The concept of a linear lattice imperfection called a *dislocation* arose primarily from the study of plastic deformation of crystalline materials. The dislocations are borderlines where the atomic planes are out of register. At dislocations some of the covalent bonds in silicon are broken. The dislocations may therefore carry electric charge.

Because of the disregister, the dislocations are surrounded by stress fields and may attract impurity atoms.

In *n*-type silicon, donor impurities can provide electrons to fill the missing charge from a missing bond at the dislocation. As a result of the acquisition of electrons, the dislocation becomes negatively charged, which again may attract the positively charged donor impurities. This situation may lead to a space charge region in the form of a cylinder in which positively charged donor ions surround a negatively charged dislocation.

In *p*-type material, the dopant atoms may accept electrons from a dislocation. In this case the cylinder-shaped space charge region has a positively charged dislocation surrounded by negatively charged acceptor ions.

The category of *point defects* include vacancies, interstitials and impurities either present as intentionally dopant atoms added to control the properties of silicon or unintentionally incorporated as contaminants from the raw materials, processing or crystal growth.

A *vacancy* is a missing atom at a silicon site. The result of the removal of a silicon atom is the formation of four dangling atomic bonds with unpaired electrons and some lattice relaxation. Vacancies thus tend to exhibit acceptor-like behaviour. The concentration of vacancies, n/N_0, in silicon at a given temperature can be determined from the following expression:

$$n = N_0 \exp(-E_v/kT)$$

where n = number of vacancies/volume, N_0 = number of atoms/volume, k = Boltzmann's constant and T = temperature in K. E_v is the formation energy, which is the energy required to take an atom from a lattice site inside the crystal to a lattice site on the surface. In silicon, $E_v \approx 2.3$ eV.

A *self-interstitial* can be formed by inserting a silicon atom into one of the holes in the structure. The energy of formation of interstitials, E_i, in the loosely packed diamond structure is lower than the formation energy of vacancies, $E_i \approx 1.1.$ eV.

An interstitial has four valence electrons that are not involved in covalent bonding with the adjoining atoms. These electrons may be lost to the conduction band and the interstitial may behave as a donor.

At low concentrations the impurities exist as single atoms in the matrix – so-called *solid solutions*. Atoms in the solid solution are incorporated in the matrix in two ways. They can substitute for an atom of the host crystal and maintain the regular atomic structure of the crystal. In this case they are known as *substitutional impurities.* Alternatively, the impurity atoms can occupy positions squeezed in between the atoms of the host crystal. Then they are known as *interstitial impurities*.