Semiconductor

Switchable Conductor/Insulator

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Derivation: From Latin *semi*, half, and from Middle English *conducten*, from Latin *conducere*, to bring or lead together, to induce, to employ.

Electrical energy is transported by charged atomic particles—charges. Materials with moveable charges are called conductors. Materials that lack moveable charges are called insulators. Semiconductors can have qualities of both conductors and insulators.

The charges in conductors are very loosely bound. They behave like a "sea" of moveable charges that will flow easily. The charges in insulators are very tightly bound. It's tough to make them move.

Metals are generally good conductors, while plastic, rubber, glass, and other materials tend to be good insulators. This is why electrical wires are copper that is covered with plastic insulation, not plastic that is covered with copper. The copper lets the charges—and the energy—move, while the rubber or plastic insulation around the copper keeps the charges from flowing out and causing trouble.

Structurally, conductors have only a few electrons in the outer shell of their atoms, and they give them up easily. Insulators have atomic shells that are full or almost full, and they don't give the electrons up easily. Semiconductors are in the middle, with half-filled outer shells. Pure semiconductors are insulators (if poor ones). But with doping, and by applying some energy, their electrons can be freed, making them into conductors.

Common semiconductor materials are silicon (the most prevalent), gallium, germanium, and selenium. By adding minute quantities of other materials (called dopants) to these materials, their semiconducting qualities can be enhanced, modified, and varied.

These enhanced semiconductors can be used in a variety of ways. Applying light, heat, radiation, voltage, or other forces to a semiconductor can make it act like an insulator, a conductor, or something in between.

When they were first discovered, semiconductor materials were just a scientific curiosity. But soon many applications were found, and today these materials are critical for the operation of millions of electronic devices. Using these materials has made electronic devices faster, smaller, more reliable, and more efficient. Semiconductor devices include transistors, integrated circuits, and various types of diodes, including light emitting diodes (LEDs).

A semiconductor device in its simplest form is like a switch or faucet. External stimuli can turn this switch on, off, or somewhere in between. Before semiconductors, this function was handled by vacuum tubes. Tubes typically work at very high voltages, generate a lot of waste heat (which causes them to wear out), and are more fragile than semiconductors. A semiconductor device does the same job using less energy, and is much more durable, even though it is hundreds of times smaller. A single microprocessor chip does the job that a large building full of vacuum tubes did before the discovery of semiconductors.

Computers and other electronic devices rely on components turning on and off. This switching is essential to the logic operations that make a computer function. Semiconductors allow an enormous amount of electronic functionality to be built into a very small package. Transistors, one of the most common applications, use a tiny amount of energy to control a large amount. This is the basic principle of amplifiers and inverters.

In the renewable energy realm, semiconductor materials and devices are used in inverters, charge controllers, diodes, and PV modules. Modern inverters would be impossible without huge (large current) field effect transistors (FETs). The inverter is perhaps where transistors have most changed our industry. PVs are semiconductor devices—photo-diodes. Meters, efficient lighting, and other electronic devices rely on semiconductor materials too.

Semiconductors are basic electronic building blocks. Without them, our modern world would look very different. They have the ability to act as insulators or as conductors, and can be switched in simple and complex ways to make our toys and tools work.

Access

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