Experiment: Current-Voltage Characteristics of a PN Junction Diode

AIM: Study and measurement of current-voltage (I-V) characteristics of a PN junction Diode (Ge and Si)

APPARATUS REQUIRED: Variable DC power supply (0-30 V), Breadboard, Multimeters (two Nos.), PN junction diode, resistors of different values, connecting wires and crocodile clips, Resistors of different values: 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ and 1MΩ

THEORY: A PN junction diode is active electronics component made of semiconductor material such as silicon (Si). The basic feature of the diode is that it conducts significantly when forward biased, beyond a certain critical voltage called "***diode cut-in voltage***." Forward biasing refers to the p-side connected to positive and n-side connected to the negative terminal of the battery. The value of cut-in voltage is about 0.7 V for a Silicon PN junction diode. The value of cut-in voltage is about 0.3 V for a Germanium PN junction diode. In the reverse bias condition (n side connected to positive terminal and p-side to the negative terminal of the battery), negligible current flows through the diode till the voltage across the diode reaches the breakdown value. The diode breakdown voltage may vary from a few volts to few hundreds of volts and is controlled by various design, process and material parameters of the diode. The precise measurement and understanding of diode I-V characteristics are important for using these components in a variety of electronic circuits.

SETUP FOR I-V MEASUREMENT: The schematic of a circuit used for measuring the I-V characteristics of a PN junction diode under forward biasing is illustrated in Fig. 5.1. For measurement under reverse biasing, the polarity of the diode is reversed. In the measurement setup presented here, the current through the diode is determined by measuring the voltage across the resistor R using a multimeter as shown in Fig. 5.1. The value of the resistor is chosen such that the voltage across it falls in the measurement range of the multimeter used. With this arrangement, current as low as 10 nA could be measured fairly accurately. One can also use an ammeter for current measurement if the instrument with the required range and accuracy is available in the Lab.

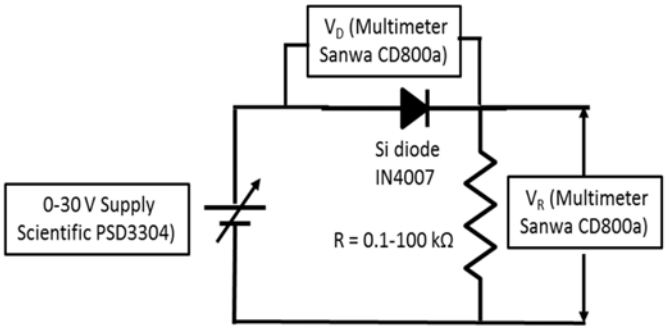
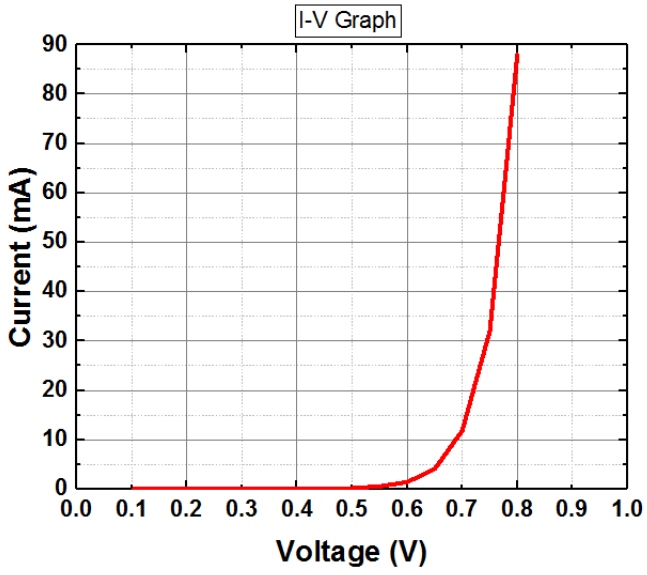


Fig. 5.1 Measurement setup for I-V measurement of pn junction diode under forward biasing

OBSERVATION TABLE: The I-V measurement results under **forward biasing** are presented in the Table below.

S. No.	V_D (mV)	V_R	R	$I = V_R / R$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				



The I-V measurement results under **reverse biasing** are presented in the Table below.

S. No.	V_D, V	V_R	R	$I = V_R / R$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Note: From the measurements, it is apparent that the breakdown voltage of the diode is more than 30 V.

From the graph, estimate the cut-in voltage of the diode. Tabulate static resistance, dynamic resistance and average resistance of the diode as defined by eq. (1), eq. (2), and eq. (3) respectively.

$$R_D = \frac{V_D}{I_D} \tag{1}$$

$$r_d = \frac{26mV}{I_D} \tag{2}$$

$$r_{av} = \frac{\Delta V_D}{\Delta I_D} = \frac{V_{D1} - V_{D2}}{I_{D1} - I_{D2}} \tag{3}$$

RESULTS AND DISCUSSIONS: The data on I-V measurement is plotted on a graph sheet to comprehend the diode behavior in forward and reverse bias conditions. The accuracy of measurement lies in selecting the proper value of the resistor R connected in series with a diode for current measurement. Its value should be chosen such that the voltage across it falls in the measurement range of the multimeter. With proper selection of the resistor value, low current values in the range of 10 nA can also be measured using an inexpensive multimeter which is readily available in the lab.