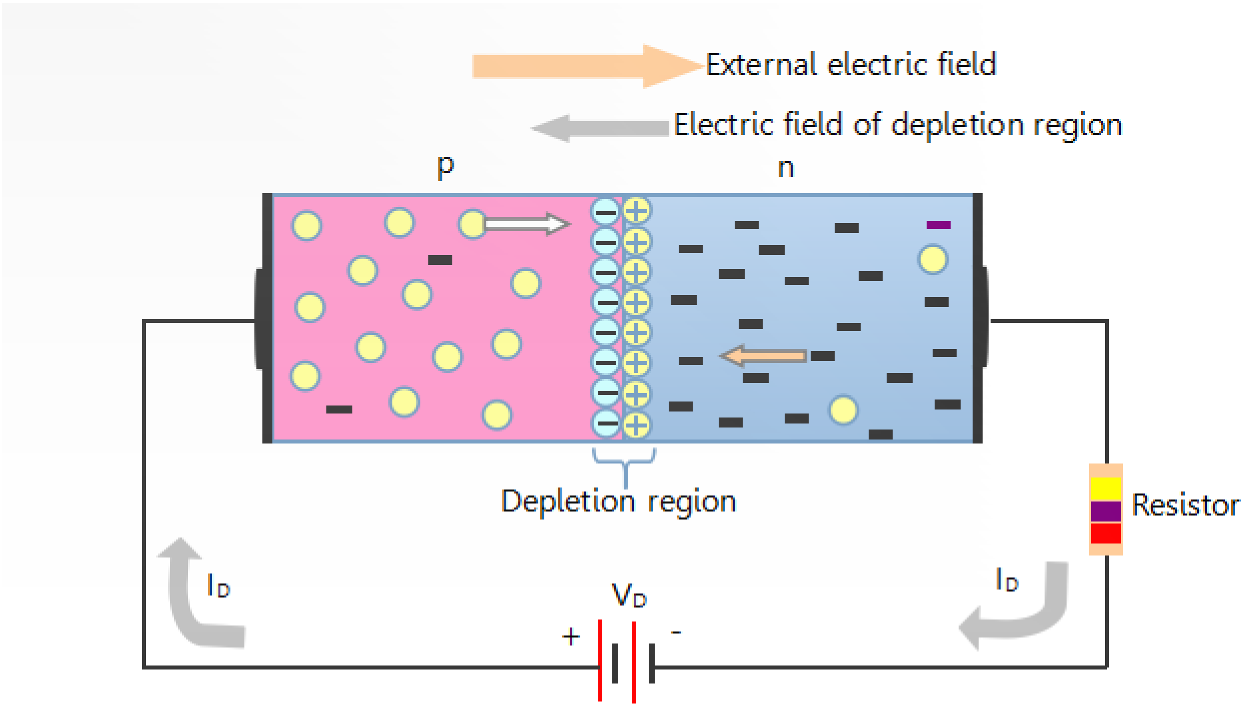
Forward biasing

When the positive terminal of the battery is connected to the p-type material and the negative terminal of the battery is connected to the n-type material, such a connection is called forward bias.



Forward biased p-n junction

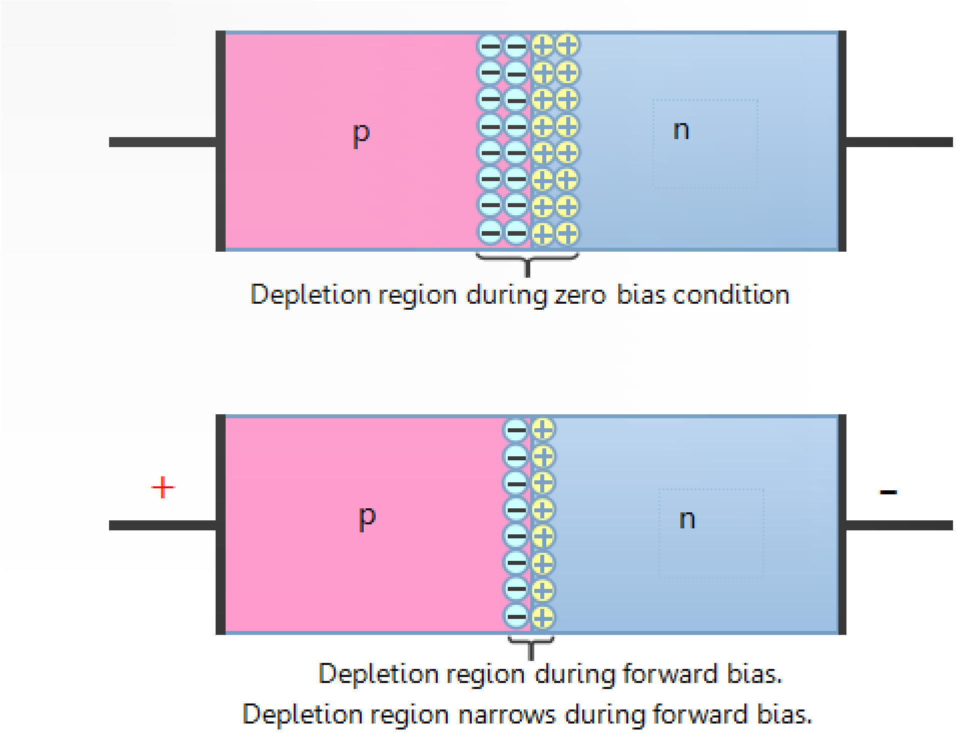
Above figure shows the p-n junction diode in forward bias condition. The p region is connected to the positive terminal and n region is connected to the negative terminal of the DC voltage source. A resistor is also connected in series with the diode to make sure the current in the circuit does not rise above the maximum limit and damage the diode. When the diode is forward biased, the electric field in the depletion region and the external electric field due the DC voltage source are in opposite direction (This is shown in the above figure). This reduces the effective/net electric field in the depletion region. Recall that in the previous section on p-n junction diode, we had discussed that the flow of electrons and holes ceased due to the electric field. Since the net electric field is now reduced due to forward bias, electrons and holes now crosses the junction and constitutes a current. The direction of current is from p-region to n-region.

The flow of current can be explained as follows. The electrons and holes crosses the p-n junction as a result of reduced electric field in the depletion region. Electrons from the n-region crosses the junction and enters the p-region.Since the positive terminal of the battery is connected to the p-region, the electrons experiences an attractive force and moves to the positive terminal of the battery. Same discussion can also be applied to holes. Thus we can conclude that current flow takes place when the diode is forward biased.

Now we shall see the effect of applying forward bias to the diode. The topics we shall discuss are as follows

- Effect on depletion region due to forward bias
- Effect of barrier potential during forward bias

When the diode is connected in forward bias, the electric field due to external voltage source and the electric field due to depletion region are in the opposite direction. This reduces the net electric field in the junction and the electrons can now pass from n-region to the p-region. As more electrons now flows into the depletion region, the number of positive ions is reduced. Same discussion can also be applied to holes. With the reduction in net electric field, the holes can now flow into the n-region. As the holes pass through the depletion region, the number of negative ions also decreases. Hence the the width of depletion region decreases due to reduction in the number of positive and negative ions. This is shown graphically in the figure below.



Effect of barrier potential during forward bias

Before preceding with this discussion, let us have a quick revision of what is called as barrier potential (the concept is explained in detail here). When p-type and n-type materials are joined together, the electrons from n-type material starts to move towards p-type material and forms negative ions. Similarly the holes from the p-type material starts to move towards n-type material and forms positive ions. This separation of positive and negative ions creates an electric field. When the electric field becomes sufficiently strong, it prevents further movement of electrons and holes. The potential resulting from such electric field act as barrier for further movement of electrons and holes. This potential is called barrier potential.

Now we come to the actual discussion- what is the effect of barrier potential when the diode is forward biased? When no bias is applied, the electrons cannot gain sufficient energy to overcome the potential barrier and move to the p-region. With the diode is forward biased, the electrons get enough energy from the voltage source to overcome the potential barrier and cross the junction. Similarly the holes get sufficient energy to overcome the barrier and cross the junction. The amount of energy required by the electrons to cross the junction is equal to the barrier potential (0.3 V for Ge and 0.7 V for Si). This simply means that when the diode is forward biased, the voltage drop across the diode is approximately 0.7 V (for Si). Actually, the amount of voltage drop is little above 0.7 V due to internal resistance of the material and contact resistance of the conducting material used to form the legs of diode.