# EXPERIMENT 10: SCHOTTKY DIODE CHARACTERISTICS

**AIM:** To plot forward and reverse characteristics of Schottky diode (Metal Semiconductor junction)

**APPARATUS:** D.C. Supply (0 - 15 V), current limiting resistor 1KΩ, Diode IN5822 , IN 4007 , Digital multimeter, milli ammeter (0-1mA) (0-10mA) , micro ammeter ( 0-100μA). 75Ω resistor , signal generator , and CRO.

**THEORY:**

The Schottky diode junction is formed by plating a very pure metal, typically by evaporation or sputtering while under vacuum, onto a wafer that has been doped with either p-type or n-type dopant atoms. As soon as these materials are brought into contact and thermal equilibrium is established, their Fermi levels become equal. Electrons from the semiconductor lower their energy level by flowing into the metal. Charge accumulates at the interface, distorting the energy bands in the semiconductor. This creates an energy barrier, known as the Schottky barrier, which prevents more electrons from flowing from the n-type material into the metal without assistance from an external energy source of the correct polarity to elevate their energy above that of the Schottky barrier height. External energy of the opposite polarity increases the barrier height, thus preventing conduction.

When metal is brought into contact with an n-type semiconductor during fabrication of the chip, electrons diffuse out of the semiconductor into the metal, leaving a region known as the “depletion layer” under the contact that has no free electrons.

This region contains donor atoms that are positively charged because each lost its excess electron. This charge makes the semiconductor positive with respect to the metal. Diffusion continues until the semiconductor is so positive with respect to the metal that no more electrons can go into the metal. The internal voltage difference between the metal and the semiconductor is called the contact potential, and is usually in the range 0.3 – 0.6 V for typical Schottky diodes.

When a positive voltage is applied to the metal, the internal voltage is reduced, and electrons can flow into the metal. Only those electrons whose thermal energy happens to be many times the average can escape, and these “hot electrons” account for all the forward current from the semiconductor into the metal.

The voltage-current relationship for a barrier diode is described by the law of the junction equation. Schottky diodes are fabricated with n-type doping only. The current across a metal-semiconductor (Schottky) junction is mainly due to majority carriers. The equation that relates the current through a Schottky junction to the voltage across it is:

$$I = I_{SAT}\left(e^{\frac{q(V-IR_S)}{nKT}} - 1\right)$$

where

K = Boltzmann’s constant, $1.38044 \times 10^{-23}$ J/K

q = electronic charge, $1.60206 \times 10^{-19}$ C

T = Temperature, K

$R_S$ = series resistance, Ω

$I_{SAT}$ = saturation current, A

n = ideality factor (typically 1.0)

$$I_{SAT} = AA^{**}e^{\left(\frac{-q\phi_B}{KT}\right)}$$

where

A = Area, $cm^2$

A** = Modified Richardson constant, $(A/K)^2/cm^2$

K = Boltzmann’s Constant

T = absolute temperature, K

$\Phi_B$ = barrier height, V

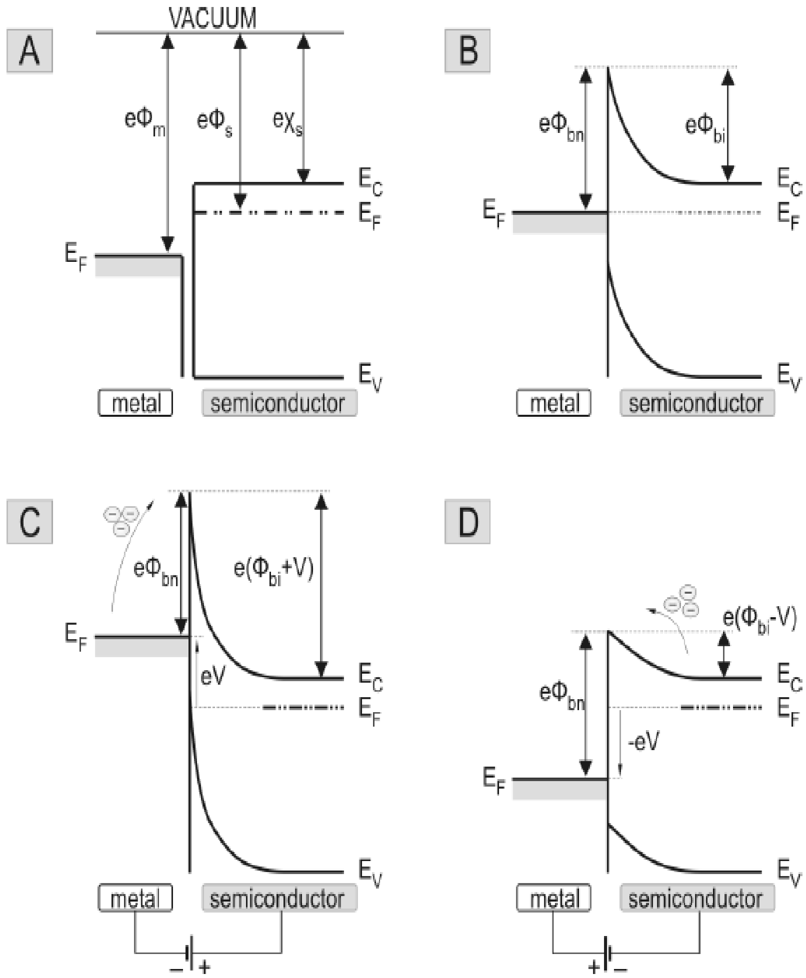


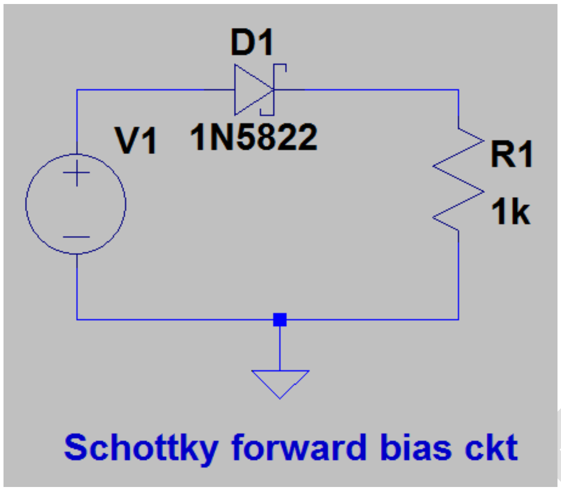

Figure : Energy-band diagrams for Schottky contact on n-semiconductor: (a) before contacting, (b) after contacting in equilibrium, (c) under reverse bias and (d) direct bias.

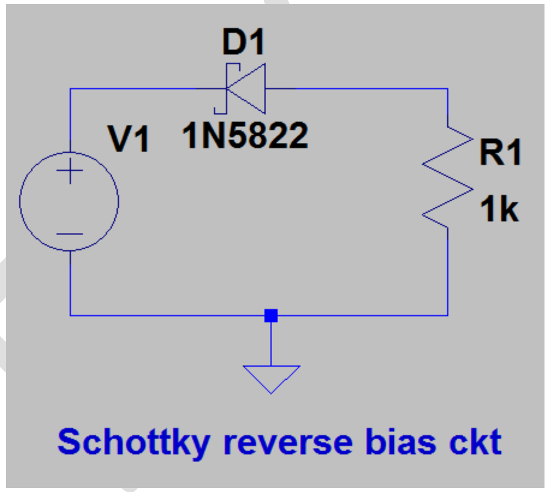
**ONLY READ ( don't include in write up ) →marked in blue**

Barrier height is a design variable for a Schottky diode, whereas it is fixed for a pn junction. This is another advantage of a Schottky junction relative to a pn junction: a Schottky junction can have significantly lower forward voltage at a given forward current than a comparable pn junction. A Schottky diode is a virtually ideal rectifier whose forward voltage can be selected by design. This makes Schottky diodes very well-suited for use as power detectors, especially at very low signal levels, and is widely utilized in frequency mixing and RF power detection circuits.

One important thing to note is that there is no flow of minority carriers from the metal into the semiconductor. Therefore, if the forward voltage is removed, current stops within a few picoseconds and reverse voltage can be established in this time. There is no delay effect due to charge storage as in junction diodes. This accounts for the predominant use of surface barrier diodes in microwave mixers, where the diode must switch conductance states at the rate of the frequency of a microwave local oscillator.

**CIRCUIT DIAGRAM:**




**PROCEDURE:**

**Part A :**

1) Connect the Schottky diode in the forward bias mode as per the given circuit.
2) Connect a current limiting resistor in series with the diode.
3) Slowly increase the voltage applied, and measure the current (I) through the diode.
5) Now connect the Schottky diode in reverse bias mode and measure current through the diode.
6) Plot current (I) vs forward voltage across the diode on graph paper.
6) Calculate the cut-in voltage of the Schottky diode from I-V curve.

**Part B :**

1) Connect 5Vpp , 1Khz sin wave input to the half wave recitifier ckt including Schottky diode and a series resistor of 75Ω.
2) Slowly increase the frequency to higher values , and observe exactly till what frequency the Schottky diode rectifier is able to maintain its rectifying property.
3) Note down the frequency for Schottky diode rectifier circuit.
4) Repeat the step2 and step3 for Si diode IN4007.

**OBSERVATION:**

Forward Biased

| Sr. No. | Supply Voltage (V) | $I_D$ (μA) |
|---|---|---|
| | | 0 |
| | | 10 |
| | | 20 |
| | | - |
| | | - |
| | | 100 |
| | | 200 |
| | | - |
| | | - |
| | | 1000 |
| | | 1mA |
| | | 2mA |
| | | - |
| | | - |
| | | 10mA |

Reversed Biased

| Sr. No. | Supply Voltage (V) | $I_D$ (mA) |
|---|---|---|
| | 0 | |
| | 1 | |
| | 2 | |
| | . | |
| | . | |
| | 20 | |

**CONCLUSION:**