

## Mg segregation at coherent and semi-coherent Al/Al<sub>3</sub>Sc interfaces

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Aluminum alloys containing Sc are promising materials for high-temperature structural applications due to the high strengthening effect of the Al<sub>3</sub>Sc (L1<sub>2</sub> structure) precipitates [1]. Further improvements in strength and nanostructural stability of Al-Sc based alloys are achieved by adding alloying elements, such as Mg, as solid-solution strengtheners. It is important to understand the effects of Mg in order to control not only the specific contribution of Mg to the properties of Al-Sc alloys (strengthening effect and creep resistance) but also the changes in the nanostructure. From previous work, it is known that Mg tends to segregate to the coherent Al/Al<sub>3</sub>Sc interface due to positive interactions between Mg and Sc atoms [2]. This paper reports measurements of Mg segregation at the Al/Al<sub>3</sub>Sc interface and compares the segregation level between coherent and semi-coherent Al/Al<sub>3</sub>Sc interfaces.

A cast Al-2 wt.% Mg-0.2 wt.% Sc alloy was annealed at 618°C in air for 24 hours, quenched into cold water, and then aged in air at 300°C for 24 hours. One sample was subsequently aged at 400°C for 240 hours. Three-dimensional atom probe (3DAP) microscopy tips were obtained by a double electro-polishing technique. Field evaporation was performed at 30 K with a pulse fraction of 20 % at a frequency of 200 kHz using a LEAP microscope. Transmission electron microscopy (TEM) imaging was performed on a JEOL 1200 microscope.

During aging at 300°C, Al<sub>3</sub>Sc precipitates are formed with a high number density ( $\sim 2 \cdot 10^{22}$  precipitates/m<sup>3</sup>), which is advantageous for random 3DAP microscope observations. The average radius of the precipitates is 2 nm and the interface is coherent (Fig. 1). After aging at 400°C, however, the average radius of the precipitates is  $\sim 19$  nm and dislocations loops are observed at the matrix/precipitate interface. The number density of precipitates has also decreased dramatically ( $\sim 10^{19}$  precipitates/m<sup>3</sup>) and is no longer sufficient for random atom probe observations. Atom probe tips were therefore observed by TEM to confirm the semi-coherent nature of the Al/Al<sub>3</sub>Sc interface and to determine the position of the precipitates with respect to the tip apex. Micro-polishing was used to position precipitates to within  $\sim 100$  nm of the apex. A TEM image of a tip is shown in FIG.2. Al<sub>3</sub>Sc precipitates are visible with dislocations at the matrix/precipitate interfaces.

Coherency loss may occur when the precipitate diameter is larger than the spacing between the misfit dislocations. This spacing is of the order of  $\alpha/\epsilon$ , where  $\epsilon = 0.62\%$  is the lattice parameter misfit between the  $\alpha$ -Al matrix containing 2.2 at.% Mg and the Al<sub>3</sub>Sc phase [3,4], and  $\alpha = 0.20$  nm is the spacing between {200} planes. The calculated equilibrium dislocation spacing is therefore 32 nm, in good agreement with the presence of interfacial dislocations for precipitates with diameter of  $\sim 38$  nm. Comparison is made between the segregation levels measured for coherent and semi-coherent interfaces. The role of the interfacial dislocations will be discussed.

### References

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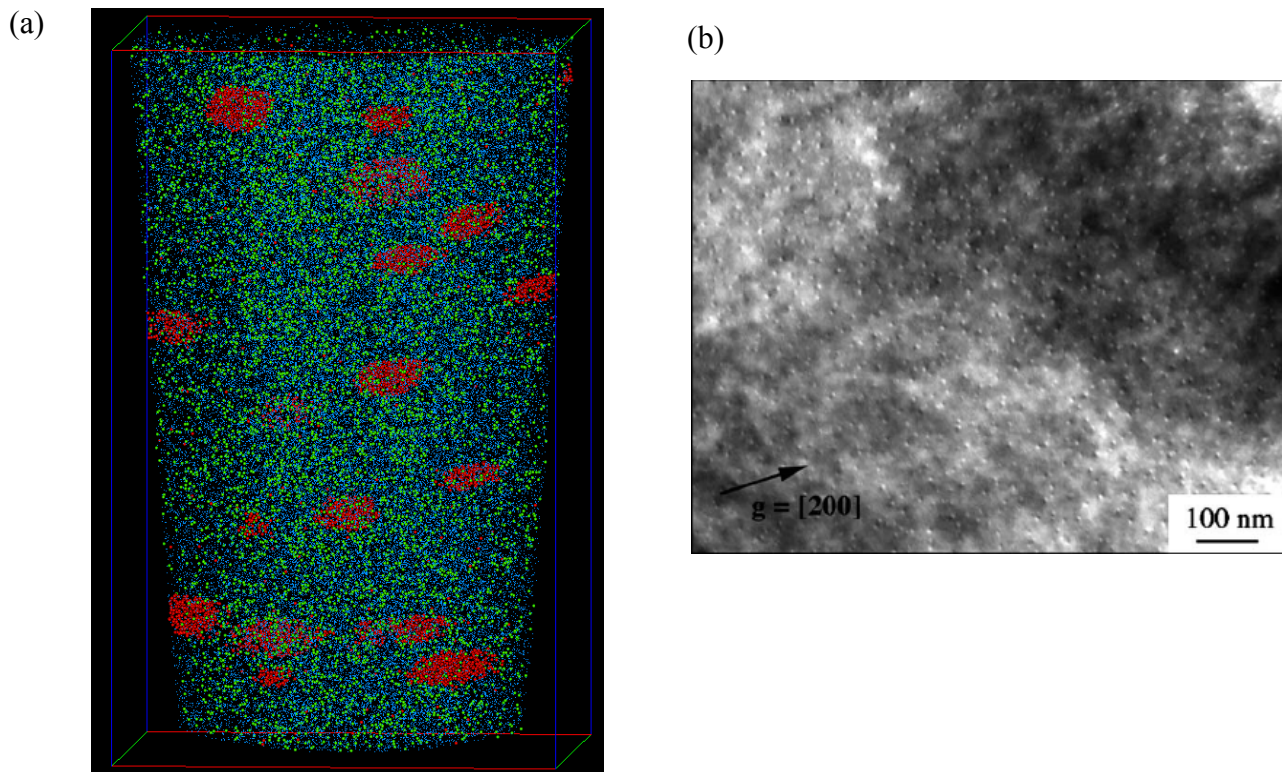


FIG. 1. Al–2.2 at.% Mg–0.12 at.% Sc alloy after aging at 300°C for 24 h: (a) 3DAP reconstruction showing Al<sub>3</sub>Sc precipitates. Al atoms are represented in blue, Mg in green and Sc atoms in red. The volume is 54nm x 54nm x 89nm. (b) CTEM micrograph showing a high number density of Al<sub>3</sub>Sc precipitates: dark-field image, exhibiting Ashby–Brown strain coherency contrast, obtained with a [200] reflection.

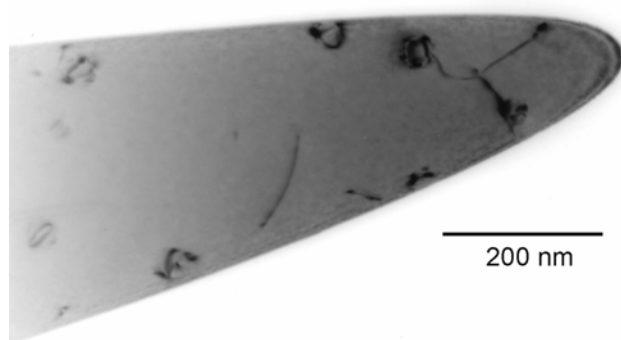


FIG. 2. Dark-field TEM image of an Al-Mg-Sc atom probe specimen containing semi-coherent Al<sub>3</sub>Sc precipitates.