

1 Wafer fabrication

1.1 Fabrication of the single crystal

1.1.1 The single crystal

A single crystal (monocrystal), as it is required in semiconductor manufacturing, is a regular arrangement of atoms. There are polycrystalline (composition of many small single crystals) and amorphous silicon (disordered structure). Depending on the orientation of the lattice, silicon wafers have different surface structures which impact various properties as the charge carrier mobility or the behaviour in wet-chemical anisotropic etching of silicon.

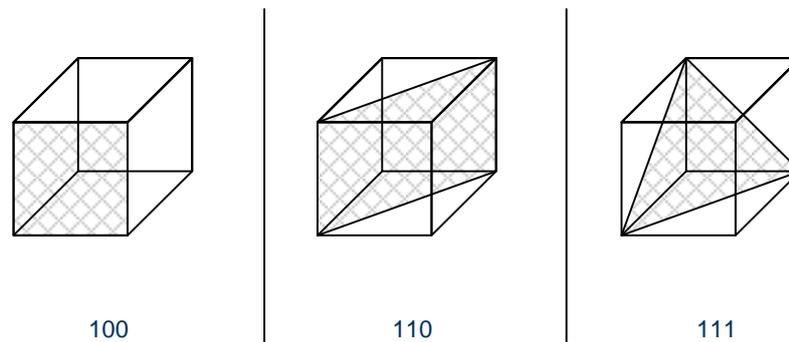


Fig. 1.1: Crystal orientation

In micromechanics the crystal orientation is of particular importance. It allows microchannels with perpendicular walls on (110) silicon, whereas flank angles of 54.74° are possible on (100) orientation.

1.1.2 Czochralski process

The polycrystalline silicon, as it is present after the zone cleaning, is melted in a quartz crucible nearly above the melting point of silicon. Now dopants (e.g. boron or phosphorus) can be added to the melt to achieve appropriate electrical characteristics of the single crystal.

A seed crystal (a perfect single crystal) on a rotating rod is brought to the surface of the silicon melt. This seed crystal pretends the orientation of the silicon crystal. In contact with the seed crystal, the melt overtakes its crystal structure. The fact that the crucible temperature is only slightly above the melting point of silicon, the melt solidifies immediately on the seed and the crystal grows.

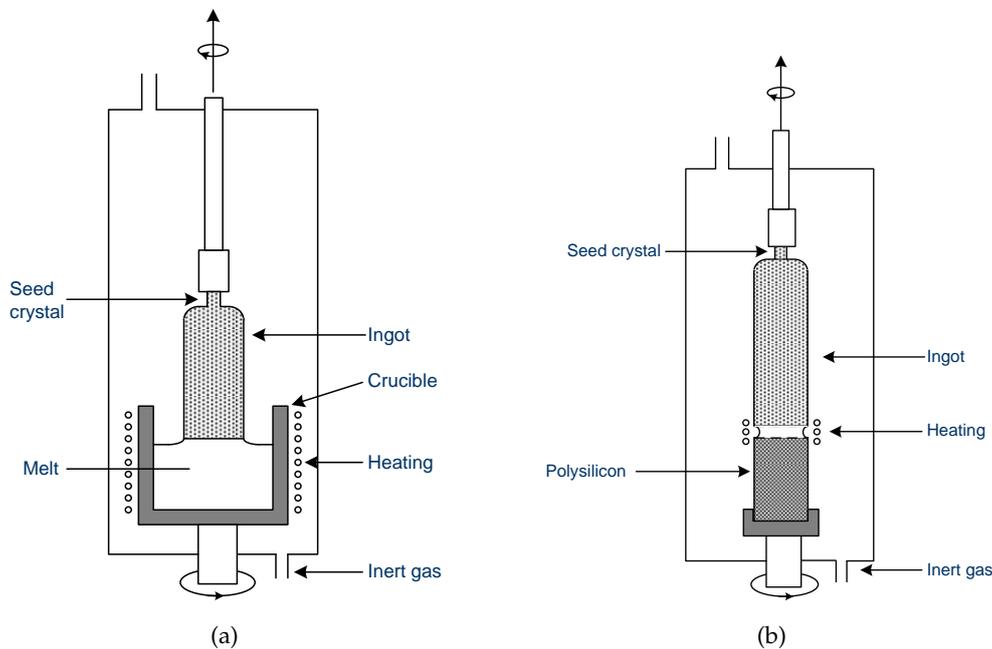


Fig. 1.2: Illustration of (a) the Czochralski and (b) the float-zone process

The seed is slowly pulled upward with constant rotation, while there is constant contact with the melt. The crucible turns in the opposite direction of the seed crystal. A constant temperature of the melt is essential to ensure a steady growth. The diameter of the single crystal is determined by the drawing speed, which provides 2 to 25 cm/h. The higher the drawing speed, the thinner the crystal. The entire apparatus is located in a controlled atmosphere, so that no oxidation of silicon can take place.

The disadvantage of this procedure is that the melt is accumulated with dopants during the process, since the dopants are more soluble in the melt than in the solid state. Thus the dopant concentration along the silicon rod is not constant. Also impurities or metals can dissolve from the crucible and be built into the crystal.

The advantages of this method are the lower costs, and the ability to produce larger wafer sizes as in float-zone processes.

1.1.3 Float-zone silicon

In contrast to the Czochralski process the polysilicon is not entirely molten, but, as in the zone cleaning, only a small area (a few millimeters).

Again, a seed crystal, which will be introduced to the end of the polycrystalline silicon rod, sets the crystal structure. The polycrystal is molten and assumes the structure of the seedling. The heated region is slowly guided along the rod, the polycrystalline silicon rod slowly transforms into a single crystal.

Since only a small portion of the polycrystalline silicon is molten, it can hardly be polluted (impurities accumulate at the bottom since their higher solubility). The doping is done by additions of dopants into the inert gas (eg with diborane or phosphine) which flows around the apparatus.