JOM, Vol. 65, No. 12, 2013
DOI: 10.1007/s11837-013-0788-8


# Progress in High-Entropy Alloys

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Strictly speaking, high-entropy alloys (HEAs) refer to single-phase, solid-solution alloys with multiprincipal elements in an equal or a near-equal molar ratio whose configurational entropy is tremendously high. But most research reports concern alloys that contain more than one phase partly for the purpose of obtaining balanced mechanical properties. As a result, there is no limit to the alloy system and composition of "HEAs" and, thus, to the microstructure and its properties.

With the aim of introducing HEAs to the general audience of *TMS*, the first symposium on HEAs sponsored by the Alloy Phases Committee and Mechanical Behavior of Materials Committee was successfully held at the Materials Science & Technology 2012 conference (MS&T'12), titled "Fundamental Understanding of High-Entropy Alloys Formation." There were 38 oral presentations organized into four sessions: High Entropy Alloy Formation, Structure and Property Relationship, Mechanical Behavior Characterization, and Computational Modeling. After this symposium and the subsequent one held at the TMS 2013 Annual Meeting & Exhibition, there has been increasing interest from academia and industry in the fundamental understanding of HEAs and alloy development, so this special topic was organized to reflect the focus and diversity of HEA research topics in the community.

This topic consists of a total of 11 invited papers. There are two overview papers, one featured paper on diffusion barrier, one theoretical paper based on density functional theory (DFT) calculations, and one study on stacking faults energy determination using DFT methods and experiments. The remaining seven papers are on single-crystal synthesis, mechanical alloying, microstructure, mechanical properties, and phase diagrams. Here I'd like to highlight the work titled "A Successful Synthesis of the $CoCrFeNiAl_{0.3}$ Single-Crystal High-Entropy Alloy by Bridgman Solidification" by S.G. Ma et al. who successfully fabricated single crystals of HEAs for the first time. Multiphase or polycrystalline alloys complicate the interpretation of the intrinsic properties of single-phase HEAs. The overview paper "Alloy Design Strategies and Future Trends in High-Entropy Alloys" by J.-W. Yeh nicely reviews HEAs from various angles and offers inspiring future directions. The theoretical work titled "Prediction of A2 to B2 Phase Transition in the High Entropy Alloy MoNbTaW" by W.P. Huhn and M. Widom is the first paper to predict the phase transformation in HEAs based on DFT. Needless to say, accurate prediction of stacking fault energy in face-centered cubic (fcc) HEAs is very important to their mechanical properties as shown in the paper "Mechanical Properties and Stacking Fault Energies of NiFeCrCoMn High Entropy Alloy" by A.J. Zaddach et al. The diffusion barrier study "Improved Diffusion-Resistant Ability of Multi-Component Nitrides: From Unitary TiN to Senary High-Entropy (TiTaCrZrAlRu)N" by S.-Y. Chang et al. enlightens this special topic and suggests that sluggish diffusion kinetics enable HEAs for high-temperature applications such as bond coatings and thermal barrier coatings. In their paper titled "Phase Evolution and Densification Behavior of Nanocrystalline Multicomponent High Entropy Alloys during Spark Plasma Sintering," S. Praveen et al. compared the phase evolution and densification of CoFeNi and CoFeNiM (M = Cr, Cu, Mn). H.M. Daoud et al. studied the tensile properties of a HEA at room temperature and at 500°C in the as-cast state and under different heat treatment conditions in their paper titled "Microstructure and Tensile Behavior of $Al_8Co_{17}Cr_8Fe_{17}Ni_{33}$ (at.%) High-Entropy Alloy," while the superplastic behavior was investigated by D.G. Shaisultanov et al. in their paper titled "Phase Composition and Superplastic Behavior of a Wrought AlCoCrCuFeNi High Entropy Alloy." The phase diagrams of HEA systems deserve great attention because they are the key to

Michael C. Gao is the guest editor for the Alloy Phases Committee—a joint committee of the Structural Materials Division and the Electronic, Magnetic, and Photonic Materials Division of TMS—and coordinator of the topic Progress in High-Entropy Alloys in this issue.

(Published online October 18, 2013)

the mechanisms of HEA formation, as shown in the paper titled “Phase Diagrams of High-Entropy Alloy System Al-Co-Cr-Fe-Mo-Ni” by C.-Y. Hsu et al.

The addition of Al to HEAs not only lowers the density, but also it increases the strength and oxidation resistance. Therefore, a lot of studies have examined how Al contents impact microstructure, tensile/compression strength, wear properties, and oxidation resistance; an example is presented in the paper “Effect of Aluminum Content on Microstructure, and Mechanical Properties of $Al_xCoCrFeMo_{0.5}Ni$ High-Entropy Alloys” by C.-Y. Hsu et al. On the other hand, Z. Tang et al., in their paper titled “Aluminum Alloying Effects on Lattice Types, Microstructures, and Mechanical Behavior of High-Entropy Alloy Systems,” reviewed Al alloying effect in several HEA systems with support from CALPHAD modeling and qualitative arguments from the viewpoints of lattice-strain energies and electronic bonds.