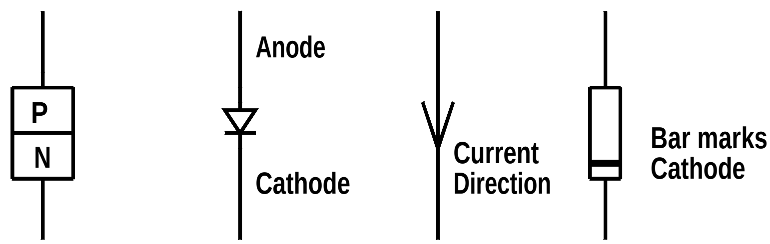
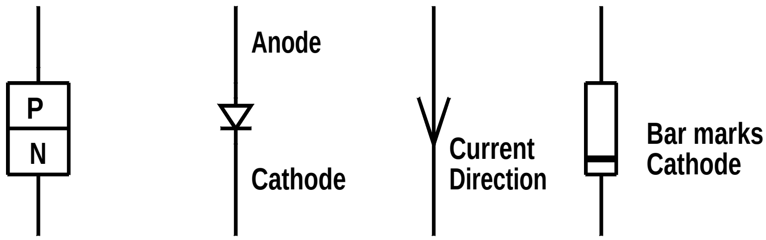
Junction diode



A diode is formed from a single crystal

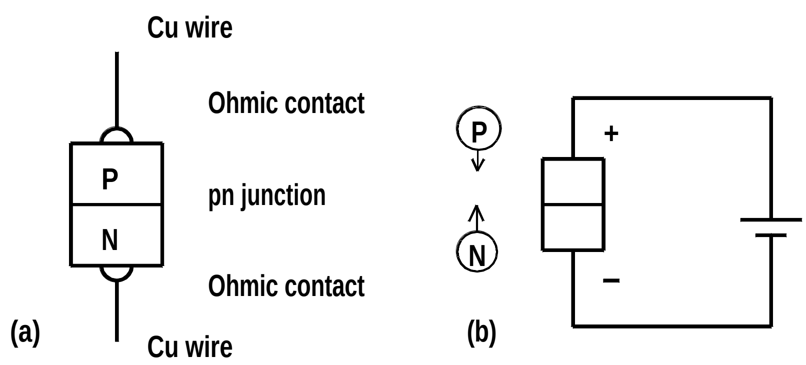
The doping changes from p to n type within the crystal.



Current flows through the forward biased diode when:—

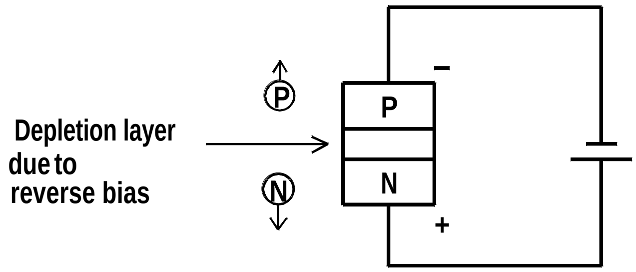
- the p type anode is at positive voltage
- the n type cathode is at a negative voltage.

Conventional current flows in the direction of the arrow of the diode symbol.



Diode construction and operation in forward bias.

Typical actual dimensions would be a cross section of $1mm^2$ with a height of 20 micron and a junction thickness of 1 micron.

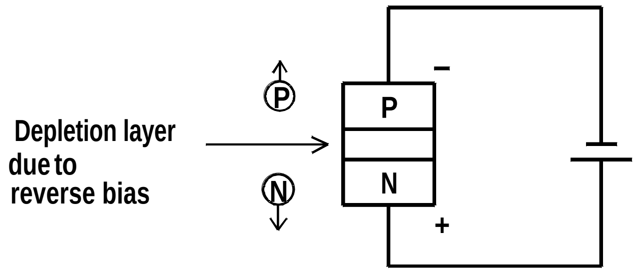


Junction diode in reverse bias Anode negative– Cathode positive.

p type carriers in anode attracted away from junction by negative voltage on anode.

n type carriers in cathode region attracted downwards away from junction by positive voltage on cathode terminal.

Effect is that the majority carriers in each region are pulled away from the junction to leave a region depleted of mobile charges called the depletion layer.



Even when the diode is reverse biased, a very small current flows.

Within the p type anode region there are some minority carriers whose concentration is given by the semiconductor equation,

$$n \times p = n_i^2$$

Similarly, within the n type cathode region there are also some p type carriers present.

The reverse bias on the diode is only a reverse bias for majority carriers

For minority carriers it is a forward bias.

So we get a very small constant current in a reverse biased diode which depends on the temperature and on the dopant concentrations in anode and cathode regions which control the minority carrier concentrations.

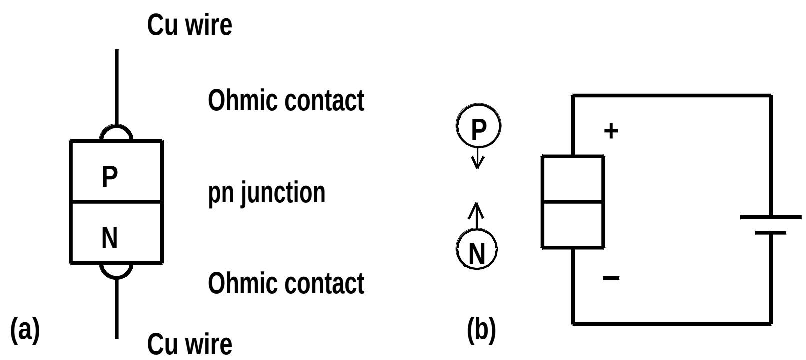
The reverse current is however independent of the reverse bias voltage.

At room temperature the reverse current is typically $10^{-10}A$ for a silicon diode and $10^{-6}A$ for a germanium diode.

Silicon and germanium have different band gap energies

Therefore the intrinsic carrier concentrations, n_i, are different.

For comparable doping levels it is reasonable to expect that the minority carrier concentrations are different and therefore the reverse bias currents are also different.



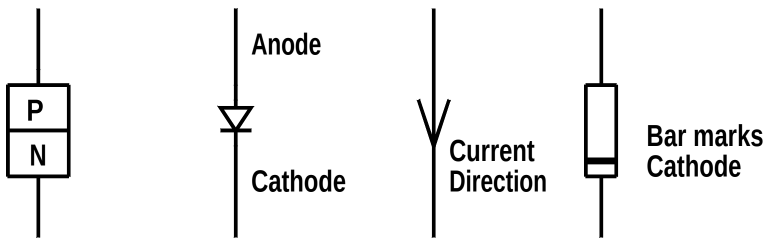
One fabrication problem relates to making a connection to the semiconductor material. If a metal, which is essentially an n type conductor, is connected to a p type semiconductor then, in principle, a pn junction is formed which would have some rectifying properties.

An Ohmic or nonrectifying contact is formed when a metal with a work function greater than that of the p type semiconductor work function is used to make the contact.

An Ohmic contact is made to an n type semiconductor by using a metal having a work function less than that of the semiconductor work function.

Choice of a different metal, with a different work function, for the contact metal can lead to the formation of a diode called a Schottky metal semiconductor junction diode.

The work function of a metal or semiconductor is the energy difference between an electron within the crystal having an energy at the Fermi energy level and an electron moving freely outside the crystal. Typical work functions are of the order of a few electron volts



The bulk resistance associated with the silicon crystal and connections is of the order of 1Ω and limits the maximum forward current through the diode.