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Generation Nio:Fe Nanoparticles By Chemical Method And Characterization As Photodetectoer Applications

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***Abstract*—Nanocrystalline NiO:Fe thin film was prepared by thermal oxidation NiO which grinding and embedding in methanol then deposited on a glass substrate by 5 drop casting method. The deposited films were examined for their morph-ology, and crystal structure by x-ray diffraction (XRD) and (AFM), In most cases. It was found that NiO:Fe have a tetragonal phase, predominantly grown on preferred (111) and (200) planes, The average grain size of the deposited thin film was about 80 nm . Deposition of NiO:Fe NP_S on silicon (Si) gives suspensions photodetector characteristics .**

Keywords—NiO:Fe ,Structural properties , chemical method, AFM, XRD , photodetector

1. Introduction

Nickel oxide (NiO) has attracted considerable attentions for technological applications. Nanosized nickel oxide has demonstrated excellent properties that are suitable for practical applications ranging from catalysts, organic light emitting diodes, fuel cell electrodes, magneto resistance sensors [1-4], gas sensors [5], transparent conducting films [6], optical and electrochemical sensors [7]. Furthermore, Nickel oxide undergoes electrochromic property involving a colourless reduced state and a dark brown oxidized form. Due to this distinguished property, NiO is also one of the most often used materials in electrochromicrelated technologies [8]. NiO films can be prepared by several methods such as thermal evaporation [9], pulsed laser deposition [10], etc. Nickel oxide (NiO) is an attractive material due to its excellent chemical stability, as well as optical, electrical and magnetic properties. Furthermore, it is considered to be a model semiconductor with p-type conductivity films due to its wide band-gap energy range between (3.6 - 4.0) eV [11]. The most useful starting point in understanding the structure of a metal oxide is to understand the ionic model. In this research Ni nanoparticles were prepared by simple chemical cost method then using rapid thermal oxidation method to invisitigate NiO thin films. The structure,optical and topographical properties of NiO thin films are investigated.

2. Experimental In a typical procedure, 1.6g of $Ni(NO3)_2$ and Fe_2O_3, (BDH Chemicals Ltd Pool England) was dissolved in 60 ml of PVP (Sigma Aldrich USA) 1WT. % and Re-distilled water was used throughout the experiment. The solution was added into a round-bottom flask with stirring. The color of the mixture was green . About 15ml of NaOH (1M) was rapidly added to the mixture, and a nanopowder suspension was formed as shown in figure 1 . The suspension was kept at 80 °C for 1 h. After cooling to room temperature, the particles were separated by centrifugation and were washed with distilled water to remove any contaminations. NiO:Fe colloidal nanoparticles which are prepared by chemical method are deposited by drop casting technique on glass substrate. It has been taken from the solution by pipette and then drop on glass surface only 5 drops, the particles were then dried by using heater at 80 °C , then XRD spectra for the crystalline NiO:Fe thin film

prepared at Oxidation temperatures 100 ºC All the synthesized NiO:Fe were tetragonal structure according to JCPDS card no.71-1179).X-ray diffractometer (XRD-6000, Shimadzu) was used to investigate the structure and crystalinity of nano-particles. The absorption of the colloidal nanoparticles solution was measured by using UV–Vis double beam spectro-photometer (CECIL, C. 7200, France).

3. Results and discussion

The XRD diffraction patterns of synthesized NiO:Fe nanoparticles film prepared by quick chemical method is shown in Figure (1).This figure reveals three peaks at 2θ = 37.14◦, 44.6◦ and 63.1◦ corresponds to (111), (200) and (220) planes respectively which belong to NiO cubic structure (JCPDS card no.71-1179), furthermore, this figure show another peaks which agreement with the cards (JCPDS 89-7129:Ni, 14-0481:Ni2O3,89-8397:NiO2).The crystal-ite size (D) was calculated by using Scheerer's formula [12]. Where λ is the x-ray wavelength of CuKα source 0.154056 nm, θ is the Bragg,s angle and β is the full width at half maximum (FWHM) of the diffraction peak in radians. The dislocation density (δ) and microstrain (η) values are evaluated by using the following relations.The information on the grain size (D) , dislocations density (σ) , microstrain (η) and density of dislocations of the deposited film has been obtained using Scherer's formula . have been listed as shown in Table 1. In general, by annealing temperature about100 ºC the grain size (D) 50 nm was observed.

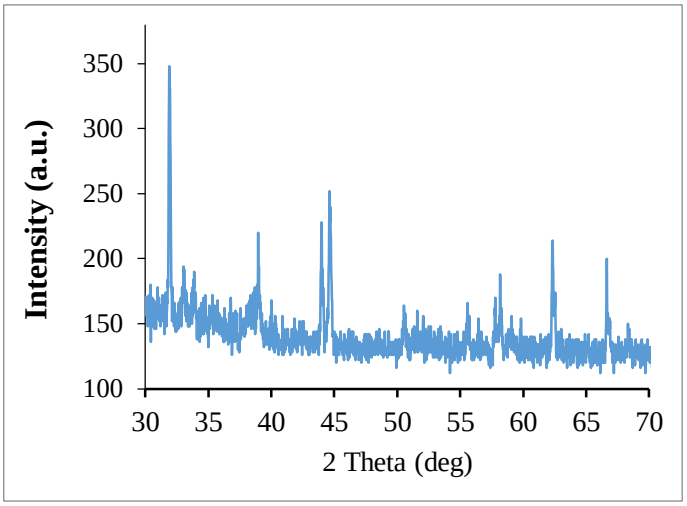

Fig. 1: XRD for NiO:Fe thin film.

Table (1) : X-Ray characterization for NiO:Fe thin film

Thermal Oxidation Temp. ºC	θ (deg)	β (deg)	D (nm)	$\delta \times 10^{14}$ (lines. m^{-2})	$\eta \times 10^{-4}$ ($lines^{-2}.m^{-4}$)	$N \times 10^{16}$ m^{-2}
100	**36.75**	**0.13**	**60.93**	**2.69**	**5.68**	**14**
	38.96	**0.18**	**46.04**	**4.71**	**7.52**	**19**
	43.99	**0.14**	**59.34**	**2.83**	**5.83**	**15**
	44.60	**0.17**	**49.83**	**4.02**	**6.95**	**18**
	51.60	**0.13**	**65.22**	**2.35**	**5.31**	**13**
	56.48	**0.12**	**70.87**	**1.99**	**4.88**	**12**

AFM image of NiO:Fe thin film give the formation of uniform surface on the glass substrate. The topographical properties of the NiO:Fe thin film which prepared by oxidation thin film at 100 º C IS shown in

figure (3), which shows 3D and 2D images. We can observe from this figure that the avgerage diameter is about 80 nm. The surface morphology of the thin film investigated by the AFM analyses is shown very smooth and homogeneous structures .The average roughness is 0.873 nm and the RMS is 1.03 nm .The particles were highly dispersed ball shaped and the grains are homogenous and aligned vertically. The average grain size results disagree with those estimated from XRD due to the fact that the AFM measurement directly visualizes the grains regardless of the degree of structural defects, while the estimation of particle size by XRD is based on size of defect free volume.

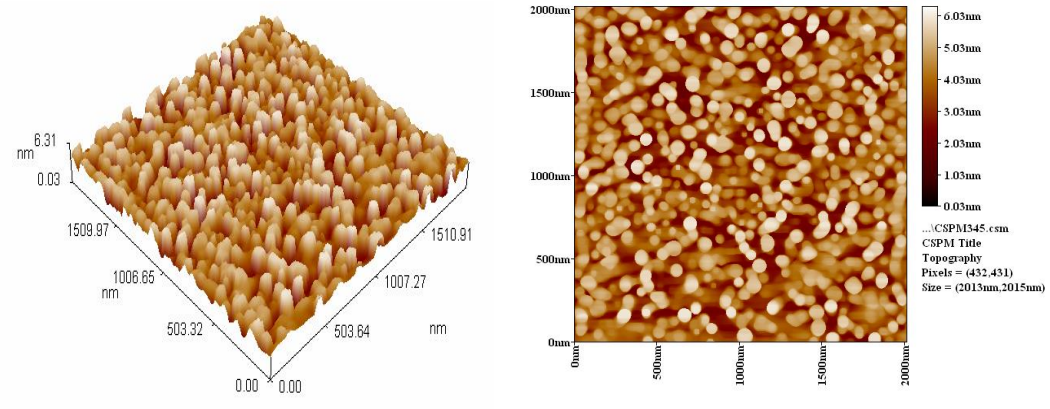

Fig. 2: AFM images of NiO:Fe thin film annealed at (a) 100 ºC.

The Transmittance spectrum is taken by Cary 100 Conc plus UV-Vis Spectro-photometer 300 nm to 1100 nm. The UV –Vis spectra is very important because it is provide the details related with the optical band . The optical transmittance of the NiO:Fe thin film at 100 ºC deposit ON glass substrate increases with increase the wavelength as shown in figure 2. Also, the Figure shows that graph between $(\alpha h\nu)^2$ versus photon renergy (hv) gives the value of direct band gap .The extrapolation of the straight line to $(\alpha h\nu)^2 = 0$, gives the value of band gap . From the UVspectra shows the absorbance decreases with increasing wavelength and the energy gap is 3.2 eV .

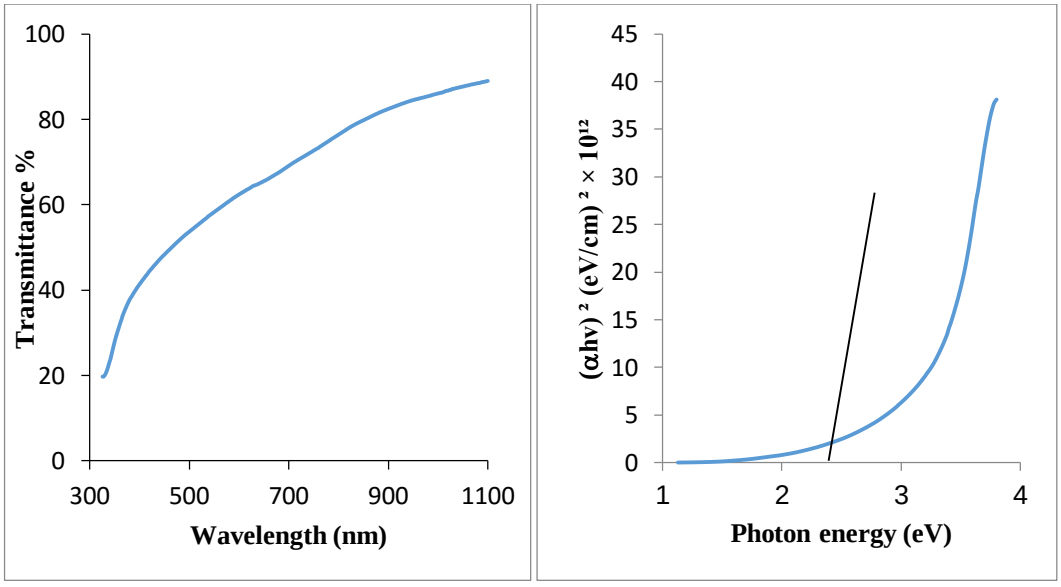

Fig. 3: Transmittion spectrum of NiO:Fe thin film and $(\alpha h\nu)^2$ versus photon energy plot .

The reflectance of NiO:Fe thin film increases to 0.2 when the wavelength 330 nm to greater as shown in figure 5 and the refractive index (n) has been calculated by formulas [13]:

A=LOG (1/T) ……..(1)

R=1-T-A ……..(2)

$\alpha = -[\ln T]\frac{1}{t}$ ……..(3)

where t is the thickness and T transmission. The energy gaps E_g of NiO:Fe thin films were estimated using Tauc relation [14] .

$$\alpha h\nu = C\left(h\nu - E_g\right)^{1/2} \ldots\ldots\ldots \quad (4)$$

where α is the absorption coefficient, Eg is the band gap energy, C is constant $h\nu$ is the photon energy.

$$n = \frac{1+\sqrt{R}}{1-\sqrt{R}} \qquad (5)$$

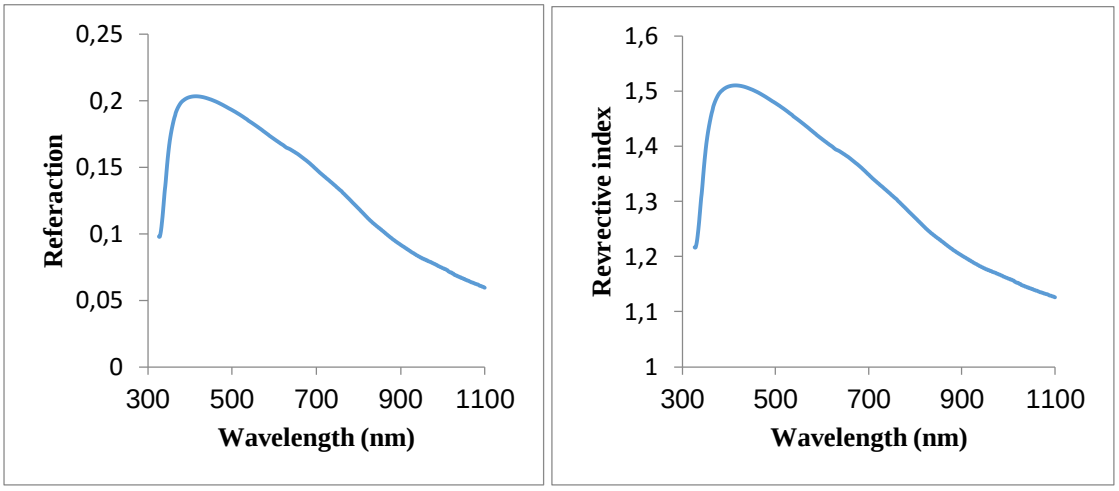

Fig.4: refraction and refractive index spectrum of (NiO:Fe) thin film which prepared by Chemical method deposited on glass substrate .

Figure 5 shows the I-V dark charac-teristics in forward and reverse direction of Al/NiO:Fe/p-Si/Al Photodetector The forward current of Photodetector is very small at voltage less than 2 V. This current is known as recombination current which occurs at low voltages only. It is generated when each electron excited form valence band to conductive band. The second region at high voltage represented the diffusion or bending region ,which depending on serried resistance .In this region; the bias voltage can deliver electrons with enough energy to penetrate the barrier between the two sides of the junction.

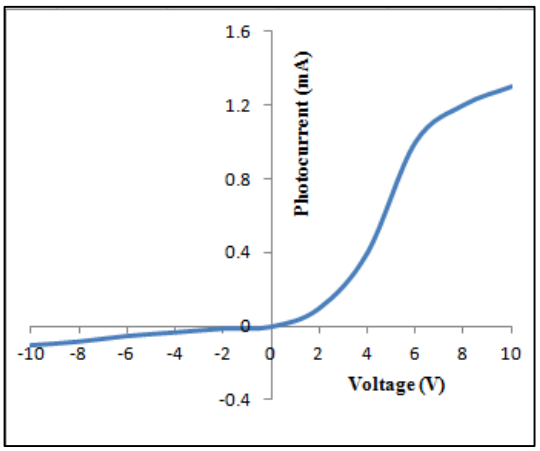

Fig.5 : I-V Charaterristics of Al/ NiO:Fe /Si / Al .

Figure 6 shows that a linear relationship between $1/C^2$ and reverse bias voltage was obtained for the structure. This linear relationship represented the Photodetector two heterojunctions between the

NiO:Fe and Si. The values of the built-in potential have been obtained and it has been found 0.93 volt depending on the etching time and current density. It represents the energy required by the electron to transfer from the NiO:Fe to Si .

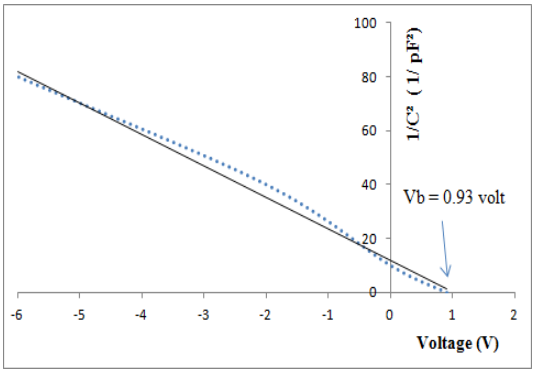

Fig.6: 1/C2 versus reverse voltage Al/NiO:Fe/ Si/Al Photodetectors.

Figure 7 displays the responsivity as a function of wavelength for Al/NiO:Fe /Si/Al Photodetector . It is clear from the figure the maximum responsivity is located at visible region and the other at the NIR region, the spectral responsivity curve of Al/NiO:Fe/Si/Al consists of two peaks of response; the first peak is located at 400 nm due to the absorption edge of NiO:Fe nanoparticles, while the second region is located at 800 nm due to absorption edge of silicon.

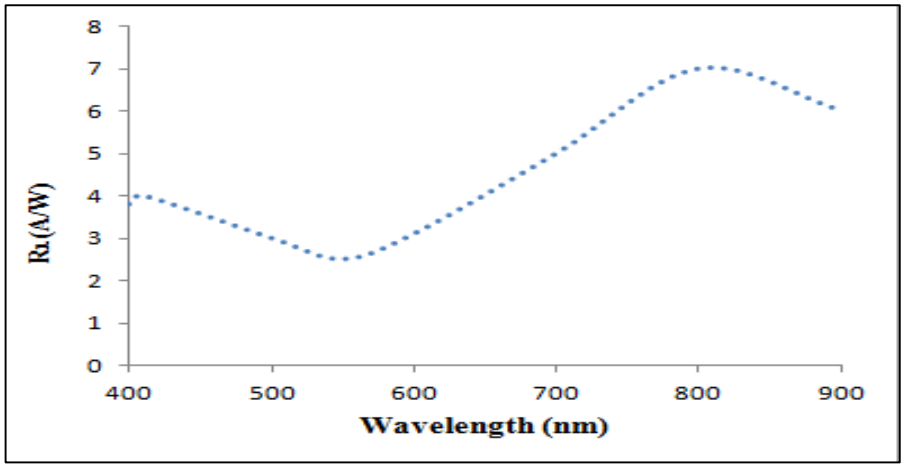

Fig. 7 : spectral responsivity as afunction of wavelength of of Al/ NiO:Fe /Si / Al .

4. Conclusion

The synthesised CdS NPS were in nanosized 80 nm prepared in methanol by chemical method and the optical properties revealed that the direct band gap of NiO:Fe NPS indicated to the effect of quantum size. X-ray diffraction (XRD) measurement disclosed that the CdS NPS are polycrystalline and have hexagonal crystal structure and no other phases were noticed, Deposition of NiO:Fe NPS on silicon (Si) gave suspensions photodetector characteristics enhanced the properties porous photodetectors. The spectral responsivity (Rλ) of Al/NiO:Fe/Si/ Al photodetector was around 0.7A/W at ≈ 800 nm wavelength due to the absorption edge of silicon and around 0.4A/W at ≈ 415 nm wavelength due to the absorption edge of NiO:Fe NPS .

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