STRUCTURAL AND OPTICAL PROPERTIES OF CERIUM DOPED V_2O_5 THIN FILM USING SPRAY PYROLYSIS TECHNIQUE

K. Veera Prabhu[1] , , N.R. Senthil Kumar[2] and T. Rajesh Kumar*[3]

[1]Department of Physics, MKU Evening College, Dindigul, Tamil Nadu, India
[2]Department of Physics, Sourashtra College, Tamil Nadu, India
[3] Department of Physics, G.T.N Arts College, Dindigul, Tamil Nadu, India

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Abstract - *The cerium doped vanadium pentoxide (V_2O_5) thin film were prepared by spray pyrolysis technique on glass substrate. The structural, morphological, optical and electrical properties were characterized by X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), UV-visible spectrometer. The optical band gap of cerium doped V_2O_5 thin film was varied from 2.99 eV to 2.24 eV for the various molar concentrations of cerium like pure, 1%, 3% and 5%.*

Key Words: vanadium pentoxide, Spray pyrolysis, structural properties, optical properties, SEM

1. INTRODUCTION

Vanadium pentoxide (V2O5) is a well-known catalyst for oxidation, but in the last two decades investigation about V2O5 has opened new application areas such as lubricants [1] electrochromic devices and optoelectronic switches [2-4] along with the development of thin film technologies. The present developmental trend is towards newer types of devices, monolithic and hybrid circuits, field effect transistors, metal oxide semiconductor transition sensors for different applications, switching devices, cryogenic applications, high density memory systems for computers etc [5]. In the present work, Cerium doped V_2O_5 thin film has been prepared by Spray Pyrolysis Technique (SPT) for different concentrations of cerium like pure, 1, 3 and 5 mole%. The structural, morphological, optical and electrical properties has been studied by using the X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), UV-visible spectrometer, luminescence spectrometer.

2. Experimental work

Cerium doped V_2O_5 thin films were obtained with Vanadium Chloride (VCl_3) as precursor in water solvent and Cerium is a dopant. 0.03M of Vanadium Chloride (VCl_3) first dissolved in 20 ml of Double Distilled water, and then molar concentration(0.03M in 20ml double Distilled Water) of cerium Nitrate varied from pure (0%),1%,3% and 5% and stirred for 1 hours at room temperature. Totally four set of samples were prepared by varying the molar concentration of Cerium Nitrate by fixing the Vanadium Chloride concentration. The experiment the parameters like Substrate temperature (450°C), substrate to nozzle distant (25cm), spraying time (3 min) and pressure (45 Pa) are optimized. The prepared precursor solution was sprayed on the glass substrate to form cerium doped V_2O_5 thin film.

2.1 Material Characterization

The structure of the prepared material was found by using X-ray powder diffraction with x'per PRO Model. SEM is used to find the morphology of the prepared V2O5 thin film with VEGA3 TESCAN model and EDAX analysis by Bruker Nano Gmbh, Germany. The optical properties of the prepared samples were studied using UV-Visible spectrophotometer perkin elmer lamda 25 and photo luminescence studies on Jasco-8000.

3. RESULTS AND DISCUSSION

3.1 Structural Studies

Fig.3.1 shows that the XRD profile of un doped and Ce:V_2O_5 thin films prepared at 1%, 3% and 5% . The spectrum reveals that the strong peaks are observed at 2θ = 19.9º and this peaks are well assigned to orthorhombic structure with lattice parameter a=9.946 Å, b=3.585 Å and c=10.042Å reported in JCPDS card (85-2422). The preferred orientation of Ce:V_2O_5 is along (201) lattice plane and it is blue shifted with increase of doping concentration [6]. The predominant peak observed at 2θ = 19.9° for pure and 19.5° for 5% Ce: V_2O_5 corresponds to the (2 0 1) reflection. It is observed that all the atoms are intense to arrange single crystalline nature by increase of doping percentage with their considerable peak shift towards lower angle. Therefore, structural properties slightly changed with the incorporation of Ce atoms in the V_2O_5 matrix. There is no other secondary phase formation detected in XRD pattern.

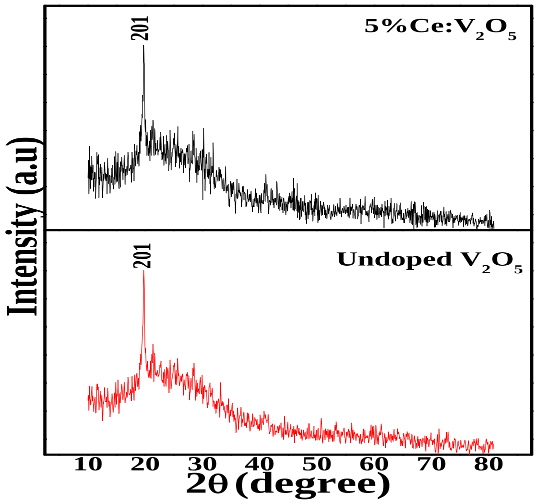

Fig.3.1 XRD patterns for pure and cerium doped V_2O_5 thin film

3.2 Surface Morphology

The SEM image shows (Fig. 3.2) that the prepared sample pure and doped cerium for different concentration like 0, 1, 3 and 5%. The morphological studies revels that to increase the concentration of cerium the particle size and homogeneity are improved. The film 3% dopant has the good grains compared to the other dopant concentration. The Vanadium, Oxygen and Cerium are presented in the film to confirm the EDAX analysis and no other impurities are presented.

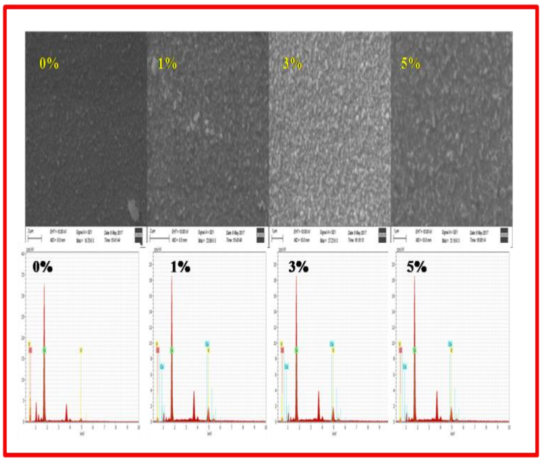

Fig. 3.2 SEM images of different concentration of cerium doped V_2O_5 thin film with EDAX analysis

3.3 Absorption spectrum

In Fig. 3.3 depicts the UV- Vis absorption spectra of pure and cerium doped films and recorded in the wavelength range from 300 to 1000 nm. The maximum absorption of for all the samples is in the range of 380-420 nm. It shows that the absorbance of doped V_20_5 increases with increasing dopent level. The band gap of the prepared film has been calculated by Tauc's plot method as shown in fig.3.4. The band gap of the cerium doped V2O5 film is found to be 2.99, 2.84, 2.24 and 2.63eV for the dopant concentration of 0%,1%,3% and 5% respectively.

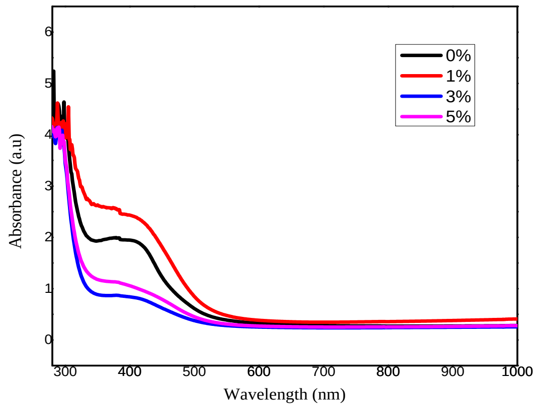

Fig.3.3 Absorption Spectrum of different concentration of cerium doped V_20_5 Thin film

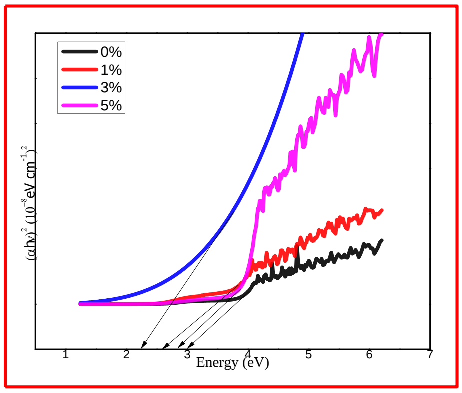

Fig 3.4 Band Gap of cerium doped V_20_5 Thin film

3.4 Photoluminescence studies

Photoluminescence (PL) Spectra recorded at room temperature for different mole percentage of cerium doped in V_20_5 thin films are shown in fig.3.5. The

Excitation wavelength was recorded at 520 nm. The Emission spectra were recorded in the range of 540-800 nm. The emission peak observed at 619 nm is due to recombination of electron – hole pairs. The PL spectra of 3% Ce: V_2O_5have higher luminescence intensity compare to other concentration it may be due to the structure defects on the surface [7]. The peak at 619 nm is responsible for recombined emission from the lowest split off bottom of the conduction V 3d band to the top of the valance band O 2p transitions [8]. Interestingly, the emission spectra revealed that the Ce:V_2O_5 thin films have exhibited considerable enhancement in the luminescence properties due to Ce atoms incorporation with V_2O_5.

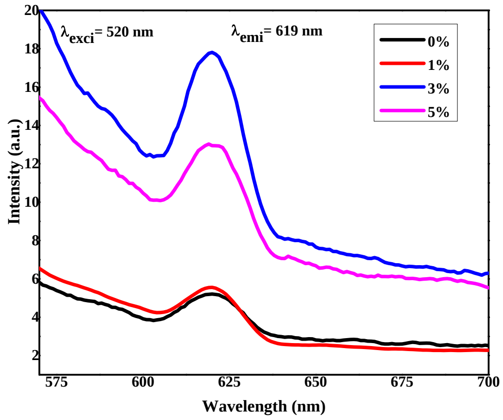

Fig. 3.5 photoluminescence spectra of different concentration of cerium doped V_2O_5 thin films.

4. CONCLUSION

The cerium doped V_2O_5 thin film has been prepared by spray Pyrolysis technique. The surface and morphological studies suggests that the film prepared at 3% Ce:V_2O_5 having good crystallinity and homogeneity distribution of particles. Optical studies depicts that the film prepared at 3% of dopant concentration gives the minimum band gap of 2.24 eV and also having the high emission intensity at the wave length 619 nm. Among the different dopent ratio 3% Ce:V_2O_5 is suitable for device fabrication.

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