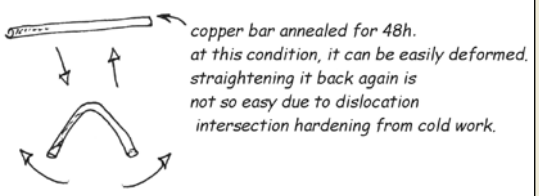
Strong Materials: Are defects good?

Although defects play a major role in materials science, the fact we call them defects immediately bring the concept of a bad thing for students. After a discussion about this, a very fun experiment can demonstrate how defects can be good.

The experiment starts with a 6-ft, commercial grade copper rod 3/8 inches in diameter. You can order one for about $80. Cut the rod into foot-long sections. These will be very hard to bend using only your hands. However, after annealing at 600°C for 48 hours, grain growth decreases the number of defects in the rods. Once the rods are slowly cooled inside the furnace, you can easily bend them. Bending the rod creates dislocations that move and intersect to harden the rod. Thus the rod cannot be easily straightened again. This is a simple but quite impressive demonstration. Bring the annealed bar to class and call a girl to bend the bar, then ask the toughest guy around to try to straighten it.



What do you need?

6-ft long, 3/8-inch diameter commercial grade copper rod cut into 1-ft bars; furnace to anneal the bars; and safety equipment to handle the operations in the lab.

To understand why dislocation intersections will harden the material, a good analogy is to consider an isolated TV cable that can be moved around very easily versus the multiple cables in the back of a typical TV system. Everyone has had the experience at least once of pulling a cable behind the TV and all of the cables coming at once. Dislocations intersections can be hard to move in a similar way.

What do they learn?: Composition isn't the only thing that matters in a material—processing history is also important. Defects can be created in materials by deformation and eliminated by thermal treatments. This means you can tune the property of a material for a specific application. Other kinds of defects in materials affect not only mechanical properties but also electrical ones, such as in the ionic conductors used in oxygen sensors in cars.