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Investigation of Composite Films of Conducting Polymer, Gaas For Their Solar Cell Applications

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ABSTRACT

The rapid development and progress of science and technology in the field of energy and material has been illuminated the significance of conducting polymer. During the last decade researcher have been struggling to rise up the power conversion efficiency of solar cell by developing new material and structure. In the present work a composite films of conducting polymer and GaAs with attractive feature have been synthesized by Electro deposition method and drop casting method respectively. The structure and morphology of the prepared films were studied from XRD and AFM pattern. And optical characteristics of the prepared films were studied from UV spectrometer it shows that the band gap of the prepared thin films of GaAs material is 1.39 ev and voltage current characteristics of the composite films shows the suitability of materials for photovoltaic application.

Keywords: conducting Polymer, GaAs, Solar cell, thin films, PEDOT: PSS.

INTRODUCTION

In earlier days, the most common solar cells were designed using single p-n junction silicon crystal. But the cost of the single silicon crystalline substrate was high and hence new absorbing materials and cheap technologies were under sought. The main advantage of the thin film technology is the material can be spread on to the large area of wafer or substrate by any suitable method in order to produce high volume.

GaAs is one of the most influential III-V semiconducting materials, which possesses high mobility and direct band gap of 1.43ev.this properties of GaAs material makes them suitable for an optoelectronics and photovoltaic application. different growth techniques are used for the synthesis of GaAs thin films, these methods are spray paralysis[11],liquid phase epitaxial[7],molecular beam epitaxial[12],electrode position, metal organic chemical vapor deposition[15],chemical vapor deposition[15] these all techniques are expensive and complicated among all various techniques, electro deposition techniques due its simplicity and inexpensiveness offer several advantages [8,17]. In this technique films thickness, structure and composition can be controlled by voltage or current, here the optimization of parameter for the deposition of single metal is easy but for binary compound it is difficult [9]. We studied the characteristics of photo electrochemical solar cell designed using GaAs thin film, acts as photo electrode and graphite as counter electrode in 2M polysulphide. D.K.Ferry reported the successful deposition of GaAs from an electrolyte whose ph was 0.7[15], Mahalinga reported the deposition of GaAs from an electrolyte of $GaCl_3$ and As_2O_3 for various pH and temperature [6]. K.R.Murali, have synthesized GaAs by varying duty cycle from aqueous solution of $GaCl_3$ and As_2O_3 [14]. Andreoly have reported the synthesis of GaAs thin films by deposing Ga on Ti substrate and As, layer was electrodeposited on Ga layer [19]. M.Chamekh has reported that the co deposition of GaAs metal at 279k and pH was 1 from gallium metal and As_2O_3 dissolved in dilute HCL [1]. In the literature.V.M.Zozlov, S.Chandra [17, 9] have been reported that large effort had been made by researcher for the deposition of GaAs thin films from acidic and alkaline solution with limited fruitful output. In this paper we present the co-deposition of gallium and arsenic metal at room temperature from a electrolyte containing gallium metal and As_2O_3 dissolved in concentrated HCL and the pH was maintain at 1.2

Before 30 year it was considered that polymers were used as an insulator but by simple modifications in the conjugated polymer their electrical conductivity has been raised. [18] The first remarkable feat in the field of conducting polymers has been taken around 1978, explained by Shirakawa.[18,3] He showed that the

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oxidation and reduction reaction in the conjugated polymer and enhance their conductivity and turn as p doping and n doping respectively[3] Conducting polymer have found large applications in the manifold fields of Electronics, Optics, Energy devices and Medicine. Studies on polymer solar cell reveals a positive effect on the efficiency and hence, the structure of inorganic – organic hetrojunction solar cell have been allured much more attention.

Generally hetrojunction solar cells are fabricated from Donar and Acceptor layers.Donar materials absorb light and generate excitons and Acceptor layer transports electrons [25, 24]. The efficiency of solar cell depends upon several factors. In the present work PEDOT: PSS layer was form on GaAs substrate by Drop casting method. And demonized water was used as solvent, in the PEDOT: PSS conducting polymer PEDOT is a polycation and PSS is a polyanion [26, 27]

EXPERIMENTAL DETAILS

Thin films of GaAs material have been electrodeposited from an electrolyte containing Ga metal and As_2O_3 dissolved in concentrated HCL. Gallium metal (99.99% pure purchased from Sigma Aldrich) and As_2O_3 (99.99% pure purchased from Sigma Aldrich) were separately dissolved in concentrated 10ml HCL,1M Gallium metal was separately dissolved in concentrated HCL and 0.1M As_2O_3 was dissolved in another 10 ml HCL. After adding two solutions in appropriate ratio, the resulting solution was stirred for 3 hours, the solution was diluted by adding double distilled water and the pH value of the electrolyte was set to 1.2 by adding concentrated KOH solution in such a way that the final volume of the electrolyte should be 40ml. ITO coated glass substrate were commercially available and it is purchased from sigma Aldrich and the size of the substrate was 2.5 cm × 2.5 cm which has a resistance of 10 Ω/cm^2 ITO coated glass substrate were initially cleaned ultrasonically in order to remove surface contamination, dust particle and then rinsed thoroughly with double distilled water, and dried at 400 C^o for 5 min.

Electrolytic cell consisted of two electrodes in contact with electrolyte, ITO coated glass substrate used as working, platinum plate acts as counter electrode and $Ag/Agcl_3$ was used as reference electrode. During the electrolysis process Ga, and As, ion attracted toward cathode and gets deposited on ITO substrate. The Stoichiometric ratio of Ga and As ions depends on the pH of the electrolyte, temperature, concentration, current or voltage parameter and electro deposition time. There is no clear cut method discussed in the previous literature for the fixing of deposition parameters for binary metal. And hence failure rate in co-deposition of metal was high. In the present work, we performed our experiment by applying a potential between 0.6 to 1.1volt. During the experiment we prepared number of samples for various deposition times while other growth parameters kept constant. Then prepared samples were removed and rinsed thoroughly with double distilled water and annealed in air for 10 min. Here, we prepared two samples of photovoltaic cells, the first sample prepared by using GaAs thin film deposited by electro deposition techniques and second was prepared by GaAs substrate (100) purchased from U.S.A. The substrates were cleaned in ultrasonic bath, isopropyl alcohol and demonized water for 5 min. and in dil. HCL solution for 2 min. in order to remove the surface contamination and annealed at temperature 100° C Si doped n - type GaAs substrate (100) with doping concentration (0.4-4) x 10^{18} and thickness of 350 micrometer purchased from Precision Micro Optics (USA) are used for device fabrication. Thermally evaporated aluminum was used as cathode, ITO used as Anode, PEDOT: PSS (Clevious PH1000) dissolved in demonized water, and (P3HT) poly-3 Hexythiophene was used hole transport layer.

CHARACTERIZATION

GaAs thin films deposited on ITO coated glass substrate were characterized by keithely XRD diffractometer operating in θ-2θ geometry XRD pattern used to identify crystalline phases ,XRD pattern shows that films are polycrystalline in nature and peaks intensity corresponding to single phase GaAs .UV absorption spectral characteristics of the prepared samples were studied at room temperature.

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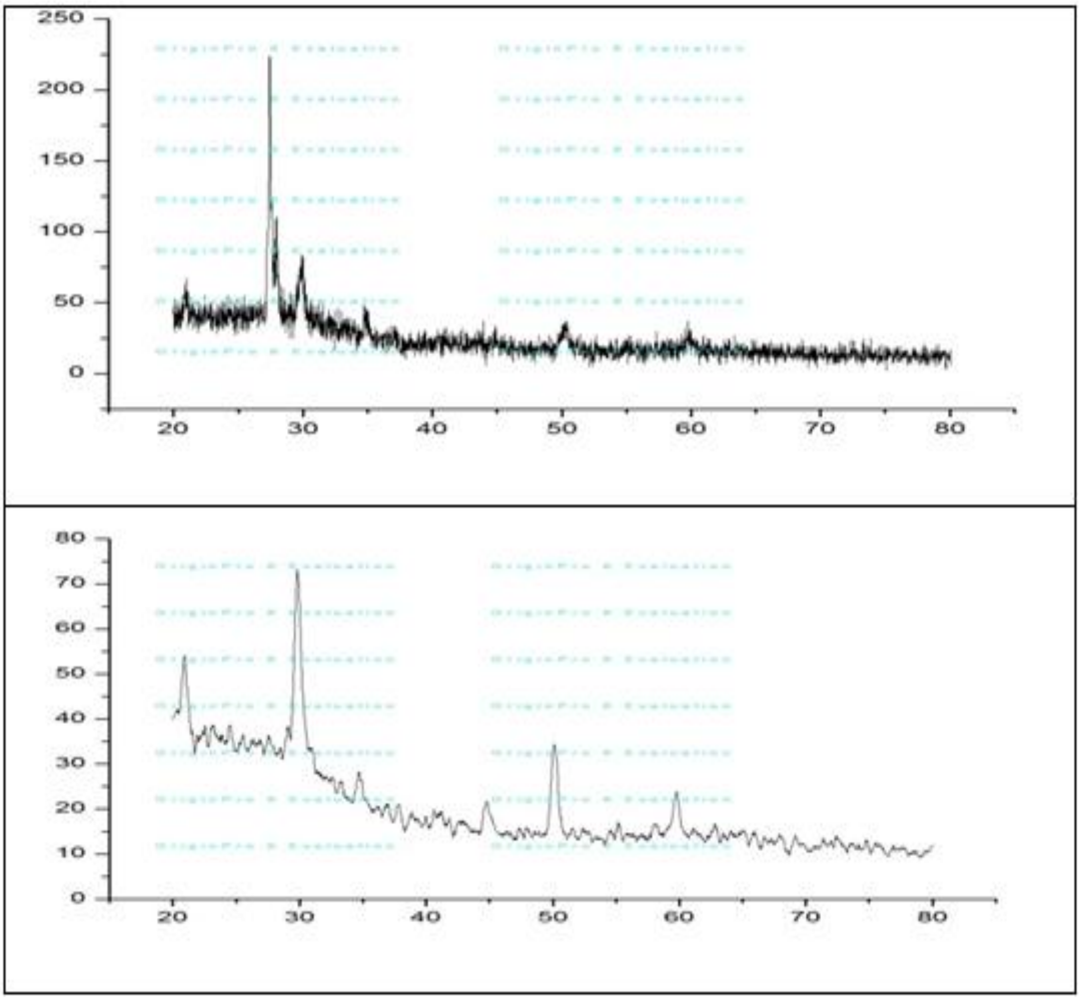

Figure 1: XRD of the prepared thin films (2θ Vs Intensity a.u.)

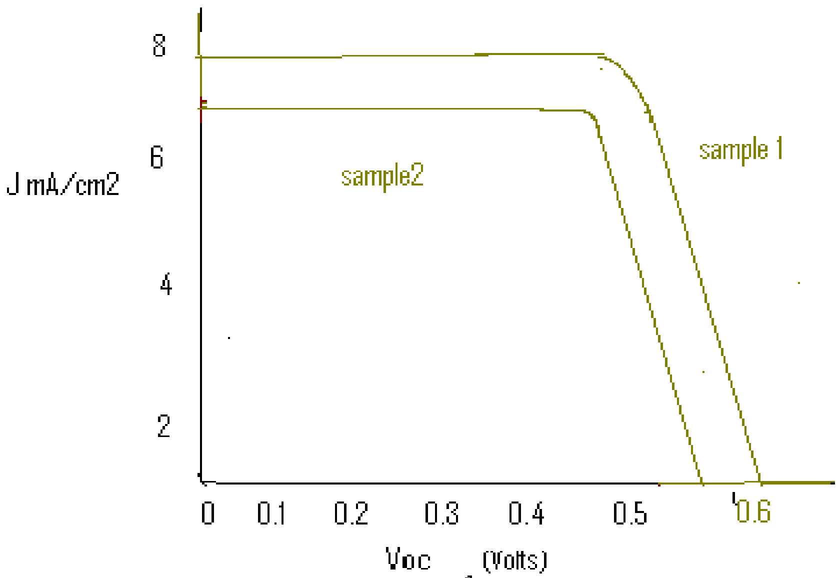

Figure-2: Voltage Vs Current characteristics of the prepared composite thin films

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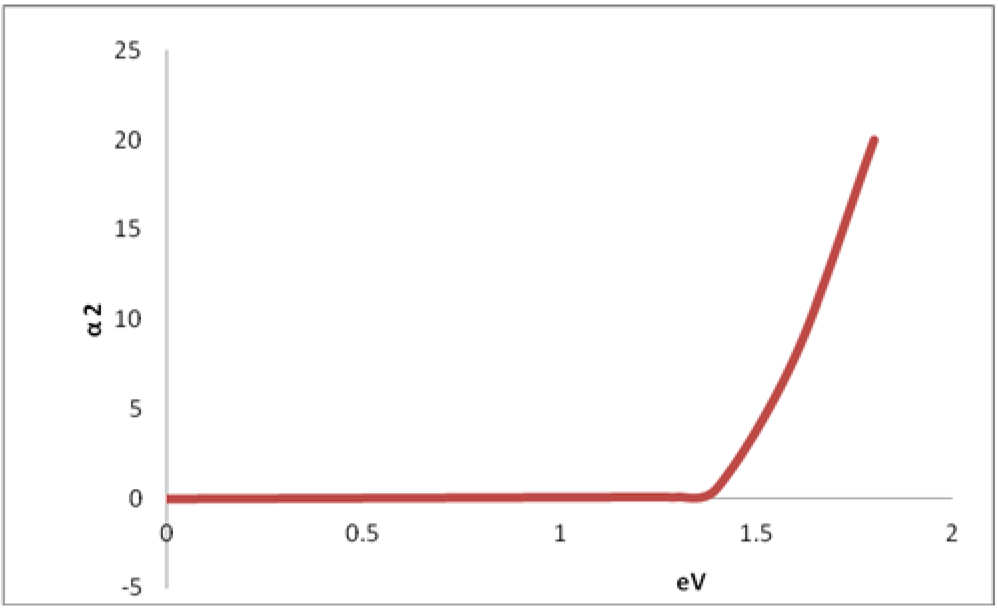

Figure-3: UV Absorption spectra E vs α

RESULT AND DISCUSSION

The sharp diffraction peak in the XRD pattern reveals that the films are crystalline in nature. Figure show that if the deposition time of the prepared film is less than 10 minute then it exhibit cubic and orthorhombic structures. [16,17] where as the film deposited at deposition time greater than 10 min shows predominantly of orthorhombic structure [19,20] .by applying Debye-Scherer formula [18], to XRD pattern we can calculated the average grain size of the prepared films

$$D = k\lambda / B\cos\theta$$

Where- k is the shape factor, λ is the X-ray wavelength and θ is the diffraction angle.

The three dimensional surface scan of the prepared GaAs thin film is analyzed by AFM technique. This study reveals that as the deposition time was increased then the average particle sizes of the surface were found to increase.

The absorption coefficient of the films is given by

$\alpha E = C\,(E - Eg)^{n}$.

Where, C is constant E is the photon energy and E_g is the band gap energy n is the constant which value is depend upon the types of transition and which may be assigned the value 2, 1/3, 1/2 for allowed indirect transition, forbidden direct transition ,allowed direct transition respectively.

GaAs is a direct semiconductor materials and hence for this materials n=1/2.the absorption coefficient α can also be calculated from the following equations which shows the relationship between the sample thickness ‘’d ‘’and transmittance’’ T’’ this equations is valid for high absorption when the reflectivity dispersion and interference effect are negligible [23]

$\alpha = 2.303 \text{ Log } (1/T)/d$

Where T is transmittance and d is thickness

Linear nature of the graph between α and E indicate that this is direct band gap semiconductor and the straight line intercept at x axis gives the value of band gap energy. Band gap is in good agreement with the values reported for GaAs thin films prepared by Galvanostatic technique. [6, 14].

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Under 110 mw/cm^2 illumination power, voltage current characteristics of prepared hybrid solar cell are measured and compared the solar cell parameters. The performance of our solar cell was more efficient than that of designed by electrodeposited GaAs layer on ITO substrate.

Parameters	**Solar cell prepared by us (GaAs)**	**Solar cell prepared by others**
Voc (Open circuit voltage)	0.610 v	0.57 v
J (Current density)	7.10 mA/cm^2	8.10 mA/cm^2
FF (Fill Factor)	0.71	0.61
η (Efficiency)	4.72 %	2.72%

CONCLUSION

GaAs material is useful for optoelectronic devices and sensors. We can increase the efficiency of solar cell with Heterojunction structure accompanied with conductive polymer which has tremendous applications in the field chemical, electrical and medical. But still there are some challenges in the field of development and implementation such as co-deposition of conducting polymer and metal.

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