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Interdiffusion kinetics in Cu-Ni(Fe) nanolaminate structures

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The decomposition of a one-dimensional composition wave in Cu-Ni(Fe) nanolaminate structures is quantified using x-ray diffraction to quantify the kinetics of interdiffusion processes. A schematic of an A/B nanolaminate structure with A (dark-shaded) and B (light-shaded) atoms is shown (below left) as viewed in cross-section. Features are shown such as a threading dislocation (d), grain boundary (gb) between columnar grains, and the A/B layer pair thickness, i.e. the composition wavelength (λA/B). Cu-Ni(Fe) is a spinodal alloy system where the growth or decay growth of the composition modulation occurs within or above the critical temperature for the chemical spinodal, respectively. A transmission electron microscope, bright-field image and selected area diffraction pattern (insert) are shown (below right) for a Cu-Ni(Fe) nanolaminate with a 4.34 nm composition wavelength, revealing its ultra-fine grain nanocrystalline structure. Evidence of a negative interdiffusivity is found for each of sixteen different nanolaminate samples that are aged at room temperature over a composition wavelength range of 2.1–10.6 nm. A diffusivity value $\check{D}$ of 1.77×10^{-24} $cm^2 \cdot s^{-1}$ is determined for the alloy system at room temperature – perhaps, the first such measurement at a ratio of melt temperature to test temperature that is greater than 5. Although this diffusivity value is extremely small, it is several orders of magnitude greater than that value extrapolated from high temperature to room temperature for a bulk diffusion mechanism. Diffusion mechanisms that are operative from room to high temperatures for the Cu-Ni(Fe) nanolaminate structures are reviewed, including the possible effects of short-circuit diffusion through interlayer grain boundaries.

Biography

Alan Jankowski completed his PhD in Mechanics and Materials Science at Rutgers University in 1987 and has held scientific, faculty, and management positions at Lawrence Livermore National Laboratory, the Texas Technological University, and Sandia National Laboratory. He has published 135 journal papers, received 29 US Patents, and given 40 invited presentations at international conferences.

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