Sciencia Acta Xaveriana
An International Science Journal
ISSN. 0976-1152

Volume 4
No. 1
pp. 81-86
March 2013

Linear and Nonlinear Optical Properties of2A5CB

S. Arulmozhi and J. Madhavan*

Department of Physics, Loyola College, Chennai – 34
*Corresponding Author: jmadhavang@yahoo.com

Abstract : Optical absorption of 2-Amino 5-Chloro Benzophenone (2A5CB) single crystal has been measured and its direct band gap was found. Theoretical calculations were carried out to determine the linear optical constants such as extinction coefficient and refractive index. Further the nonlinearity of 2A5CB has been investigated by Kurtz and powder technique. Thus optical characterization of 2A5CB reveals the various application oriented properties of the material.

Key Words : 2A5CB, 4near, Nonlinear optical, Kurtz powder Technique.

(Received January 2013, Accepted March 2013)

1. Introduction

For the past nearly three decades, optical materials with large third-order nonlinear susceptibilities and ultrafast response times have attracted extensive attention, owing to their applications in various photonic applications such as optical switching, high-speed information processing, optical image storage, optical display and etc [1-2]. In recent years, much attention has been paid to photonics in which light can be controlled by light as a stimulus as future technology. Light has a lot of properties such as intensity, polarization, and wavelength, and these properties are quite useful for information processing. In photonics, switching devices play an important role in the control of light, changing their own physical properties with the stimulus light. Among them, the design of viable all-optical switching devices for ultrafast high bandwidth optical communication and computing has been witnessed dramatic progress during the past years.

2. Linear Optical Properties of 2A5CB

The optical absorption spectrum of 2A5CB single crystal is shown in Figure 1. The spectrum indicates that 2A5CB crystal has minimum absorption in the region between 250–1200 nm. A good optical transmittance is very desirable in an NLO crystal since the absorptions, if any, in an NLO material near the fundamental of the second harmonic will lead to less conversion efficiency in those wavelengths. When absorption is monitored from shorter wavelength to longer wavelength, the enhanced transmission is observed between 390 and 1400 nm. As the entire region does not bear any absorption band it can be used for NLO applications. The absorption coefficient (α) of a crystalline solid obeys the following relationship [3]

$$(\alpha h\nu)\alpha(h\nu\text{-}E_g)^{n/2} \quad (1)$$

n is an integer equal to 1 for a direct band gap and 4 for an indirect band gap. The values of the direct optical band gap E_g were obtained from the intercept of $(\alpha h\nu)^2$ versus $h\nu$ curve plotted in Figure 2. Energy gap (E_g) was evaluated by extrapolating the linear part of the curve to energy axis. The band gap is found to be 4.7 eV. This value of optical band gap shows blue shift, which is useful for gas sensing applications As a consequence of wide band gap, the crystal under study has a large transmittance window. The band gap width E_g of crystalline materials depends on their anisotropy, temperature, pressure on effect of external electric and magnetic field forces. The other optical constants were calculated using the following theoretical formulae [4, 5].

The extinction coefficient in terms of absorption coefficient is obtained as

$$K = \frac{\alpha\lambda}{4\Pi}$$

The Reflectance is derived as a function of absorption coefficient as

$$R = \frac{1 \pm \sqrt{1 - \exp(-\alpha d) + \exp(\alpha d)}}{1 + \exp(-\alpha d)} \quad (3)$$

And the linear refractive index is given by

$$n=\frac{-(R+1)\pm\sqrt{\in 3R^2+10R-3\ (-3R^2+10R-3)}}{2\ (R-1)} \quad (4)$$

Then the complex dielectric constant is related to refractive index and the extinction coefficient as

$$\varepsilon_c=\varepsilon_r+\varepsilon_I \quad (5)$$

Where the real and imaginary and part of dielectric constant is

$$\varepsilon_r=n^2-K^2 \quad (6)$$

$$\varepsilon_i=2nK \quad (7)$$

The optical conductivity as a function of frequency response of the material when irradiated with light is calculated as

$$\sigma_{OP}=\frac{\alpha nc}{4\Pi}$$

where c is the velocity of light. The electrical conductivity can also be estimated by optical method using the relation

$$\sigma_e=\frac{2\lambda\sigma_{op}}{\alpha}$$

Extinction coefficient Vs photon energy is shown in Figure.3 and variation of reflectance with incident photon energy is depicted in Figure.4 Refractive index, complex dielectric constants and optical conductivity as a function of incident photon energy for the grown single crystal are illustrated in Figures 5, 6 and 7. It is shown that the refractive index and extinction coeffcient of 2A5CB changes with increasing Photon energy. The high transmission or low absorption in the region 300-1900nm makes the material to obtain low reflectance and refractive index which is a suitable property for antireflection coating solar thermal devices and nonlinear optical applications. The low extinction coefficient (10^{-5}) and high optical conductivity (10^9) confirms the high photo response nature of the material.

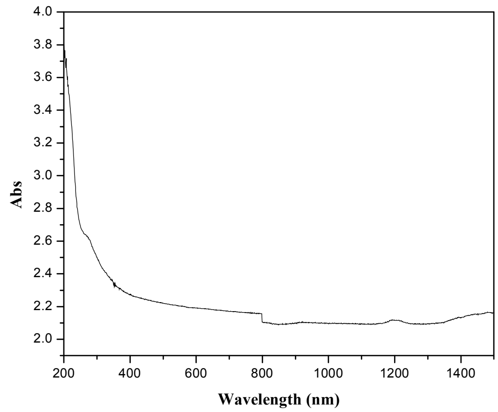

Figure 1. Optical absorption spectrum of 2A5CB

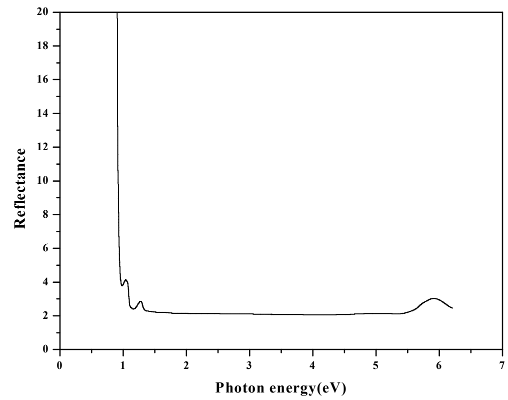

Figure 4. Reflectence Vs Incident photon energy

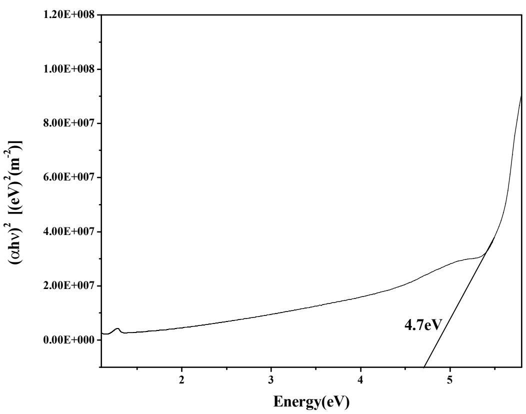

Figure 2. Energy band gap of 2A5CB

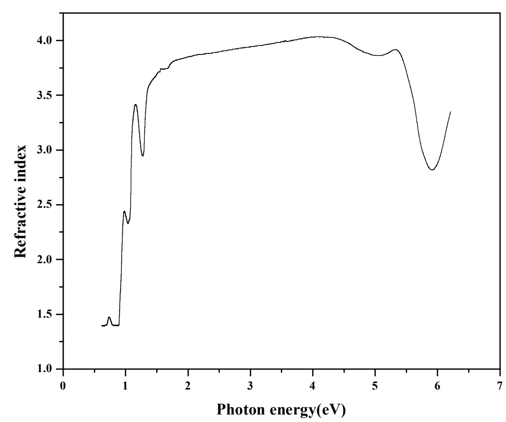

Figure 5. Refractive index Vs Incident photon energy

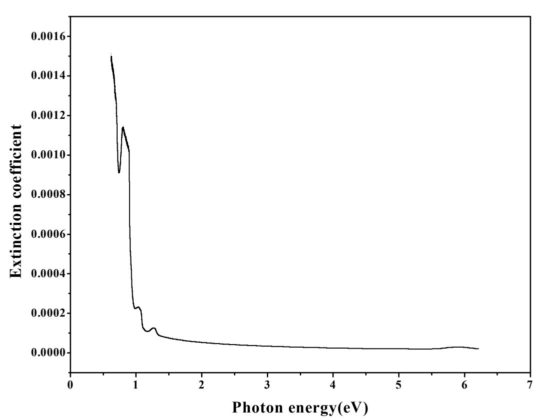

Figure 3. Extinction coefficient Vs Incident Photon Energy

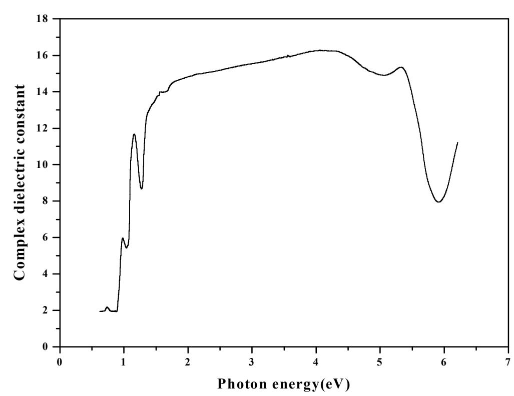

Figure 6. Complex dielectric constant Vs Incident photon energy

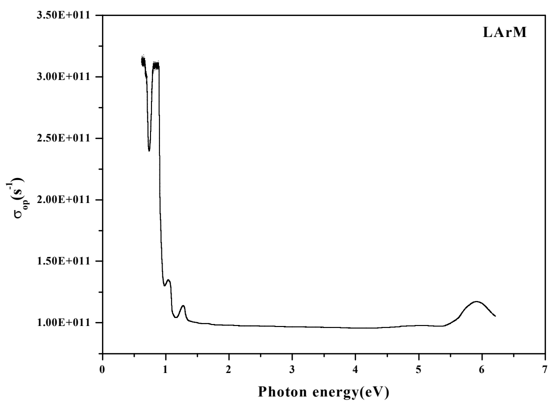

Figure 7.Optical conductivity Vs Incident photon energy

3. NLO Studies

Second harmonic generation (SHG) efficiency was measured to get an idea how much efficient the material is in transferring energy from fundamental laser beam to second harmonic beam. A high intensity Nd:YAG laser with fundamental radiation of 1064nm as the optical source and directed onto the powder sample. SHG efficiency has been estimated as three times greater than that of KDP crystal powder. Its non centro symmetric structure and SHG behavior were confirmed from the output of green light emission from the crystal [6].

4. Conclusion

Good quality single crystals of 2A5CB were grown successfully by slow evaporation technique. Its Energy band gap is calculated from Tauc's plot as 4.7eV.The optical absorption spectrum is used to study various linear optical parameters as a function of incident photon energy. The lower dielectric constant and the higher optical response suggest the better conversion efficiency of the material. It is found that 2A5CB is a suitable material for NLO applications.

References

[1] S. Senthil, S. Pari, P. Sagayaraj, J. Madhavan, Physics B 404(2009),1655-1660

[2] J. Madhavan, S. Aruna, K. Prabha, J. Packiam Julius, Ginson P. Joseph, S. Selvakumar, P. Sagayaraj., Journal of crystal growth 293(2006), 409-141.

[3] Sirohi S and Sharma T P, Opt. Materials, 13, (1999), 267.

[4] P.A. Illenikhena, African Phys. Rev. 2, (2008), 68 .

[5] J.I. Pankove, Optical Processes in semiconductors (Pentice Hall, New York, 1971).

[6] Kurtz S.K. and Perry T.T. J. Appl. Phys., Vol. 39, (1968), 3798–38l3