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Comparison of MoO_3, In_2O_3/MoO_3 and TiO_2/MoO_3 Thin Films by a low-cost Fabrication Mechanism

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Abstract: In this investigation, we report the physical properties of MoO_3, In_2O_3/MoO_3 and TiO_2/MoO_3 (bilayer) thin films synthesized by a perfume atomizer method. XRD analysis was employed to evaluate the crystalline structure of the single layer film and also of the bi-layers. It exhibited an enhanced crystalline property for a significant increase in grain size. The optical transmission studies showed an appreciable result in In_2O_3/MoO_3 bilayer thin film compared to the monolayer and showed the variation of band gap from the prepared films. An enhanced photoluminescence emission was also found at 598 nm for all the prepared films.
Keywords: Bilayer thin films; Structural properties;Perfume atomizer; Photoluminescence.

Introduction and Experimental details

An eminence research in the view of scientific and technological application aspects is widely based on transition metal oxides with diverse structural and optical properties have been focused in recent years. Among the transition metal oxides MoO_3 is found to be a suitable candidate for many technological applications such as electrochromic display devices, optical memories, gas sensors and lithium batteries [1-2]. As there is no much studies on bilayer thin films of In_2O_3 /MoO_3 and TiO_2/MoO_3, other than few attempts about doped metal oxide thin films [3-4], we wish to report the possible results obtained in this investigation exploiting a novel and cost-effective, simplified spray pyrolysis method.

MoO_3, bilayer In_2O_3/MoO_3 and TiO_2/MoO_3 thin films were prepared by a perfume atomizer method with constant temperature of 450° C. $MoCl_5$, $InCl_3$ and $TiCl_4$have been considered as sources of MoO_3, In_2O_3 and TiO_2.The steps involved in preparing the sources are of the following: (i) To start with an appropriated amount (0.03 M) of$MoCl_5$ was dissolved in 5 ml of methanol along with 35 ml of doubly distilled water and stirred vigorously using magnetic stirrer for longer period of time until we obtain a transparent solution for the preparation of MoO_3 thin film (for mono and bi-layer).(ii) For the preparation of In_2O_3 solution, 0.02 M of $InCl_3$ was dissolved in ethanol with distilled water and the final transparent solution was processed by continuous stirred as the way shown above. (iii)Similarly, a required amount of $TiCl_4$(0.02 M) was dissolved in the mixture of 5ml of HCl and 35 ml of double distilled and final solution was arrived through stirring process. The volume of the precursor solution was taken as 40 ml for fabrication process of these films. At first, on three glass substrates, MoO_3solution was sprayed and two of them have been kept ready for the coating of In_2O_3 and TiO_2. The prepared source solution of In_2O_3 has been coated over the MoO_3 layer and similarly the solution of TiO_2 coated over the MoO_3 layer. Thus, three substrates with MoO_3, TiO_2/MoO_3 and In_2O_3/MoO_3 were subjected for characterization studies. The thickness of the prepared samples was estimated by weight gain method. The structural, optical and photoluminescence studies were carried out by X-ray diffractrometer, UV-Vis-NIR spectrometer and spectrofluorometer respectively.

Results and Discussion

XRD patterns of MoO_3, In_2O_3 /MoO_3 and TiO_2/MoO_3 films are depicted in Fig. 1(a), all film exhibited three distinct well defined diffraction of (0 2 0), (0 4 0) and (0 6 0) reflections, which attributed to orthorhombic α – MoO_3 phase (JCPDS card no. 00-005-508).When In_2O_3layer was deposited over MoO_3 film, there is an additional two Bragg reflection peaks (2 2 2) and (4 0 0) were found whichare correspond to cubic phase of In_2O_3, XRD pattern of TiO_2/MoO_3 show only α – MoO_3 phase there was no peaks were found for TiO_2phase due to its amorphous nature.

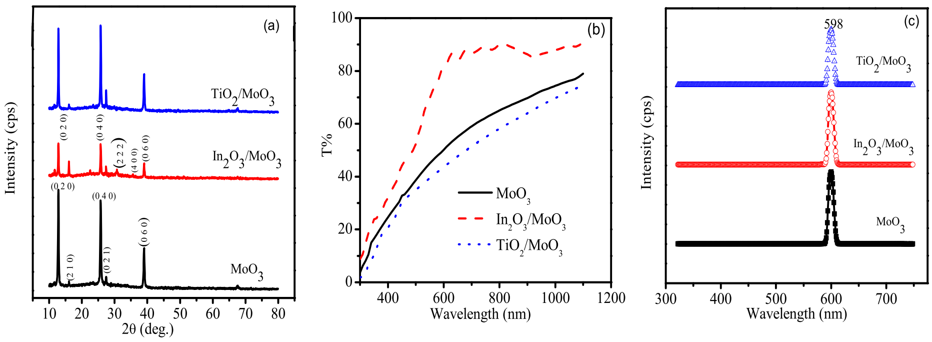

Fig. 1 (a) XRD patterns (b) Transmission spectra (c) PL spectra of MoO_3, In_2O_3 /MoO_3 and TiO_2/MoO_3

Fig. 1(c) shows the photoluminescence (PL) spectra of the MoO_3, In_2O_3 /MoO_3 and TiO_2/MoO_3 thin films with the excitation wavelength of 350 nm, all films exhibit single broad and intense emission peak located at the wavelength range of 598 nm (near 600nm), this strong emission peak was serves a potential candidate for red laser production at 598 nm [5].Transmission spectra of deposited films, as shown in Fig. 1(b), a high transmission of 88%- 90% was observed for In_2O_3/ MoO_3film, relatively a low transmission of 58% - 74% was found when TiO_2 filmas a top layer on MoO_3 film in the wavelength range of 800 nm – 1100 nm.A single layer of MoO_3 film has maximum transmission of 65%-78% was observed in region of 800 nm – 1100 nm.The optical constants estimated from PUMA software [6], were absorption coefficient and refractive index and they areshown in Fig. 2(a & b).A highest absorption value of 7.5 cm^{-1} was obtained for MoO_3 film and lower value of absorption coefficient 2.4 cm^{-1} and 1.8 cm^{-1} found for TiO_2/MoO_3 and In_2O_3/MoO_3 thin films.A high refractive index of 4.5 was obtained for single layer film of MoO3 which is due to maximum absorption edge has been reported through the present work, as it can be employed as a optical limiter in UV-Vis-NIR regions.The band gap of these films was estimated from the Tauc's plot as listed in Table. 1.A band gap value of bulk MoO_3 is 2.9 *eV*, the variation in band gaps was found for bilayer thin films. A high band gap (3.3 *eV*) attributed to the following reason: the band bending effect at particle boundaries due to high particle size of this film, which increases band edge become sharp and thus band gap increases. A decrement of band gap may be the reason of increase in tensile strain that influences the interatomic space.

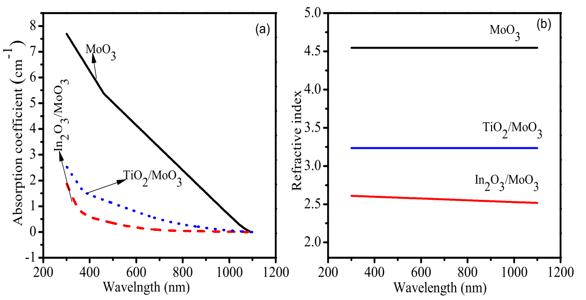

Fig. 2(a) Absorption and (b) Refractive index of MoO_3, In_2O_3 /MoO_3 and TiO_2/MoO_3

Table 1: Summary of Thickness, FWHM, grain size, dislocation density, refractive index and band gap.

Sample	Thickness (nm)	FWHM (deg)	Grain size (nm)	Dislocation density (lines/meter)	Refractive index	Band gap (*eV*)
MoO_3	105	0.26	30.28	1.09×10^{15}	4.5	2.9
In_2O_3 /MoO_3	284	0.23	34.73	8.28×10^{14}	2.7	3.3
TiO_2/MoO_3	328	0.2	39.99	6.25×10^{14}	3.23	2.7

MoO_3, In_2O_3 /MoO_3 and TiO_2/MoO_3 thin films were successfully fabricated by a perfume atomizer method. The structural analysis revealed that the enhancement of crystallinity of prepared samples and high optical transmission in visible-NIR region was found for In_2O_3 /MoO_3 films. An intense photoluminescence peaks were found at the region of 598 nm (near 600 nm) for all the samples, well suitable for optoelectronic applications.

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