Semiconductors – Construction, Function and Uses

Semiconductors are used in simple crystal radios, transistor radios, stereos, TVs, and computers to name only a few.

Construction

The primary materials used for constructing semiconductors are germanium (**Ge**) and silicon (**Si**). In their pure crystalline matrix form these elements are non-conductors because there are no free electrons present. The atoms are covalently bonded to each other to form a regular tetrahedron.

N-type material:
The matrix is contaminated (a **Ge** or **Si** atom is replaced) with an element of five valence electrons such as antimony, arsenic, phosphorus, or bismuth. Four of the five valence electrons form covalent bond with adjacent **Ge** or **Si** atoms to keep the crystal lattice intact but the extra electron has no attachment. This extra electron will act as a current carrier and thus the resistance to current flow by the germanium or silicon matrix is greatly reduced. When a battery is connected across the structure, the free electron will flow to the positive terminal. Since there is now an electron deficiency the matrix will have a positive charge. A substitute electron from the negative battery terminal will enter the matrix and flow to the positive terminal. A continuous stream of electrons will flow as long as EMF is applied. This is **n-type** material because of **current conduction by a negative charge**.

P-type material:
If the matrix is contaminated with an element with three valence electrons, only three stable covalent bonds form with the adjacent **Ge** or **Si** atoms. Contaminate elements for this application are boron (**B**), aluminum (**Al**), gallium (**Ga**), indium (**In**) and thallium (**Tl**). The contaminate must take an electron from another **Ge** or **Si** atom and when the electron is removed, a positively charge region is formed that is equal in magnitude to the charge of an electron. The **"hole"** is the area where an electron once resided and then removed. When an EMF is applied to this structure the positive hole region becomes mobile and moves toward the negative terminal of the battery supplying the EMF. The flow of holes has the same effect and as a flow of electrons except that holes move in the ***opposite*** direction of the flow of electrons. This is **p-type** material because the **charge carriers are positive holes**.

A small amount of doping (deliberate contamination) of the silicon crystal, which is normally a good insulator, will allow the silicon crystal to become a good (not great) conductor.

Diodes

Diodes are semiconductors in the simplest form, they are made of **n-type** material and **p-type** material sandwiched together. A diode will allow the current to flow in only one direction. Think of a turnstile. A person can go through the turnstile in one direction but not return in the opposite direction.

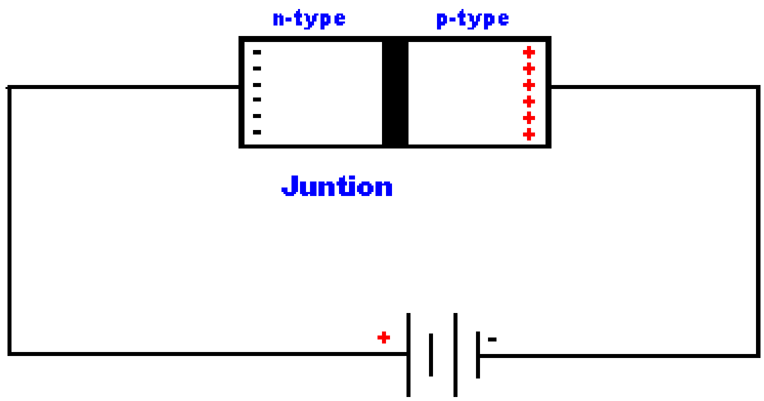

Figure A

In the figure A above the positive end of the battery is connected to the **n-type** material and the negative terminal is connected to the **p-type** material. The positive "**holes**" are attracted to and move to the end of the diode and the free electrons in the **n-type** material move toward the positive terminal. There is no movement of charge through the junction and thus, no current flows.

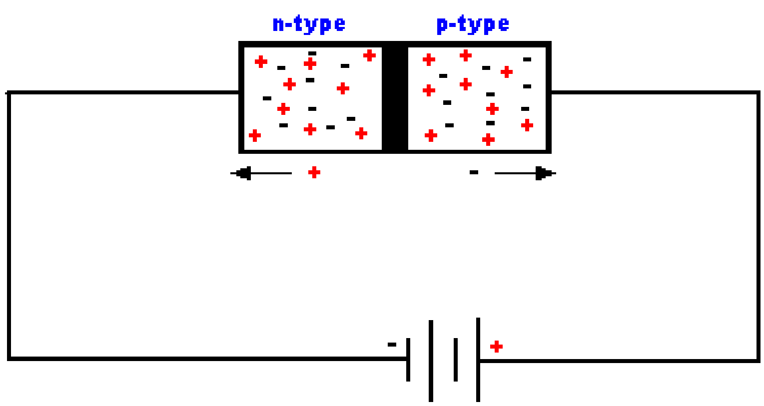

Figure B

In figure B above, the battery is reversed. Now the "**holes**" can move across the junction toward the negative terminal and the electrons move across the junction to the positive terminal. Since current is now flowing across the junction, current is also flowing one way through the diode.

Diodes are used in the TI84 calculator for one-way current flow. If the batteries are accidentally inserted into the calculator backwards, the diode will prevent the current from flowing backward through the calculator damaging it. Diodes are also used as switches, converting alternating current to direct current and separating RF signals from AF signals in the crystal radio.