The Energy Band Model Lesson

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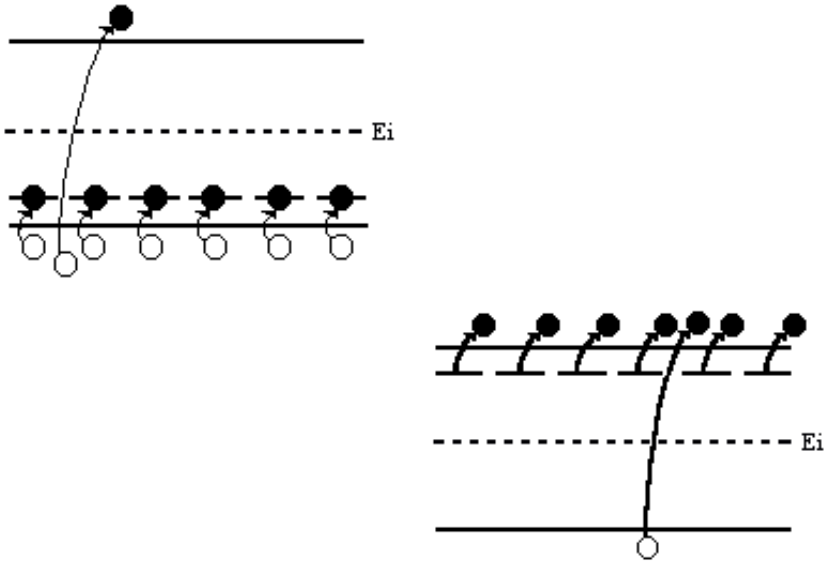

Brief Description

Throughout the book, the energy band model, or band diagram, is used to describe the behavior of electrons and holes to externally applied forces like light, heat, and/or voltage; therefore, learning how to interpret them and sketch them is basic for this course. Here we are interested in the microscopic things, like individual or groups of electrons and their actions, so we have to use our imagination quite a bit here.

The band diagram models the allowed states in the semiconductor known as energy bands. The two bands of allowed states are called the conduction band and the valence band. The two are separated by an intervening forbidden gap, which we call the band gap. To review what the allowed states are take a look at the Bohr Model of the Atom.

Definitions

Band:
A range of some physical variable, as of radiation wavelength or frequency. A range of very closely spaced electron energy levels in solids, the distribution and nature of which determine the electrical properties of a material.

Conduction:
The transmission or conveying of something through a medium or passage, esp. of electric charge or heat through a conducting medium without perceptible motion of the medium itself.

Dopant:

A small quantity of a substance, such as phosphorus, added to another substance, such as a semiconductor, to alter the latter's properties.

Energy:
The work that a physical system is capable of doing in changing from its actual state to a specified reference state, the total including, in general, contributions of potential energy, kinetic energy, and rest energy.

Gap:
A suspension of continuity; hiatus. A conspicuous difference; disparity.

Model:
A tentative description of a system or theory that accounts for all of its known properties.

Valence:
The capacity of an atom or group of atoms to combine in specific proportions with other atoms or groups of atoms. A valence electron is in the outer or next outer shell of an atom and can participate in forming chemical bonds with other atoms.

The Conduction Band

The conduction band is the upper band of allowed states. When it is drawn it is represented by a line labeled by E_c which represents the lowest possible energy state in the conduction band.

This band is usually empty, it contains few or no electrons since energy is required for them to get there from the valence band. Electrons in the conduction band are free to move about the crystal, thus the name conduction band.

If an electron does manage to get to the conduction band, it resides there for mere fractions of a second (an average lifetime). When it loses its energy it drops back down to the valence band emitting its energy as heat, light or by transferring it to another electron.

The Valence Band

The valence band is the lower band of allowed states. In the drawings it is depicted by a line labeled by E_v which represents the highest energy state in the valence band. Since electrons have a tendency to fill the lowest available energy states,the valence band is always nearly completely filled with electrons, especially as the temperature falls toward 0K. As the temperature rises or light is introduced, electrons can absorb the energy and leave the valence band to rise up to the conduction band. When an electron gains enough energy, greater than the band gap energy, and gets to the upper band, it is free to move, becoming a carrier and therefore increasing the conductivity of the semiconductor. When electrons leave the valence band they leave behind a hole which can move about the crystal, also adding to the conductivity.

To see what this looks like, take a look at the demo of a bond breaking and entering the conduction band leaving a hole behind in the valence band.