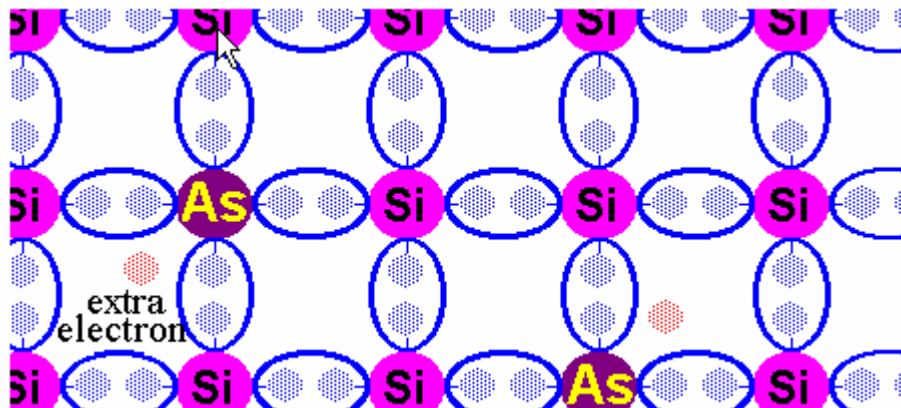


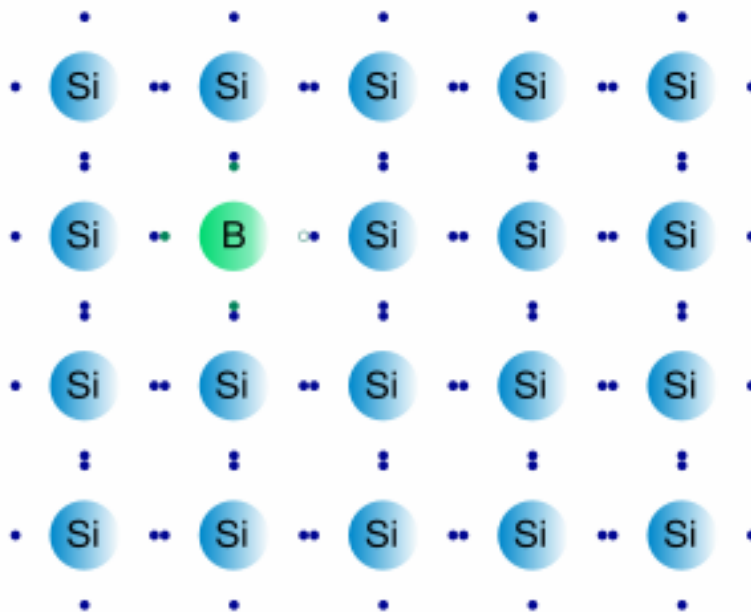
1. N and P-type Semiconductors

Neither pure silicon(Si) nor germanium(Ge) are great conductors. They form a crystal lattice by having each atom share all of its 4 valence electrons with neighbouring atoms. The total of eight electrons can not easily be jiggled out of place by an incoming current.

If , however, the crystalline array is “doped”(mixed with an impurity) with arsenic which has five valence electrons, the behaviour of the lattice will change. Four bonds will be still be made but there will be a leftover electron that can wander through the crystal. This is called an *n-type semiconductor*.



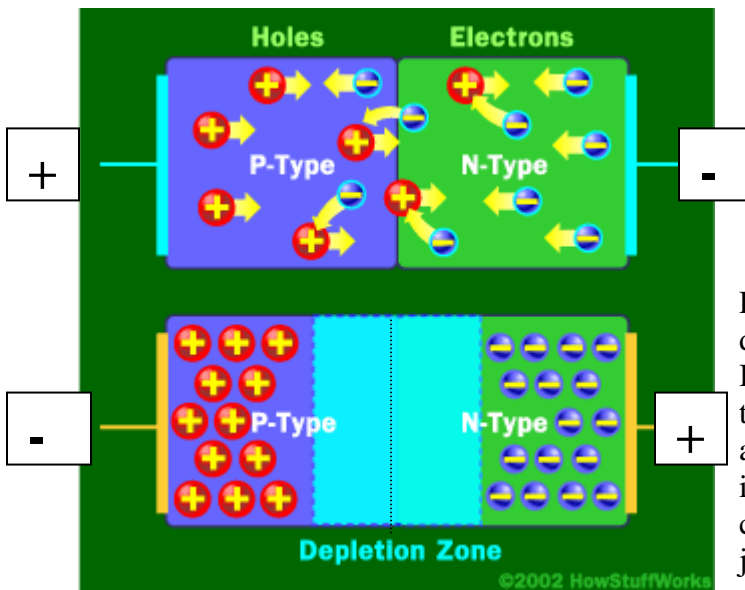
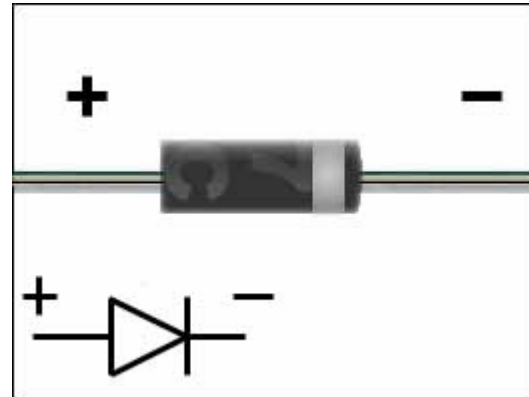
Boron can also be used to dope a pure crystal of silicon. But since boron only offers 3 of the four electrons that a silicon atom needs, each silicon center is left with a *hole*. Semiconductors made in this manner are called *p-type*.



In a p-type material if an atom from a neighbouring atom fills the hole, it will leave a hole adjacent to it. This process will continue in a domino effect and the hole will be moving in the direction opposite to electron-flow. In reality the atoms are remaining fixed in the lattice, but there is an illusion that the holes are physically moving.

2. DIODES

A solid state diode consists of p-type and n-type semiconductors placed side by side.



Diodes only allow electricity to flow in one direction through them.

In the top part of the above diagram we see that if the negative end of the battery is attached to the n-type side of the diode, incoming electrons will dislodge the crystal's extra electrons towards the junction between the p-type and type materials. Meanwhile, as the electrons from

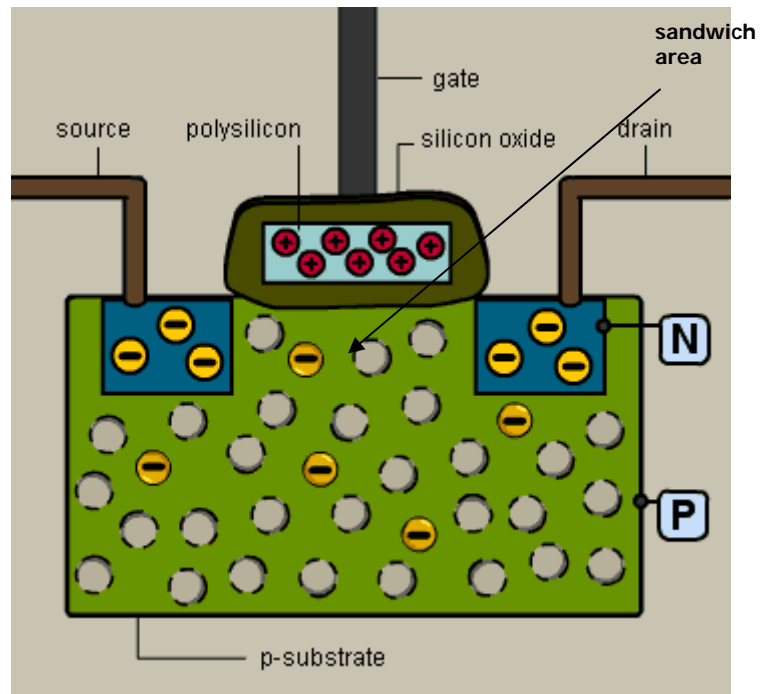
the p type material move towards the positive end of the battery, they leave a trail of positive holes. At any given moment, at the junction we now have electrons on the n-side, and holes on the p-side. Electricity will flow.

If we reverse the polarity (see bottom part of diagram), the holes will be “moving “ towards the (-) end of the battery as the electrons move towards the junction. Meanwhile, the extra electrons from the n-material will move towards the (+) end of the battery. A depletion zone is created at the junction, and the diode will not conduct.

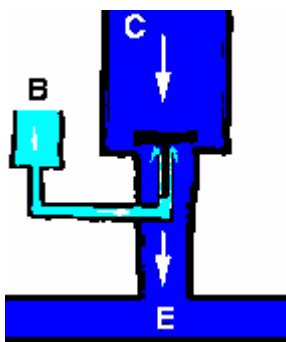
2. Transistors

Transistors use three layers of semiconductors.

One type of transistor which has become the basic element of all silicon integrated circuits is the MOSFET (**metal-oxide-semiconductor field-effect transistor**) It is made up of silicon layers with two n types and one p-type. As revealed in the adjacent diagram, the electrodes in this type of transistor are called **source**, **drain** and **gate**. The current flowing from source to drain is controlled with the charge of the gate, which is constructed of a highly conductive material, often polysilicon (IBM uses a mixture of germanium and silicon). To function properly this gate-electrode needs to be insulated (with silicon oxide) from the rest of the transistor.



When the voltage is increased, the gate's positive charge keeps increasing, attracting an increasing number of the p-type material's rare electrons. The electrons from the source to the drain will flow in proportion to the number of loose electrons they are sandwiching. At a peak voltage, the sandwich will resemble the sea of electrons that exists in metals. What the transistor has done is that, with a small energy input, it has opened the "flood gates" and then amplified the current with additional voltage.



I found a good alternate explanation on a website at <http://www.satcure-focus.com/tutor/page4.htm>

In his analogy, the transistor runs on water current. It is not exactly based on the same type of transistor, but there is a strong similarity. There are three openings, which he labeled "B" (Base), "C" (Collector) and "E" (Emitter), similar to the gate, source and drain.

There is a plunger, preventing most of the water in reservoir C from emptying into the drain (E). But the water flowing from a smaller reservoir leads to the bottom of the plunger. With an increasing upward push on the plunger (analogous to increasing the voltage), the large amount of water in C can be released. (more current will flow when electrons are attracted)

A similar MOSFET can be made by using p type materials as source and drain; n-type semiconductor would act as the substrate, and the voltage would be increasing the (-) charge within the gate. Instead of having continuous electrons, increasing voltage would create continuous holes, through which electrons could flow.

References

Cooper, Christopher. *Physics Matters: Volume 9 Electronics* Grolier. 2001

<http://nobelprize.org/physics/educational/transistor/function/index.html>

<http://en.wikipedia.org/wiki/MOSFET>

<http://www.satcure-focus.com/tutor/page4.htm>