Table 5.8 Values of δ/D_l and D_l for some elements [27]

Impurity element	Rotation rate [rpm]	$\frac{\delta}{D_l}$ [s/cm]	Diffusion coefficient, D_l [cm^2/s]
B	10	170 ± 19	$(2.4 \pm 0.7) \times 10^{-4}$
	60	84 ± 37	$(2.4 \pm 0.7) \times 10^{-4}$
Al	10	86 ± 34	$(7.0 \pm 3.1) \times 10^{-4}$
	60	40 ± 17	$(7.0 \pm 3.1) \times 10^{-4}$
P	5	127 ± 36	$(5.1 \pm 1.7) \times 10^{-4}$
	55	60 ± 19	$(5.1 \pm 1.7) \times 10^{-4}$
As	5	190 ± 53	$(3.3 \pm 0.9) \times 10^{-4}$
	55	79 ± 16	$(3.3 \pm 0.9) \times 10^{-4}$

as hard spheres, the diamond structure fills 0.34 of the available space, compared to 0.74 for a close-packed structure such as aluminium. The formation of defects in the silicon lattice creates local electronic disturbances because of the nature of the atomic bonding.

The following description follows standard textbook presentations in physical metallurgy and concentrates on some lattice defects appearing in silicon, which are important when discussing the effect of impurities on the electronic properties.

It is common practice to divide the lattice defects into the following categories:

Plane defects
- Stacking faults
- Twin boundaries
- Grain boundaries

Line defects
- Dislocations

Point defects
- Vacancies
- Self-interstitials
- Substitutional impurities
- Interstitial impurities

Volume defects
- Precipitates

Single-crystal material consists of one grain of a continuous crystal structure. Multicrystalline (mc-)/polycrystalline (pc-) material consists of many separate grains with inclined crystal planes that meet at *grain boundaries*. Depending upon the misorientation between adjoining grains, the interfaces are termed *subgrain* boundaries (0–5°) and *grain* boundaries. *Twin* boundaries arise where one crystal grain is a mirror image of its neighbour. Grain boundaries may have a more open and less well organised atomic structure. Atomic diffusion is therefore easier along grain boundaries than in the bulk crystal. Because of the lack of crystal order, some of the covalent bonds are broken and the grain boundaries may therefore carry electric charge. The electrical properties of the grain boundaries vary with the amount of atomic disregister.