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Research Paper

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The growth of manganese oxide thin films by spray pyrolysis technique

Physics

KEYWORDS : Manganese oxide, dielectric, refractive index, Band gap.

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ABSTRACT

Manganese oxide (MnO) thin films were prepared using spray pyrolysis technique at two temperatures (350˚C and 400˚C) on glass substrate. The MnO films were characterized by ultra violet (UV-VIS) optical spectroscopy, x-ray diffraction. The optical properties such as variation of Transmittance, Absorption, Reflection, refractive index, Extinction co-efficient on wave length and absorption co-efficient on band gap were analysed. Dielectric properties of the materials were also determined.

1.Introduction :

Manganese Oxide is a transitional material having interesting physical and chemical properties. Manganese dioxide (MnO)2 based thin film electrochemical capacitors have received numerous attentions since Pang et al. reported a specific capacitance value of 720F/g for ultra-thin MnO2 film in a mild aqueous electrolyte [1,2]. MnO2 thin film appears to be a promising electrode material in batteries and electro chemical capacitors due to low cost of raw materials, low toxicity and environmentally benign and excellent electro chemical properties [3,4]. MnO has its opto-electronic applications. MnO was used as a substrate in the synthesis of magnetic oxide peroviskite compounds which have a variety of electrical and magnetic properties like metal insulator transistor and colossal magneto resistance [5-7], catalysts, sensors [8], at present many techniques are available for preparation of different structures of thin films MOCVD [9], potentiostatic electrolysis [10], sol-gel [11]. They can also be prepared each other by varying the temperature and atmosephere (vaccum or air oxygen, hydrogen etc.,) of calcinations [12]. This paper reports the preparation of MnO thin films by spray pyrolysis technique and discussion of its optical dielectric, structural properties.

2.Experimental procedure :

MnO thin films were grown on glass substrate using typical spray pyrolysis technique the spraying solution was prepared by dissolving 0.1 M of manganese chloride in double distilled de-ionized water along with 2 to 3 drops of HCl. The substrate temperature was maintained at 350°C and 400°C (±5°C) through a thermo couple (Pt-100) as a sensor for temperature controller. Purified air was used as a carrier gas and it was maintained at 0.4kg/cm2 with constant flow rate of about 3ml/min. The nozzle to substrate distance was kept at 30 cm. The rate of MnO thin film formation takes place as follows

$MnCl_2 + H_2O \rightarrow MnO + 2HCl$

Optical analysis, structural analysis were carried out using Carry 500 Varian UV-VIS NIR spectrophotometer, a JEOL JDX service having CuKα radiation (λ =1.5406 A˚) respectively.

3. Result and Discussion :

3.2 Optical properties :

Fig [1] shows the transmission spectrum as a function of wave length for MnO thin film samples coated at two different temperatures and it is evident from the figure that the films have less transmission for wave lengths that are with in UV-region and the transmission starts at the visual spectrum and reaches the maximum of 45% at the temperature 350°C and at the temperature 450°C it reaches about 70% at the end of the visible region and near to the IR region. Fig [2] shows the absorption spectrum as a function of wave length. It is clear from the figure that MnO thin film shows less absorption of light waves in IR region so that large amount of light can be transmitted which holds good for solar cell application such as rechargeable batteries [8].

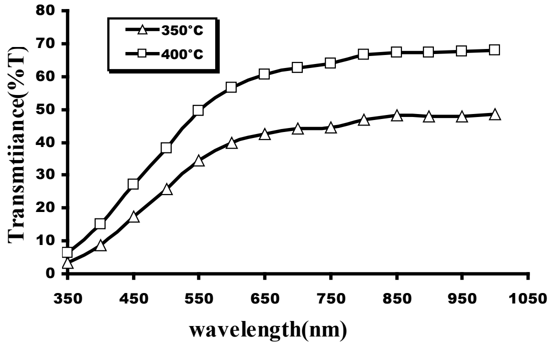

Fig [1] The transmission spectrum as a function of wavelength.

From the optical transmission and absorption, the reflection(R) of the film can be calculated using the relation

R = [1-(A+T)]

Where, A → optical absorption, T → optical transmission of the film. Reflectance as a function

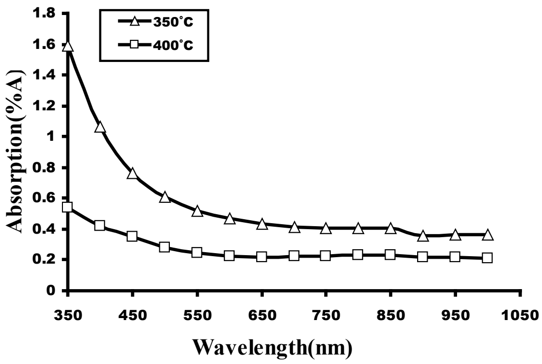

Fig [2] The absorption spectrum as a function of wavelength.

of wave length is shown in fig[3] at the temperature 350°C it shows linear increase of spectrum from the wave length (400-1000) nm where as at the temperature 400°C reflection decreases from (400-800) nm, since reflection is less compared to other material, MnO thin films can be used as antireflection coating.

Fig [4] shows the variation of absorption co-efficient (α) with photon energy eV. The absorption co-efficient sharply decrease near the band edge indicates the good crystallinity of the film.

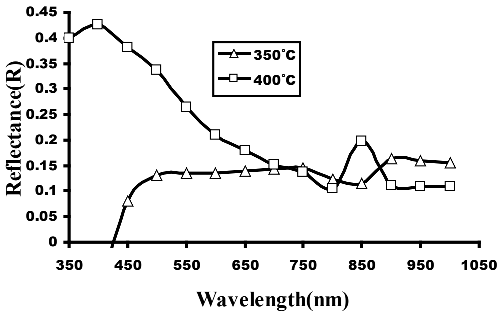

Fig [3] Reflectance as a function of wave length.

Extinction co-efficient of the film was calculated using the relation

k=2.303 log (1/T) λ/4πd

Where, T → observed transmittance, λ → wavelength of the corresponding transmittance, d → thickness of the film. From fig [5] it is seen that extinction co-efficient decreases as temperature increases this is due to decrease in thickness of the film.

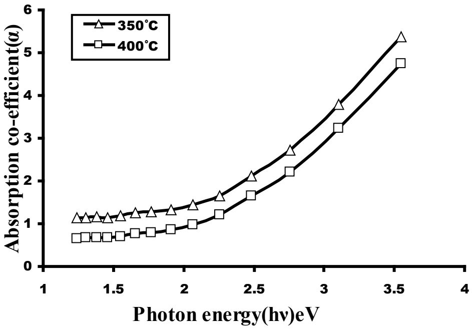

Fig [4] shows the variation of absorption co-efficient (α) with photon energy eV.

It is seen from Fig [6] that, for MnO thin film, the refractive index (n) decreases to the wave length from (400-1000) nm at the temperature 400°C and at the temperature 350°C it shows linear increase from (450-1000) nm. This difference is due to the different density of the thin films and different fitting approach.

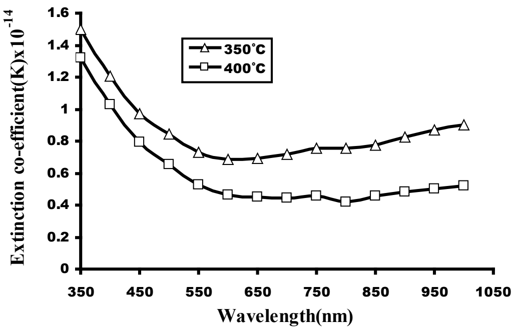

Fig [5] Extinction co-efficient as a function of wavelength.

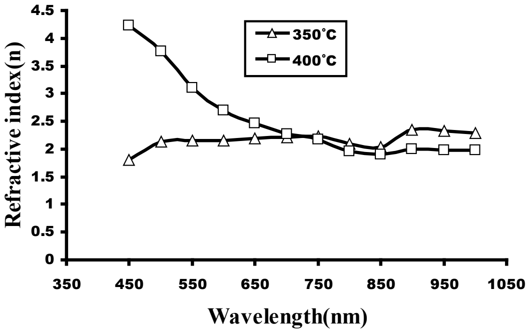

Fig [6] Refractive index (n) as a function of wavelength

Fig [7] shows (αhν)2 versus (hν) for MnO thin film the band gap energy at the temperature 350°C is 3 eV and at the temperature 400°C is 2.9 eV the band gap energy decreases with increase in temperature. This possibly due to evaporation of water molecules of the film. However the band gap energy may be affected by the thickness of the film and its crystallite size.

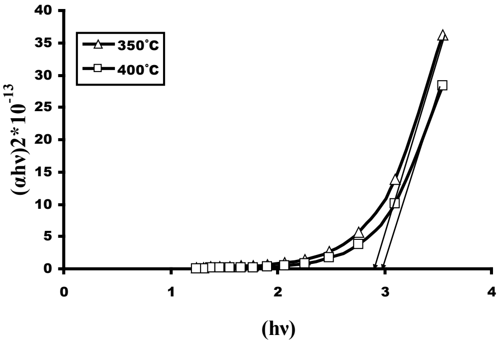

Fig [7] (αhν)2 versus (hν)

3.2 Dielectric property :

The dielectric constant (ε) of MnO films was calculated using the relation

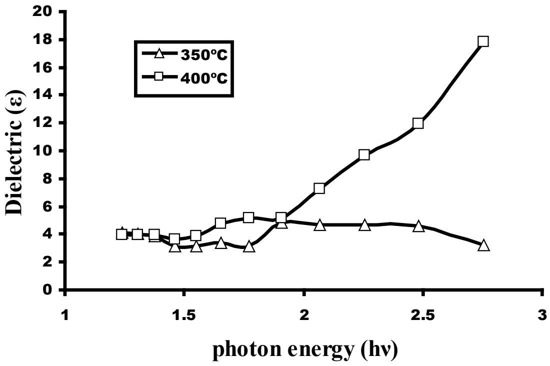

Fig [8] Dielectric (ε) as a function of photon energy

where, ε1 and ε2 are the real and imaginary parts of the dielectric constant. The ε1 and ε2 for different photon energies can be obtained from all the values of 'n' and 'k' by using the relation

ε1 = n2-k2 and ε2 = 2nk

From fig [8] it is dielectric (ε) shows linear increase with photon energy for 350°C and it does not show much variation for 400°C this is due to difference in thickness.

Conclusion:

Manganese oxide thin films were grown by spray pyrolysis technique at various temperatures (350°C – 400°C) at fixed concentration of 0.1M. From the optical data such as transmittance, absorption, reflection it is clear that the material can transmit large amount of solar energy with less absorption and reflection. MnO can be used as antireflection coating. The optical band gap energy at the temperature 350°C is 3 eV and at the temperature 400°C is 2.9 eV are calculated. These properties clearly indicates that such films may find an application in the fabrication of thin film heterojunction solar cells as an 'absorber'.

Acknowledgements

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