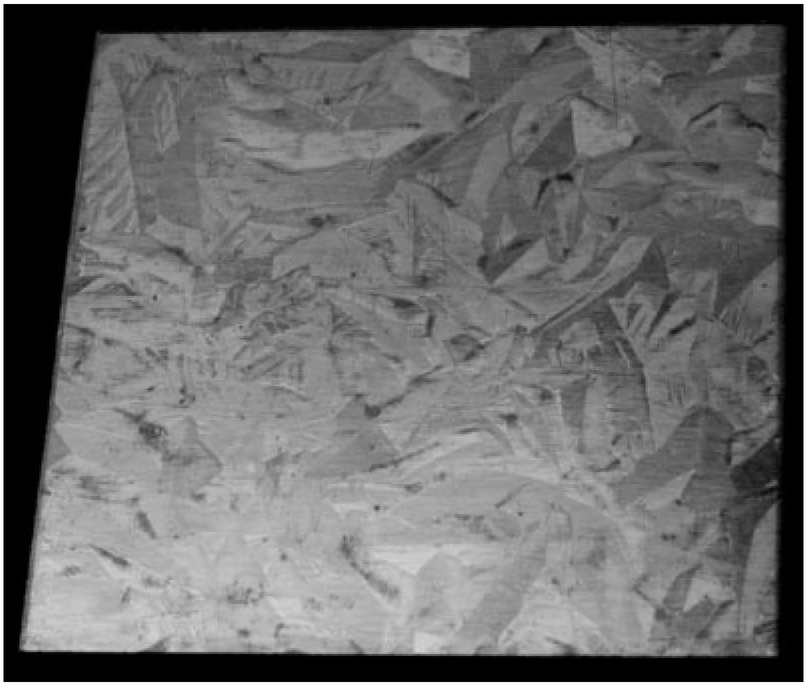
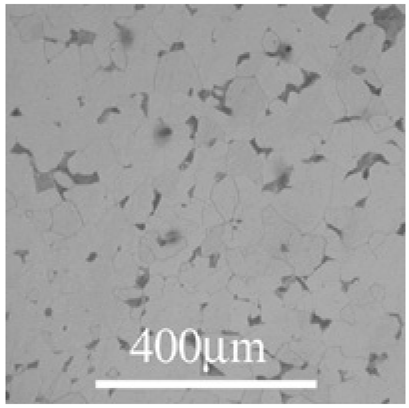
Polycrystals

Single crystals form only in special conditions. The normal solid form of an element or compound is *polycrystalline*. As the name suggests, a polycrystalline solid or *polycrystal* is made up of many crystals. The properties of a polycrystal are notably different from those of a single crystal. The individual component crystallites are often referred to as grains and the junctions between these grains are known as grain boundaries .

The size of a grain varies according to the conditions under which it formed. Galvanised steel has a zinc coating with visibly large grains. Other materials have much finer grains, and require the use of optical microscopy.

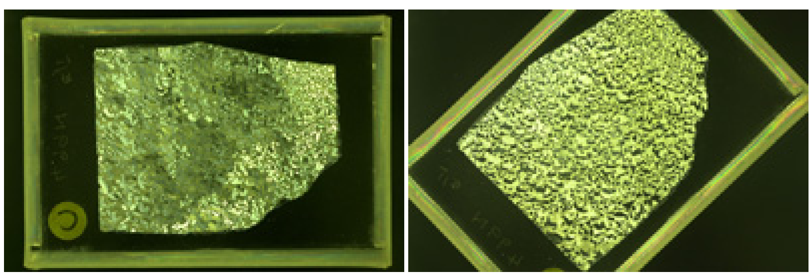


In galvanised steel, the grains are big enough to be seen unaided. The plate measures 5 cm across.



In many other metals, such as this hypoeutectoid iron-carbon alloy, the grains may only be seen under a microscope.

These photographs show a polycrystalline sample of quartz mixed with feldspar in which the grains all have optically anisotropic properties. Between the crossed polarisers, each grain allows transmission of light at a slightly different point in the rotation. This gives the strange effect seen here.



This polycrystal contains randomly oriented grains that allow transmission at different angles. Consequently different regions of the polycrystal are seen in these two photographs.

The three-dimensional shape of grains in a polycrystal is similar to the shape of individual soap bubbles made by blowing air into a soap solution contained in a transparent box.

The surface between bubbles is a high-energy feature. If the area of the surface is decreased, the overall energy of the system decreases, so*reduction of surface area is a spontaneous process*. If all the bubbles were the same size, the resulting structure would be a regular *close-packed*array, with 120° angles between the surfaces of neighbouring bubbles.

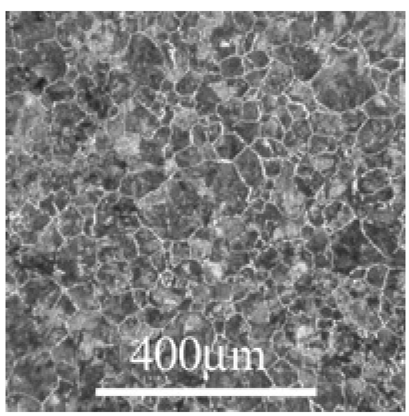
In practise, *bubble growth* can occur because the surface area of a few large bubbles is lower than that of many small bubbles. Large bubbles tend to grow, and small bubbles tend to shrink.

The bubbles are therefore different sizes so there are large deviations from the close-packed structure. On average, however, three bubbles meet at a junction, and the angle between the bubble surfaces is usually within a few tens of degrees of 120°.

The *curvature* of the surfaces is also important. Surfaces with a smaller radius of curvature have a higher energy than those with a larger radius of curvature. As a result, some small bubbles cannot shrink and disappear, even though the surface area would decrease if they did so. This is because the curvature of the boundaries, and the associated energy, would be too high.

In a real polycrystal, the grain boundaries are high-energy features, similar to the surfaces between bubbles. The soap froth is a very good model for the grain structure of a simple polycrystalline material, and many similar features can be observed in the two systems. The soap bubbles are analogous to the grains, and the surfaces of the bubbles are analogous to the grain boundaries. Compare the photographs of the soap bubbles with the micrograph of a polycrystalline material that has been etched to reveal the grain boundaries.

The packing of soap bubbles is somewhat similar to the packing of crystals - both systems seek to minimise their surface area. Note the angles at the junctions of grain boundaries.



The grains of this hypereutectoid iron-carbon alloy are packed in a similar way to the bubbles in the previous photographs.

Grain boundaries in a polycrystalline solid can *relax* (move in such a way to decrease the total energy of the system) when atomic rearrangement by diffusion is possible. In real materials, many other effects can influence the observed grain structure.

Source :http://www.doitpoms.ac.uk/tlplib/atomic-scale-structure/poly.php