IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 7, Issue 4 Ver. II (Jul. - Aug. 2015), PP 10-15
www.iosrjournals.org

Optical Properties of Barium Sulphide Thin Films Prepared By Chemical Bath Deposition Technique

Okoli Donald Nnanyere (Ph.D)
Department Of Physics and Industrial PhysicsNnamdiAzikiwe UniversityP.M.B. 5025, AwkaAnambra State, Nigeria

Abstract: *Thin films of Barium Sulphide semiconductor were deposited on glass substrate using Chemical Bath Deposition Technique. The films were optically characterized using Camspec M501 Single Beam Scanning UV/VIS Spectrophotometer. The results show that films exhibited poor absorbance and reflectance properties with values range of 0.002-0.065 and 0.002-0.0.070 respectively. The transmittance of the films to the incident radiation was found to be high with a value range of 0.950-0.993 in arbitrary unit. The films were found to possess high optical conductivity of* $7.43 \times 10^{10} S^{-1} – 5.52 \times 10^{12} S^{-1}$*, and the films thickness found to increase as the dip time increases with value range of 1.668µm – 1.775µm.The calculated refractive index was found to be within the range of 1.132-2.205 and with low extinction coefficient value of 0.00159-0.00517. The band gap energy of the deposited films was found to be 1.25-1.35eV. All these desirable properties made the semiconductor material a good candidate for applications in photonics and photovoltaic devices fabrication.*

Key words:*Thin films, absorbance, reflectance, transmittance, optical conductivity, refractive index, extinction coefficient, band gap energy and photovoltaic.*

I. Introduction

Semiconducting materials have been extensively studied because of their outstanding electronic and optical properties which make them suitable for applications in various devices such as single electron transistors [1], light emitting diodes [2], interference filters, photoconductors, IR detectors, solar cells and so on. Barium sulphide thin film is a semiconductor that belongs to metal chalcogenides group and can be synthesized using different deposition techniques such as spray pyrolysis [3], electro-deposition [4], photochemical [5], successive ionic adsorption and reaction [6] and Chemical Bath Deposition technique [7]. Among them, the Chemical Bath Deposition Technique has been proven to be most cost effective because it does not require usage of sophisticated equipment and with it large area of substrate can be coated with a film.

In this paper, Chemical bath Deposition technique was employed to fabricate thin films of Barium Sulphide.

II. Experimental Details

The glass substrates were initially degreased by immersing it in a dilute solution of HNO_3 for 24hrs after which the substrates were removed and rinsed with distilled water. The essence of this treatment of the substrate is to provide nucleation centers necessary for the formation of thin films. Thereafter, 5ml of 0.1M solution of $BaCl_2.2H_2O$ was put into the reaction bath (50ml beaker) and this was followed with the addition of 5ml of 0.1M EDTA which is the Complexing agent used in the experiment. The resulting solution was stirred for two minutes after which 5ml ammonia solution and 5ml of 0.1M thiourea were respectively added. 30ml of distilled water was later added to make up the solution to 50ml mark of the bath and the whole solution was stirred before the substrate was clamped vertically into the bath through a clean thick cardboard paper covering the mouth of the bath to prevent impurities from entering the bath.
Four other set-ups were prepared in this way and allowed to stay for various times; that is, 24hrs,36hrs, 48hrs, 60hrs and 72hrs after which the substrates were removed, rinsed with distilled and allowed to dry in open air. The reaction equation for the experiment is as follows;

$$BaCl_2.2H_2O + EDTA \longleftrightarrow [Ba(EDTA)]^{2+} + 2HCl + 2OH^-$$

$$[Ba(EDTA)]^{2+} \longleftrightarrow Ba^{2+} + EDTA$$

$$CS(NH_2)_2 + OH^- \longleftrightarrow CH_2N_2 + H_2O + HS^-$$

$$HS^- + OH^- \longleftrightarrow S^{2-} + H_2O$$

$$Ba^{2+} + S^{2-} \longleftrightarrow BaS \downarrow$$

After the deposition of the films, the samples were optically characterized in the laboratory to determine the optical properties of Barium Sulphide semiconductor material. Camspec M501 Single Beam Scanning UV/VIS spectrophotometer was employed for this purpose in the wavelength range of 332-992nm.

III. Results And Discussion

The optical properties studied include; absorbance, transmittance, reflectance, absorption coefficient, optical conductivity, refractive index, extinction coefficient and band gap energy. Three samples of the deposited films were used in the analysis due to fine nature of the films formed. They are sample 1(24hrs), Sample 2(48hrs) and sample 3 (60hrs).

Figure 1: shows the plot of absorbance against wavelength for the three samples.

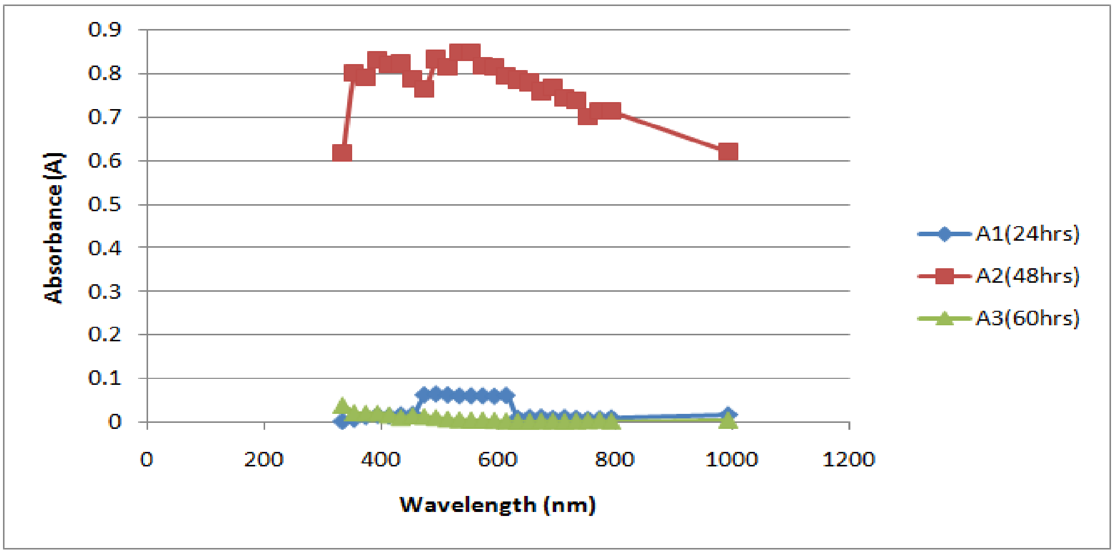

Figure 1: Plot of Absorbance against Wavelength for the three samples

The film deposited at 48hrs exhibited high percentage absorption of electromagnetic radiation than the other two deposited at time intervals of 24hrs and 60hrs respectively.
The variation of transmittance with incident radiation is illustrated in figure 2 below;

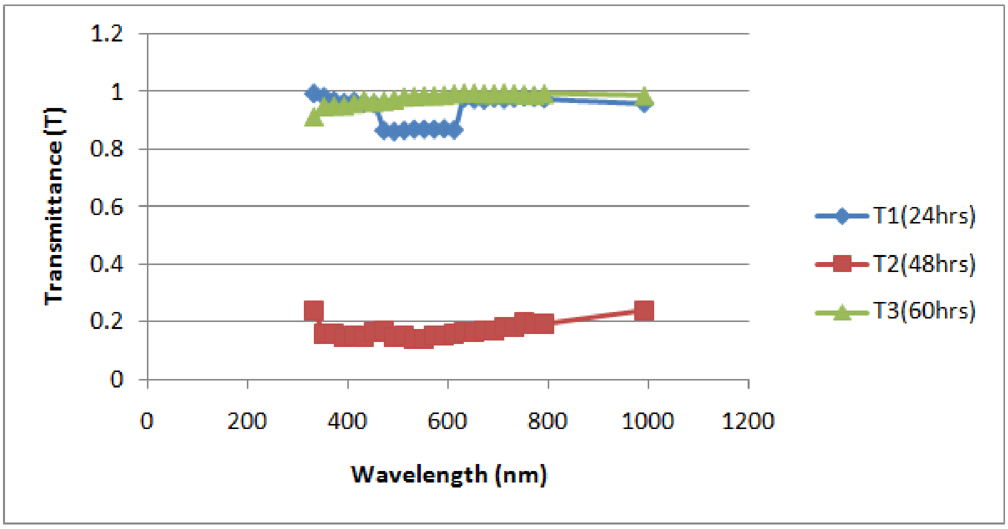

Figure 2：Plot of Transmittance against Wavelength for the samples

From figure 2, the films deposited at 24hrs and 60hrs show remarkable transmission of incident radiation than the other one fabricated at 48hrs. Materials with good transmittance properties can be deployed in manufacturing optics and photovoltaic devices. So, Barium Sulphide semiconductor can be used in this regard.
The reflection spectra for the three films are as shown in figure 3 below;

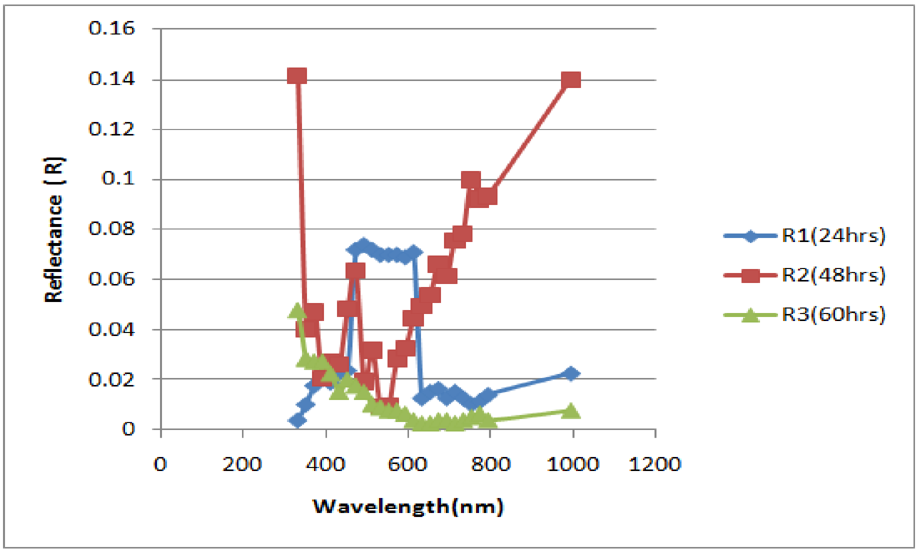

Figure 3: Plot of Reflectance against Wavelength (nm) for the three samples

The three films were found to possess low reflectance properties with the peak at 14%. This low reflectance property made the material to be a good candidate for antireflection coating for solar cells devices and opto-electronics components.
The refractive index of the three samples was calculated using the relation

$n = 1 + R^{0.5}/ 1- R^{0.5}$ 1.1

where R is the reflectance.
Figure 4 below shows the plot of refractive index against photon energy for the three films ;

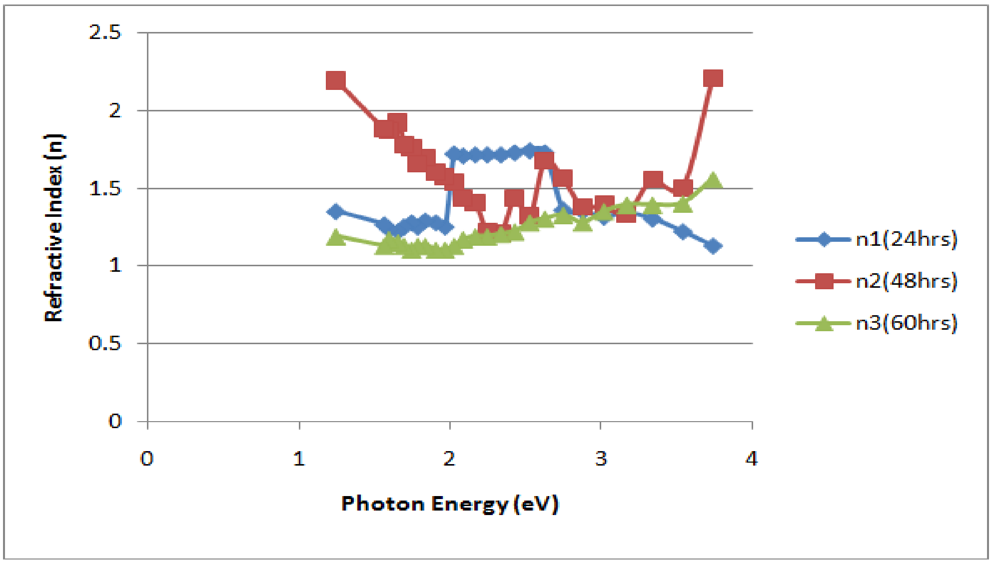

Figure 4: The spectra of the Refractive Index for the three films

From the spectra it was observed that the film deposited at 48hrs period exhibited high refractive index peak value of 2.205 . High refractive index materials are required for anti-reflective coatings and photonic devices like light emitting diodes and image sensors [8-9].

Optical conductivity is the optical response of a transparent solid [10], it is given by the relation,

$\sigma_{op}= \alpha nc/4\pi$ 1.2

where α is the absorption coefficient , n is the refractive index and c is the velocity of light.
The plot of optical conductivity as a function of photon energy for the three films is depicted in figure 5.

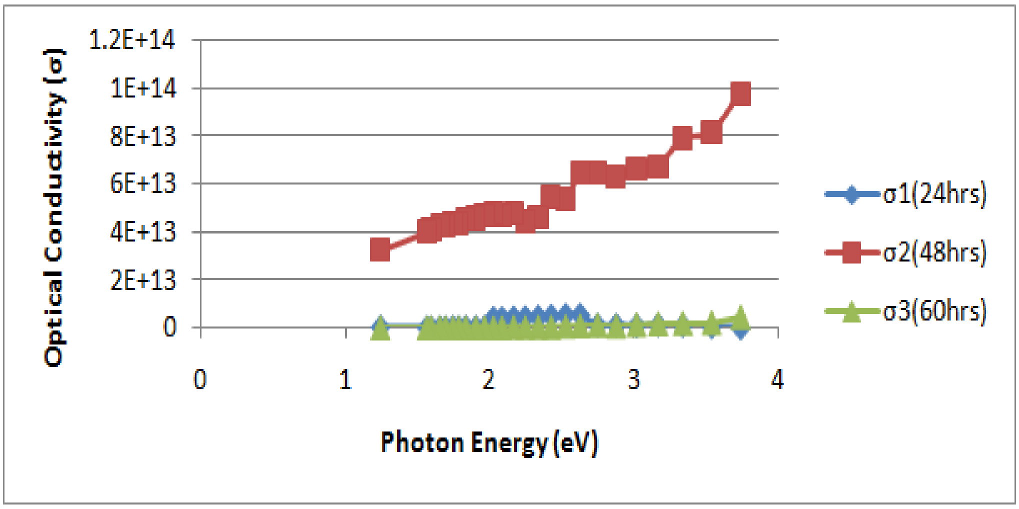

Figure 5: Plot of Optical Conductivity against Photon Wavelength for the three samples.

From the graph, it was observed that the optical conductivity of the films deposited at 24hrs and 60hrs exhibited almost constant values as the photon energy increases. But, for the case of the film deposited at 48hrs optimal time interval there is a linear relationship between the optical conductivity and the photon energy. That is as the optical conductivity increases the photon energy also increases.
The extinction coefficient (k) was also computed for the deposited films, it was obtained from the relation;

$k = \alpha \lambda / 4\pi$ 1.3

where α is the absorption coefficient and λ is the wavelength of incident radiation.

The plot of extinction against photon energy is depicted in figure 6.

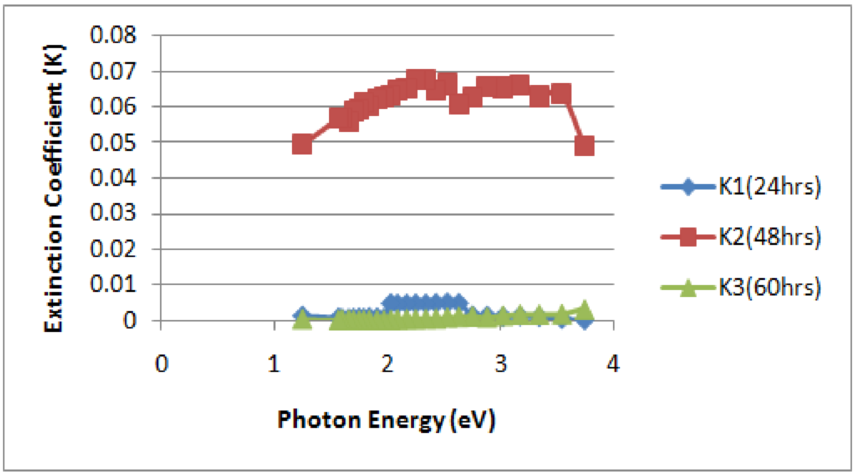

Figure 6: Plot of Extinction Coefficient against Photon Energy for the three samples

From the graph, it was observed that all the films exhibited poor extinction coefficient values but the one deposited at 48hrs period has values greater than the other two deposited at 24hrs and 60hrs respectively.
The band gap energy generally refers to the energy difference (in electron volts) between the top of the valence band and the bottom of the conduction band in insulators and semiconductors. The band gap energy of the deposited film was found by using the relation;

$\alpha = (hf - E_g)^{1/2}$ 1.4

where α is the absorption coefficient, h is the Planck's constant, f is the frequency of electromagnetic radiation and E_g is the band gap energy. The plot of absorption coefficient squared as a function of photon energy is shown in figure 7.

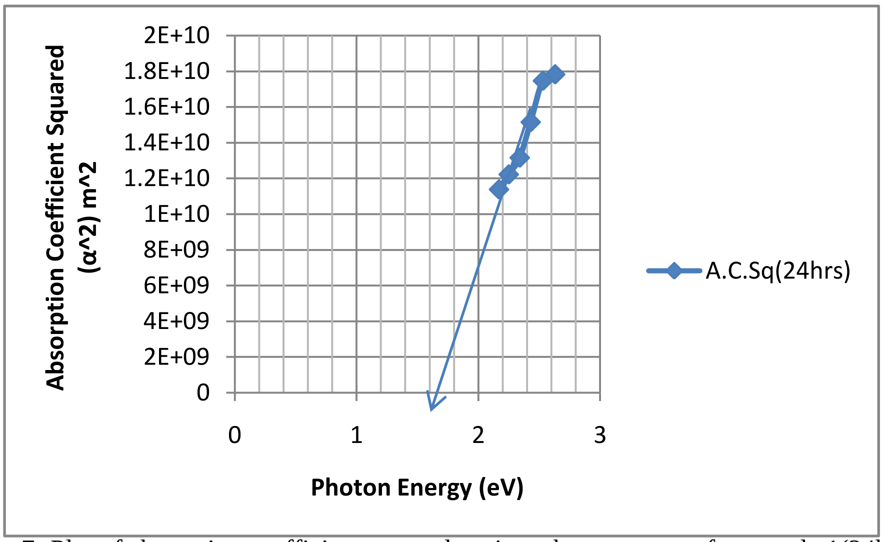

Figure 7: Plot of absorption coefficient squared against photon energy for sample 1(24hrs)

From the figure 7, it was found that linear plot intercepted the photon energy axis at 1.35eV and this value is taken to be the band gap energy of the material deposited at 24hrs. The band gap energy was also determined for sample 2(48hrs). The linear plot intercepted the photon energy axis at 1.25eV and this value is taken to be the band gap energy of the material deposited at 48hrs.This is as shown in figure 8.

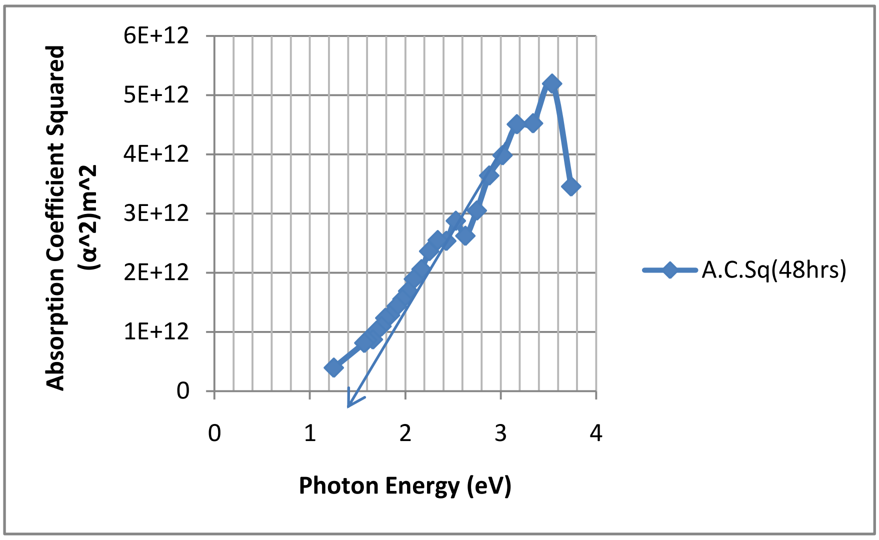

Figure 8: Plot of Absorption Coefficient Squared against Photon Energy for sample2 (48)hrs

\The thickness of the deposited films was also calculated using the relation;

$t = - \ln(T)/\alpha$ 1.5

wheret is the thickness of the film, T is the transmittance in arbitrary unit and α is the absorption coefficient. The plot of thickness as a function dip times is depicted in figure 9 below.

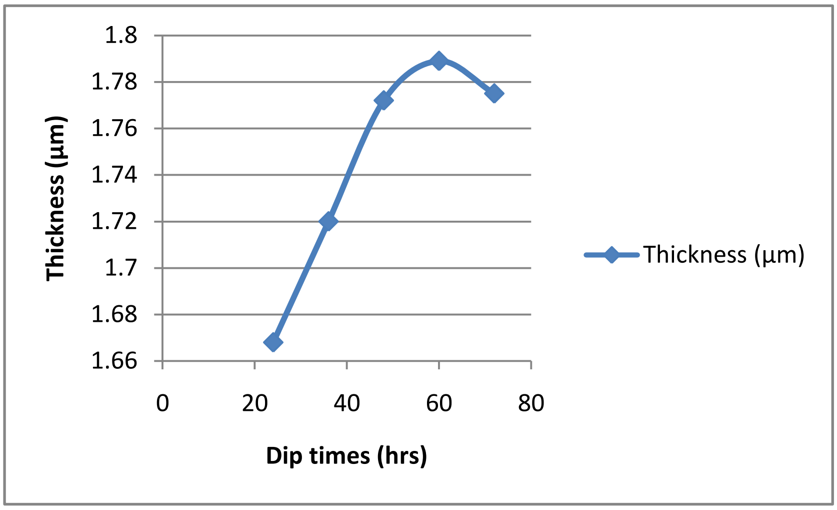

Figure 9: Plot of thickness against dip times

From figure 9 it was observed that thickness increases as the dip times increases up to a saturation point after which the thickness becomes non-linear with the dip times.

IV. Conclusion

Thin films of Barium Sulphide were successfully deposited on the glass substrate from the aqueous solution of Barium chloride dehydrate, thiourea and in which ethylenediaminetetra acetic acid (EDTA) was employed as a complexing agent.The deposited films were optically characterized using Camspec Single Beam UV/VIS spectrophotometer. The results show that the films especially one deposited at 24hrs and 60hrs exhibited poor absorbance and reflectance of incident radiation in almost region of the electromagnetic spectrum and with high transmittance property in the same regions. The refractive index was found to range from 1.132-2.205 and the extinction coefficient was also found to be low. The optical conductivity was observed to be high with band gap energy ranging from 1.25-1.35eV. All these desirable properties made the material to be a good candidate for applications in opto-electronics, photonics and photovoltaic devices.

References

[1]. Kelin D.L., Roth R., Lim A.K.L., Alivisatos A.P., and McEuen, P.L.,(1997): Nanogap resistance random acess memory based on Natural Aluminium Oxide, Nature, 389, 699
[2]. Colvin V.L., Schlamp, M.C. and Alivisatos, A.P.,(1994): Light emitting diodes made from Cadmium Selenide, Nature., 370, 354
[3]. Onyia A.I. and Okeke C.E. (1989) : Fabrication and Characterization of tin oxide (SnO2) thin films using simple glass spray system , J.Phys D: Appl Phys., 22, 1515-1518
[4]. Engelken R.D. , McCloud H.E.,(1985): J. Electrochem. Soc. 132(3) 567
[5]. Zhuge F., Li X., Gao X. Gan. X, Zhou F.(2009): Mater. Lett. 63, 652
[6]. Anuar K., Zainal Z., Hussein M.Z., Saravanan, Haslina I., (2002): Sol. Energy Mater.Sol. Cells 73, 351
[7]. Nnabuchi M.N. (2006): J.Res.Sci., 17(4), 263-271
[8]. Jin-gang Liu and Mitsuru Ueda (2009): "High refraction index polymer; Fundamental and practical applications". J.Mater.Chem 19(47): 8907
[9]. Hung-Ju Yen and Guey-Sheng Liou (2010): " A facile approach towards optically isotropic, colourless and thermoplastic polyimidothioethers with high refractive index". J.Mater 20(20) : 4080
[10]. Mahrov B., Boschloo G., Hgfeldt A., DIoczuk .L, and Dittrich Th. (2004); Appl.Phys. Lett. 84(26) 5455-5457.