Preparation and Characterization of MoO_3 Thin Films by Spray Pyrolysis Technique

[1] G.Uma Devi, [2] S.Sathish kumar,[3] K.Saravana Kumar,[4] S.Mani Menaka
[1]Associate Professor,[2,4] Research Scholar,[3]Assistant Professor
[1]PG & Research Department of Physics
[1]Govt.Arts College, Coimbatore-641018, Tamilnadu, India

Abstract : The MoO3 thin films were coated on quartz substrate using spray pyrolysis method for various concentrations of precursors at 400°C temperature. From the XRD studies the coated film has a orthorhombic α-MoO_3crystallites was at higher orientation in the planes of (040) and (060). Surface morphology revealed by the FESEM show nanorods and nanoplates structures for 0.05M and 0.075M concentrations.The optical properties confirmed that the band gap values range from 3.1 to 2.8 eV. The I-V variation observed at 0.05M and 0.075M precursor concentration were higher than other concentrations.

IndexTerms -Molybdenum tri-oxide, Thin Film, Spraypyrolysis,Nanoplates, Grain size, Absorption

I. INTRODUCTION

The deposition method in thin film decides the property of the film. In physical method it uses mechanical and thermodynamic processes in production of a thin film. At the same time in chemical methods, it involves chemical reactions and liquid precursors, it further classified into gas phase and liquid phase. In gas phase some of the methods are, chemical vapor deposition (CVD), laser CVD, photo CVD etc. In liquid phase, some methods are sol-gel process, electrodeposition, chemical bath deposition, electrolessdeposition, anodization, spray pyrolysis, liquid phase epitaxy etc. In these methods Spray pyrolysis is an easy and useful technique for deposition.

II.EXPERIMENTAL DETAILS

2.1Film Preparation:

MoO_3 thin films were deposited on quartz substrates using the spray pyrolysis technique. First, we have taken of different concentrations (0.025 M, 0.05 M, 0.075 M, and 0.1 M) of ammonium molybdate hepta tetrahydrate $(NH_4)_6MO_7O_{24}.4H_2O$ [1] as a precursor. The precursor were dissolved in 25 ml deionized water. The solution was homogeneously stirred for half an hour. To pulverize solution air was injected at the constant pressure of 2.2 kg/cm^2. The substrate was kept at constant temperature of 400°C [2] .

2.2 Film characterization:

MoO_3thin film were successfully coated and characterized on structural analysis by using X-ray Diffraction. Surface analysis of a material are taken by Scanning Electron Microscopy and the optical behavior of the films are analyzed by using UV-VIS Spectroscopy. Further electrical behavior of the films were analyzed by two probe instrument.

III. RESULT AND DISSCUSSION

3.1 Structural Properties:

Fig. 3.1 (a, b) shows X-ray diffraction (XRD) spectrum of MoO_3 thin films of 0.025M, 0.05M, 0.075M and 0.1M precursor concentrations at 400^0C substrate temperature prepared by nozzle spray pyrolysis method. In these all graphs revealed that planes are indexed with good crystalline nature and sharp peaks are found in the XRD spectra. The X-ray investigation at 0.05M revealed that the crystalline phase have been confirmed the preferential orientation along (020), (040), (060) planes directions. At the lower concentration of 0.025 M, MoO_3started appearing and as the concentrationincreases,the grain size are increased. The structure of MoO_3 is confirmed by orthorhombic phase [3]of **JCPDS No: 76-1003**. The various parameters calculated are listed in Table 3.1

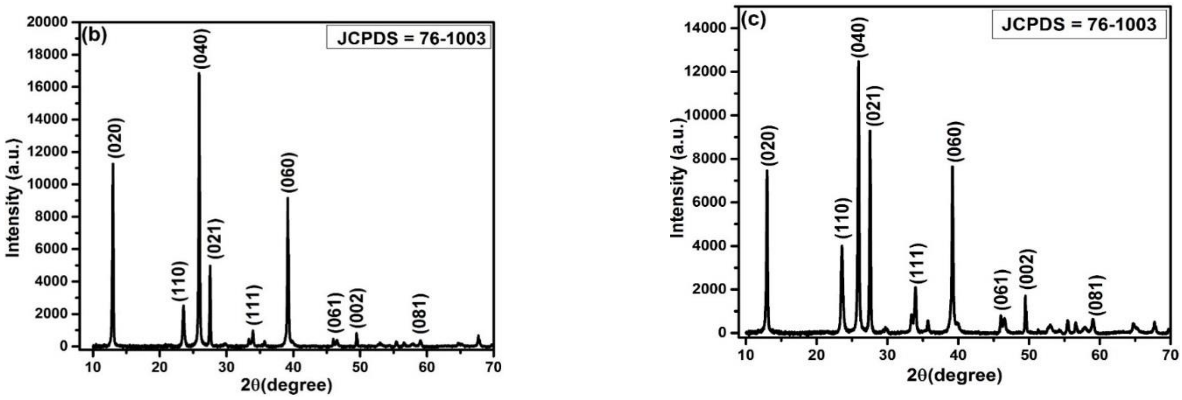

Fig.3.1(a) and (b) The XRD patterns of MoO_3 thin film at 0.050M and 0.075M

Table.3.1 Structural parameters of MoO_3 thin films of different precursor concentrations at 400ºC substrate temperature

S. No	**Precursor concentration (M)**	**Grain size (nm)**	**Microstrain ($\varepsilon \times 10^4$) (lines²/m⁴)**	**Dislocation density ($\delta \times 10^3$)**	**Lattice parameter (A°)**		
					A	**B**	**c**
1	0.050	56.90	5.805	0.3188	3.756	13.802	3.687
2	0.075	67.32	4.001	0.2237	3.780	13.632	3.125

3.2 Field Emisson Surface

Morphology

The surface morphology of the prepared MoO_3 thin films were observed by field emission electron microscopy (FESEM) shown in Fig.3.2 (a,b). Surface morphology revealed nanorods and nanoplates [4] structures at 0.05 M and 0.075 M concentrations, respectively. The optimum nanostructure formation are observed at 0.05 M and 0.075 M precursor concentrations as oriented attachment of added atoms. Due to higher surface to volume ratio of these nanoplates, are used for sensing applications. At higher precursor concentration of 0.1 M, densely packed grain are seen and this may be due to higher incoming nucleating sites during spray pyrolysis process.

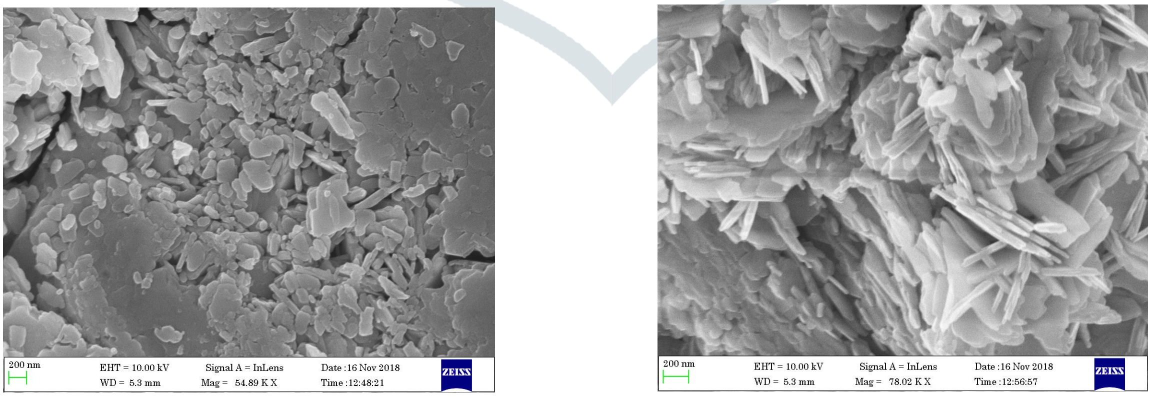

Fig.3.2 (a) and (b) FESEM images of MoO_3 at 0.050M and 0.075M

3.3Optical properties:

Fig.3.3 (a, b, c and d) shows the absorbance and transmission spectra of various precursor concentrations at 400ºC substrate temperature. These spectra of in the wavelength region of 200–900 nm. However, the absorbance value increases steeply in the around UV region. It is observed that as the precursor concentration increases from 0.025 M to 0.1 M, the absorbance edge increases from 396 to 434 nm andthe optical band gap values decreases [5] from 3.1 to 2.8eV.Oxygen defects in the coated films lead to increased roughness and band gap values increase with the packing density of the films. These values of the coated film show good agreement with previous works.

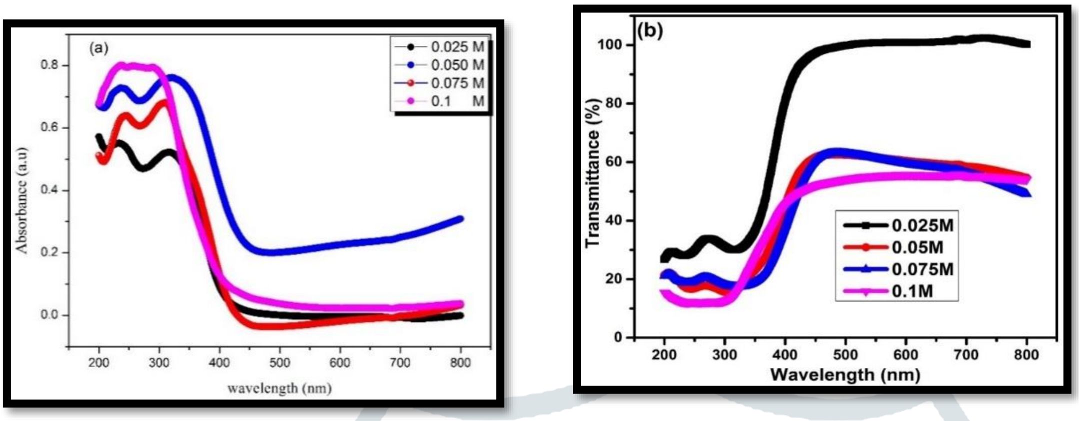

Fig.3.3.Absorbanceand Transmission spectra of MoO3 nanostructured thin films at variousconcentrations(a) 0.025M (b) 0.05, (c) 0.075 and (d) 0.1M at 400ºC substrate temperature

Table 3.2.Energy Band Gap of MoO3 nanostructured thin films at various concentrations (a) 0.025M (b) 0.05, (c) 0.075 and (d) 0.1M at 400ºC substrate temperature

Samples	Absorption edge(nm)	Energy band gap (eV)
0.025	396.88	3.14
0.050	409.79	3.03
0.075	423.81	2.93
0.1	434.71	2.85

3.4 Photoconductivity properties:

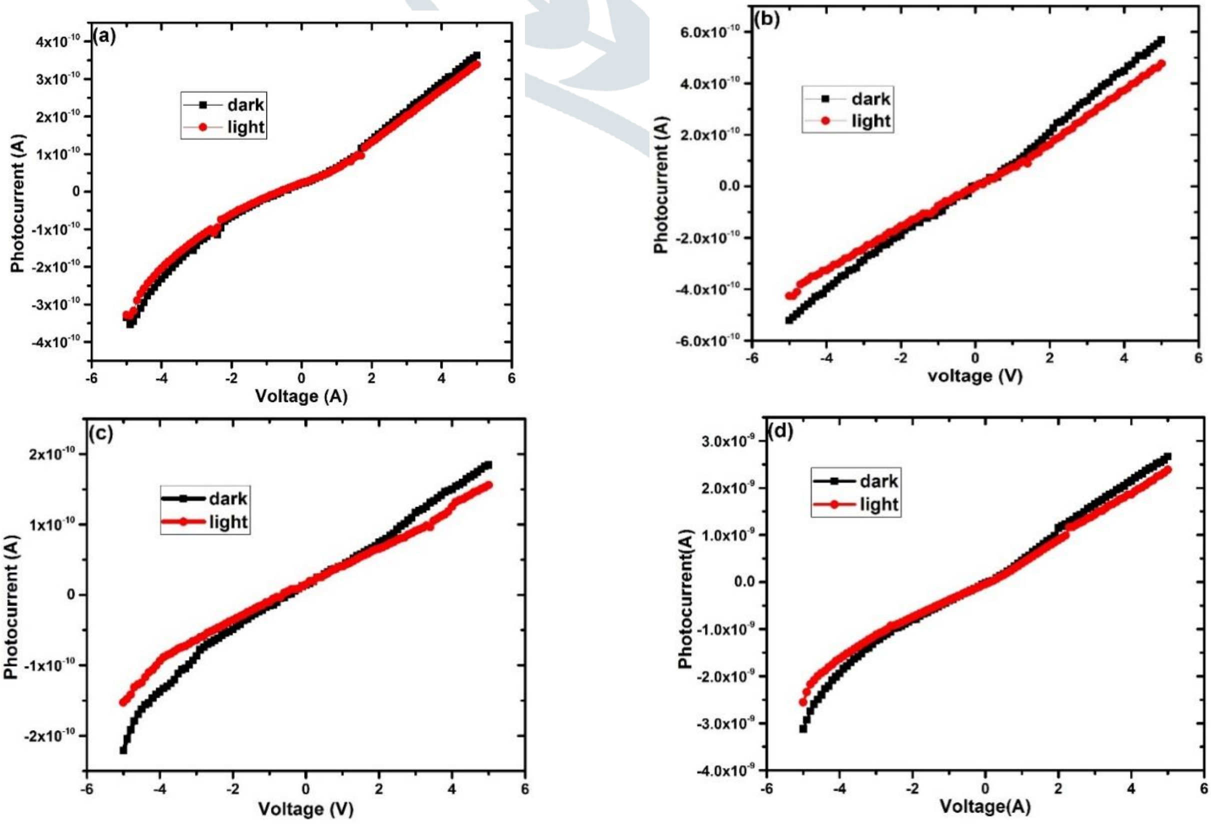

Fig. 3.4current- voltage (I-V) graph of MoO_3 nanostructured thin films of (a)0.025 M, (b) 0.05 M, (c)0.075 M and (d) 0.1 M concentrations

Fig. 3.4 (a, b, c and d)showsthat current-voltage graph of MoO_3 nanostructures with respect to different applied bias voltages under dark and UV light irradiation. From the I–V measurements, it can be observed that the photocurrent upsurges with the increase of the applied bias voltage it may due to increase in the carrier drift velocity. The nanoplates layer structured thin films revealed that increasing trends of photocurrent at UV light irradiation. Higher photocurrent variation were observed at 0.05 M and 0.075 M precursor concentration than the 0.025 M and 0.1 M concentrations. It may due to the higher surface to volume ratio of nanoplate layer structure which facilitated that good performance of photoconduction property.

IV.CONCLUSION

The MoO3thin films were coated on quartz substrate using spraypyrolysis method for various concentrations of precursors at 400°C temperature. From the XRD studies the coated film has a orthorhombic α-MoO_3 structure and the crystallites were at higher orientation in the planes of (040) and (060). Surface morphology revealed by the FESEM show nanorods and nanoplates structures for 0.05M and 0.075M concentrations. Due to higher surface to volume ratio of these nanoplates are used as sensors. The optical properties confirmed the band gap values decreases from 3.1 to 2.8 eV. Oxygen defects in the coated films lead to increased roughness and band gap values increase with the packing density of the films. Higher I-V variation were observed at 0.05M and 0.075M precursor concentration than other concentrations. MoO_3nanoplate layered structures were facilitated the good performance of photoconduction property.

REFERENCES

[1] A. Boukhachem[a,*], C.Bouzidi[b], R.Boughalmi[a], R. Ouerteni[c], M.Kahlaoui[d], B.Ouni[a], H. Elhouichet[b], M.Amlouk[a], Ceramics International 40 (2014) 13427–13435.

[2] H.H. Afifya, S.A. Hassana, A. Abouelsayedb,*, S.E. Demiana, H.A. Zayedc,Thin Solid Films 623 (2017) 40–47.

[3] H.H. Afify[a], S.A. Hassan[a], A. Abouelsayed[b,*], S.E. Demian[a], H.A. Zayed[c],Materials Chemistry and Physics 176 (2016) 87-95.

[4] A.A. Mane, M.P. Suryawanshi, J.H. Kim, A.V. Moholkar (2016)http://dx.doi.org/10.1016/j.jcis.2016.08.031

[5] M. Balaji, J. Chandrasekaran *, M. Raja, Materials Science in Semiconductor Processing 43 (2016) 104–113.