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Fabrication and Characterization of Pure and Surface Modified Nanocrystalline $CdSnO_3$ for Gas Sensing

Manisha S. Pande [1], V. D. Kapse [2], V. S. Kalyamwar [3]
[1] Department of Physics, Shri Sant Gajanan Maharaj College Of Engineering,Shegaon- 444203, India.
[2] Department of Physics, Arts, Science and Commerce College, Chikhaldara-444807, India
[3] Department of Physics, Bhartiya Mahavidyalaya,Amravati-444604, Maharashtra State, India
Corresponding author: manisha031082@gmail.com; vdk.nano@gmail.com

Abstract

For the need of today necessities different types of gas sensor had been created. Gas Sensors have many applications for commercial, health and environment controlling condition. This research paper deals with the synthesis of $CdSnO_3$ nanoparticles by coprecipitation method followed by calcinated at 800^0C for 4 h. Surface modified $CdSnO_3$ thick films were fabricated by dipping method which is followed by firing. X-ray diffraction was used to confirm the synthesis of nanocrystalline $CdSnO_3$. Surface morphology and elemental analysis of pure and surface modified nanocrystalline $CdSnO_3$ was studied by using FESEM and EDAX respectively. Fabricated thick film samples can be used for detecting toxic gases and volatile organic compounds.

Keywords: Nanocrystalline, $CdSnO_3$, Thick film; X-ray diffraction; FESEM; EDAX

Introduction:

On our earth there are number of gases in mixture form naturally and so many toxic and hazardous gases are added by human. For modern society it is very essential to detect, analyze and control over gases. Gas sensors are developing in accordance with their selectivity, sensitivity and stability parameter. Gas sensors continue to be a dynamic and fast-emerging field of research for both scientists and developers. There is an increasing interest in the finding new materials in order to develop high performance solid-state gas sensors. Semiconductor metal oxide sensors are an alternative for non-expensive and robust detection systems. There are various advantages of metal oxide gas sensors such as low cost, easy production, compact size and simple measuring electronics which have been widely used in portable gas detection systems [1,2]. Semiconductor metal oxides shows great attention in the past few years [3,4].

Perovskite-type oxide semiconductors with formula ABO_3 have been reported to be sensitive materials to both oxidizing and reducing gases. The perovskite oxides (ABO_3) were used as gas sensor materials for their stability in thermal and chemical atmospheres. Perovskite oxide has been reported as a potential gas sensing material in addition to commonly used binary oxide. Additionally, perovskite oxides with $CdSnO_3$structure was also reported to be a promising gas sensing material due to its attractive properties such as excellent gas sensitivity, mixed ionic-electronic conductivity, great doping flexibility, ability to accommodate large amount of dopants and defects, high melting and decomposition temperature. In recent years, cadmium stannate (CdSnO3), used as electrochemical material [5,6], has shown quite attractive gas sensitivity properties to various gases such as C_2H_5OH gas [7–10], butane [11], ammonia [12], CEES [13] and chlorine [14].

Experimental

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Synthesis of $CdSnO_3$ nanostructure

The synthesis of $CdSnO_3$ was done by using stoichiometric molar amount of analytically pure grade [$3CdSO_4.8H_2O$], [$SnCl_4.5H_2O$] dissolved in distilled water. To obtain a homogeneous clear solution, the solution was continuously stirred by magnetic stirrer. Then aqueous ammonia (25%) was added drop wise under rapid stirring to maintain desired pH. This precipitate was filtered were followed by washing with ethanol and distilled water for several times then precipitate were dried at 100^{0}C in oven. The dried sample was calcined at 800^{0}C for 4 h in muffle furnance to obtain nanoparticles for $CdSnO_3$ by co precipitation method.

Preparation of thick films

Thick films of $CdSnO_3$ nanostructure were prepared by using screen printing technique. In typical process, paste was formulated by mixing the synthesized $CdSnO_3$ nanostructure powder with ethyl cellulose (a temporary binder) in a mixture of three organic solvents. The ratio of inorganic to organic part was kept as 75:25 in formulating the pastes. The ready pastes were screen printed on a glass substrate in desired patterns. The films prepared were fired at 500 ^{0}C for 30 min. Prepared thick films termed as pure $CdSnO_3$ thick films.

Surface of pure $CdSnO_3$thick film were modified by dipping them into a 0.01 M aqueous solution of solution of copper chloride for intervals of time 5 min. After dipping, thick films were dried under IR lamp for 60 min. Dried thick films were calcinated at 500 ^{0}C for 30 min in air ambient. The copper chloride dispersed on the film surface was oxidized in calcination process, and this surface activated films are termed as copper chloride modified $CdSnO_3$ thick films.

Results and discussion

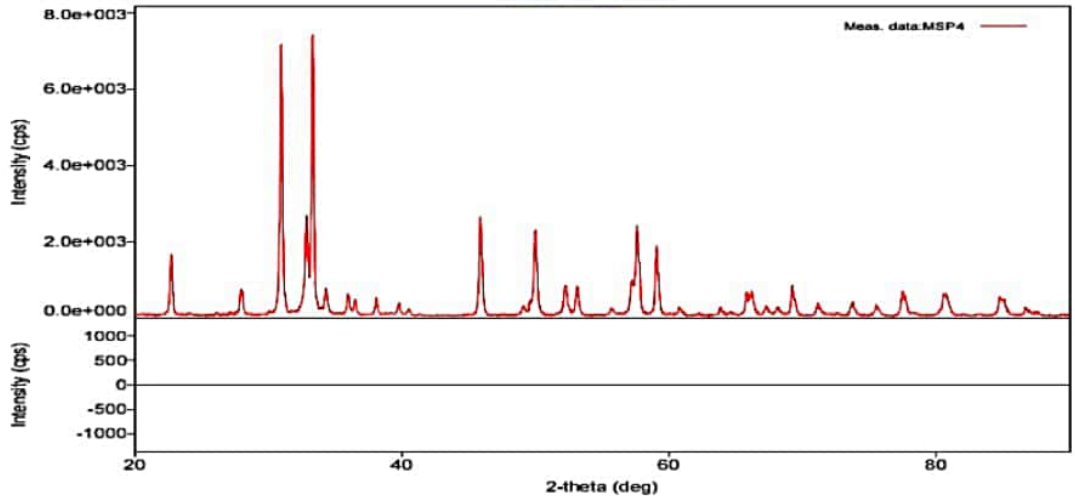

Fig.1: XRD pattern of $CdSnO_3$ powder calcinated at 800^{0}C.

X-ray diffraction (XRD) data for structural characterization $CdSnO_3$ nanostructure synthesized by chemical route method was collected on the Philips X-ray diffractometer using Cu-Kα source. Fig. 1 illustrates the x-ray diffraction pattern of the $CdSnO_3$ nanostructure synthesized by chemical route. This XRD pattern shows that all the diffraction peaks can be assigned to rhombohedral $CdSnO_3$ with lattice parameters a=b=5.456(5) A^0 and C=14.88(2) A^0

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,space group R-3,nanosized 60 nm which are good agreement with literature values JCPDS Card no. 00-034-0758.

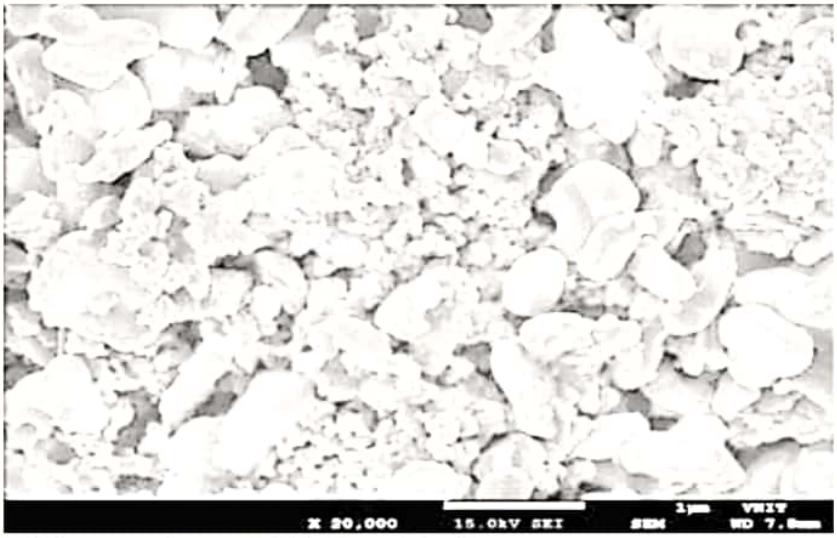

Fig.2: FESEM image of pure $CdSnO_3$ thick film.

Fig.2 shows the surface morphology of pure thick film was analysed by field Emission Scanning Electron microscope (FESEM). FESEM images shows agglomerates formed. The microstructure shows the homogeneous distribution of the particles in the sample.

Fig.3: EDAX image of pure $CdSnO_3$ thick film.

Fig.3 shows EDAX spectrum of pure $CdSnO_3$ thick film. The elemental analysis as obtained from EDAX spectrum which represents presence of Cd, Sn and O elements. EDAX spectrum shows percentages of elemental composition of pure $CdSnO_3$ thick film 40.7 Wt(%) Cd , 34.6 Wt(%) Sn and 24.7 Wt(%) O.

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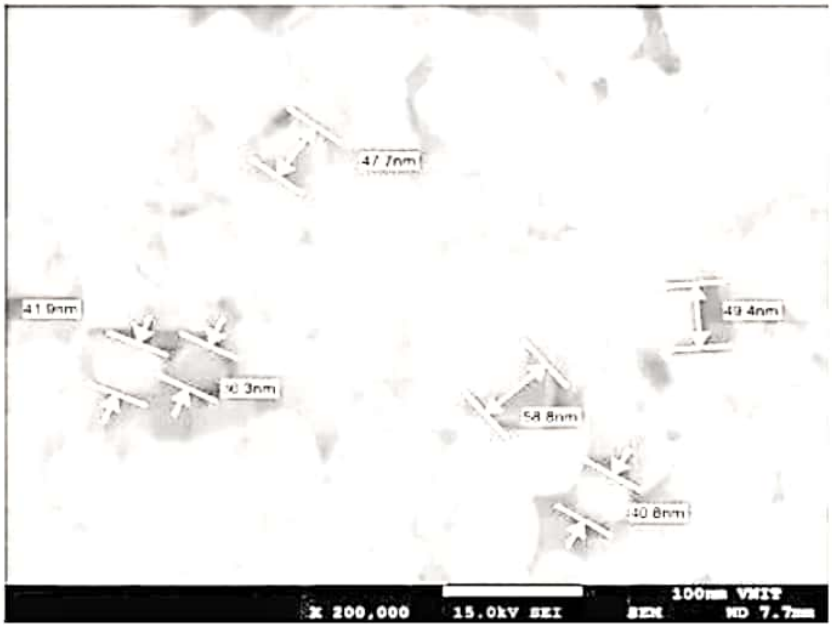

Fig.4: FESEM image of CuO modified $CdSnO_3$ thick film (5 min)

Fig.4 show the surface morphology of CuO modified $CdSnO_3$ thick film was analyzed by field Emission Scanning Electron microscope (FESEM). FESEM images shows a few particles are in the 38-60 nm range and some agglomerates formed. The microstructure shows the homogeneous distribution of the particles in the sample.

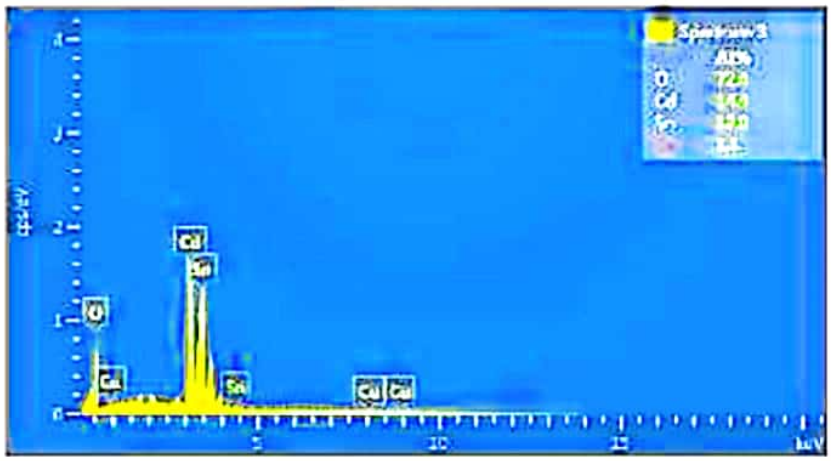

Fig. 5: EDAX image of CuO modified $CdSnO_3$ thick film (5 min).

Fig.5 shows EDAX spectrum CuO modified $CdSnO_3$ thick film. The elemental analysis as obtained from EDAX spectrum which represent presence of Cd, Sn, Cu and O elements. EDAX spectrum shows percentages of elemental composition of CuO modified $CdSnO_3$ thick film 14.4Wt(%) Cd , 12.0 Wt(%) Sn ,72.4 Wt(%)O and 1.14Wt(%) Cu .

Conclusions

The results of the sensing performance of pure and CuO modified $CdSnO_3$thick films can be summarized as

1. Nanocrystalline $CdSnO_3$ powder synthesized by chemical route method i.e., coprecipitation method.
2. XRD pattern showed that all the diffraction peaks can be assigned to rhombohedral $CdSnO_3$.

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3. Surface morphology shows pure and surface modified nanocrystalline $CdSnO_3$ was studied by using FESEM. The microstructure showed the homogeneous distribution of the particles in the sample.
4. Elemental analysis of pure and surface modified nanocrystalline $CdSnO_3$ was studied by using EDAX.

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