Lecture 14

Sunday, May 04, 2008
3:33 PM

Ref: 1. G. Dieter, **Mechanical Metallurgy, 3rd Edition**, *McGraw-Hill*, 1986.
2. Reed-Hill, Abbaschian, **Physical Metallurgy Principles, 3rd Edition**, *PWS Publishing Company*, 1994.

Course Notes:

- There is NO Lab this week -- however you have a short lab report for Lab 3 due in your TA's mailbox on the 4th Floor of Roberts
- You do have homework this week -- due on Friday
- Next exam is 2 weeks from Today

Review:

- Last time we started our discussion talking about dislocation interactions
- We talked about how an edge dislocation has a compressive stress field and a tensile stress field associated with it
- We talked about dislocation attraction and repulsion
- We talked about dislocation annihilation or dislocation kinks
- We talked about Ashby's model for polycrystalline slip -- having both statistically stored dislocations and geometrically necessary dislocations
- We talked about how during polycrystalline slip, some grains will be favorably oriented for slip and others will not be and how strain in one crystal will create strain in its neighbors
- We then switched gears and began talking about strengthening mechanisms
- We provided a definition for strength -- "The ability of a material to resist deformation under applied stress"
- We talked about how crystals deform by slip and dislocation motion and therefore, anything which makes dislocation motion more difficult increases the strength of the metal
- We discussed grain size reduction and how fine grained materials have more strain hardening and therefore more strength
- We mentioned that of all the strengthening mechanisms how grain size reduction is the only one that increases both strength and toughness
- We discussed the Hall Petch equation which empirically relates increases in strength to the reciprocal of the square root of the average grain diameter
- We discussed solid solution strengthening both interstitial and substitutional
- We noted that solid solution strengthening results in an increase in both the entire stress-strain curve
- We noted that there is more of a kick in strength associated with interstitial solid solutions (3G) than with substitutional solid solutions (G/10)
- We talked about Cottrell atmospheres and solute drag
- We then switched gears and started discussing Cold Work (plastic deformation at temperatures below the recrystallization temperature of the material -- typically 1/3 the T_m (melting point of the alloy)
- We talked about how cold work results in a significant increase in the dislocation density (from 10^6-10^8 /cm^2 to 10^{12} /cm^2)
- We talked about how as the dislocation density increases the dislocations begin to tangle with each other and obstruct one another -- how this is what is really going on during strain hardening

Point of Clarification:

After class some of your colleagues were asking questions about how it was counter-intuitive that solid solutions would be stronger than perfect crystals

- Let's clarify -- strength is NOT related to bond strength (at least not within a given alloy system)
  - Bond strength and crystal structure differentiate between material responses comparing different alloys
- Strength is related solely to the ability to resist deformation -- which is the ability to resist dislocation motion
- Solid solutions (both substitutional and interstitial) have more resistance to dislocation motion -- therefore they are stronger

Rest of Lecture is available in PowerPoint Presentation Paired with Lecture 13