

## Experiment - 4

### Aim:

To determine the resistivity of semiconductors by four probe method.

### Apparatus:

Oven (0-200°C), current generator, digital panel meter, four probe setup, Online virtual Lab simulator

### Theory:

According to band theory, the energy levels of semiconductors can be grouped into two bands, valence band and the conduction band. In the presence of an external electric field, it is electrons in the valence band that can move freely, thereby responsible for the electrical conductivity of semiconductors.

$$\rho = \frac{V}{I} \times 2\pi S = \frac{\rho_0}{f(w/s)}$$

$$\rho = A \exp \frac{E_g}{2KT}$$

where  $T \rightarrow$  temp in K

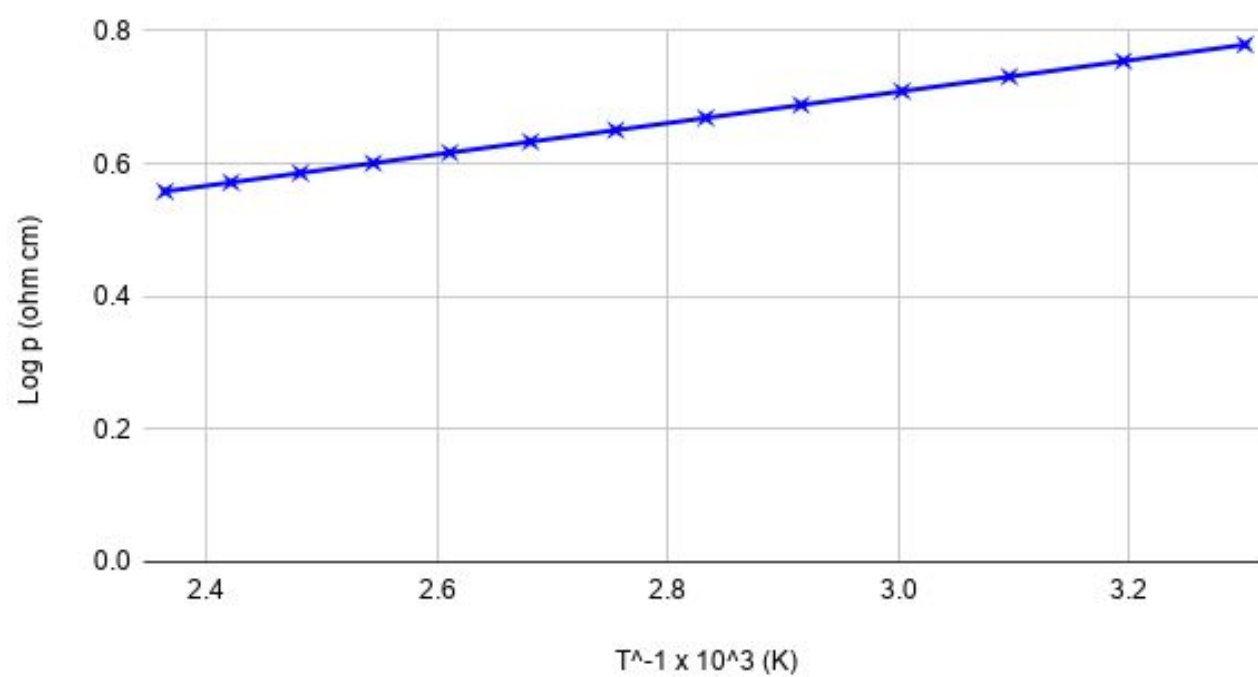
$E_g \rightarrow$  band gap of material

$K \rightarrow$  Boltzmann constant

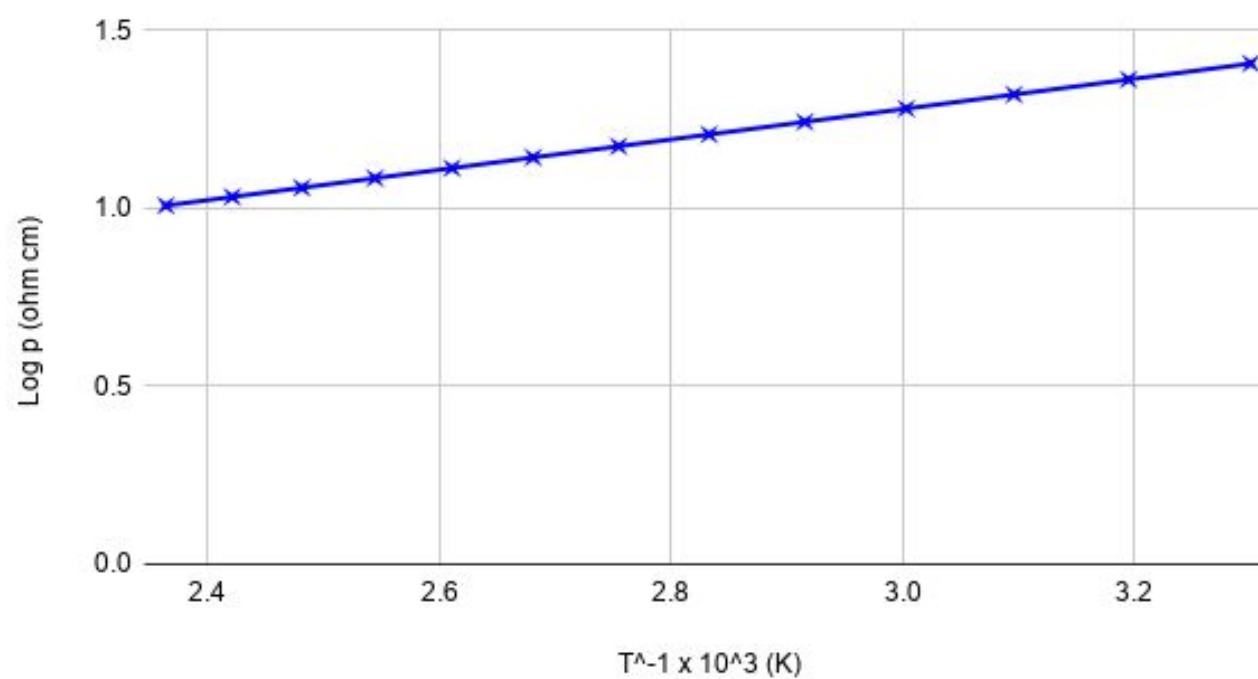
## Four Probe

<b>Germanium</b>		Current = 3mA					
T(degree C)	V (mV)	T(K)	Resistivity		1000/T (K)	Log P	
30	0.0847	303	6.0172		3.300330033	0.7793944468	
40	0.0799	313	5.6819		3.194888179	0.754493586	
50	0.0757	323	5.3843		3.095975232	0.7311292497	
60	0.072	333	5.1189		3.003003003	0.7091766455	
70	0.0687	343	4.8809		2.915451895	0.6884999099	
80	0.0657	353	4.6665		2.83286119	0.6689912702	slope
90	0.0629	363	4.4727		2.754820937	0.6505697695	0.2361587187
100	0.0604	373	4.2966		2.680965147	0.6331249241	
110	0.0582	383	4.1361		2.610966057	0.6165910303	
120	0.0561	393	3.9894		2.544529262	0.6009075833	
130	0.0542	403	3.8547		2.481389578	0.5859905838	
140	0.0525	413	3.7308		2.421307506	0.5718019681	
150	0.0509	423	3.6165		2.364066194	0.5582884694	
<b>Silicon</b>		Current = 3mA					
T(degree C)	V (mV)	T(K)	Resistivity		1000/T (K)	Log P	
30	0.3596	303	25.5598		3.300330033	1.407557451	
40	0.3242	313	23.0456		3.194888179	1.36258802	
50	0.2942	323	20.9123		3.095975232	1.320401801	
60	0.2685	333	19.0875		3.003003003	1.28074905	
70	0.2464	343	17.515		2.915451895	1.243410142	
80	0.2272	353	16.1505		2.83286119	1.208185972	slope
90	0.2105	363	14.959		2.754820937	1.174902562	0.4264903172
100	0.1957	373	13.9125		2.680965147	1.143405177	
110	0.1827	383	12.9882		2.610966057	1.113548968	
120	0.1712	393	12.1679		2.544529262	1.085215632	
130	0.1609	403	11.4363		2.481389578	1.058285539	
140	0.1517	413	10.7811		2.421307506	1.032663074	
150	0.1434	423	10.1918		2.364066194	1.008250893	

## Germanium



## Silicon



Procedure :

- Select the semiconductor material from the combo box.
- select the source current from the slider. Restrict the slider based on the range of current.
- set the temp. and range of oven.
- Click on the Run Button to start heating the oven in a particular interval and Wait Button to pause.
- Click on Set Button and Measure will show present Temp.
- select the range of voltmeter and measure voltage.
- Measure the resistivity of semiconductor in ~~the~~ measurement tab.
- Graph is plotted with log of resistivity v/s  $\frac{1}{T} \times 10^3$ .

Bandwidth Calculation:

$$E_g = 0.396 \times (\text{slope}) \text{ eV}$$

For Germanium,

$$\begin{aligned} E_g &= 0.396 \times (\text{slope})_{\text{german}} \text{ eV} \\ &= 93.5 \text{ meV} \end{aligned}$$

for Silicon,

$$\begin{aligned} E_g &= 0.396 \times (\text{slope})_{\text{silicon}} \text{ eV} \\ &= 168.89 \text{ meV} \end{aligned}$$