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THERMO ELECTRIC POWER MEASUREMENT OF BARIUM OXALATE CRYSTALS

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Abstract

An attempt is made in the present work to characterize gel grown barium oxalate crystals by Thermo Electric Power (TEP) measurement. Different parameters such as Fermi energy and mode of scattering were calculated. To calculate Fermi energy and scattering parameter of a material, a graph of Seebeck coefficient(S), versus reciprocal of temperature difference (1/ΔT) is plotted. The slope of the graph is -27.50 mV and intercept is 0.181 mV/K, and hence Fermi energy, E_F = 0.028 eV. Scattering parameter has calculated 0.4. The experimental value obtained for A = 2.10 is in well agreement to conclude that the conduction of heat in the material may be due to the lattice or phonons and can be associated with lattice or phonon scattering.

Keywords: Barium oxalate; Thermo Electric Power (TEP); Fermi energy; Mode of scattering.

INTRODUCTION

Thermoelectric power (TEP) has attracted many researchers for its applications in designing a portable refrigerator [1], and power generations. Narrow gap Bi_2Te_3 semiconductors and its alloys, are found to be the most efficient thermo-electric materials [2]–[5], as its Figure of merits ($Z = S2/k\rho$, where S is Seebeck coefficient, k is thermal conductivity and ρ is resistivity) have high Seebeck coefficient and therefore they have high demand in electronics field. Many insulators have shown the characteristics of exhibiting large TEP. Insulators have extremely high resistance; therefore conduction can take place by several mechanisms such as thermal or Schottky emission, tunnelling, Poole-Frenkel effect, field emission, space charge limited conduction etc. [6]. Measurement of thermoelectric power has distinctive advantages over other methods because measured thermoelectric voltage is directly related to the carrier concentration [7]. Many researchers have reported thermoelectric power measurement of semiconducting materials [8]-[9], and some on organic materials [10]-[17]. However, there are no such studies are reported on oxalate material.

Looking at the importance of the thermoelectric power (TEP), author of this paper has therefore carried out a systematic investigation of gel grown barium oxalate crystals. Different parameters such as Fermi energy and mode of scattering were also calculated.

EXPERIMENTAL

Gel method is simple, inexpensive and suitable to grow crystals at ambient temperature [18]. The barium oxalate crystal grown by the gel method [19-20] was used for the thermoelectric power studies. Thermo electric power of barium oxalate single crystal was measured on an instrument assembled in the Physics Research Lab, Shri V. S. Naik Arts, Commerce and Science College, Raver (Maharashtra). A single crystal of barium oxalate was placed in the instrument at a proper position and made all equipment ready for working. One end of the crystal was heated with the heating device upto certain fixed temperature. The temperature difference occurred between two ends and corresponding developed e.m.f. were recorded.

OBSERVATIONS AND RESULTS

Employing electrical heating device to one end of a crystal produces a temperature gradient, (ΔT) between two ends of a material and give rise to an e.m.f. This developed e.m.f. is known as thermo e.m.f (ΔE), which is directly proportional to ΔT. The temperature difference, ΔT between two ends of a crystal is ranging within a limit of 9 to 12K.Thus, Seebeck coefficients 'S' at different temperatures were calculated by using the equation:

$$S = (\Delta E/\Delta T)$$

The variation of thermo electric power, or Seebeck coefficient 'S' with respect to absolute temperature is shown in **Fig. 1.**

To calculate Fermi energy and scattering parameter of a material, a graph of Seebeck coefficient(S), versus reciprocal of temperature difference ($1/\Delta T$) is plotted and shown in **Fig. 2**.

The slope of the graph is -27.50 mV and intercept is 0.181 mV / K

So the Fermi energy,

$$E_F = \text{(slope X charge on an electron)}$$
$$= 27.50 \times 1.6\times10^{-19} \text{ joules}$$
$$= 27.50 \text{ meV}$$
$$= 0.028 \text{ eV}$$

$$\text{Constant} \quad A = \frac{\text{(intercept)}}{K_B} \quad \text{meV / K}$$

Where K_B is Boltzmann constant

$$\text{Constant} \quad A = \frac{(0.181\text{X}10^{-3})\text{eV/K}}{(8.617\text{X}10^{-5})\ \text{eV/K}}$$

$$A = 2.10$$

Scattering parameter

$$\alpha_s = (5/2) - 2.10$$
$$= 0.4$$

DISCUSSIONS

The value of Fermi energy E_F is obtained from the slope of a graph and the constant A obtained from the intercept on Y-axis. The value of constant 'A' gives valuable information regarding the mode of scattering occurred in the material during the conduction of heat.

Table 1: Values of A and their corresponding Mode of scattering

Scattering mode	Constant A
Ionized impurity	4
Piezoelectric (ionic lattice)	3
Grain boundary	-
Lattice or phonons	2
Vibrations at	1
Constant frequency	0.5
Ionic lattice	2.5
Degenerate system	-

The experimental value obtained for A, 2.10 is in well agreement to conclude that the conduction of heat in the material may be due to the lattice or phonons and can be associated with lattice or phonon scattering [6] (**Table 1)**.

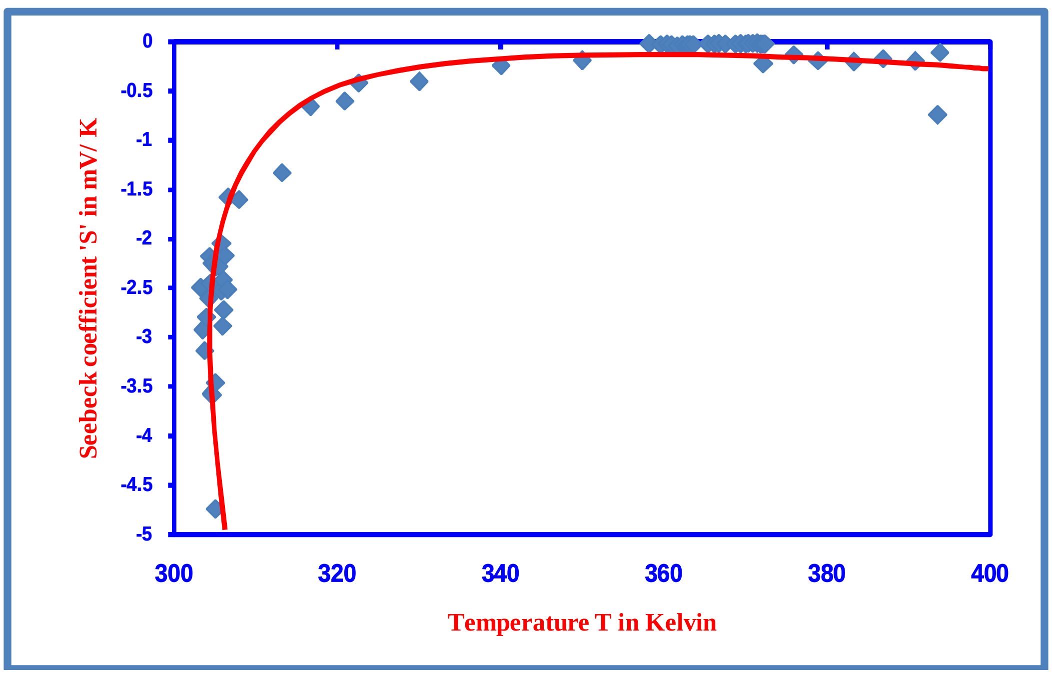

Fig. 1: Plot of Seebeck coefficient (S) versus Temperature (T)

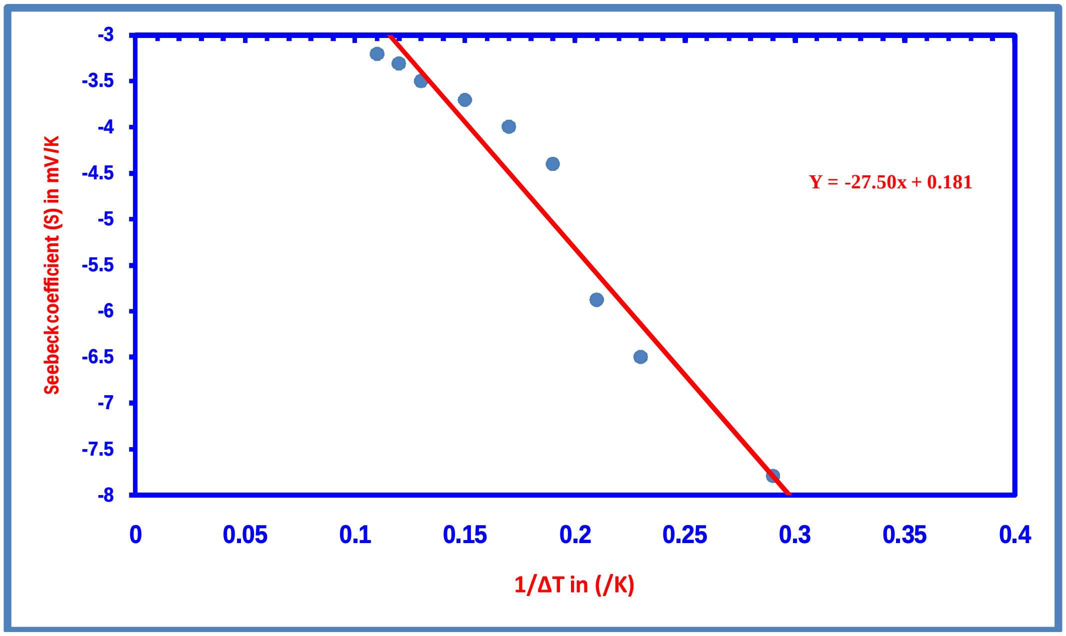

Fig. 2: Plot of Seebeck coefficient 'S' versus Reciprocal of Temperature

CONCLUSIONS

In the present study, gel grown barium oxalate single crystal was characterized by Thermo electric power (TEP) measurement. From the above studies, following points are observed:

1. Calculated Fermi energy $E_F = 0.028$ eV
2. Calculated Scattering parameter $\alpha_S = 0.4$
3. It is concluded that the conduction of heat in the material may be due to lattice or phonon
4. And, can be associated with lattice or phonon scattering.

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