CHAPTER V

CHAPTER - V

Studies on CdS-PbS Heterojunction

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5.1 Introduction

The interest in heterojunction between two different semiconductors has been stimulated in the recent years by the wide extent of their applications ranging from photovoltaic cells to light emitting diodes.[1-4] In particular, limited band photodetection has been achieved by means of the heterojunction "window" effect, which originates due to the difference in forbidden gap of the two semiconductors,[5] photons with energies intermediate between the two gaps, are absorbed at the interface and create electron-hole pairs. The electrons and holes are separated by the junction field before recombination takes place. This gives rise to photovoltage at the diode terminals. In this way it is possible to detect the photons with high sensitivity together with short response time.

Heterojunctions involving PbS are highly interesting for their use as near an medium IR detectors. The fabrication of one such combination of CdS-PbS, has been reported by Watanabe and Mita.[6,7] In the present investigation the CdS-PbS heterojunctions have been fabricated by depositing polycrystalline films of PbS and CdS by chemical bath deposition technique and the attempts have been made to study the electrical characteristics like I-V and C-V curves to find the basic parameters of junctions like flat band potential and diode ideality factor.

5.2 Experimental

The PbS films were deposited on CdS to form CdS-PbS heterojunction by chemical bath deposition technique as described in chapter III. Electrical contact to PbS film was made and the heterojunction was kept in front of tungston filament lamp of 500 W.

ECPV cell properties

i) Dynamic characteristics :

The circuit diagram for the study of dynamic I-V characteristics of CdS-PbS heterojunction solar cell is shown in fig. 5.1. The dark voltages and currents were recorded with the help of digital voltmeter Pla DPM 10 and an Aplab FET nonoammeter TFM:13 respectively.

The CdS-PbS heterojunction was then exposed to light from tungsten filament lamp; and voltages and currents were recorded. All measurements in the light were carried out under the same conditions, similar to those in the dark.

ii) Photovoltaic output characteristics :

Fig.5.2 shows the circuit diagram to study photovoltaic output characteristics of CdS-PbS heterojunction. The short circuit current, I_{sc} and open circuit voltage, V_{oc} were noted with the help of an Aplab FET nanoammeter TFM:13 and digital voltmeter Pla DPM 10, by varing resistance R_L.

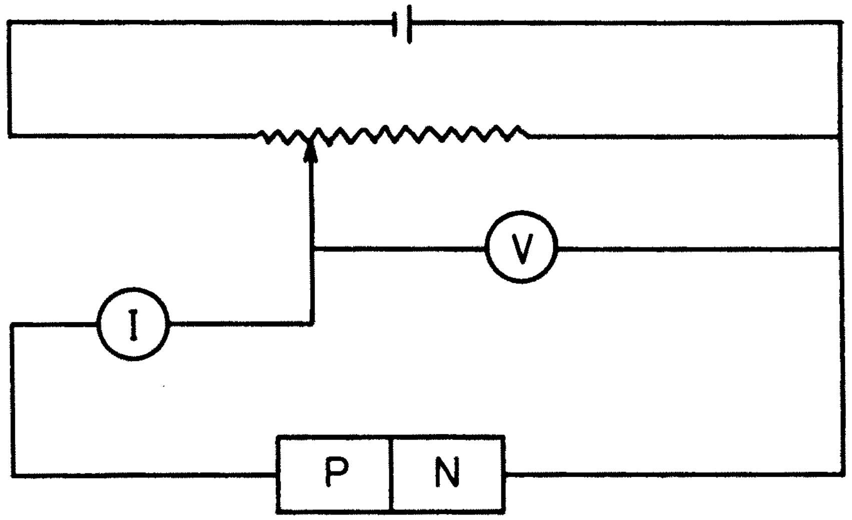

Fig. 5.1 Circuit diagram for the dynamic I-V characteristics of CdS-PbS hetrojunction.

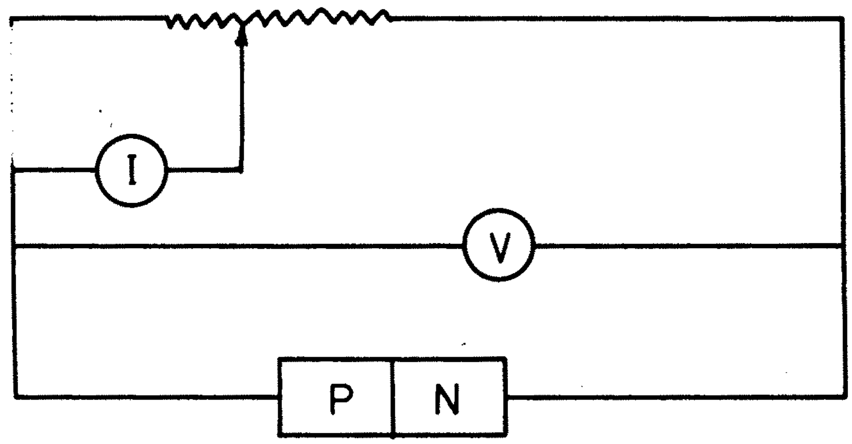

Fig. 5.2 Circuit diagram for the photovoltaic output characteristics of CdS-PbS heterojunction.

iii) Capacitance-Voltage characteristics :

The capacitance-voltage measurements in the dark were carried out by a potentiometric arrangement as shown in Fig.5.3. The potential applied to the junction was measured by Pla digital d.c. voltmeter DPM-10. The junction capacitance was measured by a digital display capacitance meter (VCM-13A).

5.3 Results and Discussion

5.3.1 Dynamic characteristics :

The current-voltage (I-V) curve for CdS-PbS heterojunction in dark was studied, both in forward and reverse direction to investigate the charge transport across the interface between both the semiconductors. The nature of the I-V curve in dark for CdS-PbS heterojunction is shown in fig. 5.4. It is possible to represent the I-V curve by the following expression

$$I = I_o \left[\exp. \left(\frac{eV}{nkT} \right) - 1 \right] \qquad \ldots \qquad (5.1)$$

where I_o is the reverse saturation current, V is the voltage, n is the junction ideality factor and other terms have their usual meanings. For the voltage exceeding $\frac{3KT}{e}$, one can neglect the last term in the bracket and write :

$$I = I_o \exp \left(\frac{eV}{nkT} \right) \qquad \ldots \qquad (5.2)$$

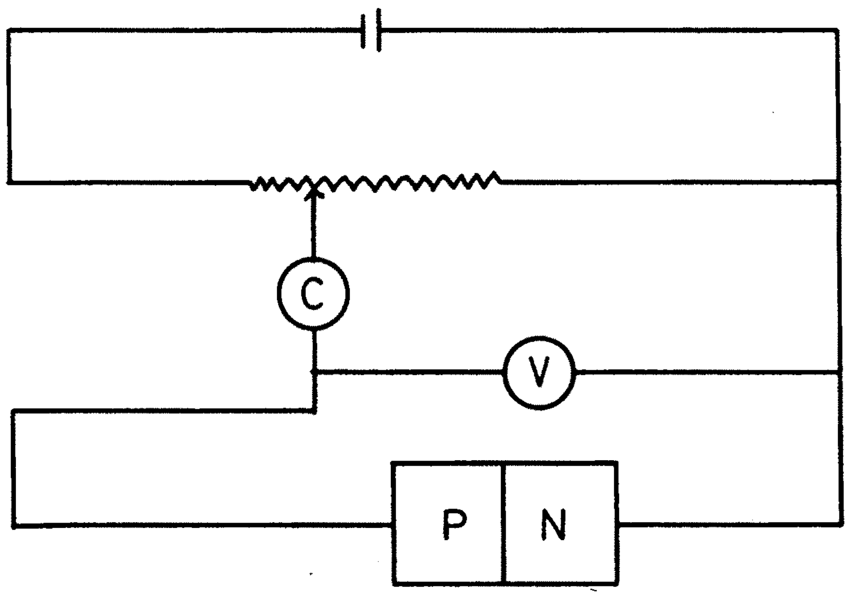

Fig.5·3 Circuit diagram for capacitance-voltage characteristics of the CdS-PbS heterojunction .

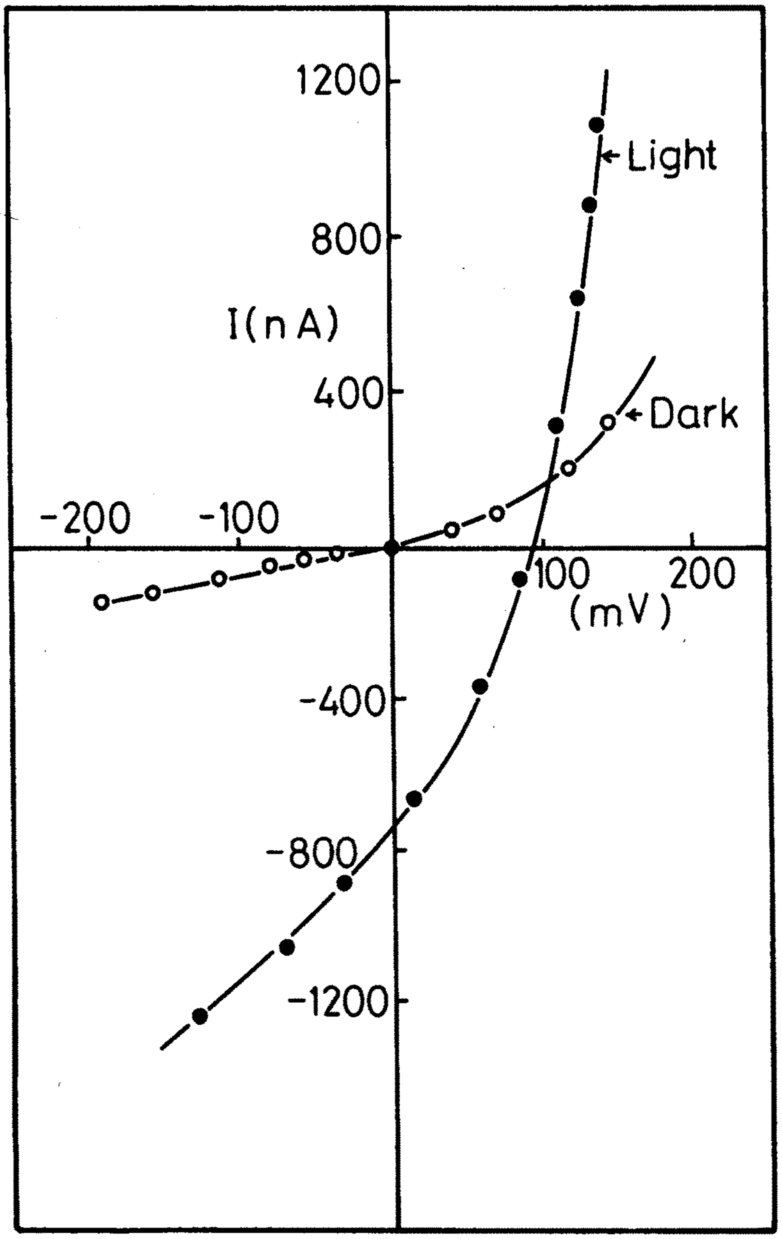

Fig. 5·4 Dynamic current - voltage characteristics for F : SnO_2 /CdS/PbS/M heterojunction cell in the dark and light .

where validity of this expression was tested by plotting the graph of log I versus V and is shown in fig. 5.5. The value of dark ideality factor n_d was determined by using the slope of this straight line curve and it was found to be 3.75.The higher value of n_d might be due to degree of recombination of the charge carriers in the depletion region and indicative of non ideal junction.[8]

The dynamic I-V curve was also recorded when junction was exposed to white light source. The nature of behaviour of I-V curve for the junction is shown in fig.5.4 . It was found that the I-V curve in light was shifted in fourth quadrent which shows that the CdS-PbS heterojunction solar cell was the generator of electricity.[9] The cross over of two curves indicates that heterojunction was photoconducting.[9]

5.3.2 Photovoltaic output characteristics of the CdS-PbS heterojunction

When the junction was exposed to light, it works as the generator of electricity. The characteristics of this generator were measured in terms of voltage and current as applied to the external load. The voltage and current drawn from CdS-PbS junction solar cell, depends on load resistance R_L in closed circuit. When $R_L = 0$, i.e. voltage drop across the load was zero, the current flowing through the circuit was maximum, called as short circuit current and denoted by I_{sc} (750 nA).

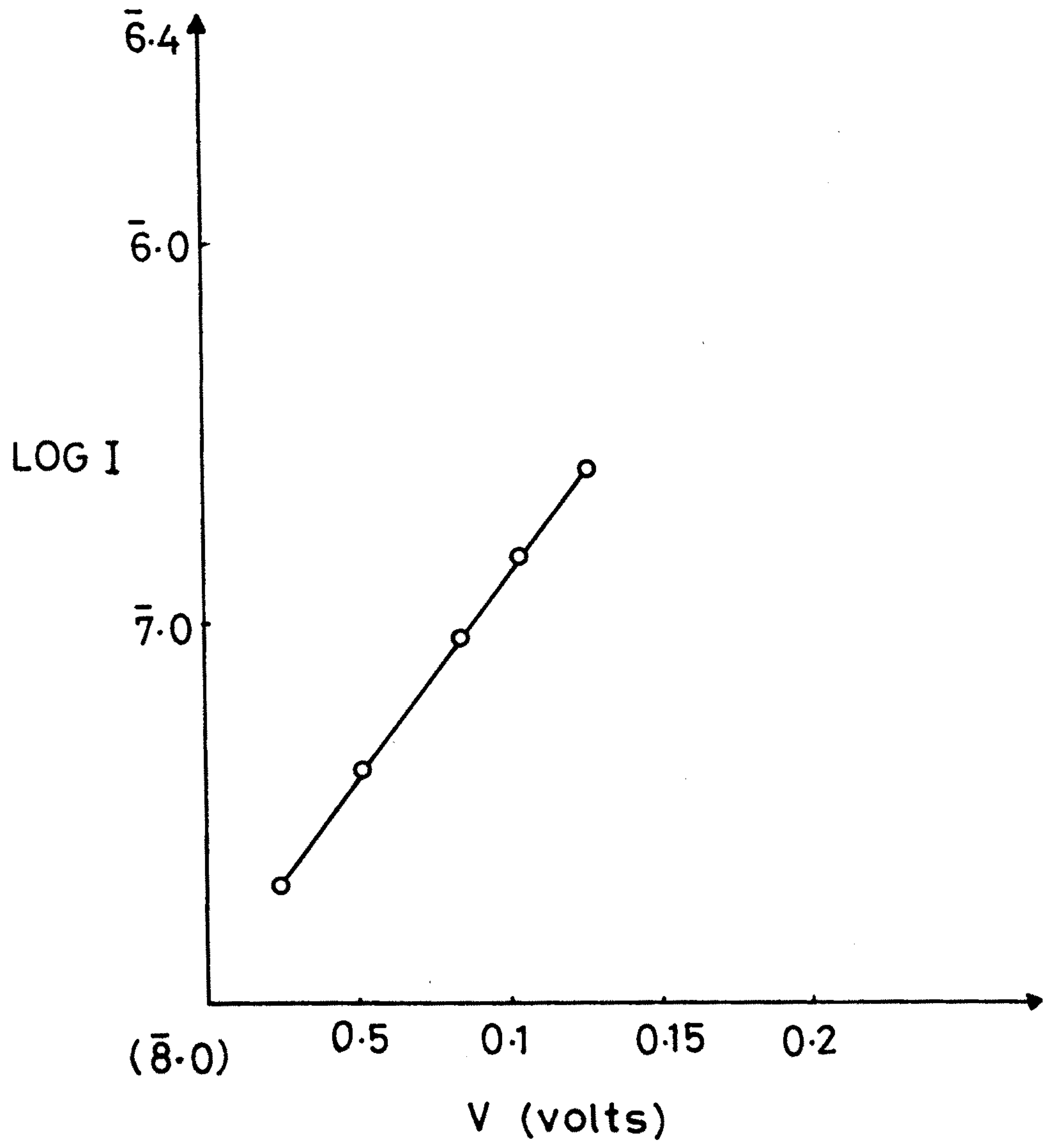

Fig 5·5 Plot of log I versus V.

when R_L was infinite, i.e. the current flowing through the circuit was zero, the voltage drop across the load R_L was maximum, called as open circuit voltage V_{oc} (90 mV).

The magnitudes of I & V, recorded for the other values of load resistances between o and ∞ yields the I-V curve. The nature of this I-V curve is shown in fig. 5.6. The area under the curve gives the total power available from CdS-PbS heterojunction solar cell. The maximum power available was found at a point on the I-V curve where the product IV was maximum. The values of I and V corresponding to this point were denoted by I_m and V_m respectively and these are (500 nA and 55 mV respectively).

5.3.3 Capacitance-voltage characteristics :

Flat band potential (V_{fb}) is a measure of potential which must be applied to the semiconductor such that bands become flat at the interface. The V_{fb} determines the amount of band bending at the interface. The flat band potential of CdS-PbS heterojunction solar cell was estimated by studying C-V measurements. Fig. 5.7 shows the Mott-Schottky plot for the cell in dark. The junction capacitance 'c' as a function of applied bias V in dark was measured. It was observed that the measured space charge layer capacitance; decreases with increase in reverse bias. The linear variation of C^{-2} as a function of applied voltage V indicates that the Mott Schottky relation was valid. The intercept of the plot, C^{-2} vs V, to the voltage axis yields the value of flat band potential (0.15 V).

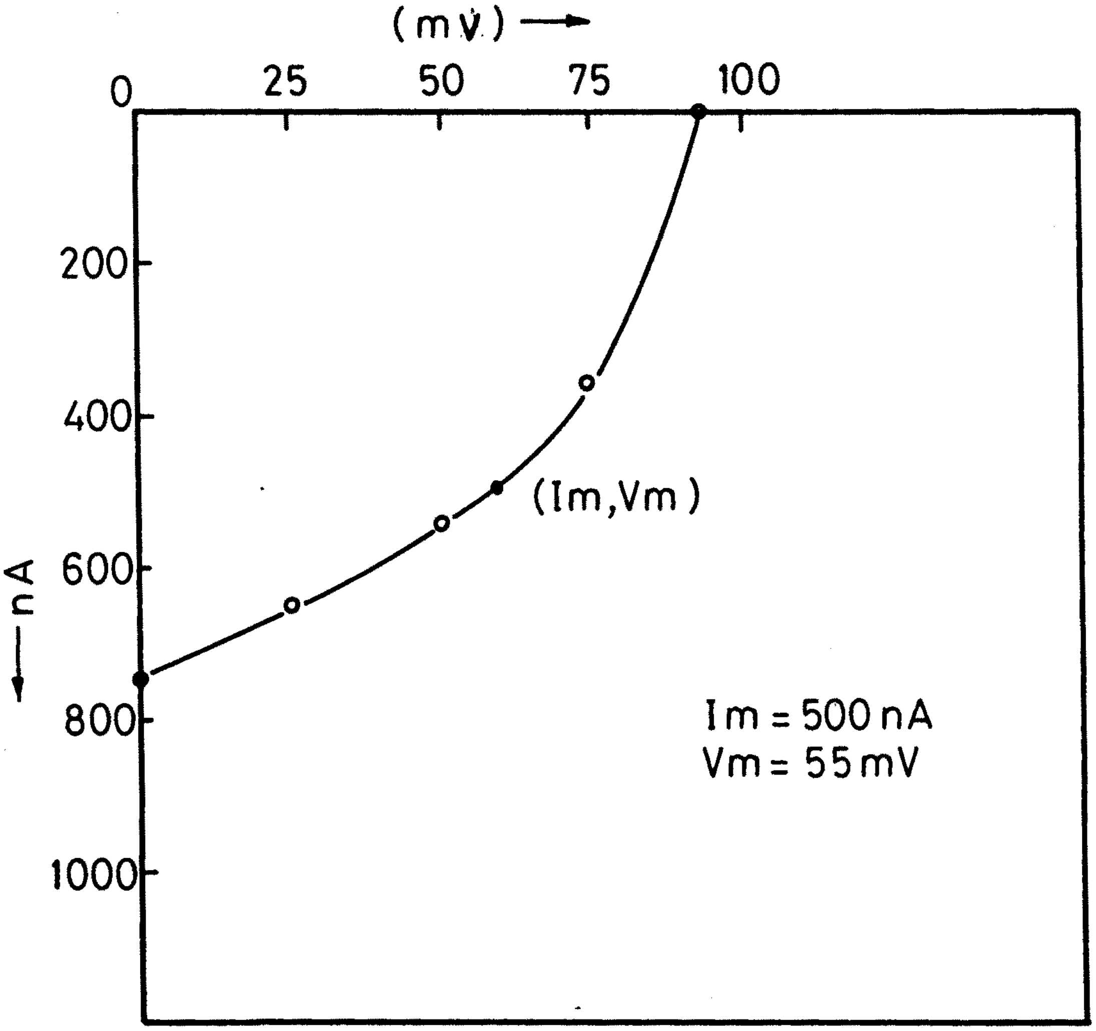

Fig.5·6 Photovoltaic output characteristics for CdS-PbS heterojunction .

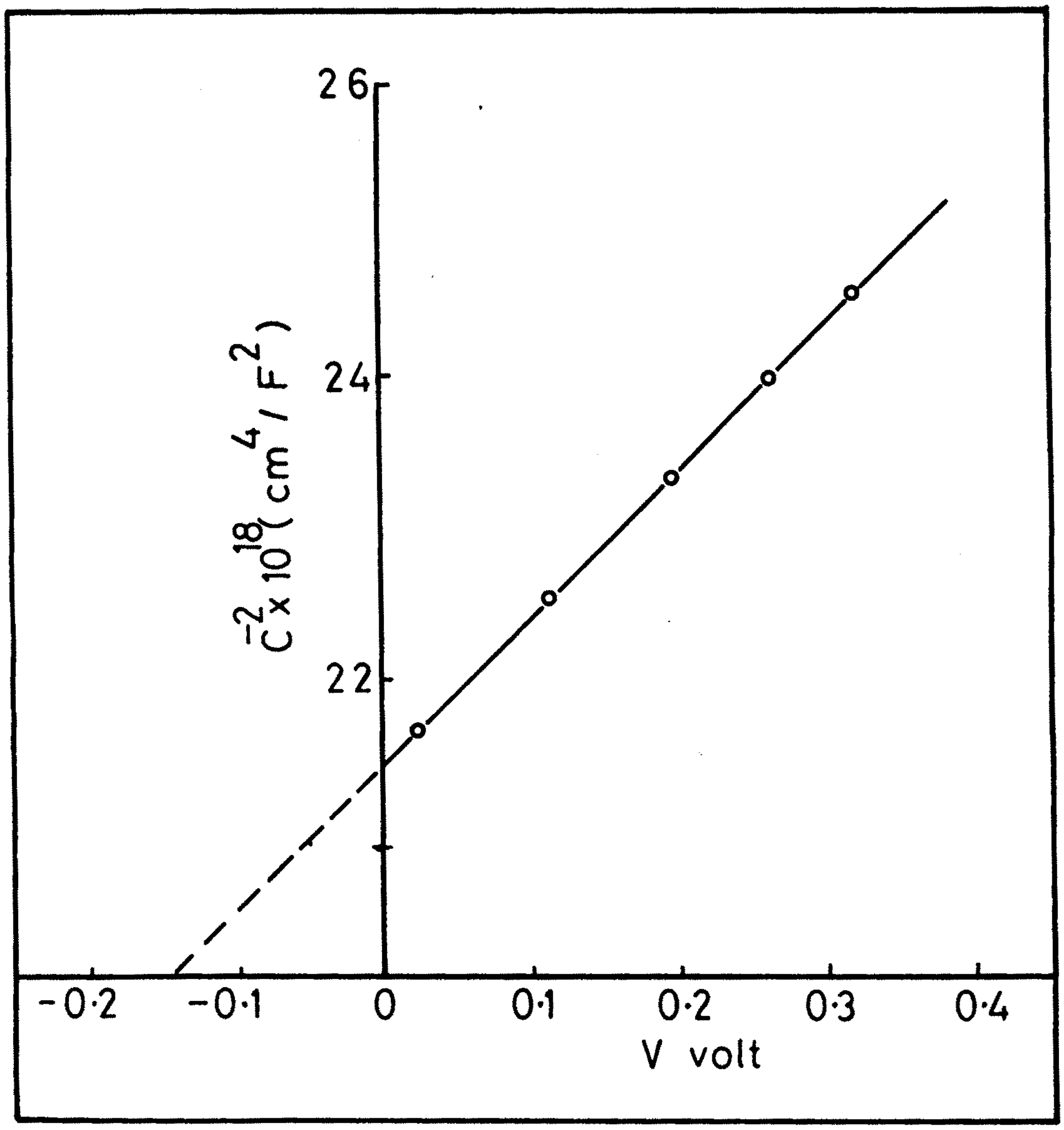

Fig. 5·7 Variation of $\bar{C}^{2}$ versus V .

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