ABSTRACT

Determination of the Local Diffusion Flux in Alloys

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Despite the importance of atomic diffusion in controlling high temperature deformation and microstructural changes, it remains difficult to generally determine diffusion flux through alloys. We present thermomechanical nanomolding, where a nanomold array is filled by the alloy's local diffusion flux under a stress gradient, to determine the flux diffusing through an alloy's microstructure. Local resolution is better than 10 nm2 and measurements are taken in parallel over macroscopic dimensions, ~cm2.

This flux is collected in the nanomold forming nanorods. Length and composition vary significantly over the microstructure and their analyses of the formed nanorods allow us to determine rate and composition of the local flux, and further allow estimation of the constituents' diffusivities in this flux. We verify this technique on metals and simple alloys, and then reveal diffusive flux in general alloys. When comparing to microstructures we reveal diffusive flux differences between grains and grain boundaries, grain boundaries of various misfit angle, and grain boundaries and phase boundaries.

Generally, we cannot, a priori predict the local diffusive flux of an alloy. However, for alloys that can access a eutectic composition in their alloy system, the flux's composition is that of the eutectic, which can be very different from the alloy's nominal composition. Moreover, the flux's overall diffusivity is greatly enhanced. This, so far unknown, eutectic mechanism is present in the majority of multicomponent alloys.