Synthesis of Nanosized perovskite-type materials $CdSnO_3$ for Gas Sensor Applications

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Abstract— Various types of gas sensor had been created for the need of today necessities. Sensors are used for commercial, health and environment controlling condition Due to many application of gas sensors, researcher have been focus on different types of sensors. This research paper focused on Perovskite oxides are excellent candidates for exhaust gas depollution processes.

This research paper will focus on synthesis of $CdSnO_3$ nanoparticle by coprecipitation method in which preparation condition were controlled properly and calcinated at 800^0C for 6 hours and the principle and use of Semiconductor metal oxide sensors for several applications, for gas detection, and environmental monitoring. The XRD Spectrum indicates that the sample is rhombohedral $CdSnO_3$ with lattice parameters a=b=5.456(5) A^0 and C=14.88(2) A^0 and nanosized 60 nm. This paper focused that nanostructured perovskite-type oxide can be used as a new type of gas sensitive material for detecting LPG, NH_3 and Cl_2, because of their toxicity and organic vapours such as ethanol have also been detected.

Keywords-*$CdSnO_3$ perovskite nanoparticle, environmental monitoring, different gas sensors.*

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I. INTRODUCTION

By different poisonous gases today environment get polluted. Hence in order to detect such gases one should focused on method how such gases detect. Hence today need researcher focused on that to control and monitor these gases by different gas sensors. [1]Recently, gas sensing technology increasing attention in both industry and academia. Gas sensing mechanism has become more impotance because of its widespread and common applications in the following areas: industrial production , automotive industry , medical applications , indoor air quality supervision , environmental studies (e.g., greenhouse gas monitoring). During the last fifty years, different studies have established various branches of gas sensing technology.[2]

Perovskites are inorganic complex oxides with the empirical formula ABO_3, where A-site cations are typically rare earth metals, while B-sites are occupied by transition metals with mixed valence states. Perovskite ABO_3 recently it is good candidates for gas sensors because it shows thermal stability and chemical stability. The activity of perovskites is practically determined by the nature of their cations, which play an important role in adsorption of gas species and their catalytic activities. The electronic properties and catalytic activity of the perovskite-type oxides can be advanced by addition of ions into the A or B sites. [3] Nanostructured materials have been focused and creating interest area due to their fundamental significance for addressing some of their properties in fundamental physics and their applications as

advanced materials with collective properties. Perovskite-type oxides are the excellent candidate in condensed-matter research.[4]Nanoparticles characteristics of high surface area to volume ratio. This favours the adsorption of gases on the sensor and can increase the sensitivity of the device because the interaction between the analytes and the sensing part is higher. Many studies, then, have focused on reducing the size of the metal oxides in the form of nanoparticles and nanowires.[5] Based on different sensing principles, a large variety of sensors such as semiconductor gas sensors, optical sensors, thermal conductivity sensors, catalytic sensors, electrochemical sensors and electrolyte sensors have been developed. But Semiconductor metal oxide perovskite materials for gas sensors have been used for several decades for low-cost detection of combustible and toxic gases.[6]

II. EXPERIMENTAL DETAILS

Coprecipitation method were used for synthesis of $CdSnO_3$ nanoparticle.All reagent were purchased from Sigma Aldrich. Stannic tetrachloride($SnCl_4.5H_2O$) and Cadmium Sulphate($CdSO_4.7H_2O$) taken as starting material in same molar ratio,which were dissolved with distilled water in conical flask to obtain transparent solution.Solution made under magnetic stirring for 30 min. at normal room temperature. Then 25% ammonia solution add dropwise in solution to maintain pH=9 and during continuous stirring white ppt were obtained.Ppt washed several times by water.Ppt dried in electric oven at 100^0C for four hours.Then powder collected in crucible and crushing it for 15 min. Then transfer it in muffle furnace at 800^0C for 6 hours and powder sample were obtained.

III. GAS SENSING MECHANISMS

The gas-detection property of metal oxide is depend on the change of the depletion layer at the grain boundaries in the presence of reducing or oxidizing gases, which lead to variation in the height of the energy barriers for free charge carriers to flow, thus lead to a change in the conductivity of the sensing material.

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The active sensing layer of sintered and thick-film type gas sensors comprises of number of interconnected metal oxide grains. The adsorption of gases like O_2 are helpful to remove the electron from the surface region of the grains, is to forms various types of oxygen ion as O^-_2 ,O^-,O^{2-} and depending on the certain conditions such as temperature, and forms a depletion layer around the grain boundaries. The depth of the depletion layer is determined by the oxygen partial pressure and the surface characteristics of metal oxide materials.

Higher potential barrier is the result of the depletion layer on the grain boundaries; thus, the grain boundaries become the bottlenecks for electric grain-grain transfer. When the sensor comes in contact of combustible gases, the surface oxygen species react to form combustible products. This type of reaction results in lowering the oxygen species coverage, returns the free electron charge carriers to the bulk of the oxide material and increases electrical conductivity. This surface reaction modulated conductance serves as a gas response signal of the sensor.

IV.FACTOR INFLUING SENSING PERFORMANCE

- surface reactions and gas sensing process are closely related with each other
- Various types of metal oxides shows variety of reaction activation towards different the target gases.
- Research shows that advanced metal oxides usually show excellent gas response property than the basic component.
- Excellent catalyst supporting materials indicates potential of catalysts can be developed.
- More dispersed catalyst particles required high surface area .
- Also,high surface area required to increase reaction contact area between gas sensing materials and target gases.
- Metal oxide gas sensors of large surface area with Porous structure with high surface areas deals the standard structure. It is assembled by lots of small grains with voids and pores among them.
- Sensitivity of nanoparticles can be increased by Grain size.
- By decreasing both surface areas and catalytic properties of the material, at high temperature small grains tend to coagulates into large entities.
- For excellent gas sensing to keep balance between decreasing grain sizes and stability is the key factor.
- Also ,crystallographic features is the important key factor.
- Atmospheric conditions and physical condition, such as temperature and humidity, have influence on the testing of sensitivity.
- Humidity impact cause to decrease the sensitivity and be harmful to repeatability.
- Fortunately, it can be eliminated by heating to high temperatures (usually >400 °C

V.RESULT AND DISCUSSION

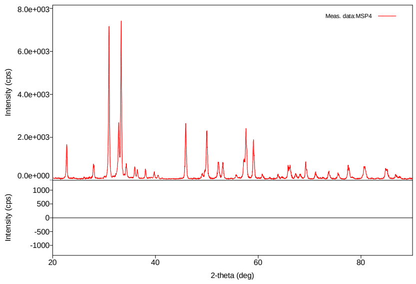

Fig.1:XRD patteren of $CdSnO_3$ which calcined at 800^0c

$CdSnO_3$ nanostructured synthesized by coprecipitation method for X-ray diffraction data for structural characterization collected on the Philips X-ray diffractometer uing Cu-Kα source.

Fig.1 shows that pattern of perovskite structure of $CdSnO_3$ confirmed. 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 ,space group R-3.nanosized 60 nm which are good agreement with literature values JCPDS Card no. 00-034-0758.

Fig.1 shows that pattern of perovskite structure of $CdSnO_3$ confirmed.$CdSnO_3$ measurement conditions and its peak list measured as follows,

MEASUREMENT CONDITIONS

X-Ray	40 kV , 15 mA	Scan speed / Duration time
Goniometer		Step width
Attachment	-	Scan axis
Filter	None	Scan range
CBO selection slit	-	Incident slit
Diffrected beam mono.	None	Length limiting slit
Detector	SC-70	Receiving slit #1
Scan mode	CONTINUOUS	Receiving slit #2

PEAK LIST MEASUREMENT

No	2-theta(deg)	ESD	d(ang.)	ESD	Height(cps)	ESD	FWHM(deg)	ESD	Int. I(cps deg)	ESD	Int. W(deg)	DB card number	Rel. int. I
1	22.77	0.009	3.9018	0.0014	1110	68	0.19	0.006	271	5.02	0.24	0	21.35
2	27.97	0.015	3.187	0.0017	488	45.1	0.24	0.012	151	4.28	0.31	1001145	11.92
3	30.99	0.006	2.8837	0.0005	5335	149	0.18	0.004	1268	12	0.24	0	100
4	32.86	0.006	2.723	0.0005	1714	84.5	0.21	0.007	509	8.75	0.3	1001145	40.14

5	33.34	0.004	2.6854	0.0003	5641	153	0.16	0.003	1252	11.1	0.22	0	98.73
6	34.32	0.016	2.6111	0.0012	416	41.7	0.23	0.014	117	3.97	0.28	1001145	9.21
7	35.96	0.013	2.4952	0.0009	375	39.5	0.2	0.011	83.8	3.27	0.22	0	6.61
8	36.49	0.016	2.4602	0.0011	272	33.6	0.2	0.014	61.8	2.67	0.23	0	4.88
9	38.07	0.019	2.3616	0.0011	309	35.9	0.18	0.014	65.6	3.14	0.21	0	5.17
10	39.79	0.021	2.2634	0.0012	214	29.9	0.2	0.028	65.3	2.91	0.31	1001145	5.15
11	40.51	0.007	2.2249	0.0003	116	22	0.21	0.014	27.9	1.24	0.24	0	2.2
12	45.9	0.007	1.9757	0.0003	1913	89.3	0.22	0.005	519	5.49	0.27	0	40.9
13	49.15	0.026	1.8524	0.0009	173	26.9	0.26	0.028	55	4.37	0.32	1001145	4.33
14	49.64	0.019	1.8349	0.0007	275	33.8	0.21	0.028	71.5	8.98	0.26	0	5.64
15	50.01	0.007	1.8223	0.0002	1806	86.8	0.21	0.008	469	12.8	0.26	0	36.99
16	52.2	0.014	1.751	0.0004	569	48.7	0.28	0.014	206	5.6	0.36	1001145	16.22
17	53.11	0.016	1.7232	0.0005	513	46.3	0.26	0.016	174	4.6	0.34	0	13.7
18	55.71	0.032	1.6486	0.0009	124	22.7	0.26	0.05	45.1	3.21	0.36	0	3.56
19	57.21	0.017	1.609	0.0004	638	51.6	0.27	0.026	224	14.9	0.35	0	17.66
20	57.62	0.006	1.5984	0.0002	1880	88.5	0.21	0.008	498	15.9	0.26	0	39.27
21	59.07	0.006	1.5625	0.0002	1559	80.6	0.19	0.007	366	6.29	0.23	0	28.85
22	60.78	0.011	1.5227	0.0002	149	24.9	0.2	0.031	39.1	3.15	0.26	0	3.08
23	63.87	0.031	1.4563	0.0006	135	23.7	0.25	0.033	37.3	3.02	0.28	0	2.94
24	64.56	0.073	1.4424	0.0014	55.6	15.2	0.31	0.078	19.9	2.43	0.36	0	1.57
25	65.83	0.012	1.4176	0.0002	473	44.4	0.21	0.016	123	8.4	0.26	0	9.69
26	66.2	0.015	1.4106	0.0003	437	42.7	0.24	0.025	130	8.32	0.3	0	10.21
27	67.28	0.029	1.3905	0.0005	166	26.3	0.27	0.034	55.6	3.22	0.33	0	4.38
28	68.15	0.029	1.3748	0.0005	133	23.5	0.28	0.037	45	3.7	0.34	0	3.55
29	69.24	0.012	1.3558	0.0002	600	50	0.21	0.013	147	5.37	0.24	0	11.55
30	71.16	0.017	1.324	0.0003	235	31.3	0.22	0.022	66.7	4.52	0.28	0	5.26
31	73.66	0.023	1.285	0.0004	243	31.8	0.3	0.021	77.5	4.06	0.32	0	6.11
32	75.54	0.026	1.2577	0.0004	209	29.5	0.29	0.026	67	3.82	0.32	0	5.29
33	77.55	0.007	1.23	0.0001	559	48.3	0.25	0.009	184	4.43	0.33	0	14.54
34	78.34	0.022	1.2195	0.0003	60.2	15.8	0.22	0.05	16.9	2.44	0.28	0	1.33
35	80.68	0.022	1.19	0.0003	404	41	0.51	0.014	219	4.95	0.54	0	17.24
36	84.83	0.025	1.1421	0.0003	346	38	0.49	0.018	188	5.15	0.54	0	14.83
37	86.72	0.02	1.122	0.0002	185	27.7	0.23	0.021	52	3.87	0.28	0	4.1
38	87.43	0.03	1.1146	0.0003	91.2	19.5	0.26	0.039	29.4	2.9	0.32	0	2.32

VI. CONCLUSION

$CdSnO_3$ nanostructured synthesized by coprecipitation method with good yield and its XRD analysis is carried out for its confirmation.It shows gas sensing property towards varaity of gases

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REFERENCES

[1] A.V.Kadu, S. V. Jagtap ,Sci. Revs. Chem. Commun. 2(3) , 172-178, 2012

[2] X. Liu, S. Cheng, H. Liu, S. Hu, D. Zhang , H. Ning, Sensors, 12, 9635-9665,2012.

[3] A. S. Mukasyan, C. Costello, K. P. Sherlock, D. Lafarga, A. Varma, Separation and Purification Technology 25, 117–126, 2001.

[4] D. D. Kajale, G. E. Patil, V. B. Gaikwad, S. D. Shinde, D. N. Chavan, N. K. Pawar, S. R. Shirsath, G. H. Jain, INTERNATIONAL JOURNAL ON SMART SENSING AND INTELLIGENT SYSTEMS, VOL. 5(2), 382, 2012.
[5] G. .Cadena, J. Riu , F. Rius, i-SECTION: CRITICAL REVIEW, 4(6) ,1112-1119,2009.
[6] G. Korotcenkov, Materials Science and Engineering, B 139, 1–23, 2007.