April 13, 2005: Deformation Mechanisms

Metal Deformation Generally by motion of dislocations:

- Glide: simple slip of dislocations.
- Note on obstacles and strengthening, strength$\propto$distance between precips. Note on fine Cu-Al intermetallic precipitates in aluminum alloys.
- Climb: (vacancy) diffusion-assisted motion between planes to get around obstacles (slow).
- Multiplication: *e.g.* Frank-Read source.
- Forms dislocation cells, power-law creep, like power-law fluid.
- Result: regimes of strain: elastic, easy glide (I), work hardening with dislocation multiplication (II), recovery as dislocs assemble into cells with something like low-angle GBs (III).

Diffusion of vacancies, also ceramics:

- Nabarro-Herring: diffusion across GBs, rate$\propto 1/d^2$.
- Coble: diffusion within GBs, rate$\propto 1/d^3$.

Increasingly important as features (grains) get smaller, both in ceramics and metals. Metals: small grains mean higher strength by Hall-Petch, if nanocrystalline then vacancy diffusion becomes important.

Note on special boundaries: shut down diffusional creep, stress corrosion cracking. Hall-Petch strengthening? Not yet known.

Superplasticity: grain boundary sliding, up to 1000% deformation!

Polymers Flow of molecules as described last time.

- Necking (E.g. PE, PC): growing region of oriented polymer, high-strength yielded region, large strains to failure followed by higher (engineering) stress.
- Crazing (e.g. PMMA): little cracks open up with polymer bundles bridging, no real “yielding” but visible damage.

Sensitivity of many polymers to solvents: touch with finger$\Rightarrow$craze in pattern of fingerprint!

Concave stress-strain curve: $d\sigma/d\epsilon > \sigma/\epsilon$ leads to stability in sheet forming. Thinner sections are stronger, thicker ones yield.