ICHEM 2027
International Conference on High-Entropy Materials
June 27 to July 1, 2027
Paris, France
www.ichem2027.com

PLASTIC DEFORMATION OF A2, B2 AND A2+B2 REFRACTORY-ELEMENT-BASED ALLOYS

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Refractory elements derive many of their exceptional mechanical properties from the peculiar nature of plasticity in body-centered cubic A2 crystal structure, where non-planar screw-dislocation cores, high Peierls barriers, and thermally activated glide strongly influence strength, strain hardening and ductility. The presentation will first briefly revisit these classical features and discuss how they are modified in concentrated solid solutions. Local chemical fluctuations and lattice distortion generate rugged energy landscapes for dislocation motion and affect the strength-determining dislocation types.
The addition of Al is regarded as beneficial in several respects, for example by improving oxidation resistance, particularly when Cr and Ta are present in sufficient concentration. However, it also causes ordering of the crystal structure to B2. The introduction of order affects plastic deformation by an increased plateau strength, the appearance of serrated plastic deformation at intermediate temperature, and most importantly a significant drop in ductility. These aspects will be discussed in terms of the peculiarities of dislocations in B2 ordered crystals and the metallurgical options to control the order.
The latest developments in the field concern the deliberate use of A2+B2 phase equilibria to generate precipitation-strengthened alloys to further improve high-temperature strength and more importantly to limit creep. Metallurgically, this bears challenges as these equilibria are bounded by miscibility gaps requiring fine adjustment of chemical composition to obtain distinct B2 particles with crystallographically sharp interface to the A2 matrix. Several such alloys are available nowadays and the presentation will capture recent results on their deformation behavior. Rafting, interface development, dislocation types and interactions with precipitates are discussed. The presentation will conclude with development trends and an objective assessment of requirements that need to be addressed for such alloys to eventually meet the broad property profile of high-temperature materials.