4.11. V-I CHARACTERISTICS OF P-N JUNCTION DIODE OR PRACTICAL DIODE*

(U.P. Tech. First Semester 2003-04) (05 marks)

If diode is used as a circuit element in an electrical circuit, there may be a requirement to know how it responds or behaves in electric circuit. This type of information may be obtained by a curve known as Volt-Ampere (V-I) characteristics of a practical diode.

The V-I characteristics of a diode is simply a curve or graph between the voltage applied across its terminals and the current that flows through the diode due to this applied voltage. The entire V-I characteristics may be divided into two parts namely:

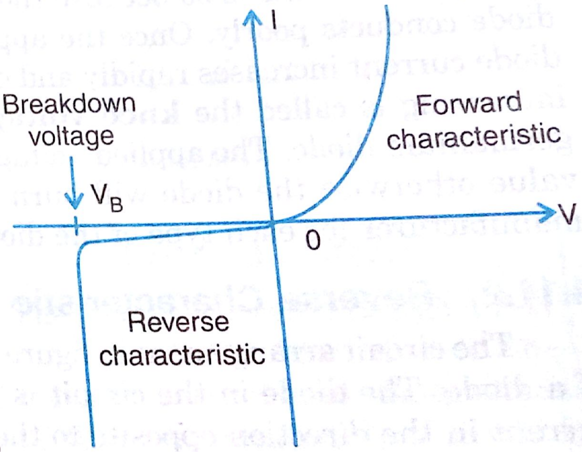

Fig. 4.14. Entire V-I characteristics of diode

1. Forward characteristics
2. Reverse characteristics

4.11.1. Forward Characteristic

(U.P. Tech. Sem. Exam. 2006-07, 2007-08) (05 marks)

The circuit arrangement shown in figure 4.15 is used in the laboratory to obtain forward characteristic of a diode. The diode in the circuit is in forward bias state because the battery V_{FF} is pushing the current in the direction of the arrowhead.

In the circuit, the battery V_{FF} is connected to the diode through potentiometer *P*. The potentiometer helps in varying the voltage across the diode. The load resistance R_L is used in the circuit to limit the current through the diode. A voltmeter is connected across the diode to measure the voltage. A milliammeter is also connected to measure the current in the circuit.

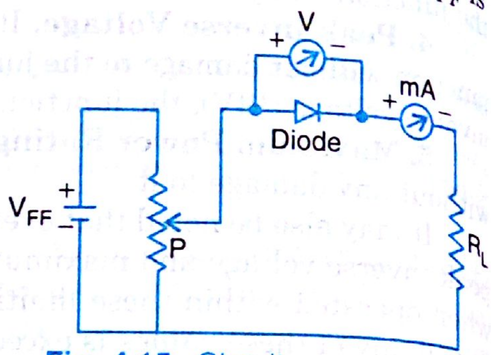

Fig. 4.15. Circuit arrangement for forward bias

To plot the characteristic, the voltage across the diode is increased gradually and the corresponding increase in the current is noted. The graph is plotted by taking voltage on the horizontal axis and current on the vertical axis.

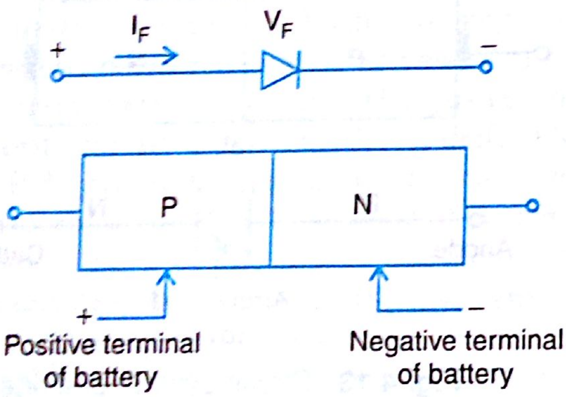

Fig. 4.16. Forward-bias condition for a P-N junction diode.

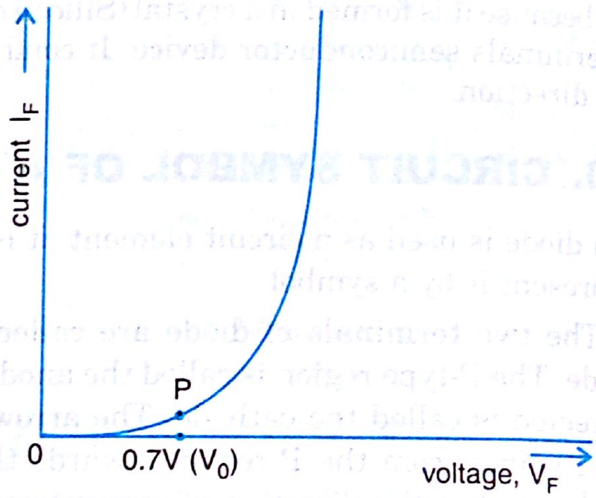

Fig. 4.17. Forward characteristics (Si diode)

A carefull look at the forward characteristic reveals the fact that upto point P, the diode current is very small. This is so because the applied voltage has to overcome the barrier potential and the diode conducts poorly. Once the applied voltage is slightly greater than the barrier potential, the diode current increases rapidly and diode conducts heavily. This voltage at which the current starts increasing is called the **knee voltage (V_0)**. Its value is 0.7 V for a silicon diode and 0.3 V for a germanium diode. The applied voltage across the diode should not increase beyond a specified safe value otherwise the diode will burn out due to heat. This specified safe value is provided by the manufacturer for each type of the diode.

4.11.2. Reverse Characteristic

(U.P. Tech. Sem. Ecam. 2006-07) (05 marks)

The circuit arrangement in figure 4.18(*a*) is used in the laboratory to obtain reverse characteristic of a diode. The diode in the circuit is in reverse bias state because the battery V_{RR} is pushing the current in the direction opposite to the arrowhead.

In the above circuit, the battery V_{RR} is connected to the diode through potentiometer *P*. The potentiometer helps in varying the voltage across the diode. A voltmeter is connected across the diode to measure the voltage. A microammeter is also connected to measure the current in the circuit.

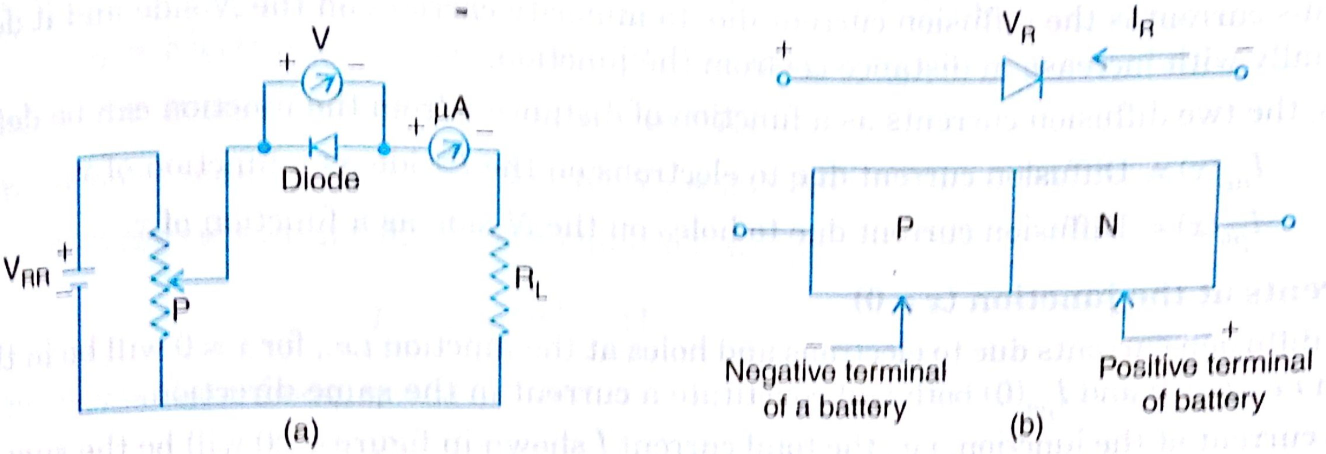

Fig. 4.18. (a) Circuit arrangement for Reverse bias (b) Reverse-bias condition for a P-N junction diode

A careful look at the reverse characteristic reveals the fact that below the breakdown voltage the diode current is very small and almost remains constant. This current is also called **reverse saturation current I_o**. It is of the order of μA for Germanium diode and nanoamperes for Silicon diode. It is due to the movement of minority carriers which are thermally generated. It means that reverse bias current is temperature dependent and does not depend upon the applied reverse bias voltage.

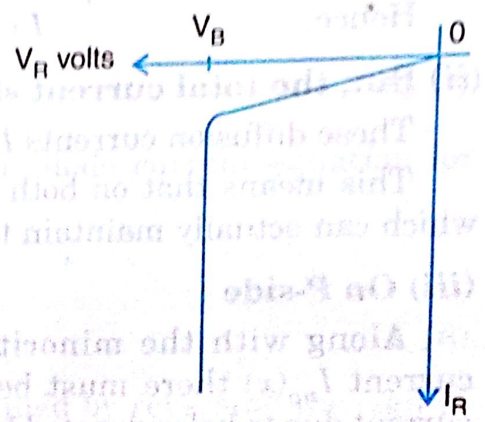

Fig. 4.18. (c) Reverse characteristics

But, if a large reverse bias voltage is applied, a process known as **junction breakdown** occurs. Due to this, the diode reverse current increases rapidly. The applied reverse bias voltage at which this occurs is called as **breakdown voltage (V_B)** of a diode.

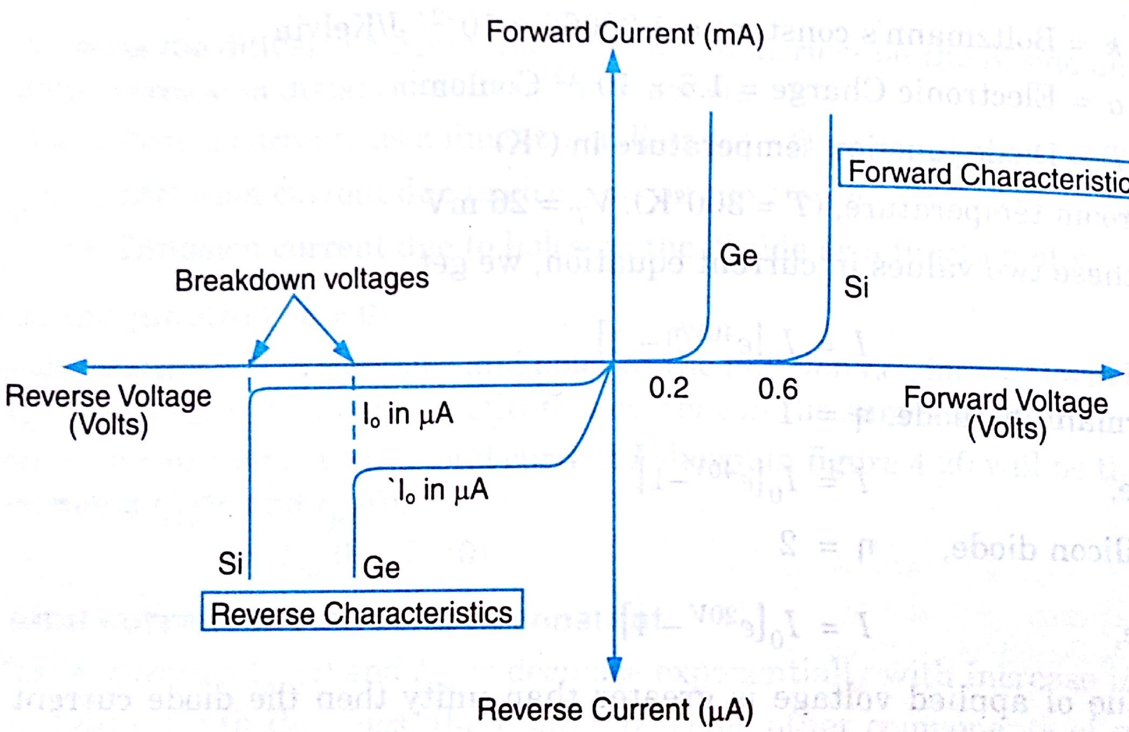

Fig. 4.21. V-I Characteristics of Silicon and Germanium diodes.

Conclusions

We can draw following conclusions from V-I characteristics of figure 4.21:

(i) Cut-in voltages for Silicon and Germanium diodes are 0.6 and 0.2 V respectively.

(ii) Breakdown voltage of Silicon diode is higher than that of the Germanium diode. Therefore Silicon diodes can withstand to a higher reverse voltage.

(iii) The reverse saturation current I_0 for a Germanium diode is few μA whereas that for a Silicon diode, it is in nA at room temperature.