitride, Boron nitride nanotubes, Tape casting, Preferred orientation, Oxidative unzipping, Grain-boundary chemistry

P-68

Effect of BN particle Size on the Sintering Behavior and Properties of Si_3N_4 Ceramics

Na-Young Kim[1,2], Yong-Ho Choa[3], Bo-Ram Lee[2], Sung-Soo Ryu[1*]

[1] *Cross-Functional Ceramic R&D Group, Korea Institute of Ceramic Engineering and Technology, Icheon 17303, Republic of Korea*
[2] *School of Advanced Materials Science and Engineering, SungKyunKwan University, Suwon 16419, Republic of Korea*
[3] *Department of Materials Sciences & Chemical Engineering, HanYang University, Ansan 15588, Republic of Korea*
[*] *ssryu@kicet.re.kr*

In recent power semiconductor modules, Si semiconductors have been replaced by SiC semiconductors, leading to a trend toward higher voltage, higher power density, and device miniaturization. Consequently, there is a growing demand for advanced heat-dissipating substrates that can effectively release heat generated from semiconductors while withstanding thermal shock. Conventional Al_2O_3 substrates exhibit low thermal conductivity and fracture toughness, making them prone to thermal shock-induced failure when applied to SiC devices. In contrast, Si_3N_4 is considered a promising substrate material owing to its superior thermal and mechanical properties and relatively low coefficient of thermal expansion. However, its poor machinability remains a drawback, and thus extensive research has been conducted on the incorporation of hexagonal boron nitride (h-BN), which possesses a low friction coefficient and excellent thermal shock resistance.

When micro-sized h-BN is incorporated, it tends to agglomerate within the Si_3N_4 matrix, leading to structural defects. Furthermore, under the applied pressure during sintering, the h-BN particles can develop a preferred orientation, which may adversely affect the thermal properties of the composites. To overcome these challenges, this study introduces nano-sized h-BN, which not only improves dispersion but also mitigates the orientation effect, thereby enhancing the overall properties of the composites.

In this study, Si_3N_4–BN composites were fabricated with varying amounts of nano- and micro-sized h-BN to investigate their effects on microstructure, fracture toughness, and thermal conductivity. The powders, including Si_3N_4, Y_2O_3, and MgO, were mixed by ball milling and subsequently sintered via spark plasma sintering (SPS) at 1800 °C for 10 min under a uniaxial pressure of 30 MPa in a vacuum atmosphere. Post-sintering analysis revealed that composites containing nano h-BN exhibited better densification and more uniform dispersion compared to those with micro h-BN. Furthermore, the $\alpha \rightarrow \beta$ phase transformation of Si_3N_4 proceeded more effectively in the presence of nano h-BN. While thermal conductivity decreased with increasing BN content regardless of particle size, fracture toughness improved for both BN types. Notably, nano h-BN enhanced fracture toughness by more than 20% compared to micro h-BN at equivalent contents

Keywords: Silicon Nitride, h-BN, nano/micro size, Thermal conductivity, Mechanical properties

P-69

Hydrogen Flame-Induced Degradation of Refractories for Glass Melting Furnaces

Keonhee Cho[1,2*], Junsu Lee[1,3], and Junghun Kim[1*]

[1]*Korea Institute of Ceramic Engineering and Technology*
[2]*Hanyang University*
[3]*Sungkyunkwan University*

Since the Paris Agreement in 2015, achieving carbon neutrality has become an unavoidable challenge for the glass manufacturing industry. Accordingly, the glass melting process is transitioning from conventional fossil-fuel-based combustion to hydrogen-fueled systems to reduce carbon emissions. Under these emerging operating conditions, it is essential to evaluate the high-temperature behavior of refractory materials and their resistance to hydrogen flame environments. In this study, we systematically investigated the degradation behavior of refractory materials used in glass melting furnaces under hydrogen flame exposure. Among the candidate materials, four representative alumina- and silica-based refractories were selected and experimentally evaluated. The results provide fundamental insights into the durability and suitability of conventional glass-furnace refractories under hydrogen combustion conditions.

Keywords: Hydrogen Gas, Refractory, Glass Melting Process, Carbon Neutrality

P–70

Thermal durability and fracture behavior of YSZ-based thermal barrier coatings in thermal cyclic exposure

Byoungchul Hwang[1*], Sang-Gyu Kim[1], Hee-Chang Shin[1], Seung-Cheol Yang[2], Junseong Kim[2], Han-Sang Lee[2], Jungkeuk Park[3]

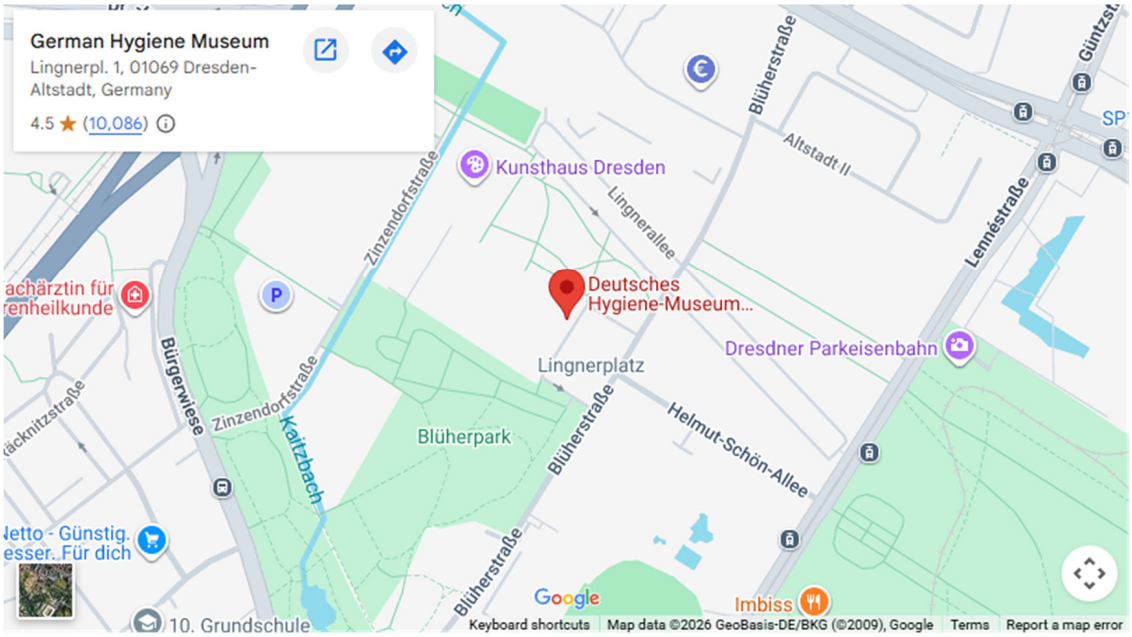
[1]*Department of Materials Science and Engineering, Seoul National University of Science and Technology, Seoul 01811, Republic of Korea*
[2]*Department of Materials Convergence and System Engineering, Changwon National University, Changwon 51140, Republic of Korea*
[3]*Power Generation Laboratory, Korea Electric Power Company Research Institute, Daejeon 34056, Republic of Korea*
[*]*bhwang@seoultech.ac.kr*

Thermal barrier coatings (TBCs) are essential for protecting the hot-section components of gas turbines and combustors operating in high-temperature environments. This study investigates the thermal durability and fracture behavior of yttria-stabilized zirconia (YSZ)-based TBCs, focusing on the effects of two bond-coating processes: low vacuum plasma spray (LVPS) and high-velocity oxygen-fuel (HVOF). TBCs were applied to IN792 superalloy substrates, followed by evaluation under jet engine thermal shock (JETS) tests simulating rapid temperature changes. Microstructural analysis was conducted before and after testing to assess the thermally grown oxide (TGO) layer and crack propagation. Results indicate that HVOF-coated samples demonstrated superior thermal shock resistance, with a longer failure cycle life (365±77 cycles) compared to LVPS-coated samples (247±0 cycles). Enhanced durability in HVOF coatings is attributed to the formation of a dense, stable α -Al2O3 TGO layer, which effectively reduces thermal stress and spallation during cyclic exposure. In contrast, the LVPS coatings exhibited a thicker, coarse TGO layer, leading to higher thermal stresses and premature failure. This study underscores the critical role of bond-coating processes in optimizing TBC performance, emphasizing the need for controlled microstructural features to balance thermal resistance and mechanical integrity

Keywords: Thermal barrier coating (TBC), Low vacuum plasma spray (LVPS), High-velocity oxygen-fuel (HVOF), Jets engine thermal shock (JETS), Fracture behavior

Venue (Mon.–Wed.): Deutsches Hygiene-Museum Dresden

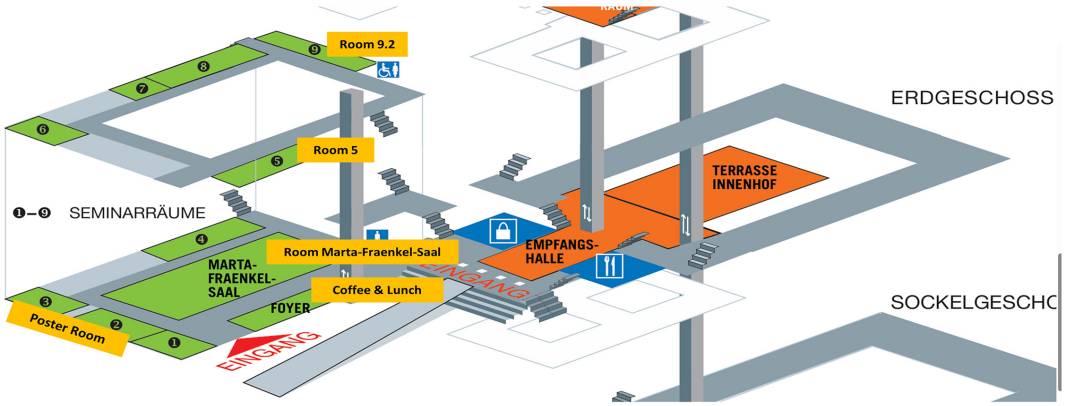
DEUTSCHES HYGIENE-MUSEUM DRESDEN



Location & Accessibility

- Address: Deutsches Hygiene-Museum Dresden, Lingnerplatz 1, 01069 Dresden, Germany
- Located Just a 15 minutes walk from the Frauenkirche in the Dresden city centre!
- Easily reachable by tram: Stop “Georg-Arnhold-Bad/Deutsches Hygiene-Museum”.
- Within walking distance of major landmarks, such as the Frauenkirche.

Layout



Venue (Thu.): Fraunhofer Institute

Fraunhofer

Location & Accessibility

- Address: Winterbergstraße 28, 01277 Dresden, Germany
- Conveniently accessible from the Main Venue (Deutsches Hygiene-Museum) via public transport.

Directions from Main Venue

- Step 1 (Walk): 8-minute walk (550m) from Deutsches Hygiene-Museum to the tram stop of the same name.
- Step 2 (Tram): Board Tram Line 1 (toward Prohlis) and ride for 5 stops.
- Step 3 (Arrival): Exit at Zwinglistraße station.
- Step 4 (Final Walk): A short 8-minute walk (600m) leads directly to the Fraunhofer Institute (IWS).

Social Program

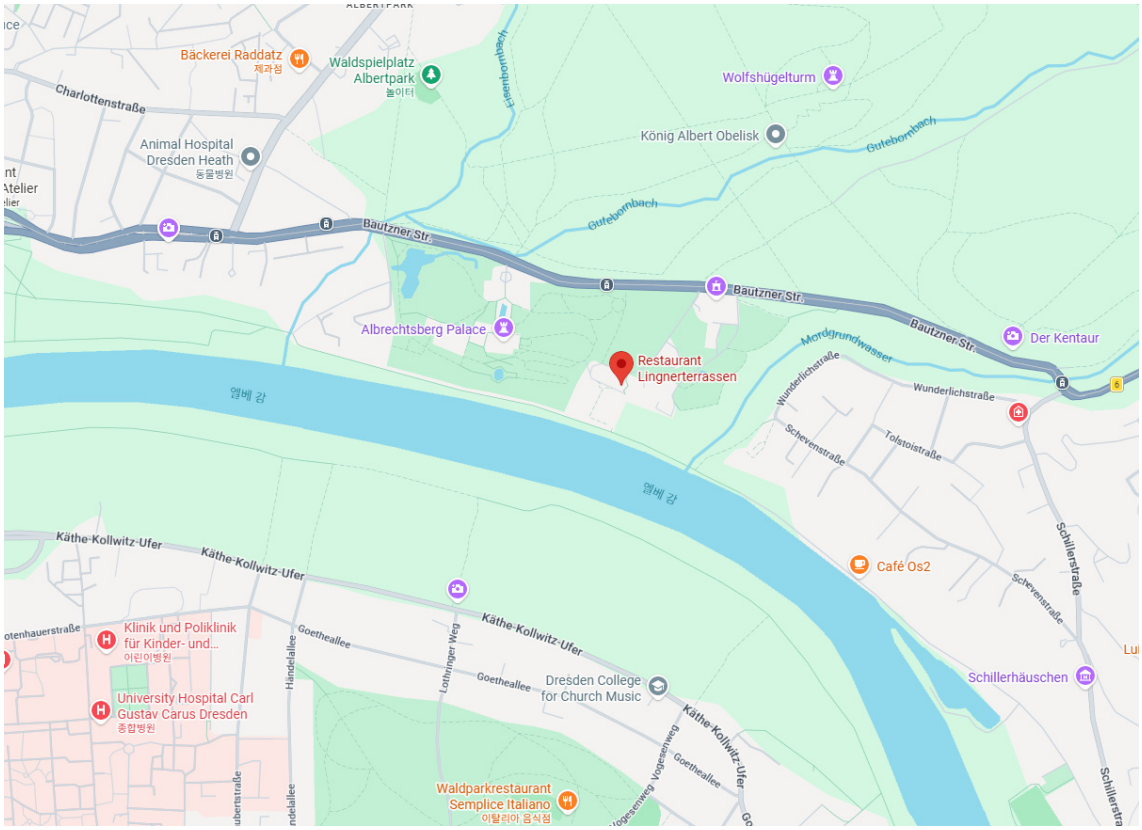
Friendship Dinner

- Time: 19:00, Monday, July 13
- Location: **Restaurant Lingnerterrassen**
- Address: Bautzner Str. 132, 01099 Dresden-Loschwitz, Germany

Directions to Restaurant Lingnerterrassen

- **Walk:** From Deutsches Hygiene-Museum to **Dresden Walpurgisstraße** stop (Approx. 15 min.)
- **Tram 11:** Take toward Dresden Bühlau and ride for 15 stops
- **Get Off:** Exit at **Dresden Elbschlösser** station.
- **Walk:** Final 10 minute walk to Restaurant Lingnerterrassen

Transportation Guide



Social Program

Gala Dinner

- Time: 18:30, Wednesday, July 15
- Location: Ballhaus Watzke
- Address: Kötzschenbroder Str. 1, 01139 Dresden

Directions to Ballhaus Watzke

- **Walk:** From **Deutsches Hygiene-Museum** to **Dresden Deutsches Hygiene-Museum** stop (Approx. 9 min).
- **Tram 9:** Take toward **Kaditz** and ride for 12 stops.
- **Get Off:** Exit at **Dresden Altpieschen** station.
- **Walk:** Final 1-minute walk to **Ballhaus Watzke** (Kötzschenbroder Str. 1).

Transportation Guide

Organized by

kpmi
Korean Powder Metallurgy & Materials Institute

Supported by

KEIT

Fraunhofer

Fraunhofer IFAM (Dresden Branch of the Institute),
Fraunhofer IKTS, Fraunhofer IWS, Fraunhofer FEP

Sponsored by

Höganäs

ASFLOW

MTIG
Material Technical Innovation Group

BK AMSOL 비케이엠솔

KPM
Korea Powder Metallurgy Co., Ltd.

DIF (주)동양아이에프

Eloi MateriaLs EML

MK

ISNNM & EKAMP 2026 Secretariat
The Korean Powder Metallurgy & Materials Institute
Room706 (The 1st building), 22, Teheran-ro 7 Gil,
Gangnam-gu, Seoul, Republic of Korea
TEL: +82-2-539-4603 , FAX: +82-0303-0947-4603
Homepage: https://isnnm.org / E-mail: secretariat@isnnm.org