1 Fundamentals

1.1 The p-n junction

1.1.1 p-n junction at thermal equilibrium

The p-n junction is the transition area between two n- and p-doped semiconductor crystals. In this area there are no free charge carriers, since the free electrons of the n-conductor, and the holes of the p-doped crystal in the vicinity of the interface recombine with each other, which means that the electrons fill the holes. This charge movement (diffusion) is obtained in consequence of a concentration gradient: since there is only a few number of electrons in the p-area and only a few number of holes in the n-region, the majority charge carriers (electrons in the n-crystal, holes in the p-crystal) move into the contrary doped semiconductor. The crystal lattice at the interface must not be interrupted, a simple "pressing together" of a p-type and a n-doped silicon crystal does not allow a functional p-n junction.

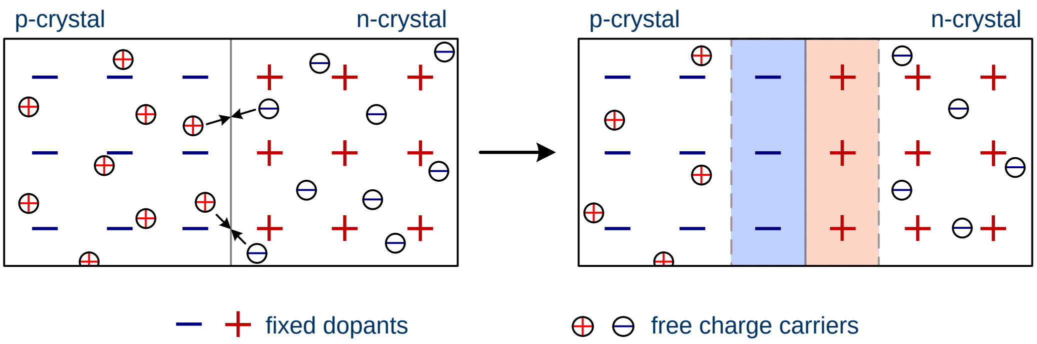


Fig. 1.1: p-n junction without an external applied voltage

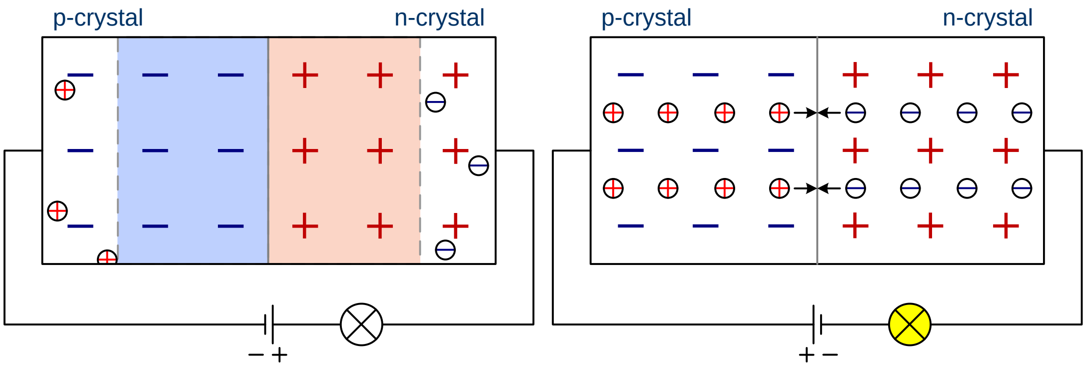
The regions near the interface are loaded due to the loss of free charge carriers (positive charge in the n-crystal, negative charge in the p-crystal). The more charge carriers recombine, the greater the depletion zone and thus the voltage difference of n- and p-crystal. With a certain amount of this potential gap, the recombination of holes and electrons comes to a complete standstill, the charge carriers can no longer overcome the electric field. In silicon this limit is at about 0.7 V.

A p-n junction represents an electrical component with the function to allow an electric current in one direction (called the forward biased condition) and to block the current in the opposite direction (the reverse biased condition): a diode.

1.1.2 p-n junction with external applied voltage

If the n-type crystal is applied to a positive and the p-crystal to a negative voltage, the electric field inside the semiconductor and the field of the voltage source are in the same direction. Thus the electric field at the p-n junction is reinforced. The oppositely charged free carriers are attracted by the poles of the voltage source, thus the barrier layer is increased and a current flow is inhibited.

If the external voltage is applied in the reverse direction, the external and internal electric field are in the opposite direction and the inner filed is weakened. If the inner field is completely eliminated from the outer field, a constantly flow of free charge carriers from the power source to the interface is possible and the carriers can recombine continuously: there is electric current.



(a) reverse direction (b) forward direction

Fig. 1.2: p-n junction with an external applied voltage

The diode can be used as a rectifier: to convert alternating current into direct current. Areas where p- and n-doped semiconductor crystals are in contact, are found in many electrical devices in the semiconductor technology.