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ABSTRACT

The Impact of Non-Equilibrium Vacancies on Mobilities and Kirkendall Porosity Formation in Diffusion Couples: Experiments and Theory for the Cu--Fe--Ni System as a Case Study

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Recently elaborated tracer-interdiffusion couple approach is used to quantify the differences of atomic mobilities measured in homogeneous alloys with purely entropic driving forces and those determined from diffusion couples under chemical gradients. First, the self-diffusion rates of Fe, Ni and Cu are measured in selected homogeneous alloys of the ternary Cu–Fe–Ni system at 1273 K using the radiotracer method. Following, a novel augmented tracer-interdiffusion couple approach is used with the Cu50Ni50 and Fe50Ni50 binary alloys as end-members and depositing the 55Fe and 63Ni radioisotopes at the initial contact plane and at the both external surfaces. The non-equilibrium vacancies are found to enhance the atomic mobilities at 1273 K in the Cu–Fe–Ni system by about 20%. The results confirm a high level of reliability and the reproducibility of the approach for producing highly accurate diffusion data for generating mobility databases. Together with a CALPHAD-like theoretical analysis and thermodynamic factors, these results present a complete data set for the quantitative verification of the theoretical description of diffusion in ternary alloys. The impact of vacancy production on the developed chemical profiles and the Kirkendall effect are analyzed. An agreement between the experimental findings and the theoretical predictions is shown.