ENEGRY GAP OF A SEMICONDUCTOR

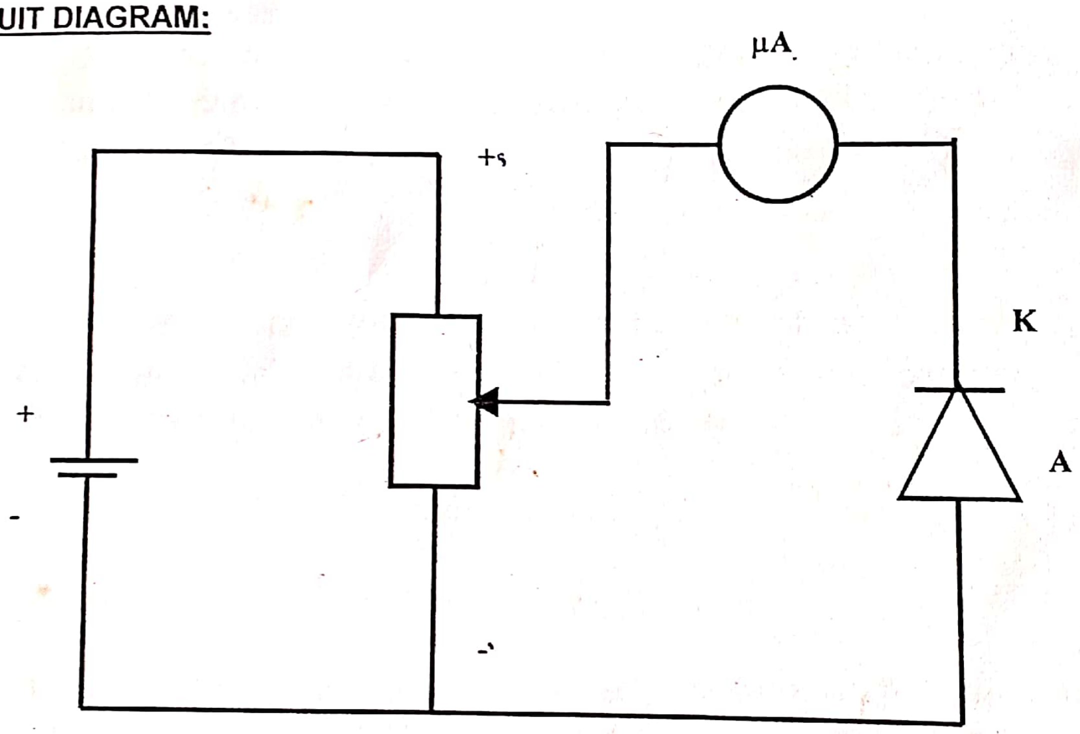
AIM:

To determine the energy gap of a semiconductor.

APPARATUS:

1) PHYSITECH'S Energy gap of a Semiconductor trainer.
2) Tumbler flask
3) Thermometer.
4) Connecting wires.

CIRCUIT DIAGRAM:



THEORY:

The relation between the diode current I and the voltage V is given by

$$I = I_S[\exp.(qv/KT) - 1].$$

Where q is the electronic charge, K is the Boltzmann constant and T is the absolute temperature. In the forward bias condition, majority charge carries are responsible for conduction. The number of these charge carriers injected at the junction increases with the voltage and thus the current increases (exponentially) with the voltage. When the diode is reverse biased and V is greater than a few volts, $I \approx - I_S$. The reverse current is therefore constant and independent of the applied reverse bias. Consequently, I_S is referred to as the reverse saturation current. Under reverse bias conditions, minority charges carriers take part in the process of conduction. It takes part in the process of conduction. It takes only a few tenths of a volt to clear all the minority carriers. Any further increase in the bias voltage does not lead to increase in the current as all the carriers have already been set in motion.

The reverse saturation current I_S is given by

$$IS = Agni^2 [(D_h/N_D L_h) + (D_n/N_A L_n)]$$

Where N_D and N_A represent donor and acceptor concentrations respectively, Lh and Ln represent diffusion lengths of holes and electrons respectively; Dhand Dn are the diffusion constants of holes and electrons respectively; A is the junction area; and n_i is the intrinsic carrier concentration.

The factor in parenthesis of the above equation as not strongly temperature dependent. Therefore temperature dependence of I_S is determined by n_i which is given by

$$Ni^2 = KT^2 \exp(-E_g/KT)$$

Where k is a constant and E_g is the width of the energy gap at absolute zero. However E_g may be assumed to be practically constant. The reverse saturation current may be represented by the relation.

$$I_S = CT^3 \exp(-Eg/KT)$$

(or)

$$\log I_S = \log CT^3 - (Eg/K)\, 1/T$$

In the operating range of the diodes, the temperature dependence of I_S is the mainly determined by the second term in the above equation. Hence, a plot of log I_S Vs 1/T is approximately linear with a slope –Eg/K from which the energy gap (Eg) is determined.

PROCEUDURE:

1) Switch ON PHYSITECH'S Energy gap of a semiconductor trainer.
2) Connect the supply provided on the trainer to the input voltage
3) Connect the micro ammeter, which is provided on the trainer to the µA terminals.
4) Connect either of the diode, which is provided on the trainer.
5) Fix the diode to the cap of the tumbler flask. Provide two holes on the cap and insert a thermometer in one and a wire stirrer in the other.

6) Fill the tumbler flask with oil heated to ≈ 1500C. Fix the cap and stir the oil well. This arrangement is good enough to maintain the temperature within ± 0.50C.
7) At any particular temperature, measure current as a function of the reverse bias voltage. This voltage can be obtained directly from the calibrations on the potentiometer. There is no need to use a separate voltmeter if a ten turn potentiometer (calibrated) is used. If the battery voltage is 1.5V, each turn corresponds to 150mV and each division on the scale corresponds to 1.5mV.
8) The biasing voltage is increased in steps and the corresponding current is noted. The constant current which is the saturation current I_S is noted from these observations at that temperature.
9) Open the cap of the flask and allow the temperature to decrease by 20^0C, stir the liquid well, fix the cap and repeat the experiment for different temperatures by cooling the liquid in steps of 20_0.
10) Represent the results graphically.
11) Plot 2.303 log10IS as a function of 1/T. evaluate the slope and the forbidden energy gap of germanium. Compare with the standard value.

Energy gap Eg = Slope*Bottzman's constant.

Bottzman's constant K = 1.38 * 10-23 J/K.

Energy gap for Germanium varies from 0.68eVd and for Silicon it is 1.1eV.

12) Repeat the same procedure for another diode also.