Name : Hunaid Siamwala S.

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Hunaid

★ Experiment No: 5 Band Gap

Objective:- Determination of resistivity & Bad gap of Semi-conductor by 4 probe Method at Different Temp.

Equipments needed:- Measurement unit, Oven arrangement, Thermometer, Four probe ; arrangement.

Theory:

* Four probe Method:-

- Many conventional methods for measuring resistivity are unsatisfactory for semiconductor because metal-semiconductor contacts are usually rectifying in nature Also there is generally minority carriers injection by one of current carrying contacts.
- The method describes here overcome the difficulties of mentioned above & also offers several other adv.. In this manner the resistivity on both side p-n junction can be determine with good accuracy before the material is also applicable to silicon & other semi-conductor materials.

Procedure:-

1. Before Switch 'ON' measurement unit connect both red 'banana terminals of four probe arrangement to the current terminals & black terminals to the voltage terminals.
2. Place the 4 probe arrangement in oven & insert thermometer from top through the hole provided.

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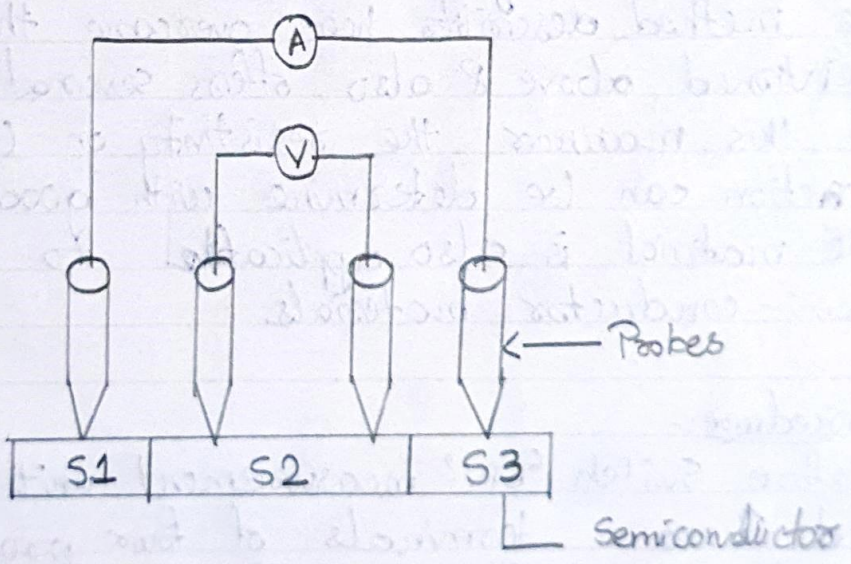
Observation Table:-

Sr.No	Temp T°C	Voltage V (mv)	Temp T°K	ρ_0	Resistivity = ρ ohm cm	$-\frac{1}{T}$ °K^{-1}	$\log_{10}\rho$
1	35	176.8	308	739.0	59.78	3.2×10^{-3}	1.777
2	40	178.3	313	745.29	60.29	3.19×10^{-3}	1.781
3	45	180.5	318	754.49	61.04	3.14×10^{-3}	1.786
4	50	181.5	323	758.67	61.38	3.09×10^{-3}	1.789
5	55	1801.5	328	758.67	61.38	3.04×10^{-3}	1.789
6	60	180	333	752.4	60.87	3×10^{-3}	1.785
7	65	177	338	739.86	59.85	2.95×10^{-3}	1.778
8	70	171	343	714.78	57.83	2.91×10^{-3}	1.763
9	75	165	348	689.7	55.80	2.87×10^{-3}	1.747
10	80	156.3	353	653.33	52.85	2.83×10^{-3}	1.724
11	85	139	358	581.02	47.00	2.7×10^{-3}	1.673



Model for 4 probe resistivity measurements.

3. Connect the Header terminals of oven to Measurement unit.
4. Set the controls of measurement unit as follows:-
   - Current / voltage rotary at current Position.
   - x_1/x_2 at x_1 position.
5. Switch 'ON' the instrument of 4 probe set up.
6. Meter will display 0 Condition.
7. Rate of heating can be selected with toggle switch.
8. Select rotary switch towards voltage position.
9. If voltage is over range.
10. Keep oven toggle switch 'ON' position.
11. Now temp. will started to increase slowly.
12. Record the temperature from room temp. to max. given temp. on Thermometer.
13. Record the temp. into the table & note down the corresponding voltage from display.
14. $$\rho = \frac{\rho_0}{G\left(\frac{w}{s}\right)} \qquad \rho_0 = \frac{V}{I} \times 2\pi s$$

$$G\left[\frac{0.23}{20}\right] = G(0.115) = > \text{is} \quad \underline{\underline{12.36}}$$

$$\text{So } \rho = \frac{\rho_0}{12.36}$$

15. Plot graph of $\log_{10} \rho$ Vs $10^{-3}/T°K$
16. The Slope of curve $\Rightarrow \frac{\log \rho}{1/T} = \frac{E_g}{2k}$

$$E_g = 2k \frac{\log \rho}{1/T°}, \text{ where } k = 8.6 \times 10^{-5} \text{ eV/k}$$

Precautions:-

1. Sample crystal is attached with probe, in case if it is not making proper contact with probes then adjust the pipe holding the four probe rest in middle of the sample. Apply a very gentle pressure on probes & tighten pipe in this position.
2. Oven on toggle switch at "OFF" position.
3. Potentiometer at fully anticlockwise.
4. Adjust the constant current to a desire value say 3mA.

Results:-

Energy Band Gap of Ge crystal E_g = 3.96 eV/K°

Conclusion:-

- We can conclude that how we can determine the resitivity & Band gap of Semi-conductor at dif. temp.

Calculations:-

We know that,

$$Eg = 2k \frac{\log_e P}{\frac{1}{T}}$$

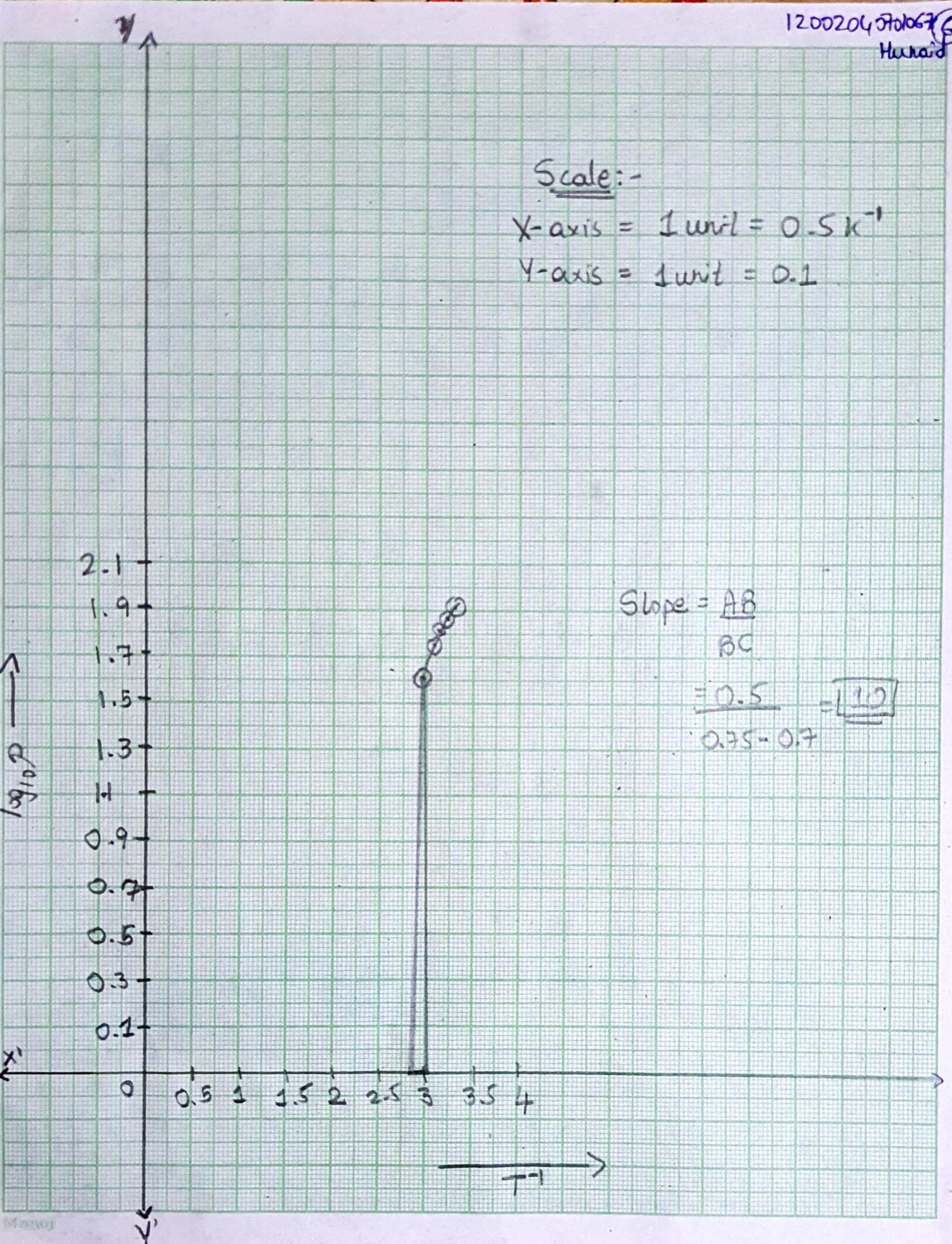
where k is Boltzmann's constant = 8.6×10^{-5} ev/°k

From the graph the Eg = (2k * Slope * 2.303) / 10^{-3}

$$Eg = \frac{2 \times 8.6 \times 10^{-5} \times 10 \times 2.303}{10^{-3}}$$

$$= 3.96.116 \times 10^{-2}$$

$$= 3.96 \text{ ev/ok}$$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Scale:-
X-axis = 1 unit = 0.5 K⁻¹
Y-axis = 1 unit = 0.1
Slope = AB / BC
= 0.5 / 0.75 - 0.7 = 1.0
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.1
log10P
X'
0
0.5
1
1.5
2
2.5
3
3.5
4
X
T⁻¹
Y'