Metals (2)

Definitions

> **Slip plane**
>
> A two-dimensional plane in which slip occurs - this is aligned with a dislocation

> **Lattice defects**
>
> Imperfections/irregularities in the regular lattice structure. Examples include the dislocation.

> **Dislocations**
>
> A missing particle in a lattice structure, which allows slip to occur

> **Alloys**
>
> Compounds of multiple metals. Alloys are often strong as alloy particles can "pin" dislocations.

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.

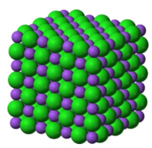

Figure 1: A 3-D NaCl crystal

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".

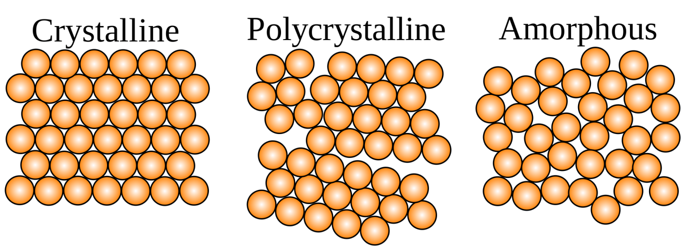

Figure 2: Crystallinity vs. polycrystallinity

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 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.

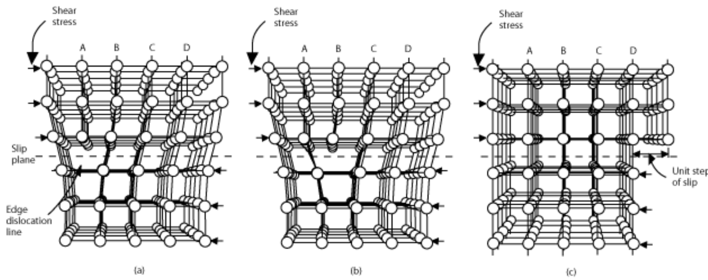

Figure 3: Dislocation and slipping

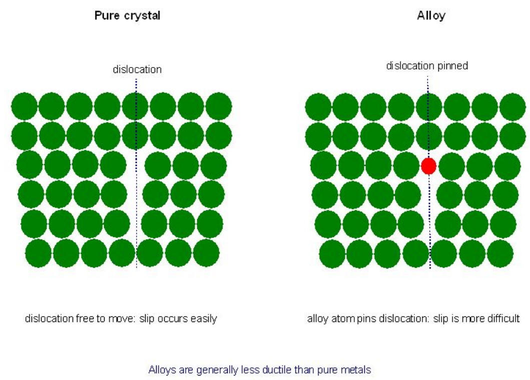

Figure 4: Pinned dislocation in an alloy

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.

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 [2], so it should be as pure as possible to maximise its conductivity and hence the performance of the chip.

Other lattice defects

Other lattice defects can also occur. One of these is a "vacancy". This is when "an atom is missing from its lattice point " [3]. The result of a vacancy is that "there is a change in the coordination of atoms around the defect. This means that the forces are not balanced in the same way as for other atoms in the solid, which results in lattice distortion around the defect" [4].

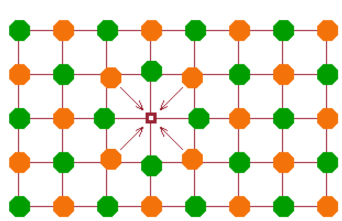

Figure 5: Vacancy in a lattice

Another defect is the "interstital particle". This is when there is an "extra" particle in the lattice. This defect has a similar effect to a vacancy [4].

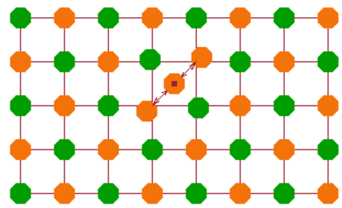

Figure 6: Interstital particle in a lattice

Both vacancies and interstital particles are highly mobile, and if they meet each other, they can “annihilate”, or cancel each other out [3].

Another type of lattice defect is an impurity - this is where “a “wrong” atom is placed on a regular lattice point” [3].

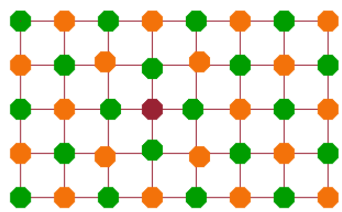

Figure 7: Impurity in a lattice

References

[1] Lawrence Herklots, John Miller, and Helen Reynolds. *A level Advancing Physics for OCR*. Oxford university press, third edition, 2015. Lots of useful information - although not very in depth.

[2] placeholder https://electronics.stackexchange.com/users/11861/placeholder. Why is silicon used to make microchips? https://electronics.stackexchange.com/questions/59815/why-is-silicon-used-to-make-microchips/59819#59819. Accessed: 31/10/2017. Very detailed technical explanation of the usage of silicon in microchips.

[3] Condensed Matter Physics. Lattice defects and their dimensionality. http://users.aber.ac.uk/ruw/teach/334/defects.php. Accessed: 31/10/2017. Provides a good if technical summary of different lattice defects.

[4] University of Virginia. Imperfections in solids. http://www.virginia.edu/bohr/mse209/chapter4.htm. Accessed: 31/10/2017. Some more detail on the effects of other defects.

[5] DoITPoMS. Dislocations in 2d. https://www.doitpoms.ac.uk/tlplib/dislocations/dislocations_in_2D.php. Accessed: 31/10/2017. Quite in depth, but can provide some useful context.

[6] Jim Breithaupt. *Physics*. Palgrave Macmillan, 2nd revised edition, 2003. Has some useful information, agrees with other sources.

[7] Mark Miodownik. How it works: Metal. https://online.clickview.co.uk/. Accessed: 31/10/2017. Perhaps a somewhat friendlier show about metals.