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SYNTHESIS OF NANOCRYSTALLINE CADMIUM DOPED INDIUM OXIDE BY COMBUSTION METHOD

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Abstract

Nanocrystalline Cd doped Indium Oxide was successfully synthesized by combustion method at a lower calcinations temperature in a short time. The synthesized particles were characterized by X-ray diffraction (XRD). The average crystallite size Cd doped In_2O_3 from XRD was found to be 20.17 nm by using Scherer' s equation. Cd doped In_2O_3 is widely used in gas sensing technology.

Keywords: Cadmium, Indium oxide, Combustion method, XRD.

1. Introduction

In the modern development of science and technology, the science of nanomaterials is one of the most striking and likable field of research. There are several applications of nanomaterials are immeasurable in almost every branch of science . Nanomaterials of conducting oxides like zinc oxide (ZnO), tin oxide (SnO_2), titanium oxide (TiO_2), Cadmium oxide (CdO) and Indium oxide (In_2O_3) have fascinated the interest of researchers over the last two decades by reason of their outstanding application in gas sensors, solar cells, fuel cells, consumer electronics, smart windows and optical transmission devices. Crystalline indium oxide is insoluble in both water and acids, whereas amorphous indium oxide is insoluble in water but soluble in acids. The crystalline In_2O_3 have a band gap of about 3 eV. Metal oxides such as ZnO, In_2O_3, SnO_2 etc have been studied broadly for their gas response to oxidizing and reducing gases [1]. Normally, gas sensitive metal oxides materials are porous thick films. In a gas sensor, molecular adsorption or reaction of molecules pre-adsorbed chemical species, results in a change of the electrical conductivity, can be easily detected and is often used as the gas response signal [2]. The physical properties of In_2O_3 could be improved for gas sensing or optoelectronic applications by doping with cadmium (Cd) which tunes its n-type conductivity and increase the band gap [3].

For synthesis of nanomaterials various methods and techniques are used. But for , Cd doping we have chosen the combustion method here for the synthesis of Cd doped In_2O_3 nanostructure, in view of the fact that an extensive literature review infers that this method is good for the synthesis of metal oxide nanoparticles [4]. The combustion synthesis is form of exothermic reaction, which is initiated at the ignition temperature and generates heat of the order of above 1000 K during the combustion, which can volatilize low-boiling point impurities and therefore results in purer and more homogeneous products than those obtained by conventional technique. Heat of combustion helps in crystallization and formation of desire phase. However a very high flame temperature can adversely affect powder characteristic like increase in crystallite size, formation of hard agglomerates and thereby reduction in the surface are and sintereablity [6]. During the combustion process, a large amount of gas is liberated with the occurrence of yellowish flame, and finally, a white phosphor product is obtained. In a combustion process, metal nitrate acts as an oxidizing reactant and urea as a reducing reactant, .This process is a low cost process, and easy to control the particle size [5].

2. **Experimental**

Analytical grade Indium nitrate ($In(NO_3)_{2.}xH_2O$) M.W 300.83, Cadmium nitrate ($Cd(NO_3)_2.4H_2O$) M.W 308.48 and Urea ($(NH_2)_2CO$) M.W 60.06 use to synthesize Cd doped In_2O_3 nanoparticles. All these chemicals were used without further refinement. Initially, Indium nitrate, Cadmium nitrate and urea is taken in mortar and this mixture is well grinded for 25-35 min. As Indium nitrate get moisturized in air, we get viscous mixture. The mixture was heated in crucible in a muffle furnace which was preheated to 500^0C. It was auto ignited with the rapid evolution of large volume of gases leaving behind a residual greenish yellow colour fine powder.

3. Results and discussion

The X-Ray Diffraction (XRD) pattern to analyze crystal structure of material was measured by X-Ray Diffractometer (PANalytical Xpert Pro Cu Kα- 1.54 A^0) while electric voltage and current at 45kV and 40 mA respectively. Fig.1 shows the XRD peak pattern of synthesized Cd doped In_2O_3 powder sample. In XRD peak pattern, Cd doped In_2O_3 is excellent material in crystalline nature due to higher intensity peak. JCPDS card no 01-071-2195 of In_2O_3 is well matches with obtained XRD peak pattern of material with slight displacement of -0.036 which may be due to doping of 5 wt% of cadmium (Cd). Measured XRD pattern of Cd doped In_2O_3 showed cubic crystal system with space group number 206 . Calculated density of Cd doped In_2O_3 material is 7.10 g/cm^3. Lattice constant parameter of Cd doped In_2O_3 material are well matches with lattice parameter of JCPDS card no 01-071-2195.

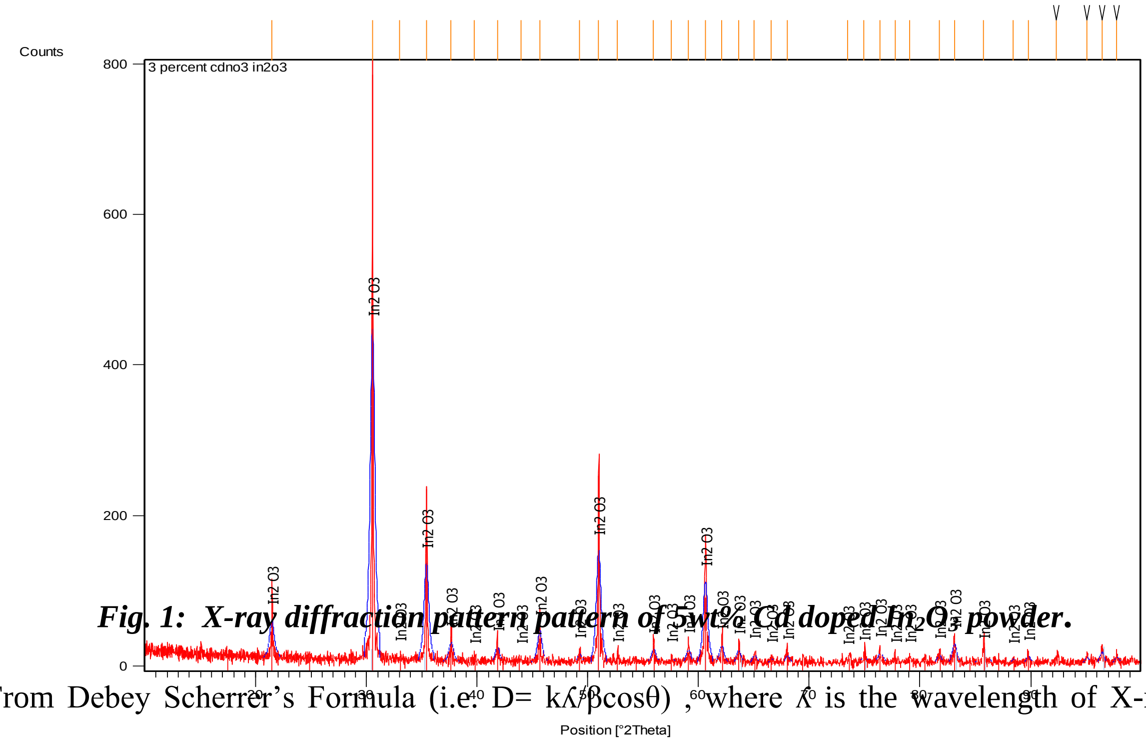

Fig. 1: X-ray diffraction pattern pattern of 5wt% Cd doped In_2O_3 powder.

From Debey Scherrer's Formula (i.e. D= kλ/βcosθ) ,where λ is the wavelength of X-ray radiation, k is constant, 2θ is the diffraction angle, β is the full width at half maximum., average crystalline size of Cd doped In_2O_3 is 20.17 nm and crystallinity of Cd doped In_2O_3 powder is 83.17 percent.

4. Conclusions

Nanocrystals of Cd doped In_2O_3 have been effectively synthesized through a combustion method using high purity $In(NO_3)_3.xH_2O$, Cd $(NO_3)_2.4H_2O$ and urea (NH_2CONH_2). Structural properties of synthesized nanoparticles was characterized. XRD result showed the average crystallite size is 20.17 nm. The size of In_2O_3 nanoparticles is changed by doping Cd. Cd doped In_2O_3 may find its application in gas sensing due to its cubic structure and crystallite size.

5. References

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