Band Gap

Basics

- This is just a quick reminder of the most fundamental electronic property of crystals, the *band gap* in the energy states of the electrons in a crystal.
  - If atoms condense into solids, the overlap of the energy states of the outermost electrons means that according to the **Pauli principle**, the energy levels must split into many level because no two electrons can be in the same (energy) state.
  - These levels may have energy gaps, i.e. within a band gap there are no allowed states for electrons. Bands need not be fully filled; the **Fermi energy** marks the energy state where just half of the available levels are occupied. At finite temperatures, the distribution function around the Fermi energy is "soft" and symmetric.
- Crystals can be classified according to their band structure. Materials without a bandgap or a very small bandgap are conductors, materials with a very wide bandgap are insulators.
  - Materials with a bandgap of about **0,5 eV - 2,5 eV** are semiconductors with especially remarkable electronic properties. This is due to the fact that there carrier densities can be influenced dramatically by introducing additional states in the bandgap via defects
  - This is usually done with substitutional impurity atoms (dopants), but crystal lattice defects in general also introduce states in the bandgap and thus influence the electronic properties of semiconductors.
- Semiconductors like **Si** or **GaAs** are the mainstay of modern technology only because it proved to be possible to control their crystal lattice defects to an unprecedented level of accuracy. But we should always bear in mind that among the huge number of semiconducting crystals most are technically useless because we cannot control their defects!
  - More about band gaps and semiconductors can be found in the *hyperscript* "Semiconductors".