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Growth and Characterization of $GaAs_xP_{1-x}$Nanowires

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Abstract:

The optical properties of bulk as well as nano $GaAs_xP_{1-x}$Nano wiresdeveloped by the Chemical Bath Deposition (CBD) were investigated in this paper. Results of optical Transmission, absorption, reflection spectra, optical conductance, refractive index, extension coefficient, real and imaginary dielectric constants studies are reported. The optical properties were obtained using UV-VIS Double Beam Spectrophotometer Version 6.51 in the wavelength range 200-1100 nm. The optical transmittance of the film of nano $GaAs_xP_{1-x}$Nano wiresformed at 50^0C was 99% at wavelength ≈ 475nm then decreases to 90% at wavelength ≈482nm for thin film of nano $GaAs_xP_{1-x}$Nano wiresat room temperature and 75% transmittance at wavelength ≈490nm for thin film of bulk $GaAs_xP_{1-x}$Nano wires. The band-gap was also calculated from the equation relating absorption co -efficient with the wavelength. The energy band gap changes from 2.5eV (Bulk $GaAs_xP_{1-x}$Nano wires**)** to 3.6eV (nano $GaAs_xP_{1-x}$Nano wiresat 50^0C). The plotted graphs show the optical characteristics of the film which varied with the wavelength and the photon energy. The optical conductance and band-gap indicated that the film is transmitting within the visible range. The dielectric constant and optical conductance of the film initially increases slowly then abruptly and finally becomes constant with increase in photon energy. The extinction coefficient and refractive index of the films also evaluated, which affected with the change in transmittance. The dielectric constant changes with change in photon energy.

Keywords: Chemical bath deposition; transmittance; absorbance; reflectance; band-gap; dielectric constant; refractive index; extinction coefficient; $GaAs_xP_{1-x}$ Nano wires.

1 Introduction

Currently there is a great deal of interest in optical and structural properties of nanometer sized semiconductor particle or thin films [1]. $GaAs_xP_{1-x}$Nano wireshas intermediate energy band gap, reasonable conversion efficiency, stability and low cost therefore it is one of the most widely used material for $GaAs_xP_{1-x}$Nano wiressolar cells or device applications [2]. Nano crystalline thin films of II-VI semiconductor have attracted particular attention, because they are relatively easy to synthesis in the size range required for quantum confinement. They are currently of great interest for their practical applications such as zero- dimensional quantum confined material, and in optoelectronics and photonics. Numerous reports are available in the literature on synthetic techniques as well as potential applications of nano-sized semiconductor particles [3]-[7] They show significantdepartures from bulk optical and structural properties when scale of confinement approaches to excitonicBhor radius which sets the length scale for optical process [8]. $GaAs_xP_{1-x}$Nano wiresis a wide band gap semiconductor with Eg≈2.4eV [9]. The optical properties of $GaAs_xP_{1-x}$Nano wires have been extensively studied [10]. Reduction in particle size strongly influences the crystalline of the film. The thickness of the film was observed about 34.8nm when film was annealed at 360^0C for 1 hr[11]. $GaAs_xP_{1-x}$Nano wires thin film have been fabricated using several deposition techniques such as screen printing [8], electro deposition [9], molecular beam epitaxy (MBE)[1], physical vapor deposition[10]. All these techniques require high sophisticated instrument and mismatch of thermal expansion coefficient between the film and substrate cause micro cracks. One of the promising techniques for producing large areas of inexpensive

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$GaAs_xP_{1-x}$Nano wires film is chemical bath deposition and here we followed this method to synthesis the $GaAs_xP_{1-x}$Nano wiresfilms.

2 ExperimentalDetails

2.1 Preparation of Bulk CdS Thin Film

Bulk $GaAs_xP_{1-x}$Nano wiresthin films were prepared by Chemical Bath Deposition method from aqueous solution containing cadmium chloride (0.01M), zinc chloride (0.1M), thiourea (0.1M), 25% ammonia solution and triethanolamine (TEA) as a capping agent. The chemical bath is prepared from CdCl2 solutions and 4% of the volume of the metal precursors, triethanolamine. The solution is stirred well for 5 minutes and required amount of ammonia solution (25% of NH3 solution) was added to get a pH value 11. After proper stirring the solution with homogenizer for 10 minutes at the rate (125 rpm), thiourea is added into it and the reaction mixture was kept in a water bath at 50^0C. Before the deposition of cadmium sulphide on glass slides, the slides (substrate) were degreased in hydrochloric acid (HCl) for 24 hours, cleaned in detergent/cold water, and then rinsed with distilled water and allowed to drip dry in air. The substrate immersed vertically in the chemical bath and the deposition was carried out for 60 minutes. After the deposition, the films were rinsed in distilled water and dried in open air at room temperature.

2.2 Preparation of Nano $GaAs_xP_{1-x}$ Nano wires

Nano $GaAs_xP_{1-x}$Nano wireswas prepared from aqueous solution of **ca**dmium sulfate (1M) as a source for cadmium, thiourea (1M) as the source of sulphur and NH4OH solution. The Chemical bath is prepared from the solution of CdSO4 and (NH2)2CS. The solution is stirred well for 5 minutes and required amount of NH4OH is added to get pH of 10.25. The solution was stirred with homogenizer continuously at the rate (125 rpm). A cleaned glass substrate (were degreased in hydrochloric acid (HCl) for 24 hours, cleaned in detergent/cold water, and then rinsed with distilled water and allowed to drip dry in air) was immersed vertically in the chemical bath and the deposition was carried out for 60 minutes. After the deposition, the films were rinsed in distilled water and dried in open air at room temperature.

3 Results and Discussion

3.1 UV Spectral Studies

3.1.1 Optical Transmittance Spectra

The transmittance spectrum of samples is taken by UV-VIS Double Beam Spectrophotometer Version 6.51 in the wavelength range 200-1100 nm. The UV spectra of the material provide important information about the details related with optical band. It shows the wavelength dependence transmittance of the films of bulk and nano material $GaAs_xP_{1-x}$Nano wiresin the wavelength range 300nm-900nm.

The optical transmittance of the film formed at 50^0C was about 99% at wavelength≈ 475nm then decreases to 90% transmittance at wavelength 482nm and of 75% transmittance at wavelength 490nm for thin film of bulk $GaAs_xP_{1-x}$Nano wires. The optical transmittance increases from bulk to nano$GaAs_xP_{1-x}$Nano wiresthin film at 50ºC. It is observed that the transmission spectra shift towards shorter wavelength as the particle size decreases which suggest the increase in optical energy band gap. It is supposed that the tightly adherent collides are formed with the change in micro to nano particle size. . From the UV spectra, it is clear that the absorbance decreases with increase in wavelength. This increase in transmittance indicates the presence of optical band gap in the material. The optical band gap of the films increases from 2.5eV to 3.6 eV from bulk to nano$GaAs_xP_{1-x}$Nano wires. The difference in the optical band values achieved was mainly due to the difference in the deposition techniques employed and the process parameter maintained during the growth of the films.

The energy corresponding to this determines the band gap of the semiconductor material. The $GaAs_xP_{1-x}$Nano wiresshows absorption coefficient (α) of about 1.4×10^{-6} m^{-1} near the absorption edge of wavelength 600 nm for $GaAs_xP_{1-x}$Nano wires$1.48x10^{-6}$ for bulk $GaAs_xP_{1-x}$Nano wiresnear the edge of wavelength 500 nm at room temperature and $2.5\ x10^{-5}$ for $GaAs_xP_{1-x}$Nano wiresnear the edge of wavelength 420 nm at 50 ºC .This shows that the deposited semiconductor films have a direct band gap material. It is observed that the absorption edge shifts towards shorter wavelength from bulk $GaAs_xP_{1-x}$to $GaAs_xP_{1-x}$Nano wiresat 50ºC. The absorption onset in $GaAs_xP_{1-x}$Nano wiresthin film obtained at 300nm, gives band gap of 4.13eV [13].

The $GaAs_xP_{1-x}$Nano wiresat room temp decreases up to 400nm then increases abruptly of 15% and after that it decreases with increase in wavelength. The reflectance of the $GaAs_xP_{1-x}$Nano wiresat 50ºC initially increases up to 480nm after that it decreases abruptly up to 530nm then increases slowly with increasing wavelength up to 650nm then again decreases and shows parabolic path up to 900nm because of change in transmittance The reflectance is high (20%) in near infrared and visible region shown.

The increased optical conductivity at high photon energies is due to high absorbance of $GaAs_xP_{1-x}$Nano wiresin that region. The optical conductance and band gap indicated

that the film is transmittance within the visible range [14]. The conductivity is constant up to 2eV of photon energy after that it increases with increase in photon energy. This shows that when the absorption of photon by film increases in that region. The conductivity peak of the films increases from bulk to nano$GaAs_xP_{1-x}$Nano wires

The refractive index of the bulk $GaAs_xP_{1-x}$ initially increases with increase in photon energy up to 2.6eV after that it decreases with increase in photon energy due to increase in reflectance. The refractive index of $GaAs_xP_{1-x}$Nano wiresdeposited at room temperature increases exponentially with increase in photon energy whereas the refractive index of the $GaAs_xP_{1-x}$Nano wiresdeposited at 50^{o}C initially decreases then increases and finally decreases with increase in photon energy due to change in reflectance of the film.

The extinction coefficient increases with photon energy up to 2.8 eV then it becomes almost constant for $GaAs_xP_{1-x}$Nano wires. It increases with up to 2.8 ev then decreases slightly for nano thin film of $GaAs_xP_{1-x}$Nano wiresat room temperature. Nano thin film at 50^0C initially decreases up to 2.3 eV then increases from 2.3eV to 4eV

4 Conclusion

This work has clearly presented how $GaAs_xP_{1-x}$Nano wiresand nano material was grown using Chemical Bath Deposition techniques and how the effect of the solid state properties on spectral absorbance, transmission, and reflectance were obtained. The behaviour of the film as illustrated in the graphs shows that the film is a visible transmitting thin film. The absorbance at the near infrared domain is low with high transmittance at the same region. The data explain the relationship between extinction coefficients, refractive index, real and imaginary dielectric constants and optical conductance.

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