High pressure electrical resistivity study on nonlinear single crystal zinc thiourea sulphate (ZTS)

S. Ariponnammal*[1], S. Radhika[1], R. Selva Vennila[2], and N. Victor Jeya[2]

[1] Department of Physics, Gandhigram Rural Institute, Deemed University, Gandhigram – 624 302, Dindigul District, Tamil Nadu, India
[2] Department of Physics, Anna University, Chennai – 600 025, India

Received 10 June 2004, accepted 1 September 2004
Published online 15 June 2005

Key words ZTS, electrical resistivity, EDXRD.
PACS 66.10.-Bh

The Tris Zinc Thiourea Sulphate (ZTS) crystals have been crystallized by slow evaporation technique. The lattice parameters of the grown crystals have been determined by the Energy dispersive x-ray diffraction technique (EDXRD) and the structure has been confirmed. And, the high pressure electrical resistivity study have been carried out on this crystal and the results have been reported here.

1 Introduction

Nonlinear optics plays an important role in the emerging photonic and optoelectronic technologies. Nonlinear optical (NLO) materials find wide applications in the area of laser technology, optical communication and the data storage technology (1,2). The search for new conversion materials over the past decade has led to the discovery of many organic NLO materials with high nonlinear susceptibilities. However, their often inadequate transparency, poor optical quality and lack of robustness, low laser damage threshold and inability to grow to large size have impeded the use of single crystal organic materials in practical device applications. Hence, recent search is concentrated on semiorganic materials due to their large nonlinearity, high resistance to laser induced damage, low angular sensitivity and good mechanical hardness [3]. Some of the notable semiorganic materials are Zinc thiourea sulphate (ZTS), Zinc thiourea chloride (ZTC), Cadmium thiourea chloride (BTCC) and copper thiourea chloride (CTC). The single crystals of these materials have very high laser damage threshold [3]. Motivated by these considerations, the Zinc thiourea sulphate (ZTS) has been crystallized for the present study. The high pressure electrical resistivity study has been carried out and the results are presented in this paper.

2 EDXRD

The single crystal of ZTS have been grown by slow evaporation technique. And, they were analysed by Energy dispersive x-ray diffraction technique using the radiation produced by Rigagu rotating anode x-ray generator. The collected EDXRD pattern is shown in fig. 1. The peaks were indexed by XRD analysis software and presented in table. 1. The crystal was found to be crystallized in orthorhombic structure with lattice parameters $a = 11.1947 \pm 0.0658$ Å, $b = 7.8170 \pm 0.0975$ Å and $c = 15.4433 \pm 0.0000$ Å, $\alpha=\beta=\gamma= 90^0$ and the cell volume $V = 1351.433$ Å^3.

3 High pressure electrical resistivity study

Measurements of high pressure electrical resistivity (ρ) study were carried out in Bridgmann opposed anvil device by using the four probe method. The anvils made of EN 24 (AISI 4340) alloy steel (Composition : C – 0.40%, Mn – 0.6%, Ni – 1.55%, Mo – 0.3%, Cr – 1.1 % and balance % Fe hardened to RC 60) with working

* Corresponding author: e-mail: ariponnammal@yahoo.co.in

face of 10 mm dia were used. Pyrophllite and steatite was served as the material for gasket and pressure medium respectively [4]. A hydraulic press was used to apply the force. The variation of log of resistivity (ρ in Ω - metre) as a function of pressure is shown in fig. 2

Table 1 EDXRD Analysis data of zinc thiourea sulphate.

S.No	Observed Energy [E_{obs}] in Kev	d in (Å)	h k l
1	12.151 ± 0.070	3.4993	022
2	12.673 ± 0.043	3.3552	310
3.	13.229 ± 0.034	3.2142	220
4	14.421 ± 0.017	2.9486	214
5	15.014 ± 0.048	2.8320	313
6	17.392 ± 0.016	2.4448	016
7	20.560 ± 0.042	2.0681	332
8	21.080 ± 0.094	2.0171	234
9	22.668 ± 0.013	1.8758	235
10	26.562 ± 0.017	1.6008	440
11	29.438 ± 0.036	1.4444	350
12	30.462 ± 0.104	1.3958	055
13	32.867 ± 0.036	1.2937	707
14	34.086 ± 0.093	1.2474	553
15	36.715 ± 0.033	1.1581	737
16	40.361 ± 0.036	1.0535	10 0 5
17	46.783 ± 0.281	0.9089	577

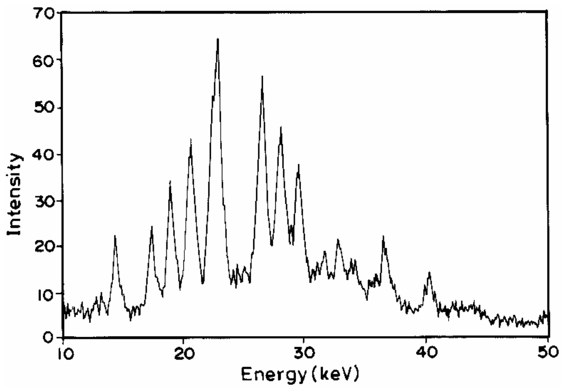

Fig. 1 EDXRD Pattern of Zinc thiourea sulphate.

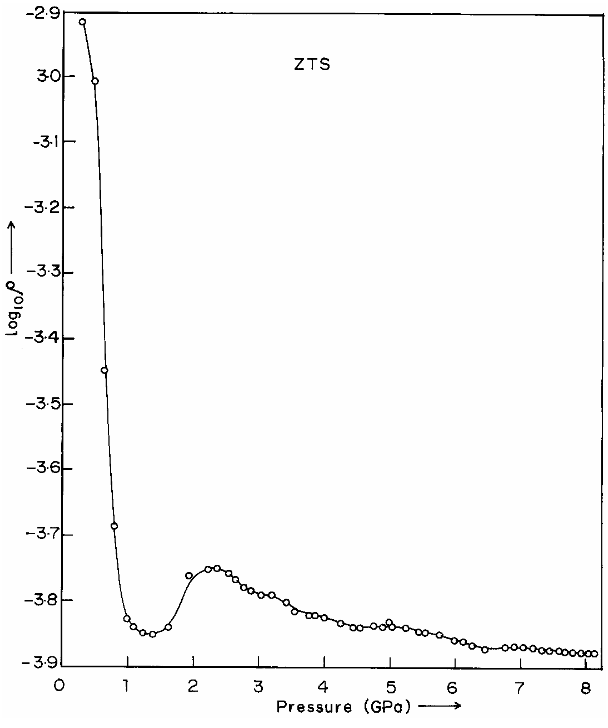

Fig. 2 The log of electrical resistivity versus pressure.

4 Results and discussion

The high pressure electrical resistivity study (fig. 2) on the crystal gives the hints for possible phase transitions. Initially, the electrical resistivity is found to be decreased sharply with increase of pressure. Then, at a particular pressure, there is a rapid increase in resistance after which the resistance again drops with the increase of pressure. This is similar to the behaviour observed in SnTe [5,6] in which the increase of resistivity at 1.8 GPa corresponds to a first order structural transformation. It is also notable that SnTe is also having the same orthorhombic structure Therefore, the observed discontinuous rise in the resistivity of this crystal ZTS at about 1.5 GPa may be due to the pressure induced phase transition. The smooth drop beyond the maximum represents the effect of pressure on the resistivity of the high pressure phase. The nature of phase transition may be confirmed by the high pressure x-ray powder diffraction studies.

5 Conclusions

The ZTS single crystal has been crystallized in orthorhombic structure. The electrical resistivity first decreases sharply, then increases and then again slowly drops. This increase of resistivity may be due to the pressure induced phase transition whose nature may be confirmed by the high pressure x-ray diffraction studies.

References

[1] P. A. Angeli Mary and S. Dhanushkodi, Cryst. Res. Technol. **36**, 1231 (2001).
[2] R. Rajasekaran, R. Mohan Kumar, R. Jayavel, and P. Ramasamy, J. Cryst. Growth **311**, 270 (2002).
[3] R. Rajasekaran, P. M. Ushasree, R. Jayavel, and P. Ramasamy, J. Cryst. Growth **229**, 563 (2001).
[4] N. Victor Jaya, Ph.D. thesis, Anna University, Madras (1988).
[5] J. A. Kafalas and A. N. Marians, Science **143**, 952 (1963).
[6] S. Ariponnammal, C. Venkateswaran, and S. Natarajan, phys. stat. sol. b **197**, K1 (1996).