

A semiconductor is a solid whose electrical conductivity can be controlled over a wide range, either permanently or dynamically. Semiconductors are tremendously important technologically and economically. Semiconductors are essential materials in all modern electrical devices, from computers to cellular phones to digital audio players. Silicon is the most commercially important semiconductor, though dozens of others are important as well.

Semiconductor devices are electronic components that exploit the electronic properties of semiconductor materials, principally silicon, germanium, and gallium arsenide. Semiconductor devices have replaced thermionic devices (vacuum tubes) in most applications. They use electronic conduction in the solid state as opposed to the gaseous state or thermionic emission in a high vacuum.

Semiconductor devices are manufactured as single, discrete devices or integrated circuits (ICs), which consist of a number – from a few devices to millions – of devices manufactured onto a single semiconductor substrate.

Overview of semiconductors

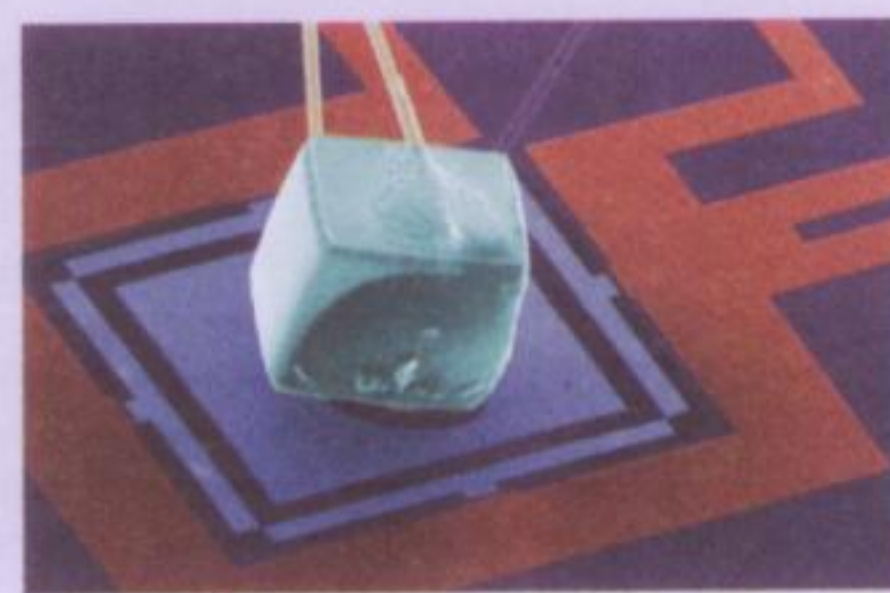
Semiconductors are very similar to insulators. The two categories of solids differ primarily in that insulators have larger band gaps – energies that electrons must acquire to be free to flow. In semiconductors at room temperature, just as in insulators, very few electrons gain enough thermal energy to leap the band gap, which is necessary for conduction. For this reason, pure semiconductors and insulators, in the absence of applied fields, have roughly similar electrical properties. The smaller bandgaps of semiconductors, however, allow for many other means besides temperature to control their electrical properties.

Semiconductors' intrinsic electrical properties are very often permanently modified by introducing impurities, in a process known as doping. Usually, it is reasonable to approximate that each

impurity atom adds one electron or one "hole" that may flow freely. Upon the addition of a sufficiently large proportion of dopants, semiconductors conduct electricity nearly as well as metals. The junctions between regions of semiconductors that are doped with different impurities contain built-in electric fields, which are critical to semiconductor device operation.

In addition to permanent modification through doping, the electrical properties of semiconductors are often dynamically modified by applying electric fields. The ability to control conductivity in small and well-defined regions of semiconductor material, statically through doping and dynamically through the application of electric fields, has led to the development of a broad array of semiconductor devices, like transistors. Semiconductor devices with dynamically controlled conductivity are the building blocks of integrated circuits, like the microprocessor. These "active" semiconductor devices are combined with simpler passive components, such as semiconductor capacitors and resistors, to produce a variety of electronic devices.

In certain semiconductors, when electrons fall from the conduction band to the valence band (the energy levels above and below the band gap), they often emit light. This photoemission process underlies the light-emitting diode (LED) and the semiconductor laser, both of which are tremendously important commercially. Conversely, semiconductor absorption of light in photodetectors excites electrons from the valence band to the conduction band, facilitating reception of fiber optic communications, and providing the basis for energy from solar cells.



Cube of Germanium

Semiconductors may be elemental materials, such as silicon, compound semiconductors such as gallium arsenide, or alloys, such as silicon germanium or aluminium gallium arsenide.