Research Journal of Physical Sciences ISSN 2320–4796
Vol. 2(**1**), 1-4, April (**2014**) *Res. J. Physical Sci.*

Microhardness, Dielectric and Photoconductivity studies of 2- Amino 5- Nitro Pyridinium Nitrate NLO Single crystals.

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Available online at: www.isca.in
Received 10th January 2014, revised 4th February 2014, accepted 27th March 2014

Abstract

A second order non linear semi organic optical crystal 2- amino 5- nitro pyridinium nitrate (2A5NPN) was grown by slow evaporation technique and characterized by micohardness, dielectric and photoconductivity studies. Hardness values were measured using Vickers hardness tester. The study of dielectric measurement was done by HIOKI HITESTER instrument. The photoconductivity of grown crystal was elucidated by using KEITHLEY 485 picometer.

Keywords: Microhardness, dielectric, photoconductivity, pyridinium, single crystals.

Introduction

Second Order Non Linear Optics (SONLO) has attracted much attention in recent days owing to their potential applications in emerging opto electronic technologies[1,2]. According to the roadmap of opto-electronics industry, the growing demand in the field of data communication requires that optical fiber network operates at the rate of tetra byte per second by the year 2013. A world wide effort is under way to achieve that goal, so as to enable very high speed technology, optical communication, optical computing, optical information processing, optical disc data storing, laser fusion reaction, laser remote sensing, colour display and medical diagnosis[3,4]. Though organic Non Linear Optical (NLO) crystals have good non linearity efficiency, fast response and good flexibility, their applications are restricted by their poor chemical stability, poor phase matching and red shift of the cut off wavelength possessed by larger organic π- conjugated system. The merits are limited and their shortcomings may over come, when the choice switches over to semi organic complex crystals. Therefore, 2-Amino 5- Nitro Pyridinium Nitrate (2A5NPN) is one such material suitable for non linear optics (NLO) applications. It belongs to a class of semi organic crystals. 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) has high Second Harmonic Generation (SHG) efficiency and its wide spread application is largely limited by the difficulty in obtaining high optical quality crystals of bulk size[5-8]. In our earlier work we have reported the synthesis, crystal growth of 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN)[9]. In this present work, we report microhardness, dielectric and photoconductivity nature of 2- amino 5- nitro prydinium nitrate (2A5NPN) non linear optical (NLO) crystal for the possible usage in photonics device fabrication.

Methodology

Microhardness measurements: Microhardness method is widely used for studying individual structure constituent elements of metals, alloys, minerals, glasses, enamels and artificial abrasives. The hardness depends on not only properties of the materials under test, but also imposes on the condition of the measurement. The most popular and simplest test is Vickers micro hardness tester. The Vickers pyramid indenter whose opposite faces contains an angle (α) of 136^o is the most accepted Pyramid indenter. The face of the Vickers pyramid is the square under depth of the indentation when corresponds to 1/7 th of the indentation diagonal. Therefore hardness is defined as the ratio of the applied load to surface area of the indentation. The microhardness number H_v of the most popular diamond pyramid number (DPN) is defined as

$$H_v = 2P\sin(\alpha/2)/d^2 \quad (1)$$

where, P is the applied load in Kg. d is diagonal length of indentation mark in mm. H_v is the Vickers hardness number (VHN). Vickers hardness measurements were calculated for varying applied load in terms of gram from 5g- 25 g at an interval of 10 s. The experiment was conducted on well defined face (100) of 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) crystal. Vickers micro hardness (H_v) varies with the applied load (P) is shown in Figure-1. From the figure we can report that the micro hardness of the crystal decreases with increase in the applied load. The decrease of microhardnesss with increasing load is in good agreement with the normal indentation size effect (ISE). The work hardening co- efficient is calculated from the plot of log P against log d by least square method. 1.48 is the hardening co efficient (n) for the (100) plane. According to Onistch, $1.0 \leq n \leq 1.6$ for hard materials and n is greater than 1.6 for soft materials[10]. The work hardening coefficient was found to be 1.48. Hence it is concluded that 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) Non linear Optical (NLO) crystal is a hard material.

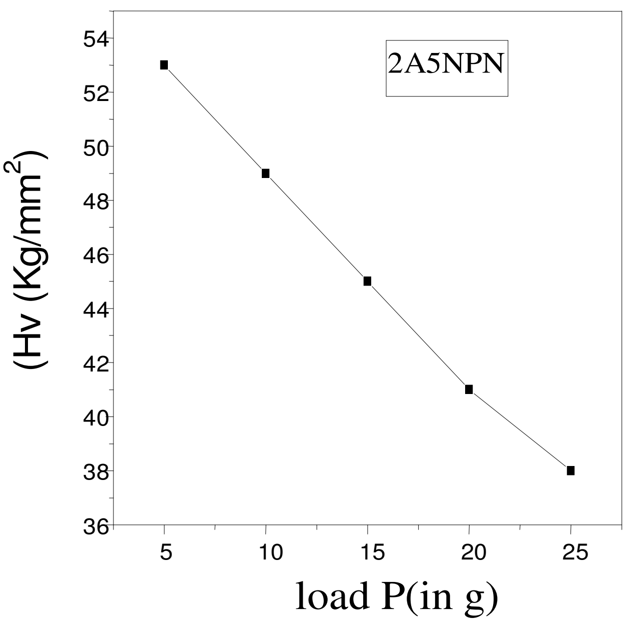

Figure-1(a)
Variation of H_v Vs load p

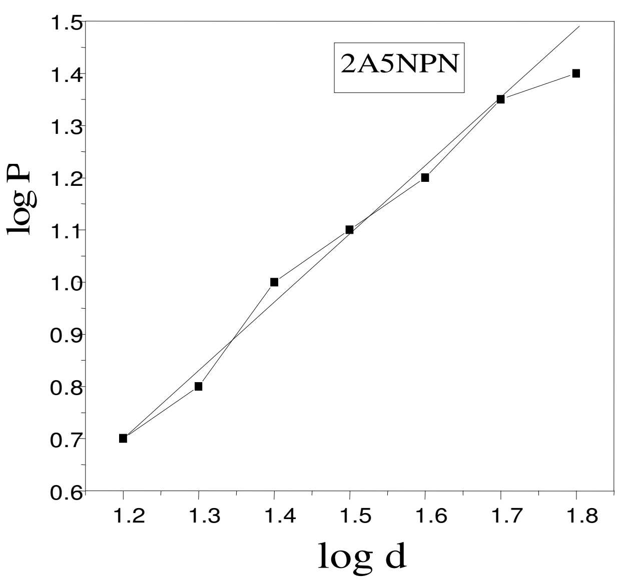

Figure-1(b)
Log d Vs log p

Dielectric studies: The electrical property of the dielectric substance is described in terms of dielectric constant. Lattice vibration, excitation of bond electron, dipole orientation and space charge polarization contributes dielectric constant ε_r at low frequency. At very low frequency all the four contributions may be active. The sample was mounted between the copper platform and parallel electrodes. In order to obtain good electric conduct between the crystal and the electrodes, the crystal faces are coated with silver paint. Proper care was taken that the silver paint does not spread to the sides of the crystal. The capacitance and the dissipation factor of the parallel plate capacitor were measured by the copper plate and electrodes having the sample. The dielectric measurement was measured using a HIOKI 3532-50 LCR HITESTER and conventional two terminal sample holders. The dielectric constant and dielectric loss were calculated using the equations (2) and (3) respectively.

$$\varepsilon = Cd/\varepsilon_o A \quad (2)$$
$$\varepsilon' = \varepsilon \tan(\delta) \quad (3)$$

Where, C is the capacitance of the parallel capacitor, d is the thickness of the sample. A is the area of the sample and tan (δ) is the loss tangent of the crystal. The observations are made in the frequency range 100 Hz to 100MHz at room temperature. It is observed that the dielectric constant ε_r of 2- amino 5- nitro prydinium nitrate (2A5NPN) crystal decreases with increase in frequency. At low frequency, the dielectric constant is very high due to the presence of space charge polarization. The space charge contribution depends on the purity and projection of the material influences and it is mainly obtain at low frequency region. Figure-2. shows the variation of dielectric constant with low frequency for 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) non linear optical crystal. It is noticed that the dielectric loss of 2A5NPN decrease with increase in frequency. The low value of dielectric loss suggests that the grown 2-Amino 5- Nitro Prydinium Nitrate (2A5NPN) non linear optical (NLO) crystals are in good quality. The dielectric loss at lower frequency due to larger values associated with ionic mobility[11]. The trend of dielectric constant and dielectric loss as a function of frequency depicts the good dielectric nature of the material. The curve suggested that the dielectric loss is strongly dependant on the frequency of the applied field, similar to that of dielectric constant. This behavior is common in the case of ionic system also[12-13].

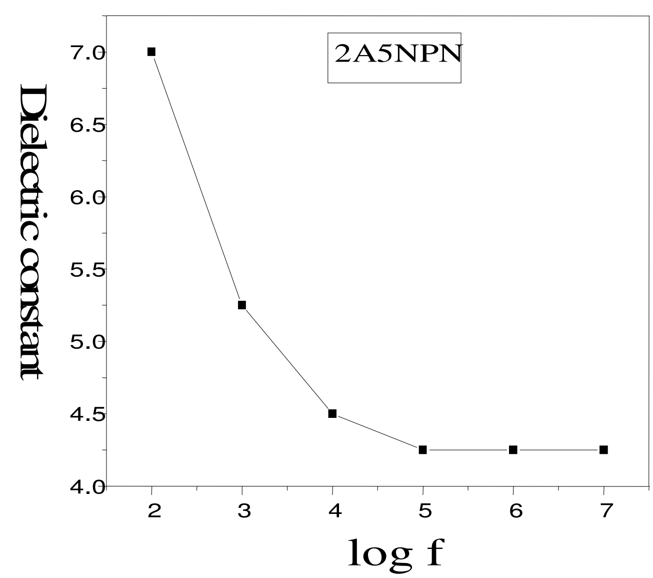

Figure-2(a)
Variation of Dielectric constant

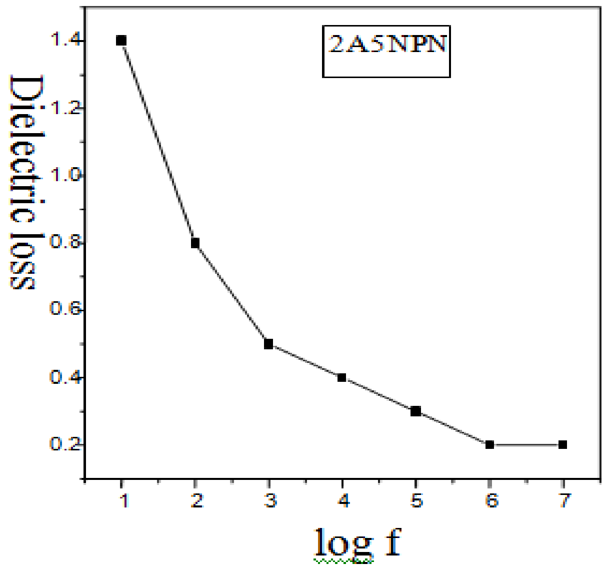

Figure-2(b)
Variation of Dielectric loss

Photoconductivity studies: Photo detection technology is becoming more and more important in military applications, particularly in guided weapons and communication through fiber optics. Infrared developments are based on solid state photonic devices. Further developments in these fields demand a good understanding of the basic principles of photoconductivity process. Photoconductivity is an important property of solids by means of which the bulk conductivity of the sample changes due to incident radiation. Photoconductivity is not an elementary process in solids. Photoconduction as the name suggests, includes the generation and recombination of charge carries and their transport to electrodes. Obviously, the thermal and hot carrier relaxation process, charge carrier statistics, effects of electrodes, and several mechanism of recombination are involved in photoconduction. Above all every mechanism is a complicated one, and therefore photoconductivity in general is a very complex process. In spite of the complexity of the photoconductivity process, it provides useful and valuable information about physical properties of materials and offer applications in photo detection and radiation measurement. Historically, the first photo conductivity effect was recorded in 1873 by W. Smith, who observed that the resistivity of selenium was decreased by the radiation falling on it. According to literature, this is very first experimental detection of photoconductivity. The Non Linear Optical crystal of 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) crystal was subjected to photoconductivity measurements by using KEITHLEY 485 picometer. Initially, the sample was kept away from any other radiation. The Dark current (Id) of the sample was calculated by connecting a DC power supply and picometer in series. Silver paint was coated on the sample to get electrical conducts. Radiation from a halogen lamp containing iodine vapour focused on the sample with the help of a convex lens to calculate photo current(I_p) of 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) non linear optical crystal. Initially the Dark current (I_d) was measured by varying voltage from 5 to100 v in steps of 20v. Fig 3 shows the variation of the dark current (I_d) and photo current (I_p) of the sample with applied field. It is evident from the figure that both the dark current (I_d) and photocurrent (I_p) increase linearly with the applied field. For the same applied field the photo current (I_p) is less than the dark current (I_d) which reveals that the negative photoconductivity behavior of the sample. This negative photoconductivity may be due to the reduction in number of charge carries in the presence of radiation[14-15]. The decreases in mobile charge carriers during negative photoconductivity were also explained by stockman model[16]. Though the material shows negative photoconductivity for visible radiation, the material is excited to create more charge carriers for intense beam laser.

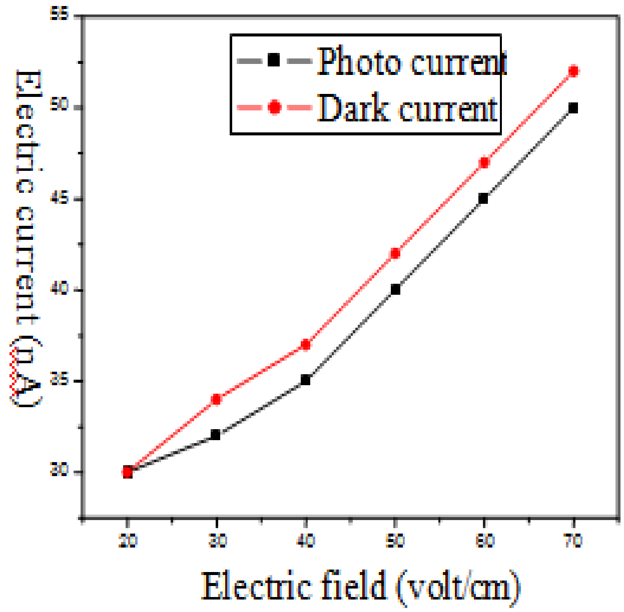

Figure-3
Photoconductivity studies of 2A5NPN crystal

Conclusion

In the present work single crystals of 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) were characterized by micro hardness, dielectric and photoconductivity studies. Micro hardness indicates that 2- Amino 5- Nitro Prydinium Nitrate (2A5NPN) non linear optical (NLO) crystal belongs to hard material. Photoconductivity study of 2- amino 5-nitro prydinium nitrate (2A5NPN) non linear optical (NLO) crystal confirms the negative conducting nature of the crystal. The dielectric study indicates that the 2- amino 5- nitro prydinium nitrate (2A5NPN) non linear optical (NLO) crystal posses good optical quality with less defects. Studies like NMR spectral analysis, laser damaged threshold and etching studies are in progress.

Acknowledgements

The authors would like to thank the Board of Research in Nuclear Sciences- Department of Atomic Energy (BRNS-DAE) (File no: 2012/34/63/BRNS/2865 dt: 01 March 2013) for funding this major research project.

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