Interfacial segregation and structure of precipitates in aluminium alloys

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Solid-state precipitates are key components in high-strength aluminium alloys used in a multitude of structural applications, from packaging and construction to automobiles and aerospace. Precipitates that are most effective at blocking dislocations and hence strengthening an alloy are usually metastable phases with high aspect ratios and one or two dimensions at the nanoscale or even sub-nanoscale [1]. Interfacial structure therefore constitutes a critical part of the structure of such precipitates. An understanding of interfacial segregation and structure is important not only for developing models of precipitate nucleation and growth, but also when addressing the issue of recycling aluminium [2]. Yet it is only in the last 10-15 years that such structures have been experimentally characterised at the atomic scale, thanks mainly to high-resolution scanning transmission electron microscopy (STEM).

Here we present experiments and simulations of interfacial structures and solute segregation behaviour of precipitates in several model binary and ternary aluminium alloys, some of which form the basis of important engineering alloys. STEM experiments reveal that even in seemingly simple and well-known binary alloys, precipitates can possess complex interfacial structures or unexpected phases [3-5]. Density-functional theory calculations enable a partial understanding of the experimental observations. For example, the calculated solute defect energy can provide an indication as to whether this solute will segregate at coherent interfaces [3, 4, 6]. However, there exists as yet no predictive model for complex interfacial structures. This will be discussed, as well as the challenge remaining in using atomistic observations and calculations to predict thermodynamic behaviour, such as precipitates nucleation and growth.


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