Graduate Student Research Seminar

Fall 2021

A solute drag model of regular solution alloys

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3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

Most material systems are polycrystalline aggregates; each two differently oriented grains meet at an internal interface, termed a grain boundary (GB). GBs play a critical role in many phenomena during materials processing or under service conditions. Of particular interest is GB migration and the resultant grain growth, as these processes control many crystal-size dependent properties in metallic systems. In alloyed systems, the interaction of migrating GBs with elemental species influences GB dynamics, where the GB solute atmosphere exerts a drag, resisting GB migration. Here, we present a solute drag model in regular solution alloys that accounts for solute-solute interactions in both the bulk and GBs and captures effects such as monolayer, multilayer, and asymmetrical segregation. Our analysis shows that deviations from ideal solution thermodynamics play a paramount role, in which solute drag is shown to scale with solute-solute interaction parameters. Further, it is found that the asymmetry in GB segregation introduces an additional component to solute drag. A universal solute drag-GB velocity relation is proposed and used to explain recent experimental observations of sluggish grain growth in a wide range of engineering alloys. In broad terms, our model provides avenues to explore the role of alloy concentration and GB structures in GB segregation.

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