International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.5, pp 2645-2648, Aug-Sept 2014

Investigations on Electrical Properties of Glycine Magnesium Chloride Single Crystal

Suresh Sagadevan*

***Department of Physics, Sree Sastha Institute of Engineering and Technology, Chembarambakkam, Chennai, 600123, India.**

***Corres. author: sureshsagadevan@gmail.com**

Abstract: The field of nonlinear optics became practically a reality after the invention of laser. High performance electro-optic switching elements for telecommunications and optical information processing are based on materials with high nonlinear optical (NLO) properties. The development and encroachment of high technology, from transportation, computation to information is based on the availability of materials in the form of single crystals. Single crystal of Glycine Magnesium Chloride (GMC) was grown by slow evaporation method. The crystal structure and lattice parameters are determined for the grown crystal by single X-ray diffraction studies. One of the most important parameters widely used is the relative dielectric constant or relative permittivity. The study of dielectric constant of a material gives an insight into the nature of bonding in the material. The dielectric constant is defined as the ratio of the field strength in vacuum to that in the material for the same distribution of charge. The dielectric constant of a substance is a property of the constituent ions. Dielectric constant and dielectric loss have been obtained as a function of frequency between 50 Hz -5 MHz and different temperatures. Photoconductivity is an important property of solids by means of which the bulk conductivity of the sample changes due to incident radiation. Photoconduction includes the generation and recombination of charge carriers and their transport to the electrodes. Obviously, the thermal and hot carrier relaxation process, charge carrier statistics, effects of electrodes, and several mechanisms of recombination are involved in photoconduction. Photoconductivity study reveals negative photoconductive nature of the crystal.
Key words: Single crystal, dielectric loss, dielectric constant, DC conductivity and Photoconductivity studies.

1. Introduction

The nonlinear optical (NLO) materials play a major role in nonlinear optics and in particular they have a great impact on information technology and industrial applications. In the last decade, however, this effort has also brought its fruits in applied aspects of nonlinear optics. This can be essentially traced to the improvement of the performances of the NLO materials. There has been a growing interest in crystal growth process, particularly, in view of the increasing demand for materials for technological applications [1-3]. The wide range of applicability of single crystals is evident in the fields of semiconductors, polarizers, infrared detectors, solid state lasers, nonlinear optic, piezoelectric, acousto-optic, photosensitive materials and crystalline thin films for microelectronics and computer industries. The growth of single crystals and their characterization towards device fabrication have assumed great impetus due to their significance in both academic research and applied research. The present investigation, deals with the growth of GMC single crystal by slow evaporation technique. The grown crystal has been subjected to XRD, dielectric, and photoconductivity studies. Dielectric properties are related with the electric field distribution within solid materials. This is a normal dielectric behaviour that both dielectric constant and dielectric loss decrease with increase in frequency. The results of these investigations are discussed.

2. Materials and Methods

Glycine Magnesium Chloride (GMC) was synthesized by the reaction between the glycine and magnesium chloride taken in equimolar proportions in aqua solution. Slow evaporation of the solvent at room temperature yielded many small crystals. Defect-free, optically clear, and perfectly shaped tiny crystals were chosen as seeds for the growth experiment. A good optical transparent crystal harvested in a growth period of four weeks is shown in Fig.1. Dielectric measurements for GMC single crystals were carried out using HIOKI 3532-50 LCR HITESTER. Carefully selected samples were cut using a diamond saw and polished using paraffin oil and fine grade alumina powder to obtain a good surface finish, and coated with conducting silver paste in order to increase the ohmic contact. Dielectric permittivity measurements were carried out with the sample placed inside a dielectric cell whose frequencies could be varied in a controlled manner for different frequencies and different temperatures, respectively. The crystal was perfectly cut in to rectangular slaps and then polished using silicon carbide paper. From the single crystal X-ray diffraction data, it was confirmed that the grown crystal belongs to hexagonal crystal system. The cell parameters are: a = 7.02 Å, b = 7.03 Å and c = 5.48 Å, $\alpha=\beta=90^\circ$, $\gamma=120^\circ$ and V=235.5 Å^3.These values agreed well with the reported values [4].

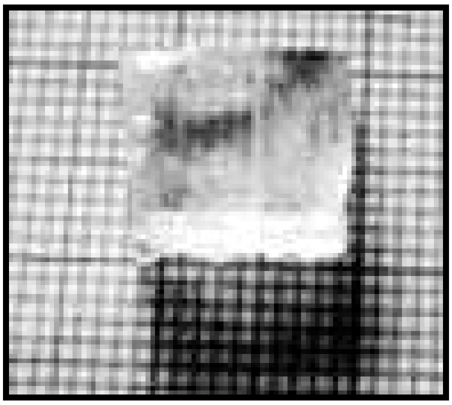

Fig.1. Photograph of as-grown GMC single crystal

3. Results and Discussion

3.1. Dielectric Properties

Dielectric properties are related with the electric field distribution within solid materials. One of the widely used parameters is the relative dielectric constant or relative permittivity and the dielectric constant of a material gives an insight into the nature of bonding. The dielectric properties are correlated with electro-optic property of the crystals particularly when they are non conducting materials [5]. Microelectronics industry needs low dielectric constant (ε_r) materials as an interlayer dielectric [6]. The dielectric studies were carried from 308-368K for frequency varying from 50 Hz to 5 MHz. Fig. 2 shows the variations of dielectric constant with log frequency. The dielectric constant is calculated using the formula

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

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 x 10^{-12} Fm^{-1}. Figs.2 & 3 show the dielectric constant (ε_r) and the dielectric loss of the doped crystal for different frequencies with various temperatures. From the figure, it is found that the values of dielectric constant and dielectric loss increase with the increase in temperature and decrease with the increase of frequency. This may be due to the contributions of all the four polarizations such as electronic, ionic, dipolar and space charge, which are predominant in the lower-frequency region. Fig. 2 shows the variation of dielectric constant of GMC 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.

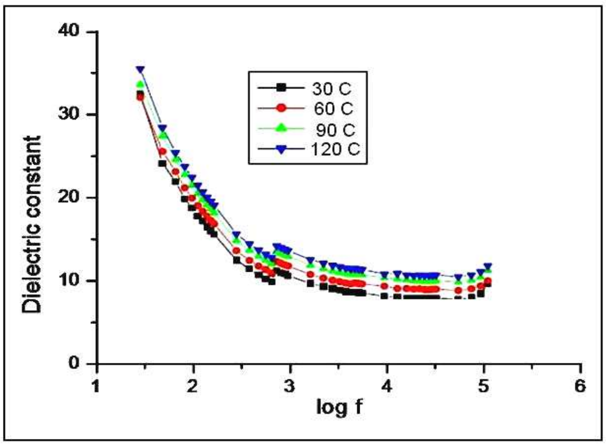

Fig.2. Dielectric constant with log frequency

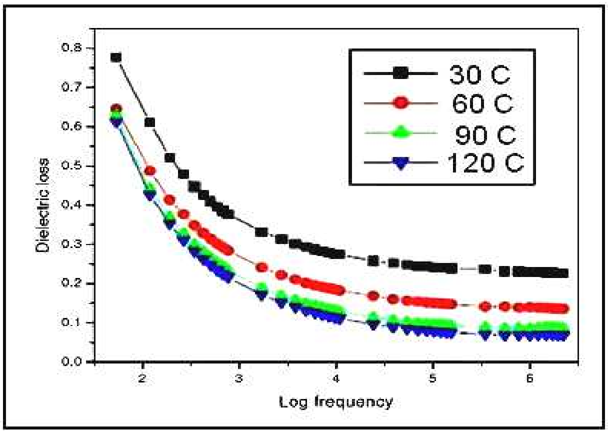

Fig.3. Dielectric loss with log frequency

3.2 Photoconductivity Studies

Photoconductivity measurements were carried out on a cut and polished sample of the grown single crystal by fixing it onto a microscope slide. The sample was connected in series with a DC power supply and KEITHLEY 485 Picoammeter. The sample was then exposed to light radiation and the photocurrent was recorded for the same values of the applied voltage. The field dependence of dark and photocurrent of GMC are shown in Fig.4. It is observed that both the dark and photo currents increase linearly with the applied electric field, but the photocurrent is less compared to the dark current which is termed as negative photoconductivity. The negative photoconductivity exhibited by the sample may be due to the reduction of the number of charge carriers in the presence of radiation [8]. In the Stockmann model, a two level scheme is proposed to explain negative photoconductivity [9]. As a result, the recombination of electrons and holes takes place resulting in decrease in the number of mobile charge carriers, giving rise to negative photoconductivity.

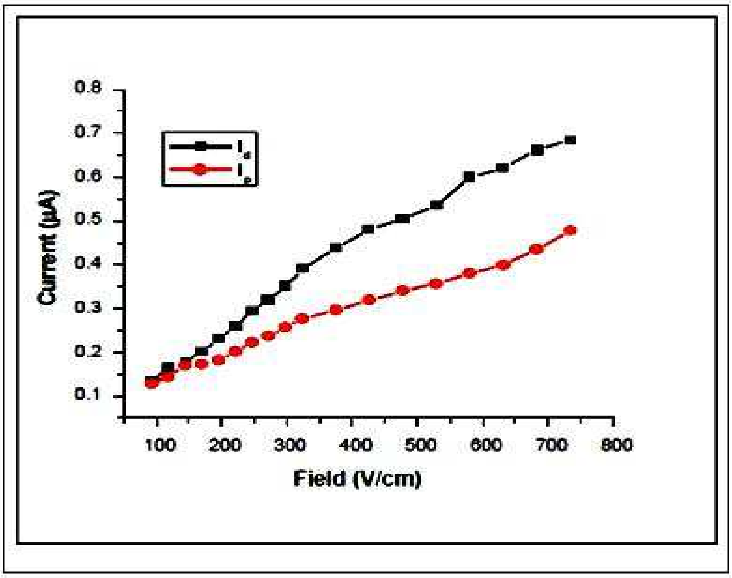

Fig.4 Field dependent photoconductivity of GMC

4 Conclusion

Glycine Magnesium Chloride (GMC) single crystal was grown by slow evaporation technique. From the single crystal XRD data obtained, it is proved that the crystals belong to hexagonal crystal system. The dielectric constant and dielectric loss of GMC 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 low dielectric constant and dielectric loss of the crystal in the high frequency region implies good optical quality. It is concluded from the photoconductivity studies that GMC has negative photoconducting nature**.** From all those analysis, it can be concluded that GMC is not only a potential nonlinear optical material but also a promising low dielectric constant value dielectric material, expected to be useful in the micro electronics industry. The encouraging dielectric properties of the crystal indicate the suitability of this crystal for photonics device fabrication.

References

1. R.A.Laudise, R.Ueda and J.B.Millin, Crystal Growth and Characterization, North-Holland Publishing Co, (1975).
2. J.C. Brice, ‘Crystal Growth Processes’, Halsted Press, John Wiley and sons, New York, (1986).
3. H.S.Nalwa and S.Miyata S, ‘Nonlinear Optics of Organic Molecules and Polymers’, CRC Press Inc., New York, (1996).
4. T. Thaila and S. Kumararaman, Archives of Applied Science Research, 4 (3), 1494-1501(2012).
5. S,Boomadevi, H.P.Mittal, R.Dhanasekaran, J.Cryst. Growth 261, 55(2004).
6. B.T.Hatton, K.Landskron, W.J.Hunks, M.R.Bernett, D.Shukaris, D.D.Perovic, G.A.Ozinna, Mater. Today 9 (2006)22.
7. I. Bunget, M. Popescu, in: Physics of Solid Dielectrics, Elsevier, New York, 1984.
8. R.H. Bube, Photoconductivity of Solids, Wiley Interscience, New York, 1981.
9. Joshi, V.N., Photoconductivity, Marcel Dekker, New York, 1990.

*****