Text books often claim that the rectifier effect of a pn junction is due to the depletion layer at both sides of the contact surface between the p and the n region.

“If the n layer is connected with the plus terminal and the p layer with the minus terminal of the source, the depletion layer gets wider. The diode is blocking. If instead the p layer of the diode is connected with the plus terminal and the n layer with the minus terminal, free electrons and holes enter the depletion layer. Thereby this layer loses its effect and the diode becomes a conductor.”

Deficiencies:
It is true that the thickness of the depletion zone changes as a function of the applied voltage. Thus, the above conclusion seems plausible. However, to infer the resistance from the density of the charge carriers is only correct if the charge carriers maintain their identity within the considered section of the diode. Such a conclusion is not valid if the charge carriers are subject to reactions. This is indeed the case for the pn junction. For forward polarity electrons and holes react to photons and phonons. For reverse polarity the reaction proceeds in the opposite direction, though with a much lower reaction rate, since at normal temperatures only few photons and phonons are present. It is this asymmetry of the reaction rate which is responsible for the asymmetry of the resistance.

The region in which the rectifying effect takes place is given by the diffusion length which, by the way, is 1000 times the thickness of the depletion layer.

Origin:
The traditional repugnance of the physicist against chemical arguments. It leads to the futile attempt to explain the processes in a semiconductor diode only with Ohm’s Law and the laws of electrostatics, i.e. with the tools of electricity. Actually it is impossible to explain the diode, as well as the pnp and the npn transistor without recourse to the laws of chemistry. The explanation is most elegant when using the chemical potential gradient as a driving force which is analogue to the electric potential gradient.

Disposal:
The semiconductor diode working as a rectifier or a LED may be explained as follows: In forward polarization electrons from the n layer and holes from the p layer move towards the pn junction. There they react to create photons and phonons. The diode behaves like a closed switch. As an LED the diode is optimized in such a way that as few as possible phonons and as many as possible photons are created. In reversed polarization charge carriers should flow from the middle, i.e. the contact region outwards. Since there is no source of charge carriers at the pn contact no charge carriers can flow away. There is no electric current and no light is emitted. Only when examining more carefully one can notice that electrons and holes are indeed produced at a very low rate by the ambient thermal radiation. These charge carriers are responsible for the reverse current.

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