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3.21 Kinetics of Materials—Spring 2006

April 7, 2006

Lecture 20: Diverse Short Topics: Anisotropic Surfaces, Diffusional Creep, and Sintering.

References

1. Balluffi, Allen, and Carter, *Kinetics of Materials*, Sections 14.2, 16.1, 16.3 and C.3.

Key Concepts

- Anisotropic interfaces have orientation-dependent excess free energies per unit area, i.e., γ is a function of the inclination of the interface specified by its unit normal, $\hat{n}$.

- From a polar plot of $\gamma(\hat{n})$, the *Wulff construction* gives the equilibrium shape of a body with anisotropic surfaces. (The equilibrium shape is a sphere when γ is isotropic).

- Anisotropic surfaces with orientations that are not in the equilibrium shape may be unstable with respect to *faceting* into two or three low-energy orientations, producing what is sometimes called a "hill-and-valley" structure (see *KoM* Fig. 14.9).

- The morphologies of growing or dissolving particles with anisotropic interfaces can be determined by anisotropy of the particle interface growth velocity, and this can lead to nonequilibrium particle shapes (i.e., ones that do not minimize total surface energy). Growing particles tend to retain orientations corresponding to the *slowest* growth directions, while dissolving particles tend to retain orientations corresponding to the *fastest* growth directions (see *KoM* Figs. 14.11 and 14.12, respectively).

- Diffusional creep involves time-dependent deformation of a crystalline body under the influence of applied mechanical forces. Many creep processes involve contributions to the diffusion potential from both capillarity and mechanical forces (arising from gradients of curvature and gradients of hydrostatic pressure in the simplest cases). Kinetic models for the creep rate in simple structures like a wire with a "bamboo" structure can be developed for different diffusion paths such as volume, surface, and grain-boundary diffusion.

- Sintering is the process by which powder particles join together so as to eliminate excess surface free energy. *Densification* in sintering occurs when the centers of mass of adjacent particles move together and it requires removal of material from the grain boundary at the particle/particle interfaces by either grain-boundary diffusion, volume diffusion, or both. Sintering is a common manufacturing process used to form many small "near net-shape" parts. It is often desirable to process such parts to "full density" thus necessitating elimination of porosity from the sintered part during processing.

Related Exercises in *Kinetics of Materials*

Review Exercise 14.4, pp. 359–360.