Metals (2)

Definitions

> **Crystalline**
>
> Particles are arranged in a regular lattice

Crystallinity

A crystalline structure means that "individual particles are arranged in a regular pattern over distances many times the spacing between the particles" [1, p. 96]. The important thing is the existance of some regular structure. Such a regular square grid may also be called a lattice - these can be used pretty much interchangeably. Most metals, in addition to *crystals* and ionic compounds, are crystalline in structure.

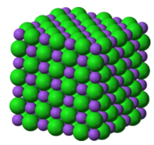

Figure 1: A 3-D NaCl crystal

Polycrystallinity

A "polycrystalline" material "consists of a number of grains all oriented differently relative to one another but with an ordered, regular structure within each individual grain." [1, p. 98]. Here a grain is a part of the material, on the microscopic level, which is like a single "proper" crystal. The boundary between grains is called the "grain boundary".

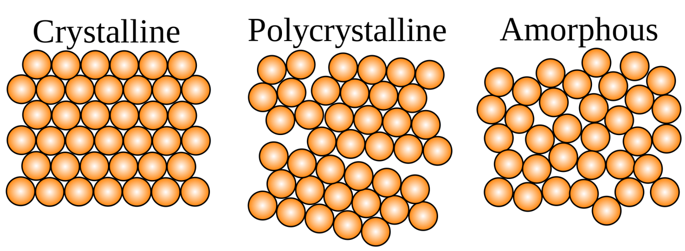

Figure 2: Crystallinity vs. polycrystallinity

Dislocation

A dislocation is a "mismatch in [a] regular row of atoms" [1, p. 96]. Dislocations allow atoms to slide, or "slip" over one another. This happens in a certain plane, which is called the "slip plane". This process of slipping accounts for why metals are relatively

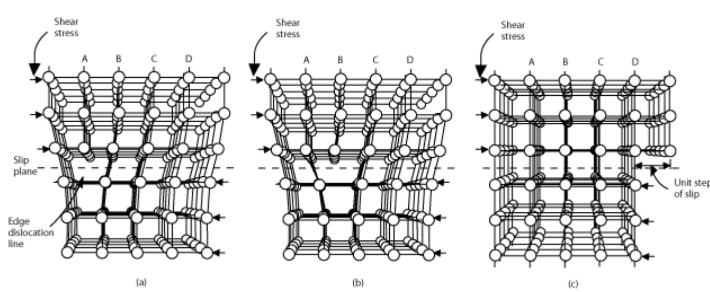

Figure 3: Dislocation and slipping

malleable and ductile, as only a couple of atoms have to be "moved" - if metals were ideal crystals, whole layers of atoms would have to be moved to deform the metal.

The fact that they are malleable also results in metals being tough, ie are very unlikely to shatter when they break. This is because, as they are malleable, cracks will just become blunt and stretch when subjected to stress, rather than propagate, as they might in a ceramic.

Alloys

An alloy is a “metal made by combining two or more metallic elements”. Alloys are often stronger than just metals, and this can be explained in terms of slipping. Alloy atoms can ”pin” a dislocation, preventing slip.

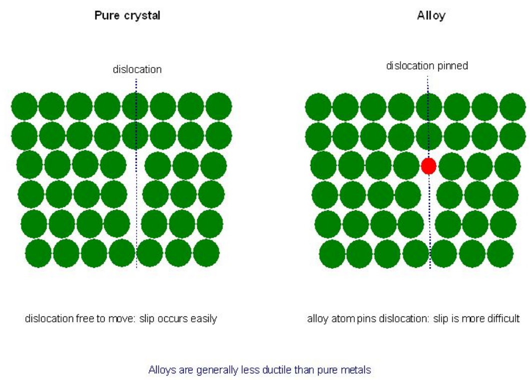

Figure 4: Pinned dislocation in an alloy

Pure crystals

Sometimes a pure crystal is desired. Solids are often made by cooling liquids until they freeze. Liquids are amorphous, so by quickly cooling them, the amorphousness of the liquid is “captured” and the resulting solid isn’t very crystalline. Cooling them more and more slowly can yield more crystalline structures, with fewer dislocations. A very pure crystal can be made simply by cooling a liquid very slowly.

An example of this is high-purity silicon used in microchips. Here silicon is used as a semiconductor, so it should be as pure as possible to maximise its conductivity and hence the performance of the chip.

References

[1] Lawrence Herklots, John Miller, and Helen Reynolds. *A level Advancing Physics for OCR*. Oxford university press, third edition, 2015.