A2-12 Further Semiconductor Components

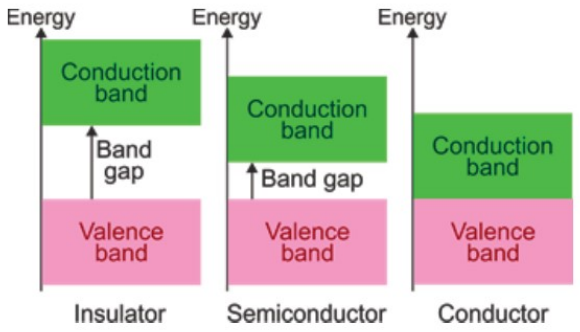
Revision sheet

1 Conduction In Semiconductors

All electronics device components are made of semiconductors.

1.1 Materials

There are three different types of materials in semiconductors. A diagram called an *Energy Band Diagram* can be used to show the energy level of electrons within types of materials. Electrons that have sufficient energy to escape from their 'home' atom are found in the conduction band. Electrons with less energy cannot leave the valence band and be part of an electric current - they are found in the valence band and are known as valence electrons.



1.2 Conductors

In conductors, electrons don't need much energy to escape the atom therefore the material conducts at all temperatures.

1.3 Insulators

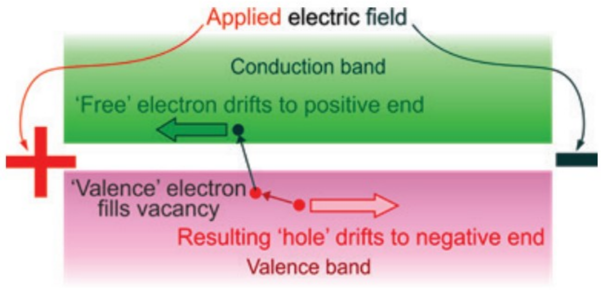
Electrons need a lot of energy to escape the atom therefore little-to-no current flows.

1.4 Semiconductors

At room temperatures these are poor insulators and at warm temperatures they begin to conduct a little.

1.5 Electrons And Holes

At high temperatures, electrons can jump from the valence to conduction band. If we apply a voltage, then a current flows. This is known as Intrinsic Semiconductor Behaviour.

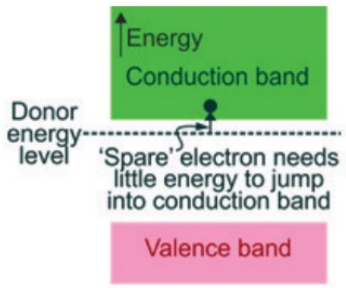


1.6 Impurities

The addition of impurities can change the electrical properties radically. This is very useful as new energy levels can be created.

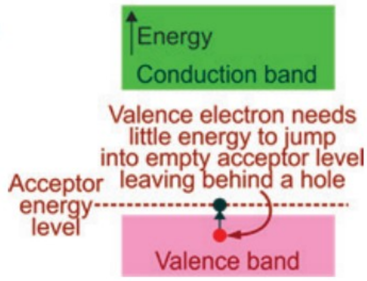
1.6.1 N-Type

Add a new donor atom with one more electron than the semiconductor. This adds a free electron at a new energy level, close to the conduction band.

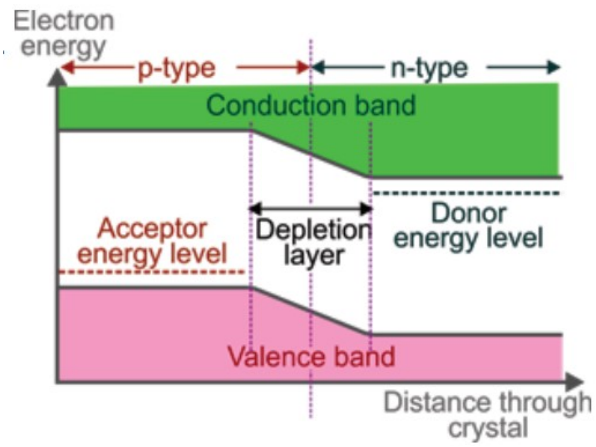


1.6.2 P-Type

Add an acceptor atom with one less electron than the semiconductor. This adds a free hole at a new level close to the valence band.



2 P-N Junction



It is possible to combine two different impurities into one piece of semiconductor so that junctions can be formed, in this way a p-n junction can be formed. Electrons combine with holes therefore there are no charge carriers present at the point p and n meet, this is called the ‘depletion zone’. At the junction, a small battery is created, it has a voltage of 0.7V (called the potential barrier). This barrier is a barrier to electron flow as the negative ions repel electrons and positive ions repel holes.

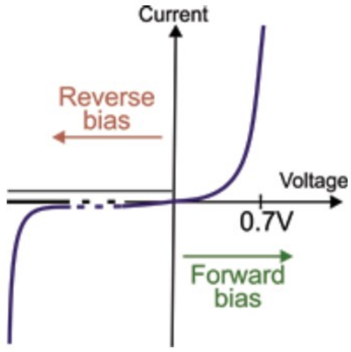
2.1 Forward Bias

Apply a positive voltage to P, sucks free electrons toward depletion zone. Apply negative voltage to N, sucks holes towards depletion zone therefore current flows. Applied voltage has to be greater than 0.7V to get over potential barrier.

2.2 Reverse Bias

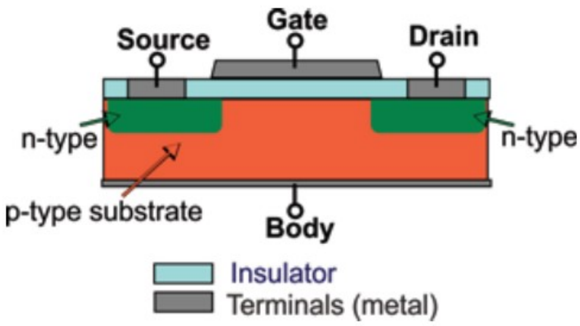
Positive voltage applied to N, pushes the holes back into P. Negative voltage applied to P, pushes electrons back into N.

2.3 Conduction Diagram

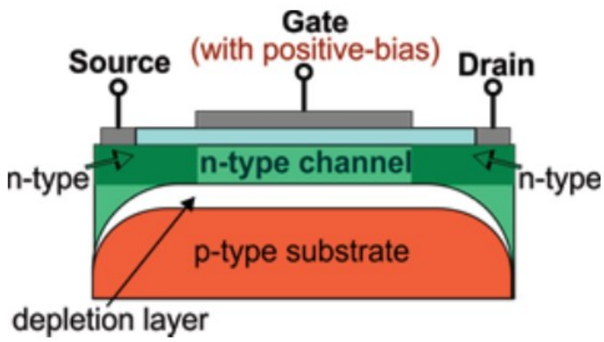


3 The MOSFET

Metal Oxide Semiconductor Field Effect Transistor. The diagram below shows the layout of the p and n regions.



This is an Enhancement Type N-Channel MOSFET. The p-region is very lightly doped therefore there aren’t many free holes. With no gate voltage, no current flows. However when we apply a positive voltage to tha gate, electrons are attracted towards the gate and holes are pushed away, giving the following p and n region arrangement.



This forms a conducting n-type channel between the source and drain (where the gate voltage greater than 3V).

3.1 Properties Of MOSFETs

They have a low on-resistance therefore they don't dissipate much power ($r_{DS_{ON}}$). They have an extremely high off-resistance. They have an infinitely high input resistance because the gate is insulated.