PN JUNCTION DIODE : TEMPERATURE DEPENDENCE OF REVERSE SATURATION CURRENT

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1. Aim

Determination of Boltzmann constant using a PN junction diode.

2. Theory

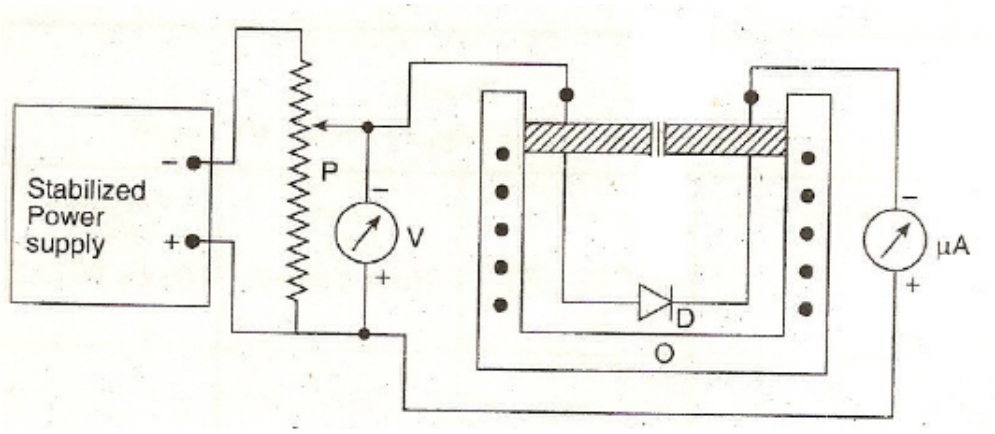
In a PN junction diode, the reverse current is due to the diffusive flow of minority electrons from the p-side to the n-side and the minority holes from the n-side to the p-side. Hence I_S, reverse saturation current depends on the diffusion coefficient of electrons and holes. The minority carriers are thermally generated so the reverse saturation current is almost unaffected by the reverse bias but is highly sensitive to temperature changes. The reverse saturation current I_S is

$$I_S = \frac{AeE_g}{\nu k_B T}$$

Where A is nearly constant independent of temperature and dependent on diffusion coefficients of electrons and holes. E_g is the band gap of the semiconductor, k_B is the Boltzmann constant. ν is a constant; 1 for germanium and 2 for silicon; and T is the absolute temperature. Band gap of silicon is $1.12eV$ and that of germanium $0.66eV$.

3. Procedure

Connect the circuit as shown below. The circuit involves a PID controlled oven, diode and a power supply.



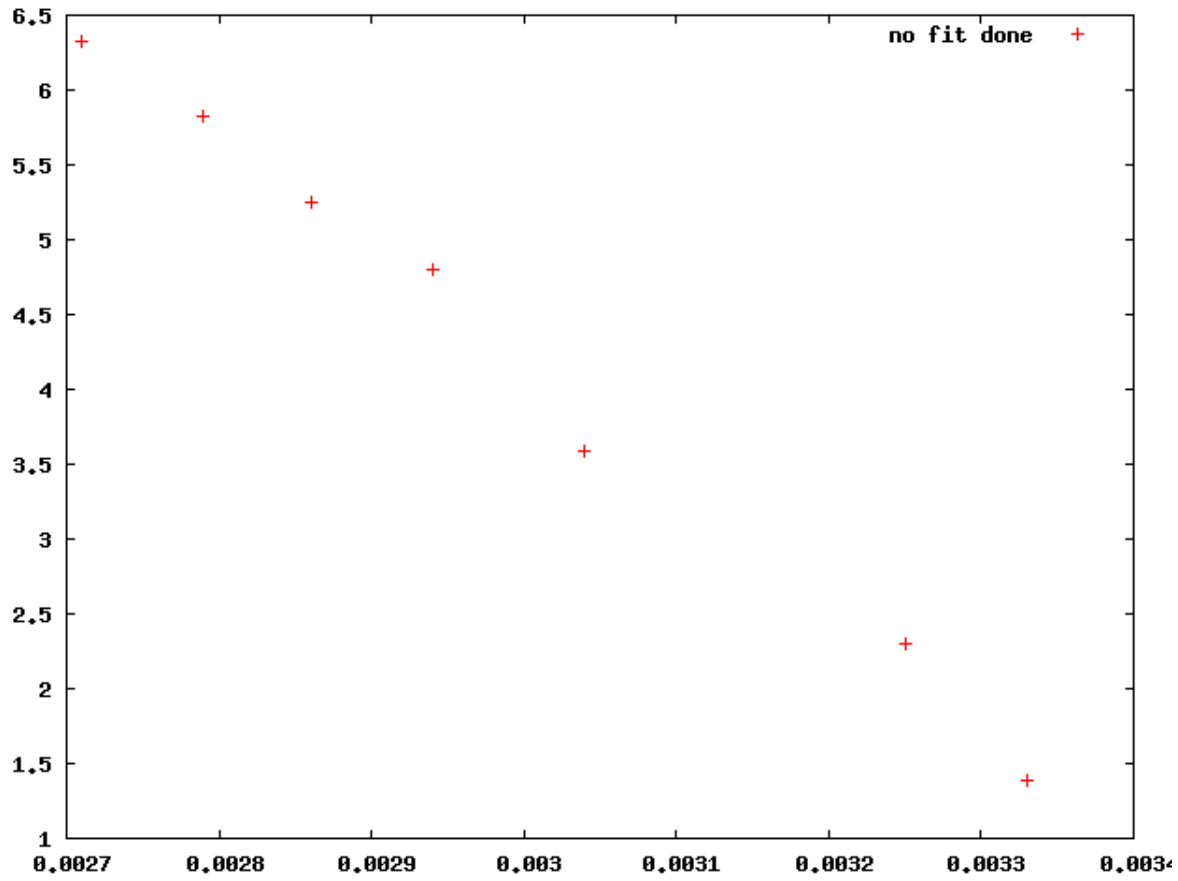
I did the experiment only for the heating curve. Using the PID controlled oven, increase the temperature in small steps starting from room temperature and note

the value of saturation current I_s. Now, plot a graph of lnI_S versus $1/T$ and calculate the slope. From this the Boltzmann constant can be calculated.

4. Observations and Results

S.no	Temperature T	Saturation Current I_S μA
1	300.4	4
2	340	121
3	349.4	191
4	358.9	338
5	369.3	561

From this the required graph can be plotted and is as follows :



From the calculation for the slope, the Boltzmann Constant is calculated and is found to be $1.29\mathbf{x}10^{-23}JK^{-1}$.