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Symposium PM04 : High-Entropy Alloys

Nov 26

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Symposium Organizers

Haruyuki Inui, Kyoto University

C. Cem Tasan, Massachusetts Institute of Technology

Easo George, Oak Ridge National Laboratory

Dierk Raabe, Max Planck Institute for Iron Research

Symposium Support

JEOL USA, Inc.

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PM04.01: Mechanical Properties and Cryogenic Phenomena

Session Chairs

Monday AM, November 26, 2018

Hynes, Level 1, Room 105

8:30 AM - *PM04.01.01

Damage-Tolerance in Medium- and High-Entropy CrCoNi Alloys

[Robert Ritchie](#)^{1,2}, [Jun Ding](#)², [Mark Asta](#)^{1,2}, [Bernd Gludovatz](#)³, [Easo George](#)⁴, [Qing Yu](#)⁵

University of California, Berkeley¹, Lawrence Berkeley National Laboratory², University of New South Wales³, Oak Ridge National Laboratory⁴, Zhejiang University⁵

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9:00 AM - PM04.01.02

Low-Temperature Deformation Pathways of a High-Entropy Alloy by *In Situ* Neutron Diffraction

[Muhammad Naeem](#)¹, [Haiyan He](#)¹, [Bing Wang](#)¹, [Stefanus Harjo](#)², [Takuro Kawasaki](#)², [Si Lan](#)¹, [Zhenduo Wu](#)¹, [Hailong Huang](#)³, [Fan Zhang](#)³, [Zhaoping Lu](#)³, [Xun-Li Wang](#)¹

City University of Hong Kong¹, Japan Atomic Energy Agency², University of Science and Technology Beijing³

 Hide Abstract

High-entropy alloys, which consist of five or more alloying elements in equal molar ratios, are an intriguing new class of structural materials. Despite the complex chemistry, they can form a single phase solid-solution with an incredibly simple lattice. CrMnFeCoNi is a face-centered cubic (FCC), for example. Several deformation mechanisms are known to operate in high-entropy alloys. At room temperature, CrMnFeCoNi deforms like a conventional FCC alloy, showing clear stages of dislocation slip and dislocation entanglement. At liquid-nitrogen temperature, the dominant deformation mechanism changes from dislocation to twinning, leading to high strength and large ductility. Here we show that, at even lower temperature, the serrated deformation dominates. Deformation behavior of CrMnFeCoNi high-entropy alloy was studied at 15K by *in-situ* neutron diffraction, to obtain insights of the effect of low temperature on the underlying deformation mechanism and the corresponding evolution of structure. Due to the highly penetrating power of neutrons, the *in-situ* neutron diffraction is a powerful tool to capture changes in phase and deformation mode. The *in-situ* neutron diffraction data thus obtained clearly revealed crossover of different mechanisms and their demarcation points with deformation. The ultra-high strength of ~ 2.5 GPa was achieved for the single phase CrMnFeCoNi high-entropy alloy with enhanced ductility at 15K mediated by serrated deformation, thus overcoming the strength-ductility trade-off, and showing the potential of this alloy for structural applications at low temperatures.

9:15 AM - PM04.01.03

Peculiarities of Deformation of CoCrFeMnNi at Cryogenic Temperatures

Alexander Kauffmann¹, Aditya Srinivasan Tirunilai¹, Jan Sas¹, Klaus-Peter Weiss¹, Hans Chen¹, Dorothee Vinga Szabó¹, Sabine Schlabach¹, Sebastian Haas², David Geissler³, Jens Freudenberger³, Martin Heilmaier¹

Karlsruhe Institute of Technology (KIT)¹, University Bayreuth², IFW Dresden³

 Show Abstract**9:30 AM - PM04.01.04**

Strain Hardening in Face Centered Cubic High Entropy Alloys

Feng He^{1,2}, Zhijun Wang², Jincheng Wang², C. Cem Tasan¹

Massachusetts Institute of Technology¹, Northwestern Polytechnical University²

 Show Abstract**9:45 AM - PM04.01.05**

Microstructure and Mechanical Properties of Yttrium-Doped Bulk CrMnFeCoNi High-Entropy Alloys by Spray Forming

Zhouran Zhang¹, Atsushi Sato¹, Patrick Grant¹

University of Oxford¹

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**10:00 AM -
BREAK**

PM04.02: Local Structure and Mechanical Properties

Session Chairs

Monday AM, November 26, 2018
Hynes, Level 1, Room 105

10:30 AM - *PM04.02.01

Universal Relation Between Critical Resolved Shear Stress and Mean Square Atomic Displacement in Random High Entropy Alloys

Shigenobu Ogata^{1,2}, Haruyuki Inui², Vei Wang³

Osaka University¹, Kyoto University², Xi'an University of Technology³

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11:00 AM - PM04.02.02

Property Targeted Quantitative Design of Complex Concentrated Alloys

Hyunseok Oh¹, SangJun Kim¹, Khorgolkhuu Odbadrakhk², Wookha Ryu¹, Kooknoh Yoon¹, Sai Mu³, Fritz Körmann⁴, Yuji Ikeda⁴, C. Cem Tasan⁵, Dierk Raabe⁴, Takeshi Egami^{3,6}, Eun Soo Park¹

Seoul National University¹, Joint Institute for Computational Sciences, University of Tennessee and Oak Ridge National Laboratory², Oak Ridge National Laboratory³, Max-Planck-Institut für Eisenforschung⁴, Massachusetts Institute of Technology⁵, University of Tennessee⁶

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11:15 AM - PM04.02.03

Variable Chemical Order Opens a New High-Entropy Playground

Qing-Jie Li¹, Howard Sheng², Evan Ma¹

Johns Hopkins University¹, George Mason University²

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11:30 AM - PM04.02.04

Tunable Stacking Fault Energies by Tailoring Local Chemical Order in CrCoNi Medium-Entropy Alloys

Sheng Yin², Jun Ding¹, Qin Yu¹, Mark Asta^{1,2}, Robert Ritchie^{1,2}

Lawrence Berkeley National Laboratory¹, University of California, Berkeley²

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11:45 AM - PM04.02.05

Lattice Distortion Measurement Using HR-STEM

Yi Chou¹, Chanho Lee², Peter Liaw², Yi-Chia Chou¹

National Chiao Tung University¹, The University of Tennessee²

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PM04.03: Elementary Deformation Mechanisms

Session Chairs

Monday PM, November 26, 2018
Hynes, Level 1, Room 105

1:30 PM - *PM04.03.01

In Situ TEM Characterization on Deformation of NiCrCo Alloy at Room and Cryogenic Temperature

Scott Mao⁴, Qian Yu¹, Robert Ritchie², Easo George³, Hongbin Bei³, Bernd Gludovatz²

Zhejiang University¹, University of California Berkeley², Oak Ridge National Laboratory³, University of Pittsburgh⁴

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2:00 PM - PM04.03.02

In Situ TEM Straining Experiments in A3S and Cantor's HEA Alloys at Liquid Nitrogen and Room Temperature

Marc Legros¹, Michal Mroz², Anna Fraczkiewicz²

CEMES CNRS¹, Ecole des Mines de Saint Etienne²

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2:15 PM - PM04.03.03

TEM/STEM Investigations of the TRIP Effect in a Dual-Phase High-Entropy Alloy

Wenjun Lu¹, Zhiming Li¹, Christian H Liebscher¹, Gerhard Dehm¹, Raabe Dierk¹

Max-Planck-Institut für Eisenforschung GmbH¹

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2:30 PM - PM04.03.04

Light Weight High Entropy Alloys for Cryogenic Applications

Kooknoh Yoon¹, Hyunseok Oh¹, Eun Soo Park¹

Seoul National University¹

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2:45 PM - PM04.03.05

Multiscale Modeling of Mechanical Behavior of AlxCrCoFeNi High-Entropy Alloy

Zhenhai Xia^{4,1}, Yu-Chia Yang¹, Cuixia Liu², Chun-Yu Liu¹, Jeffrey Lloyd³

University of North Texas¹, Xi'an Technological University², U.S. Army Research Laboratory³, Northwestern Polytechnical University⁴

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**3:00 PM -
BREAK**

PM04.04: Microstructure Control for Mechanical Properties

Session Chairs

Monday PM, November 26, 2018
Hynes, Level 1, Room 105

3:30 PM - *PM04.04.01

Microstructure Control and Resultant Change in Mechanical Properties in High Entropy Alloys

Nobuhiro Tsuji^{1,2}, Tilak Bhattacharjee², Yu Bai¹, Nokeun Park³, Shu Kurokawa¹, Pinaki Bhattacharjee⁴, Rajeshwar Eleti¹, Shuhei Yoshida¹

Kyoto University¹, ESISM, Kyoto University², Yeungnam University³, Indian Institute of Technology Hyderabad⁴

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4:00 PM - PM04.04.02

Design of Non-Equiatomic FeNiCoAl-Based High Entropy Alloys with Heterogeneous Lamella Structure Towards Strength-Ductility Synergy

Cheng Zhang¹, Chaoyi Zhu¹, Tyler Harrington¹, Kenneth Vecchio¹

University of California San Diego¹

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4:15 PM - PM04.04.03

Microstructural Design to Improve the Mechanical Properties of an Interstitial TRIP-TWIP High-Entropy Alloy

Jing Su¹, Z. Li¹, Dierk Raabe¹

Max-Planck-Institut für Eisenforschung GmbH¹

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4:30 PM - PM04.04.04

Pressure-Induced Phase Modifications in Al-Based High-Entropy Alloys $\text{Al}_x\text{CoCrFeNi}$ ($x=0.1, 0.3, 0.75, 1.5$)

Chenxu Wang¹, Cameron Tracy¹, Sulgiye Park¹, Chien-Hung Chen¹, Tengfei Yang², Congyi Li², Yugang Wang³, Yong Zhang⁴, Wendy Mao¹, Rodney Ewing¹

Stanford University¹, The University of Tennessee, Knoxville², Peking University³, University of Science and Technology Beijing⁴

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4:45 PM - PM04.04.05

Structural Screening of FCC and BCC Thin-Film HEAs Using Compositional Gradient Samples

Azin Akbari¹, Artashes Ter-Isahakyan¹, John Balk¹

University of Kentucky¹

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PM04.05: Poster Session

Session Chairs

Easo George
Haruyuki Inui
Dierk Raabe

Monday PM, November 26, 2018
Hynes, Level 1, Hall B

8:00 PM - PM04.05.01

Microstructure, Mechanical Properties and Wear Performance of Ultrafine-Grained CrFeNi-Based Medium Entropy Alloys

Fuzeng Ren¹, Dingshan Liang¹, Weiwei Zhu¹, Cancan Zhao¹

Southern University of Science and Technology¹

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8:00 PM - PM04.05.02

Bicontinuous BCC HEA/Cu Nanocomposite Made by Liquid Metal Dealloying Process

Kooknoh Yoon¹, Ilhwan Kim¹, Eun Soo Park¹

Seoul National University¹

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8:00 PM - PM04.05.03

Spacegroup Monte Carlo Method Applied on Configurational Entropy of High Entropy Alloys

Guan-Rong Huang², Yu Cheng Chen¹, J.P Chou³, Peter Liaw⁴, J.W. Yeh⁵, Alice Hu³

National Chiao Tung University¹, National Center for Theoretical Sciences², City University of Hong Kong³, The University of Tennessee, Knoxville⁴, National Tsing Hua University⁵

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8:00 PM - PM04.05.04

Tailoring Strength and Ductility of Non-Equiatomic Ti-V-Nb-Ta-Mo High Entropy Alloys

SangJun Kim¹, Hyunseok Oh¹, Eun Soo Park¹

Seoul National Univ¹

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8:00 PM - PM04.05.06

Microstructure of a New Type of Co and Ni Based High Entropy Alloys

Florian Pyczak¹, Daniel Laipple¹, Andreas Stark¹, Marcus Rackel¹

Helmholtz-Zentrum Geesthacht¹

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8:00 PM - PM04.05.07

High-Entropy Ceramics of Five-Component, Equimolar, Rare-Earth (RE) Oxides

Kuo-Pin Tseng¹, Waltraud Kriven¹

University of Illinois at Urbana-Champaign¹

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8:00 PM - PM04.05.09

Ordering in a Series of Al-Containing Refractory High Entropy Alloys Ta-Nb-Mo-Cr-Ti-Al

Alexander Kauffmann¹, Hans Chen¹, Sascha Seils¹, Torben Boll¹, Sandra Kauffmann-Weiss¹, Ian Harding², Sharvan Kumar², Dorothée Vinga Szabó¹, Sabine Schlabach¹, Christian H Liebscher³, Franz Müller⁴, Bronislava Gorr⁴, Hans-Jürgen Christ⁴, Martin Heilmaier¹

Karlsruhe Institute of Technology (KIT)¹, Brown University², Max-Planck-Institut für Eisenforschung GmbH³, Universität Siegen⁴

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8:00 PM - PM04.05.10

Possible Correlation Between Strength and Mean Square Atomic Displacement in Cr-Mn-Fe-Co-Ni High Entropy Alloys

Kodai Niitsu¹, Makoto Asakura¹, Norihiko Okamoto², Koretaka Yuge¹, Kyosuke Kishida¹, Haruyuki Inui¹, Takashi Fukuda³, Tomoyuki Kakeshita³

Kyoto University¹, Tohoku University², Osaka University³

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8:00 PM - PM04.05.11

Anomalous X-Ray Scattering Study of the Local Structure of Mo Atoms in FeCoCrNiMox (x = 0.11 and 0.23) High Entropy Alloys

Haiyan He¹, Bing Wang¹, Si Lan^{1,2}, Jacob Ruff³, Chain Tsuan Liu¹, Xun-Li Wang¹

City University of Hong Kong¹, Nanjing University of Science and Technology², Cornell University³

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8:00 PM - PM04.05.12

Plastic Deformation of Single Crystals of a Cr-Co-Ni Equiatomic Medium Entropy Alloy

Kazuki Ehara¹, Makoto Asakura¹, Kodai Niitsu¹, Kyosuke Kishida¹, Haruyuki Inui¹

Kyoto University¹

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8:00 PM - PM04.05.13

Effect of Impurity Solute Atoms on Strength of α -Al (fcc) Single-Crystal Micropillars

Soichiro Takeyasu¹, Naoki Takata¹, Asuka Suzuki¹, Makoto Kobashi¹

Nagoya University¹

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8:00 PM - PM04.05.14

Micropillar Compression Deformation of Single-Crystal in CrMnFeCoNi High-Entropy Alloy

Zhenghao Chen³, Norihiko Okamoto^{1,2}, Shu Fijimoto³, Yuki Kambara³, Marino Kawamura³, Hirokata Matunoshita³, Katsushi Tanaka⁴, Haruyuki Inui^{3,2}, Easo George⁵

Tohoku University¹, Center for Elements Strategy Initiative for Structure Materials², Kyoto University³, Kobe University⁴, Ruhr University Bochum⁵

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