Lecture 11: Semiconductors: donors, acceptors and excitons

The band structures of Si and Ge are discussed. The valence band is fitted by LCAO while the conduction band is nearly free-electron-like. The small indirect band gap and the cigar shaped electron pockets are discussed. The small band gap leads to a large dielectric constant ε. Replacing Si by P leads to extra positive charge and extra electron, which form a hydrogen-like bound state called the donor level. The small mass m^* and large ε lead to small binding energy $\varepsilon_d = (m^*/m)/\varepsilon^2$ Rydberg and large effective radius $r_0 = (m/m^*)\varepsilon a_0$ of the donor level. Similarly, doping by Al forms acceptor level. The large overlaps between donors allows them to form bands and an insulator-to-metal transition may occur. The small energy scale allows us to control the electrical property of doped semiconductors with small potentials. The optical absorption edge in semiconductors is dominated by the electron-hole bound state called the exciton.

Reading: Mardar 19.3, 21.4