

Editorial



Complex Concentrated Alloys (CCAs)—Current Understanding and Future Opportunities

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1. Introduction and Scope

Complex concentrated alloys with multiple principal elements represent a new paradigm in alloy design by focusing on the central region of a multi-component phase space and show a promising range of properties unachievable in conventional alloys. High configurational entropy leads to single-phase solid solutions in a certain subset of these multi-principal element alloys (MPEAs), which have been termed as high entropy alloys (HEAs). The core effects of high configurational entropy, lattice distortion, sluggish diffusion, and simultaneous activation of multiple deformation mechanisms lead to a gamut of attractive properties including high strength-ductility combination, resistance to oxidation, corrosion/wear resistance, and excellent high-temperature properties. The published papers in this special issue aim to report on the current state of research in complex concentrated alloys as well as compelling future opportunities in wide ranging applications.

2. Contributions

Eight research articles, four reviews, and one perspective have been published in this special issue of Metals. The subjects are multidisciplinary and divided into several topics including: (i) simulation and modeling for predicting structure and properties [1], (ii) unique deformation mechanisms in multi-principal alloys [2-4], (iii) microstructure and properties resulting from various processing routes [5–10], (iv) corrosion and surface degradation behavior [11,12], and (v) perspectives on ways to design mechanically and functionally advanced concentrated alloys [13]. Beyramali Kivy et al. [1] reviewed the computational tools for studying the structure and properties of multi-principal alloys and identified the advantages as well as limitations of simulations in accelerating design and development of new alloys. The unique deformation mechanisms of concentrated alloys are discussed in one review article and two research papers in this special issue [2–4]. Brechtl et al. [2] reviewed the serration behavior during deformation in HEAs and its dependence on composition, microstructure, and testing condition (i.e., strain rate and temperature). They highlighted the complex dynamic behavior of serrated flow and its occurrence due to dislocation pinning by solute atoms, nanoparticles, twinning, grain boundaries, and phase transformation during deformation. Mridha et al. [3] evaluated the activation volume and activation energy of multi-principal alloys using a first-order shear bias statistical model. Results indicated heterogeneous dislocation nucleation, higher activation volume, and higher activation energy for concentrated alloys in comparison to pure metals, which suggests complex cooperative motion of atoms for deformation in MPEAs. Sadeghilaridjani et al. [13] studied creep behavior of multi-principal alloys as a function of temperature and load. Dislocation glide was reported as the dominant mechanism for creep in MPEAs. The creep stress exponent decreased with increasing temperature due to thermally activated dislocations and increased with load due to higher density and entanglement of dislocations.

The processing-microstructure-properties relationship in complex concentrated alloys are discussed in one review article and five research papers in this special issue [5–10]. Dong et al. [5] reviewed the structure, evolution in properties, and deformation behavior of HEAs after high-pressure treatment (HPT). A certain group of concentrated alloys showed phase transformation under high pressure while others remained stable, which indicates unique structural changes and phase transitions in complex concentrated alloys (CCAs) under high pressure. Kafexhiu et al. [6] investigated the microstructure and wear behavior of dual phase HEAs as a function of aging time. Maximum hardness and negligible wear were seen for intermediate aging time. Zhang et al. [7] evaluated the distribution in microstructure and mechanical properties of HEAs obtained after spark plasma sintering (SPS). Sha et al. [8] and Zhao et al. [9] researched the effect of chemical composition on the microstructure and properties of Al_xCoCrFe_{2.7}MoNi and Al_xCoCrFeNiTi_{0.5} HEAs, respectively. Increase in Al content led to an increase in hardness and wear resistance [8] and a change in erosion mode from ductile to brittle [9]. Lu et al. [10] studied the effect of SiC reinforcement on microstructure and mechanical properties of Nb solid solution. They demonstrated that flexural strength, compressive strength, and Vickers hardness of Nb matrix composites increased, while fracture toughness decreased with an

Surface degradation and corrosion behavior of complex concentrated alloys are discussed in one review article and one research paper in this special issue [11,12]. Ayyagari et al. [11] reviewed the corrosion, erosion, and wear behavior of complex concentrated alloys. The superior corrosion, erosion, and wear resistance of CCAs compared to conventional alloys based on an extensive literature survey was attributed to multiple elements participating in complex passive-layer formation and associated improvement in surface degradation characteristics. Ren et al. studied the corrosion behavior of additively manufactured HEA [12]. The additively manufactured HEA showed higher pitting and polarization resistance when compared to a conventional as-cast counterpart, which was attributed to the homogeneous elemental distribution and lower defect density. Lastly, the perspective article by Basu and De Hosson [13] explore the interplay of defect topologies and large composition gradients in CCAs essential for designing future alloys for potential use in diverse applications.

3. Conclusions and Outlook

increase in the fraction of SiC particles.

A wide range of research topics have been collected in the current special issue of Metals, providing comprehensive insights into recent advances in diverse aspects of complex concentrated alloys. I would like to sincerely thank all the authors for submitting their high-quality work to this special issue and anonymous reviewers for their contributions. I would also like to give special thanks to all the staff in the Metals editorial office, especially to Ms. Sunny He, for managing and facilitating this Special Issue.

Conflicts of Interest: The author declares no conflict of interest.

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