Phase strength effects on forced chemical mixing during severe plastic deformation
Cordero, Zachary, zcordero@mit.edu; Schuh, Christopher, MIT, United States

ABSTRACT
Forced chemical mixing during severe plastic deformation of binary transition metal couples tacitly requires that the input materials codeform during processing. Although it is qualitatively understood that the amount of codeformation is a sensitive function of the input phases’ strengths, predicting the degree to which couples will chemically homogenize based upon the input phases’ mechanical properties, is not yet possible. As a first step towards developing this predictive capability, we mechanically alloyed several W-transition metal couples with a range of different strengths and characterized the as-milled powders’ properties as a function of milling time. Analysis of the evolution in microstructure, mechanical properties, and amounts of chemical mixing revealed a clear separation between couples that mixed and those that did not, which we attribute to differences in strength between W and the alloying element. We explore these effects in the context of a driven systems analysis using kinetic Monte–Carlo simulations of a mechanically driven binary alloy that accounts for differences in strength. Such simulations provide insight into the combined effects of phase strengths and volume fraction as well as milling temperature on the steady state chemical mixity, and support our interpretation of the experimental data. The discussion will conclude with a case study on the application of these insights to the design of a nanocrystalline, W-based alloy powder that can be rapidly compacted into fully dense, ultrafine grain compacts possessing dynamic yield strengths >4 GPa.