EXPRESSION OF DEPLETION REGION

When a metal and n-type semiconductor are brought into close contact to form a metal semiconductor junction, the fermi level of the two materials coincide at thermal equilibrium by removal of electrons from semiconductor side to metal at the interface.

As a result a barrier potential is created which further opposes the movement of electron from semiconductor to metal. This ~~poten~~ potential barrier is also called depletion region or the space charge region.

If $\rho(x)$ be the volume density of space charge and ϵ is the permittivity of the semiconductor.

Then, According to differential form of Gauss law we have

$$\frac{dE}{dx} = \frac{\rho(x)}{\epsilon} \quad \text{—— (1)}$$

where
E is the electric field in the region
ϵ = permittivity of medium

At $x = 0$
electric field $E = 0$

$$\int_0^E dE = \int_\omega^x \frac{\rho(x)}{\epsilon}\,dx$$

$$[E]_0^E = \frac{eN_D}{\epsilon}\int_\omega^x dx \qquad [\because \rho(x) = eN_D]$$

$$= \frac{eN_D}{\epsilon}[x]_\omega^x$$

or $E = -\frac{eN_D}{\varepsilon}(\omega - x)$ — (II)

From equation (II) we can observed that The electric field is maximum at $x=0$

∴ The maximum barrier field is given by

$$\boxed{|E| = \frac{eN_D\omega}{\varepsilon}} \quad \text{at } x=0$$

Now the electric potential gradient at any point inside the semiconductor is

$$E = -\frac{dV}{dx} = -\frac{eN_D}{\varepsilon}(\omega - x).$$

$$\text{or} \quad \frac{dV}{dx} = \frac{eN_D}{\varepsilon}(\omega - x)$$

At $x=0$
$V=0$

$$\int_0^V dV = \frac{eN_D}{\varepsilon}\int_0^x (\omega - x)\,dx$$

$$\text{or,} \quad [V-0] = \frac{eN_D}{\varepsilon}\left(\omega x - \frac{x^2}{2}\right)$$

$$\text{or,} \quad V = \frac{eN_D}{\varepsilon}\left(\omega x - \frac{x^2}{2}\right)$$

At $x=\omega$ $V=V_B$
we get:

$$V_B = \frac{eN_D}{\varepsilon}\left(\omega^2 - \frac{x^2}{2}\right]$$

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$$\therefore V_B = \frac{eN_D}{\epsilon}\left[W^2 - \frac{W^2}{2}\right]$$

$$V_B = \frac{eN_D}{\epsilon}\left[\frac{W^2}{2}\right]$$

or $$W = \sqrt{\frac{2V_B\epsilon}{eN_D}}$$

Thus, the relation depletion width W and potential barrier V_B is given by

$$\boxed{W = \sqrt{\frac{2V_B\epsilon}{eN_D}}}$$

Imp points:

1) When no bias voltage is applied then, $V_B = V_{bi}$

2) For forward bias voltage V_F we substitute $V_B = (V_{bi} - V_F)$

3) For reverse bias voltage (V_R) we substitute $V_B = (V_{bi} + V_R)$ respectively.

So it is clear that the width of depletion region increases or decrease with forward or reverse biasing applied voltage.

Schottky Diode I-V characteristics

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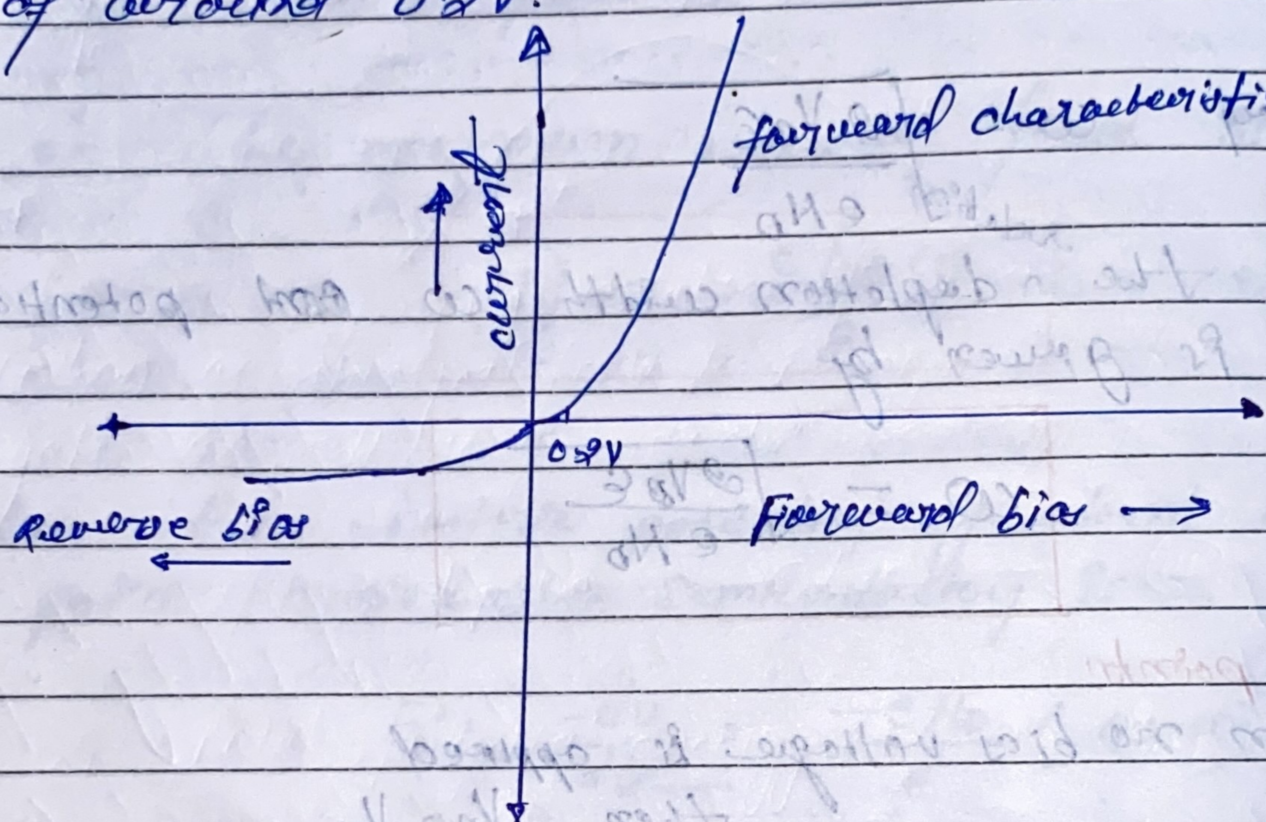
The I-V characteristics of schottky diode is shown below. In forward bias, the current raises exponentially, having a knee or turn on voltage of around 0.2V.



Fig(a): I-V characteristics of schottky diode.

In the reverse bias direction, there exist also a current in this reverse direction.

The use of a guard ring in the fabrication of diode has an effect on its performance in both forward and reverse direction.