



band theory, intrinsic and extrinsic silicon, and the p-n junction diode



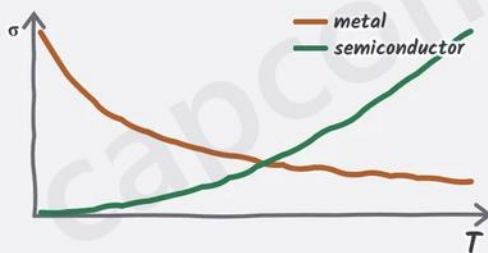
Conductors, insulators, semiconductors

- conductivity $\sigma = nq\mu$
- n is carrier density, q the carrier's charge, μ its mobility
- conductors (metals): about 10^{28} free electrons per m^3
- conductivity falls as temperature rises
- insulators: only about 10^7 free electrons per m^3 , effectively none
- semiconductors: conductivity between the two, tailorable
- unlike a metal, conductivity rises with temperature
- silicon, germanium are elemental semiconductors, group 14, valence 4
- each atom covalently bonded to four neighbours in a tetrahedral lattice

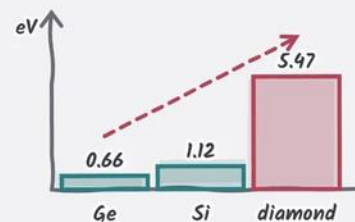
Band theory, in brief *

- an isolated atom's electrons occupy discrete energy levels
- in a solid, Pauli's exclusion principle splits each level into a huge number of sub-levels
- these sub-levels appear as a continuous energy band
- topmost occupied band: the valence band
- next higher band, where conducting electrons live: the conduction band
- the band gap: the empty range between them
- roughly 1.12 eV for silicon, 0.66 eV for germanium at 300 K
- about 5.47 eV for diamond
- metal: valence and conduction bands overlap, easy to conduct
- insulator: gap is wide (~ 5 eV), hard to cross
- semiconductor: gap is small (about 1 eV), thermal energy alone crosses some electrons

Conductivity and the band gap



conductivity vs temperature: a metal's falls as T rises, a semiconductor's climbs



band gap in eV: diamond's is nearly five times silicon's