SEMICONDUCTOR MATERIALS

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Semiconductor materials are a class of substances whose electrical conductivity falls between that of conductors and insulators. Unlike metals, which conduct electricity freely, or insulators, which resist it completely, semiconductors allow for controlled conduction depending on temperature, light, or the presence of impurities. This unique property makes them indispensable in modern electronics.

At the atomic level, semiconductors are often made from elements like silicon (Si), germanium (Ge), or compounds such as gallium arsenide (GaAs). In pure form (intrinsic semiconductors), these materials have a crystalline structure with a specific band gap between the valence band (where electrons are bound) and the conduction band (where electrons can move freely). At absolute zero temperature, the conduction band is empty, but as temperature increases, some electrons gain enough energy to cross the band gap and become mobile. This transition leads to electrical conductivity.

The real power of semiconductors comes from their ability to be doped—a process where small amounts of foreign atoms are added to modify their electrical properties. Doping with atoms that have more electrons (such as phosphorus) creates n-type semiconductors, while doping with atoms that have fewer electrons (like boron) creates p-type semiconductors. These two types are combined in various ways to build diodes, transistors, solar cells, and integrated circuits.

Another key advantage of semiconductors is their sensitivity to external influences such as heat, magnetic fields, and light. For instance, when exposed to light, semiconductors can generate current (as in photovoltaic cells), or their conductivity can change drastically with temperature, which is used in thermistors.

Today, semiconductors are foundational in every field involving electronics — from computing and telecommunications to medicine and energy. Continuous research in materials science, nanotechnology, and quantum physics is pushing the limits of semiconductor performance and enabling revolutionary technologies.

References:

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