CHAPTER VI

THERMALLY STIMULATED CONDUCTIVITY

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6.1 INTRODUCTION

Conductivity of any material is a measure of the electrons in the conduction band.

Increases in the temperature causes an increase in the number of electrons in the conduction band.

In the case of semiconductors there are same free electrons at room temperature. Hence it shows some conductivity.

But in the case of insulators, the band gap between the valance band and the conduction band is large. Thus, there are no electrons in the conduction band and no conductivity at room temperature.

By increasing the temp. it is possible to transfer electrons from valence band or traps to conduction band and the resultant conductivity is called thermally stimulated conductivity (TSC).

The temperature required to transfer the electrons from valence band to conduction band depends on the band gap energy of the material.

Thus, we can estimate the band gap energy of the material from the change in resistivity with temperature.

6.2. EXPERIMENTAL PROCEDURE

The resistivity of the material at different temperatures is measured by four probe method. The experimental set up is described in chapter-II. A sample in the form of sintered pellet is placed in the sample holder, and probes are placed so as to make good contacts. The sample was then placed in the oven and temperature was increased.

The current and corresponding voltage are measured at different temperatures. The resistivity of the material is calculated by using the formula.

$$\rho = \frac{2\pi s V}{G_7(W/s)\ I} \quad .. \ (6.1)$$

Where I is the current through the phosphor, V is the voltage between two voltage probes, S is the distance between the probes and $G_7(W/s)$ is the function of thickness of the sample and the distance between the two prbes.

The value of G_7 (w/s) is used from the data given by the manufacturer.

The band gap energy is given by the formula.

$$Eg = 2\ k\ \frac{\log e \rho}{(1/T)} \quad .. \ (6.2)$$

The value of $\frac{\log_e \rho}{(1/T)}$ is obtained from the slope of the $\log_{10}\rho$ vs 1/T graph where 'T' is in °k.

6.3 RESULTS AND DISCUSSION

a] Condcutivity of Phosphors

It is observed that phosphors behave as insulators at room temp. This means they have large band gap energy as compared to the semiconductors. As the temperature is increased to beyond 170°c. the phosphors show conductivity. This may be due to the electrons and holes thermally created. Electrons from traps or valence band are transferred to the conduction band.

The values of conductivity and resistivity for CaS, BaS and Sr are given in table 6.1.The nature of the plots $\log_{10}\rho$ vs 1/T are similar for the three. The conductivity is found to initially decrease and then increase with increase in temperature.

b] Band gap energy

The actual reported value of band gap eneergy for CaS phosphor is around 4.5eV (1,2,3). In present study the band gap energy is calculated by plotting the graph between $\log_{10}\rho$ and 1/T(fig. 6.1). The band gap energy thus calculated is 2.758 eV for CaS, 2.29 eV for SrS and 1.98eV for BaS.

The band gap energy estimated by four probe method does not agree with the reported band gap values. The following may be the reason for it.

The transfer of electrons from valence band to conduction band actually requires higher temperatures. The four-probe apparatus provides a temperature range upto 210 °c. In this range of temperature (room temp.-210°c) electrons may be transferred from intermediate traps to the conduction band instead of from conduction band. This indicates that calculated energy may not be band gap energy but trap depth from which electrons are transferred to conduction band. This explanation requires confirmation with additional data and experimentation.

A correlation between thermoluminescence and thermally stimulated conductivity has been established for CaS:Bi phosphor (4). The two factors ere simultaneously measured after suitable excitation. More efforts in this direction may help in understanding mechanisms involved in the two phenomena.

TABLE 6.1

Variation of conductivity with temperature
JDCO (undoped CaS)

Temp°k	ρ (Ωcm)	conductivity $(\Omega cm)^{-1}$
438	0.59×10^{6}	1.60×10^{-6}
448	0.59×10^{6}	1.69×10^{-6}
451	0.54×10^{6}	1.85×10^{-6}
453	0.51×10^{6}	1.96×10^{-6}
458	0.43×10^{6}	2.33×10^{-6}
463	0.39×10^{6}	2.56×10^{-6}
468	0.31×10^{6}	3.23×10^{-6}
473	0.25×10^{6}	4.00×10^{-6}
478	0.23×10^{6}	4.35×10^{-6}
483	0.18×10^{6}	5.55×10^{-6}
485	0.14×10^{6}	7.14×10^{-6}

contd...

contd.

JDSO (undoped SrS)

Temp°k	ρ (Ωcm)	Conductivity (Ωcm)$^{-1}$
448	0.03×10^{6}	33.3×10^{-6}
453	0.21×10^{6}	4.76×10^{-6}
458	0.24×10^{6}	4.16×10^{-6}
463	0.23×10^{6}	4.16×10^{-6}
468	0.18×10^{6}	5.55×10^{-6}
473	0.16×10^{6}	6.25×10^{-6}
478	0.13×10^{6}	7.69×10^{-6}

JDBO (undoped BaS)

453	0.195×10^{6}	5.13×10^{-6}
458	0.16×10^{6}	6.41×10^{-6}
463	0.27×10^{6}	3.66×10^{-6}
468	0.21×10^{6}	4.66×10^{-6}
473	0.23×10^{6}	4.27×10^{-6}
478	0.23×10^{6}	4.27×10^{-6}
483	0.21×10^{6}	4.66×10^{-6}

Reference

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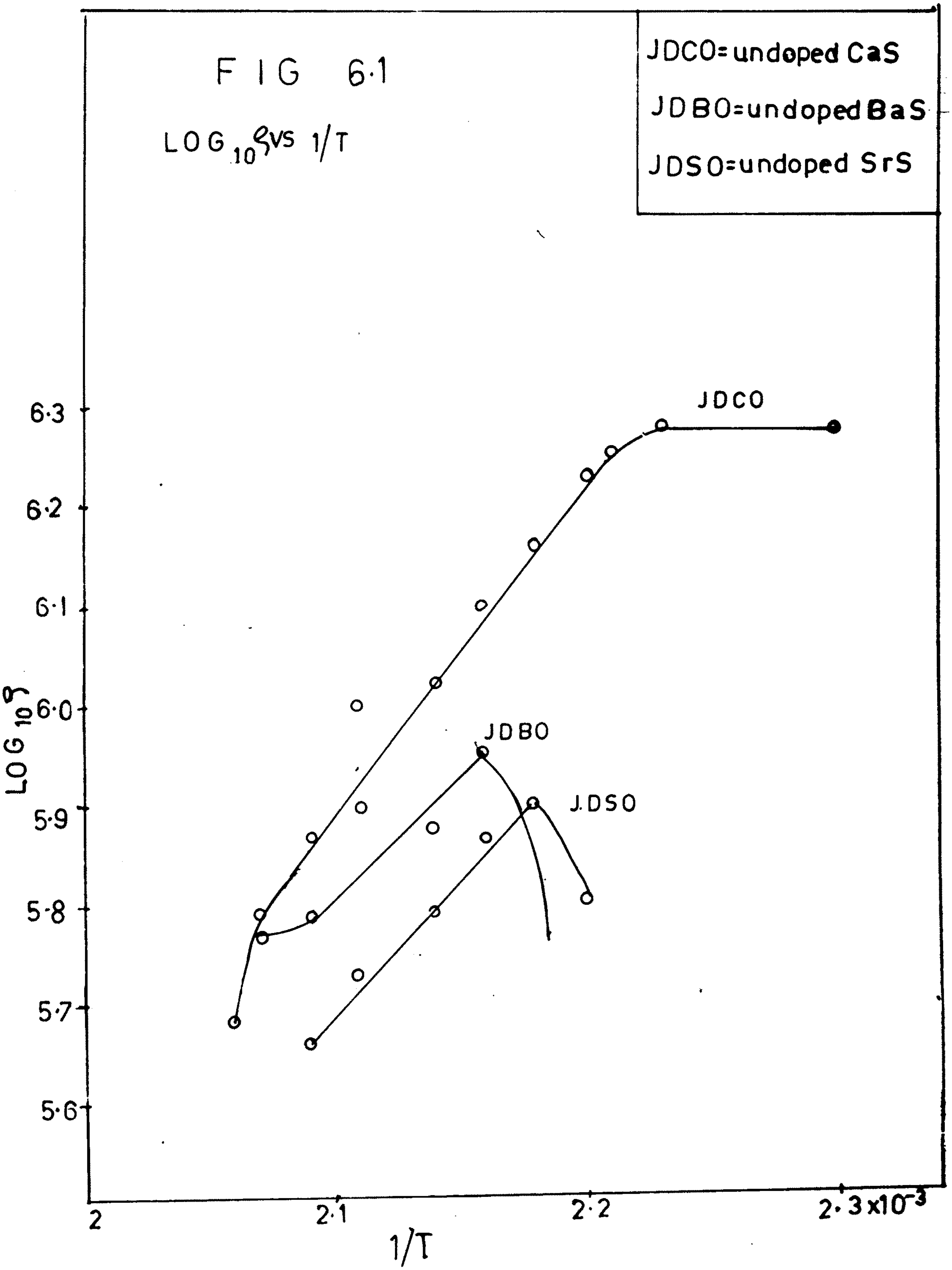
FIG 6.1
LOG10ρ VS 1/T
JDCO=undoped CaS
JDBO=undoped BaS
JDSO=undoped SrS
JDCO
JDBO
J.DSO
LOG10ρ
6.3
6.2
6.1
6.0
5.9
5.8
5.7
5.6
2
2.1
2.2
2.3x10-3
1/T