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Doping Process in Semiconductors

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Commentary

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DESCRIPTION

Doping in the manufacture of semiconductors refers to the purposeful addition of impurities into an inherent semiconductor with the goal of modifying its structural, optical, and electrical properties. An extrinsic semiconductor is the term used to describe the doped substance. A semiconductor's capacity to conduct electricity can be altered by small concentrations of dopant atoms. Low or light doping is defined as the addition of one dopant atom for every 100 million atoms. Doping is referred to as high or heavy when significantly more dopant atoms are added, on the order of one per ten thousand atoms. This is frequently denoted by an n^+ or p^+ depending on the sort of doping involved. Degenerate semiconductors are defined as semiconductors that have been doped to such high levels that they behave more like conductors than semiconductors.

Due to the higher carrier concentration, increasing doping typically results in increased conductivity. Degenerate semiconductors are frequently utilized in place of metal in integrated circuits because they exhibit conductivity values that are comparable to metals. To indicate the relative doping concentration in semiconductors, superscript plus and minus symbols are frequently used. As an illustration, the symbol n^+ designates an n-type semiconductor with a high, frequently degenerate, doping concentration. When a semiconductor is doped, the permissible energy levels are introduced into the crystal's band gap, but very near the energy band that corresponds to the dopant type. In other words, electron acceptor impurities produce states close to the valence band, whereas electron donor impurities produce states close to the conduction band. Dopant-site bonding energy, often known as energy bond, is the term used to describe the relatively small energy gap between these energy states and the closest energy band. Dopants also significantly alter the energy bands in relation to the Fermi level.

Nearer to the Fermi level is the energy band that corresponds to the dopant with the highest concentration. If the interfaces can be formed cleanly enough, stacking layers of materials with varied properties results in numerous useful electrical features caused by band bending, as the Fermi level must remain constant in a system in thermodynamic equilibrium. Alternately, vapor-phase epitaxy may be used in the synthesis of semiconductor devices. A gas containing the dopant precursor may be added to the reactor during vapor-phase epitaxy. For instance, sulphur is incorporated into the structure when hydrogen sulphide is introduced to gallium arsenide during n-type gas doping.

Sulfur is constantly concentrated on the surface during this process. To get the necessary electronic characteristics in semiconductors generally, only a very thin layer of the wafer needs to be doped. A dopant of the p-type is boron. Junction depths may be easily controlled thanks to its diffusion rate. Diborane gas diffusion may be used to add. The sole acceptor with enough solubility for effective emitters in transistors and other applications calling for extremely high dopant concentrations. About the same rate as phosphorus, boron diffuses. Arsenic is a n-type dopant. Because of its slower diffusion, it can be employed for dispersed connections used for underground layers. High concentrations are possible, and its atomic radius is similar to that of silicon. It is employed in applications where the dopant should remain in place during subsequent thermal processing since its diffusivity is about a tenth that of phosphorus or boron useful for shallow diffusions where an abrupt boundary with good control is sought.