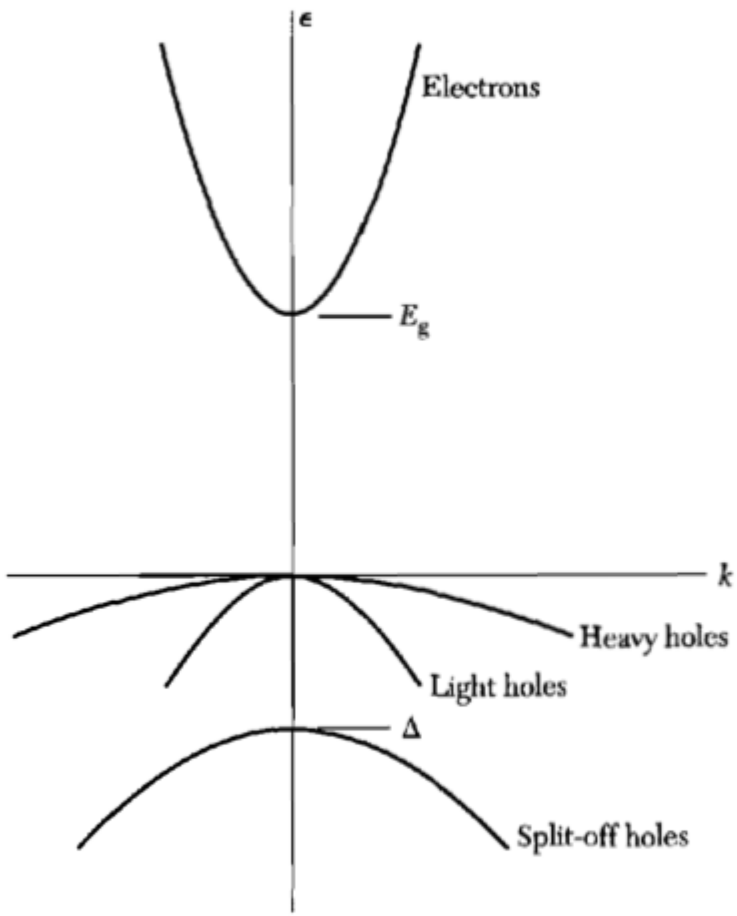
PHY404- Solid State Physics II

Assoc.Prof. Yeşim Moğulkoç

Band edge structure



At the center of the Brillouin zone (is defined as a Wigner-Seitz primitive cell in the reciprocal lattice), the band structure for direct-gap semiconductors is given in the figure.

Simplified view of the band edge structure of a direct-gap semiconductor

(The figure is used from Introduction to Solid State Physics, C. Kittel)

Band edge structure

The conduction band edge is spherical with the effective mass m_0:

$$\epsilon_c = E_g + \hbar^2 k^2 / 2m_e$$

The valence bands are characteristically threefold near the edge, with the heavy hole *hh* and light hole *lh* bands degenerate at the center, and a band *soh* split off by the spin-orbit splitting Δ:

$$\epsilon_v(hh) \cong -\hbar^2 k^2 / 2m_{hh} \; ; \qquad \epsilon_v(lh) \cong -\hbar^2 k^2 / 2m_{lh} \; ;$$

$$\epsilon_v(soh) \cong -\Delta - \hbar^2 k^2 / 2m_{soh} \; .$$

Band edge structure

The perturbation theory of band edges suggests that the electron effective mass should be proportional to the band gap, approximately, for a direct gap crystal.

Impurity Conductivity

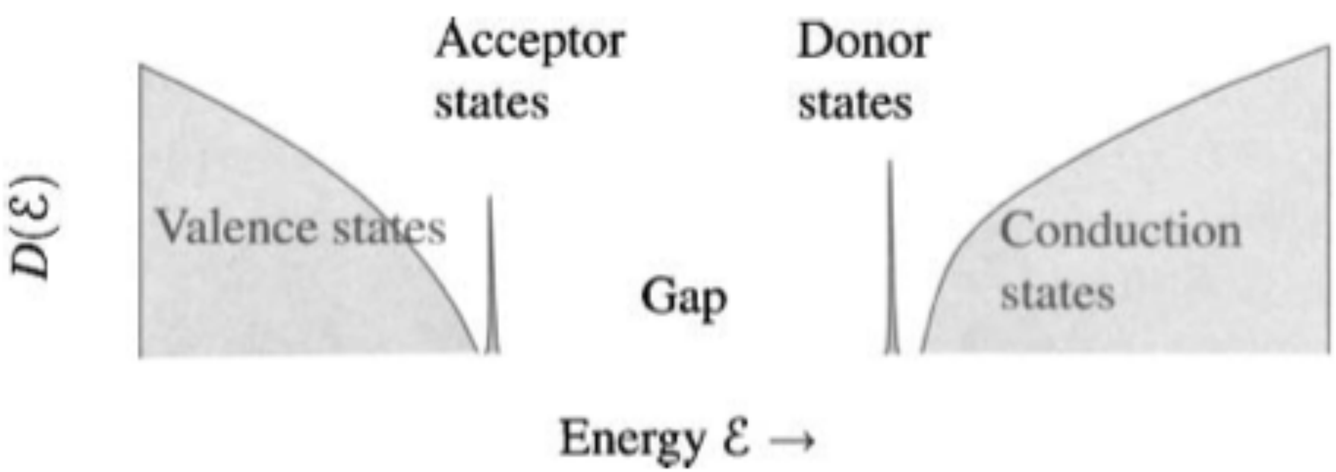
- **Impurities**
- **Imperfections**

affect

The electrical properties of semiconductor

Extrinsic Semiconductor

- The effect of adding donors to a semiconductor is to create a population of bound states sitting just below the conduction band, while adding acceptors creates bound states just above the valence band.



Extrinsic Semiconductor

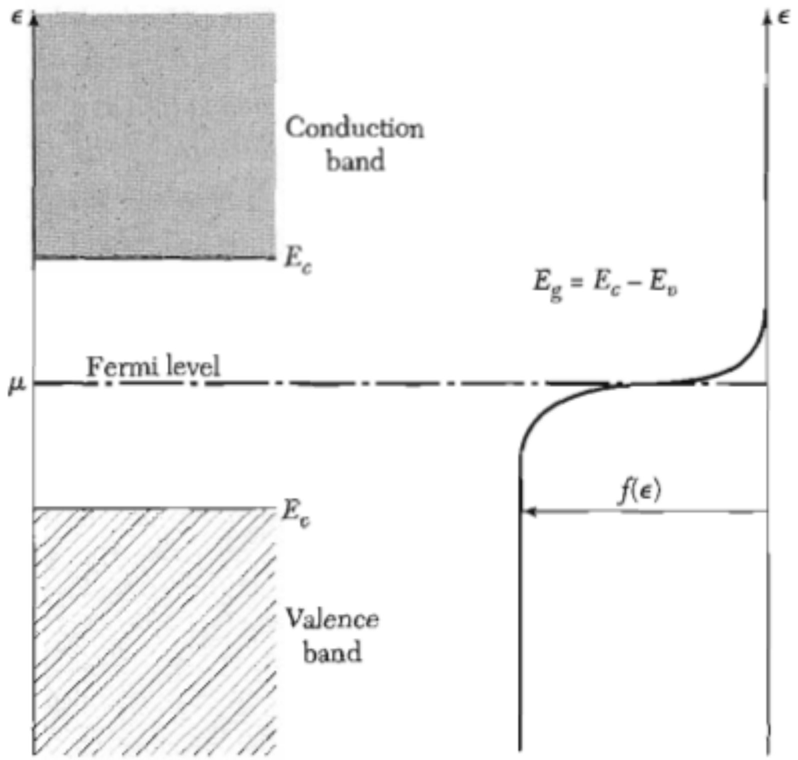
- At room temperature, almost all the bound states break apart; each donor gives an electron to the conduction band, while each acceptor gives a hole to the valence band.
- When certain sorts of impurities are used to dope a semiconductor, the physics changes rather dramatically

Extrinsic Semiconductor

- The most interesting impurities are noncompensated, lying one column to the right or one column to the left of a semiconductor in the periodic table.

Intrinsic Semiconductor

- Concentration of intrinsic carriers as a function of temperature



Energy scale for statistical calculations.

(The figure is used from Introduction to Solid State Physics, C. Kittel)