Dielectric Properties of L-Glycine Formate Single Crystal

S.Suresh and P.Mani

Abstract— Single crystal of L-Glycine Formate (LGF) was grown by slow evaporation method. Dielectric constant and dielectric loss have been obtained as a function of frequency between 50 Hz -5 MHz and temperature range between 35ºC-75ºC. The dependence of tan δ, ε ″ and σ_{ac} on temperature and frequency of the applied field (50 Hz–5 MHz) is established D.C. conductivity has been deduced from the A.C. conductivity data and activation energy is calculated.

Key words: Single crystal, dielectric loss, dielectric constant, AC and DC conductivity.

1 INTRODUCTION

The fast development in the field of optoelectronics has stimulated the search for novel non linear optical crystals for efficient signal processing, optical storage, optical communication, photonics, electro-optic modulation, optical parametric amplifiers, optical image processing etc., New non linear optical frequency conversion materials can have a significant impact on laser technology, optical communication etc., A molecular crystal suitable for use in a number of optically non linear devices required atleast four basic qualities, such as high molecular first order polarizabiity suitable crystallographic structure, sufficient crystal quality and high optical damage threshold [1,2]. The search for suitable materials displaying excellent second- order nonlinear optical (SONLO) properties is the focus of much current research activity due to their potential applications in optoelectronics, telecommunication and optical storage devices. Materials with large second-order optical nonlinearities, short transparency cut-off wavelengths and stable physicochemical performances are needed in order to realize many of these applications [3]. From Single crystal X-ray diffraction studies were carried out. The L-glycine formate crystal held its monoclinic structure with lattice parameters a = 5.07 Å, b = 11.93 Å, c = 5.42 Å, V = 945 Å^3, β= 110.64°.

2. Experimental

Single crystal of L-glycine formate was grown by slow evaporation technique of an equimolar solution of glycine and formic acid are taken and dissolved in double distilled water and stirred well for about six hours. Then it was filtered and allowed to crystallize by slow evaporation method. Within 20 days, crystals with good transparency were obtained. Figure 1 shows the photograph of the LGF single crystal.

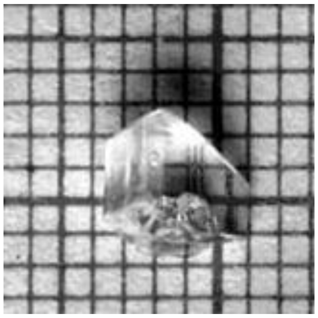

Fig.1.Photograph of as-grown LGF single crystal

3. Results and discussion

3.1 Dielectric Measurement

Dielectric properties are correlated with electro-optic property of the crystals: particularly when they are non conducting materials. [4]. Microelectronics industry needs low dielectric constant (ε_r) materials as an interlayer dielectric [5] LGF crystal was subjected to dielectric studies using a HIOKI model 3532-50 LCR HITESTER with a conventional two terminal sample holder. The sample was electroded on either side with air-dying silver paste so that it behaves like parallel capacitor. The studies were carried from 35ºC-75ºC for frequency varying from 50 Hz to 5 MHz. Figure 2 shows the variations of dielectric constant with log frequency. The dielectric constant is calculated using the formula

$$\varepsilon' = \frac{Ct}{\varepsilon_0 A} \quad (1)$$

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Where C is capacitance (F), t is the thickness (m), A the area of sample, ε_o is the absolute permittivity in the free space having a value of 8.854×10^{-12} Fm^{-1}. Fig. 2 shows the variation of dielectric constant of LGF crystal as a function of frequency at different temperatures. It is seen from the plot that the sample has high dielectric constant in the low frequency region. The very high value of dielectric constant at lower frequencies may be due to the space charge polarization. From Fig.3, it is observed that the dielectric loss decreases with increase in frequency at different temperatures.

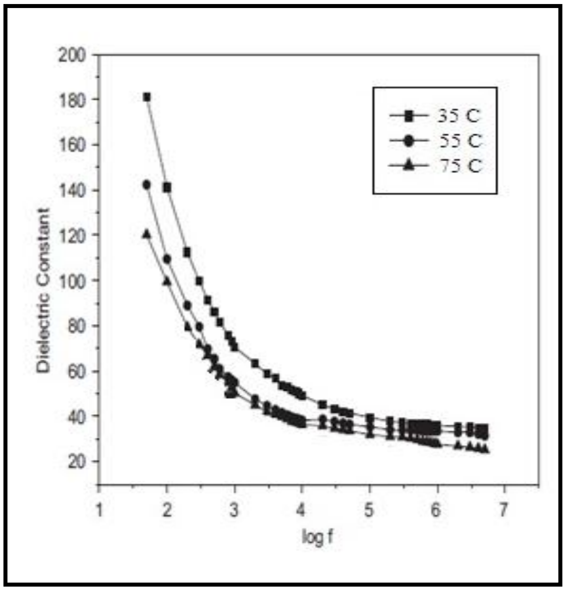

Fig.2. Dielectric constant with log frequency

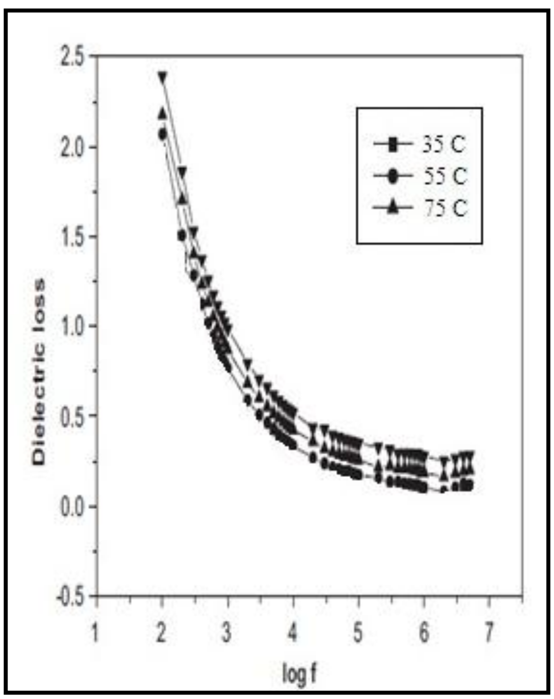

Fig. 3. Dielectric loss with log frequency

3.2 AC conductivity study

The AC conductivity study of the LGF crystal was carried out at 1 kHz. In the high temperature (intrinsic) region, the effect of impurity on electrical conduction has not made any appreciable change whereas in the low temperature (extrinsic) region, the presence of impurity in the crystal has an impact and particularly increases its conductivity. The electrical conduction in dielectrics is mainly a defect controlled process in the low temperature region. The presence of impurities and vacancies predominantly determine this region. The energy needed to form the defect is much larger than the energy needed for its drift. It is found from the Arrhenius plots (Figs. 4 and 5) for the LGF crystal that the conductivity increases with temperature. Accordingly, the value of activation energy is estimated from the slope of the plot and its value is found to be 0.070 eV.

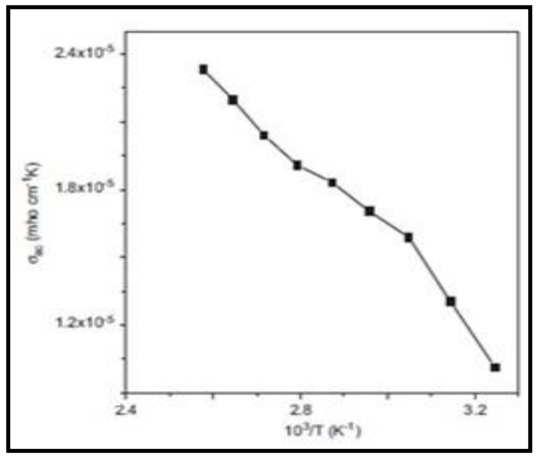

Fig.4.Variation of AC conductivity with 1000/T

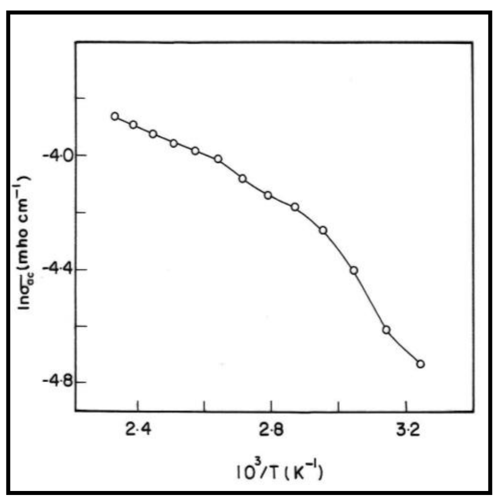

Fig.5. Plot of ln (σ_{ac}) T versus 1000/T

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3.3 DC conductivity study

The DC conductivity of LGF crystal was carried out. The experiment was carried out using the conventional two-probe technique at different temperature ranging from 35ºC-75ºC. Well-sized crystal of LGF was used for conductivity study. The crystal was perfectly cut in to rectangular slaps and then polished using silicon carbide paper. The DC electrical conductivity (σ_{dc}) of the crystal was calculated using the relation $\sigma_{dc}T = d / RA$, where R is the measured resistance, d is the thickness of the sample and A is the area of face in contact with the electrode. The sdc values were fitted into the equation $\sigma_{dc}T = \sigma_0 \exp(-E / KT)$. The conductivities of LGF are shown in Figs. 6 and 7. Fig. 6 represents the temperature dependence of conductivity of the sample is found to increase with increase in temperature for LGF crystal. Electrical conductivity depends on thermal treatment of crystal. Thus the conductivity at low temperatures depends on the cooling speed from melting point temperature to room temperature. Thus, for slow cooing there making of the lattice can occur by the migration of interstitials to vacancies, recombination of Schottky defects or migration of vacancies to the surface or along dislocation channels. On quenching or rapid cooling, a fraction of the vacancies freeze and the pre-exponential term includes a contribution from those frozen vacancies [6]. The DC activation energy of the LGF crystal is found to be 0.055 eV.

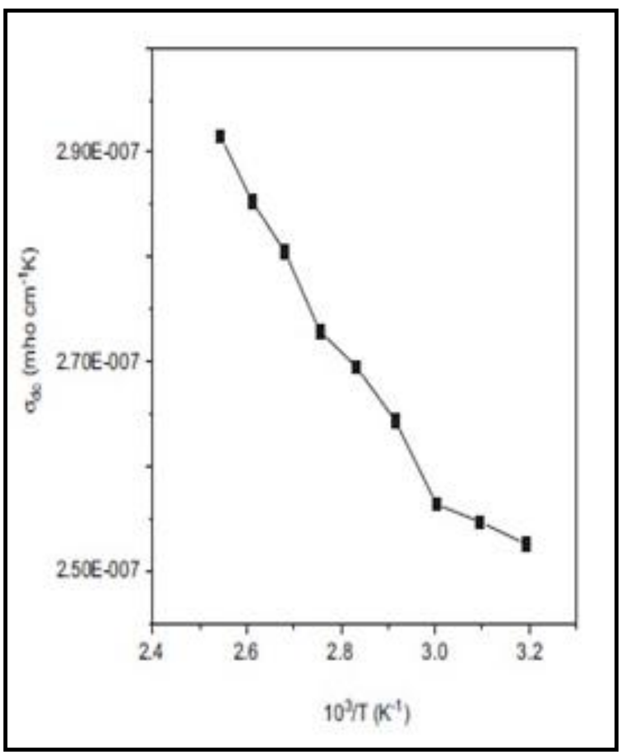

Fig.6.Variation of DC conductivity with 1000/T

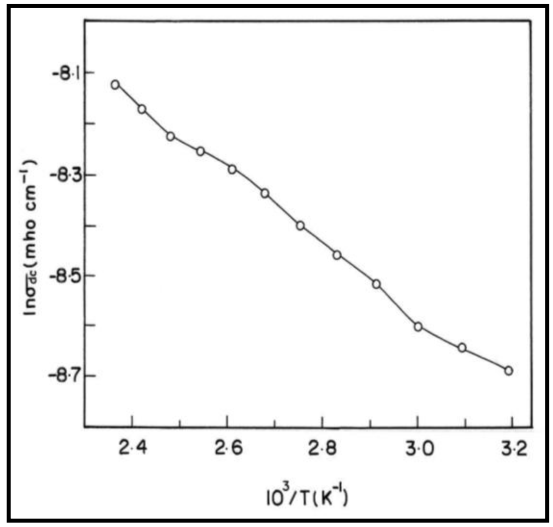

Fig. 7. Plot of ln (σ_{dc}) T versus 1000/T

3.4 Photoconductivity Studies

Field dependence of dark and photocurrent of LGF are shown in Figure 8. The photocurrent is found to be less than the dark current at every applied electric field. This phenomenon is known as negative photoconductivity. It is interesting to note that LGF crystals exhibit negative photoconductivity nature.

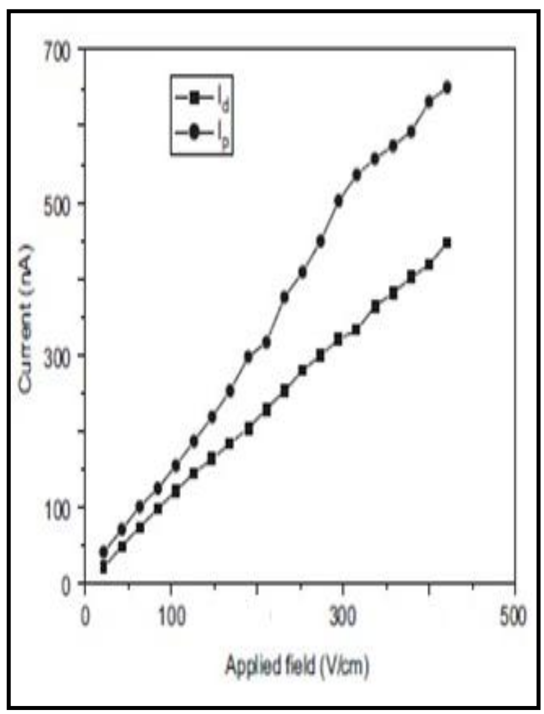

Fig. 8. Field dependent photoconductivity of LGF single crystal

4 CONCLUSION

The dielectric constants (ε′ and ε′′), dielectric loss (tan δ) and conductivity (σ_{ac}) of LGF crystals are strongly dependent on temperature and frequency of the applied ac field, the variation depends on the ranges of temperature and frequency. The dielectric constant and dielectric loss decreases with increasing frequency and higher values of dielectric constant occurs at higher temperature. The rate of variation of imaginary dielectric constant (ε") with temperature is strongly dependent on temperature and frequency of the applied field. The activation energy is determined from the plots for AC/DC conductivity. It is concluded from the photoconductivity studies that LGF has negative photoconducting nature**.** From all those analysis, it can be concluded that L-glycine formate is not only a potential Non linear Optical material but also a promising low εr value dielectric material, expected to be useful in the microelectronics industry. The encouraging dielectric properties of the crystal indicate the suitability of this crystal for photonics device fabrication.

REFERENCES

[1] J. Zyss, D.S. Chemla and J.F. Nicoud, J.Chem.Phys.8,4800(1981).

[2] C. Razetti, M.Ardino, L. Zanotti, M.Zha and C. Paorici, Cryzt. Res. Tech., 37,456(2002)

[3] X.Q. Wang, D. Xu, M.K. Lu, D.T. Yuan, J. Huang, S.G. Li, G.W. Lu, H.Q. Sun, S.Y. Guo, G.H. Zhang, X.L. Duan, H.Y. Liu, W.L. Liu, J. Cryst. Growth 247 (2003) 432.

[4] S,Boomadevi, H.P.Mittal, R.Dhanasekaran, J.Cryst. Growth 261 (2004) 55

[5] B.T.Hatton, K.Landskron, W.J.Hunks, M.R.Bernett, D.Shukaris, D.D.Perovic, G.A.Ozinna, Mater.Today 9 (2006)22

[6] I. Bunget, M. Popescu, in: Physics of Solid Dielectrics, Elsevier, New York, 1984.