Dielectric and Electrical Properties of the $SnSe_{1-x}Fe_x$(x=0.1)

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Abstract *:* Fe doped SnSe pellets have been prepared using ball milling and pressing method at room temperature. Dielectric as well as Electrical Parameters (i.e I-V & Hall Effects) have been characterised by the $SnSe_{1-x}Fe_x$ (x = 0.1) pallets. Using precession LCR meter of the range of 20 Hz to 20 MHz, we have carried out dielectric characterization of the Pallets. In this paper the dielectric properties (Dielectric constant, dielectric loss, loss tangent) and electrical properties (Hall Effect and I-V characteristic) were explored and results are discussed.

IndexTerms **- LCR meter, Complex relative dielectric function, I-V characteristic, Hall Measurement**

I. Introduction

The Group IV-VI layer-structured semiconductors SnSe have been increasingly studied for about last two decades, for their importance as holographic recording, switching, photo conducting and photovoltaic materials[1-5]. SnSe in bulk crystalline and thin film form has been used as memory switching devices, holographic recording systems, and infrared electronics devices[6-7]. In the semiconductor devices, the devise performance such as power consumption speed and size were improved due to the improvement in the dielectric material characteristic. Also semiconductor chips can integrate high capacitance capacitors inside the chip to save the circuit from using external decoupling capacitors between the power and the ground planes. Study of AC properties of SnSe was reported by Samsudi Sakrani et al[8]. In this paper the study the electrical properties of Fe doped in P-SnSe semiconductor. In this paper we also reported real part of permittivity and tan δ loss in the frequency range of 20 Hz to 2 MHz. Influence of doping of Fe on the dielectric and electrical behaviour of P-SnSe semiconductorare discussed in detail

II. Experimental procedure :

The elemental materials Tin(Sn), Selenium(se) of 99.99 %(4N) purity, were used for the preparation of the alloy with a stoichiometric proportion and sealed in a quartz ampoule of 25 cm in length and 1 cm in diameter under the vacuum of the order of 10^{-5} Torr.

This ampoule having mixtures of above was placed in a horizontal alloy mixing furnace at a temperature of about 950 ^{0}C for 48 hours, during which it was continuously rocked and rotated for proper mixing and reaction. The ingot was then cooled to room temperature over a period of 24 hour. The Temperature gradient is 65 Deg c/cm and lowering rate 0.5 Cm/hr. The crystal of SnSe was grown by the Bridgeman method. 200 mesh powder was created out off grown crystal of SnSe and mixed with Fe powder. Uniform mixing for Fe:SnSe powder by using ball milling methods. This prepared mixture is compressed using hydraulic press to form a solid pallet of 1 cm dia.

Fig 1 : Fe:SnSe Pellets Physical view

III. Result and Discussion

The pellets have been used for the study of dielectric and electrical characterizations. The results are shown bellow

3.1 Hall Effect Measurement

Hall effect measurement was performed using Van Der Pauw geometry by Hall Effect measurement (HMS-3000, Ecopia corp.)

Table 1 : Electrical Properties Measured by Hall Effect

Sr. No	Properties	Room Temperature	Liq. N2 Temperature
1	Bulk Concentration (Cm^{-3})	$4.6 \times 10^{+17}$	7.26×10^{7}
2	Mobility (Cm^2/Vs)	1.15	8.88×10^{2}
3	Resistivity (ΩCm)	$1.18 \times 10^{+1}$	9.68×10^{7}
4	Hall Coefficient	$1.35 \times 10^{+1}$	8.6×10^{10}
5	Conductivity $(\Omega Cm)^{-1}$	8.47×10^{-2}	1.03×10^{-8}

Hall Effect measurement was performed at room temperature and Liquid Nitrogen temperatures. Hall Co-efficient was found to be positive, suggesting the hole induced transport [9]. This indicate that the Fe:Snse pellets still prove the P type semiconducting behaviours. Temperature dependence on carrier concentration, conductivity and mobility are shown in **Table 1** for Fe:SnSe Pellet. This indicates that a lattice scattering is dominant at higher temperatures. As the Pellets is cooled to Liquid Nitrogen Temperature , the lattice vibration is frozen such that impurity scattering is the main mechanism for the scattering process [10].

3.2 I-V characteristic

I-V characterising of the Fe: SnSe pellets have been measured at two different temperatures. Figure 2 shows the IV behaviour of Fe:SnSe pellets at Room temperature. At Liquid nitrogen Temperature we observed that resistance of the pellets increasing drastically and pallets behaves like almost an insulator.

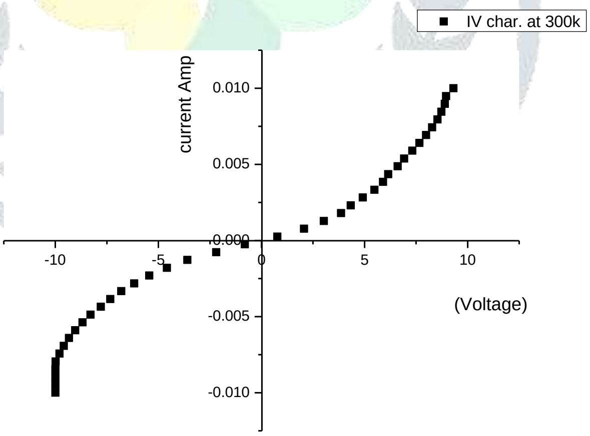

Fig 2 : IV Characteristic of Fe:SnSe Pellets

3.3 Dielectric Characterization

The dielectric measurement of Fe:SnSe samples were measured in the frequency range of 20 Hz to 2 MHz using an Agilent E 4980A precision LCR meter with solid dielectric test fixture (Agilent 164516). Using measured dielectric data, the dielectric properties were carried out and the dielectric parameters obtained at room temperature. Thus, the influence of temperature in results can be neglected [11].

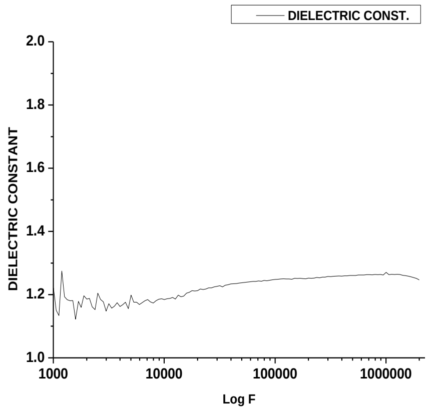

Figure 3 : Dielectric constant vs Log f

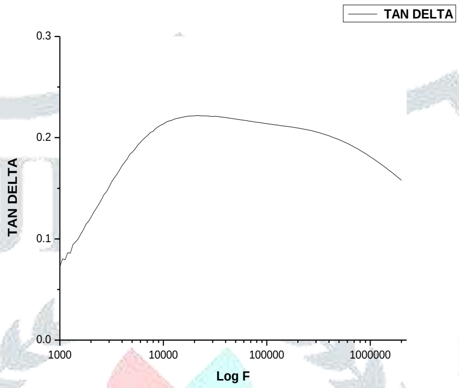

Fig 4 : Ten Delta Vs Log f

Figure 3 explained that dielectric constant is increasing with increase in frequency. This kind of dielectric behaviour was expected due to less space charge polarization which contributed to a.c conduction. The dielectric constant of Fe:SnSe pallets is vary in the range of 1.1 to 1.3 with respect to frequency from 20 to 20 MHz, which is very low value comparable to those of bulk SnSe, 13.38 [12,13]. This changes presence due to the dopant of Fe. Effective tan δ value increases with increasing in frequency and is similar to the frequency behaviour of an ideal dielectric material proposed by Debye. This kind of behaviour of dielectric constant and tan δ proves that polarization is not produce dominant effect on our sample. The interface which play important role for dielectric polarization, space-charge polarization and rotation direction polarization appear in the low frequency range is very small and will proves that defect in our prepare sample is less [14].

IV. Conclusion

The Positive hall coefficient proves the p type behaviour of Fe:SnSe pellets. Resistivity of Pallet increases drastically with decrease in Temperature. Dialectical characterization indicates that due to Fe doping the dielectric constant of Fe:SnSe pellets is in the range of 1.1 to 1.4 for the entire frequency band of 20-20 Mhz. Tan δ is increase Up to 10 khz and then decrease at high frequency.

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