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Energetics of Kirkendall effect

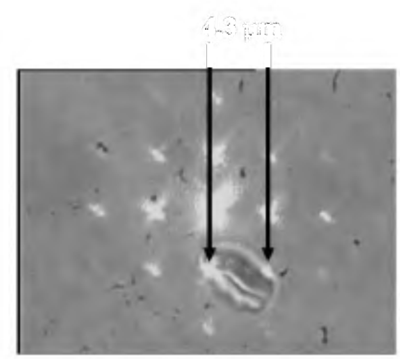
Kirkendall effect relates to volumetric strain in alloys consequent to counter diffusion of atoms at unequal rates. Dynamical analysis of the phenomenon shows that molecular kinetic theory provides a self-consistent mechanistic interpretation that is independent of the widely used thermodynamic explanation.

Molecular diffusion in gas mixtures, aqueous solutions and solid solutions is a multi-component process, with different components diffusing at different rates. Although binary diffusion in gases and liquids was recognized during the nineteenth century, Kirkendall (1942) was the first to experimentally demonstrate it in solids by maintaining a brass–copper composite at high temperatures, and recording the physical displacement of the copper–brass phase boundary. The widely accepted interpretation is that excess vacancies are created in crystal lattice on the side from which the faster atoms move, and that the subsequent migration of excess vacancies leads to observed volume strain and phase-boundary displacement. Though persuasive, this interpretation ignores forces responsible for observed strain.

The paper by Narasimhan (**page 1257**) takes a dynamical look at the Kirkendall effect based on van't Hoff's osmotic theory, Nernst's dynamical interpretation of Fick's work, and Einstein's molecular kinetic theory of heat. A central concept introduced is that the kinetic energy of the mobile diffusing atoms per unit volume constitutes an osmotic pressure, and that the osmotic stress arising therefrom plays a critical role in the observed deformation. Two models are presented, one invoking viscous drag, and the other based on volume decrease associated with energy drainage.

Optical traps

Optical traps are of considerable utility in the physical and biological sciences. They work on the principle of strongly focusing a laser beam such that a steep intensity gradient induces a force whose magnitude is stronger than the forces that are imparted by the light scattering from microscopic particles. Although traps have found diverse applications, the fact that only a single particle can be trapped with one laser beam continues to be a constraint. Hitherto, overcoming this constraint has involved the use of elaborate and experimentally unfriendly methods involving multiple laser beams or complex and costly acousto-optical components.



Spurning advice from patent lawyers, Dharmadhikari *et al.* present on **page 1265** details of a very simple way of creating multiple optical traps by making use of a wire mesh to create a 2-D diffraction pattern such that a trap is formed at each location. Each individual trap is amenable to easy control, with the distance between adjacent traps under the experimentter's control, obviating the need to timeshare a laser beam among a set of positions. The authors use their multiple trap to demonstrate intriguing possibilities of stretching a single cell under physiological conditions.

Gas-hydrates

Gas-hydrates are assumed to be continuous deposits as depicted by the presence of Bottom-Simulating Reflectors (BSRs) in the conventional multi-channel seismic data. High-frequency seismic data is collected to understand the formation and distribution of hydrates. The analysis of these datasets led to an important conclusion that the gas-hydrates are scattered with large lateral variations rather than occurring in a continuous form. This inference is reasonable as the hydrate distribution is governed by the availability and movement of hydrocarbon gases rather than a depositional process.

The seismic response is modelled for scattered hydrates for various source frequencies and source–receiver configuration. The low-frequency seismic response shows a continuous BSR whereas high-frequency seismic response shows discontinuous BSR. This observation is explained with the help of Fresnel zone, which governs the horizontal resolution of the seismic data. Therefore, the BSR amplitudes in conventional seismics can be misleading if the width of Fresnel zone is larger than the distance between the scatterers. The conventional 2-D seismic investigations for mapping the gas-hydrates in a large area may be advantageous but for accurate mapping of gas-hydrates deposits, seismic data having high vertical and horizontal resolution is required. This can be achieved by using higher frequency energy sources or deep-tow source receiver configuration. See **page 1287**.