Shape equilibration, melting and motion of Pb inclusions in Al

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Using in-situ observation in a transmission electron microscope, we were able to record the dynamic events that control phase transformations and shape changes of small Pb inclusions in Al over a range of temperatures and sizes. The evolution toward the cuboctahedral equilibrium shape depends strongly on particle size. It was found that the largest particles were frozen in non-equilibrium while the smallest particles had sufficient mobility to undergo Brownian motion. By following the trajectories of individual particles during random thermal migration over a temperature range between about 420 and 460°C it was possible to determine the mechanism and kinetics of the process. These results can be understood in a self-consistent framework that explains the kinetics of shape equilibration of large particles as well as the Brownian motion of small particles.

The role of interface structure is further demonstrated by observations of site-specific premelting on Pb inclusions bounded by different interfaces across grain boundaries in Al. Accommodation of the volume change upon phase transformation of inclusions is shown to proceed by vacancy diffusion for small particles and by dislocation loop punching for large particles. The critical need for information on the 3D shape of inclusions for a full understanding of these phenomena will be illustrated.

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