Department of Materials Science and Engineering
Massachusetts Institute of Technology
3.14 Physical Metallurgy – Fall 2003

Solutions to Quiz #2

Problem #1:

In class we discussed the several separate contributions by which a small coherent precipitate can enhance the strength of crystals. Interestingly, it has also been found that a dispersion of small voids (say, 5-15 nm in size) can also strengthen metals; this is commonly called 'void strengthening'.

Explain how voids of this size can provide strengthening. Start by listing the ways that a precipitate promotes strengthening, and explain how each of these does or does not apply to a void.

There are four kinds of strengthening associated with precipitates:

1. Elastic strain
2. Interfacial area creation
3. Antiphase boundary creation
4. Modulus effect

As related to voids…

1. Some lattice relaxation may occur around a void inducing a strain field. This strain field can interact with dislocation providing strengthening in the system.

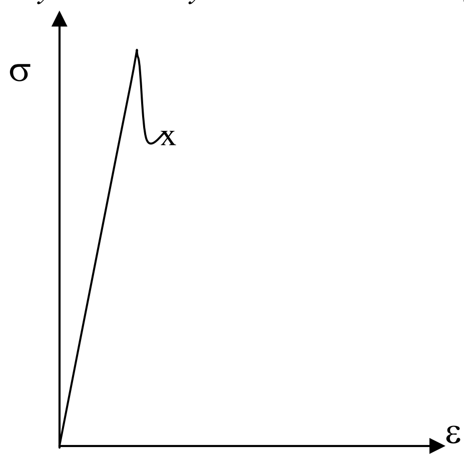
2. The interfacial area strengthening will play the largest role. As dislocations cut through the voids, new surface area is created leading to strengthening.

3. Since a void is essentially a single phase, it cannot have any APBs, therefore, no strengthening is achieved from this method.

4. A void can be considered a very soft "particle" (E = 0). Therefore, there may be interactions with dislocations in the system which would lead to strengthening.

Problem #2:

You have been hired as a 'special assistant' in a mechanical laboratory, where you mostly spend your time playing video games. However, one day you are asked to perform a tensile test on a "binary metal alloy". You start the test, and obtain the first part of a stress-strain curve:



Not expecting the large stress drop, you stop the test abruptly at 'x', and observe that the specimen has ***not*** *fractured and seems to be in fine shape. Although your mind is addled from spending months doing nothing but playing video games, you remember from your 3.14 days that this represents a rapid straining event, and you can think of two possibilities:*

1) *The stress drop results from twin formation*
2) *The stress drop results from breakaway of dislocations from solute atmospheres*

Unfortunately, you have virtually no resources at your disposal (i.e., no microscopes, analytical equipment, X-ray machine, etc.); all you really have is the tensile test machine. Propose a simple experiment that would allow you to unambiguously determine whether event (1) or (2) from above has occurred.

Since you clearly have plenty of time of your hands, you should go back to playing video games for several months – allowing the specimen to <u>anneal at room temperature</u>. (If you are very eager, you could have taken it home and annealed it in your oven). You should then perform another tensile test. If the same large stress drop occurs at a slightly higher stress (due to a small amount of work hardening), then you can conclude that the stress drop was the result of dislocations breaking away from solute atmospheres. During the months you were playing video games, the dislocations would have again been pinned by the solute atmospheres. If, however, the stress-strain curve looked normal (elastic regime followed by work hardening), you could conclude that the stress drop was a one time event caused by the reorientation of the crystal during twinning. Additionally, secondary stress drops at the same stress could also be ascribed to twinning.