International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 12 | Dec 2022 www.irjet.net p-ISSN: 2395-0072

Indium Oxide Nano Particle Preparation and Characterization using Laser Ablation method

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Abstract **– In_2O_3 (Indium oxide) is a technologically important apparent conducting oxide having a energy gap near to gallium nitride (GaN), nanoparticles of In_2O_3 were prepared by PLA (pulsed laser ablation) of a pure metal target of indium. nanocrystalline Indium oxide nanoparticles have mean diameter of 6.5nm and have cubic crystal composition established by X-ray diffraction and TEM (transmission electron microscopy). A well-built emanation peak at 3.76eV is observed by Photoluminescence spectroscopy.**

Keywords **–** ***GaN, Indium Oxide, X - Ray diffraction (XRD), transmission electron microscopy (TEM), (PL) Photoluminescence***

I. INTRODUCTION

Recent materials research paying attention toward preparation and depiction of electronic properties, structure analysis, optical properties, of thin films with bulk TCO (transparent conducting oxides) which is traditionally known as transparent conducting oxide (TCOs), is observed a key of curiosity in earlier period. Recently overview of several attractive properties of material have countered problem regarding preparation, the charge carriers character and electronic properties, effect of dopants, also hypothetical model for analytical performance restrictions [1]. Oxides of zinc, tin, indium which are transparent conducting oxides are studied mostly and have great technological importance. The cadmium stannates, fluorine-doped transparent conducting oxides shows great optical absorption and electrical conductivity. Elevated precision in visible region and elevated conductivity of transparent conducting oxides motivated researchers for investigation of TCOs [1-3].

Two important TCOs are oxides Indium and indium tin which have important applications like low-emissivity windows electro optic modulators flat-panel displays, electro chromic mirrors, solar cells, and in dissipating inert electricity as of the window on xerographic copiers [4-5]. Indium oxide have broad energy gap of 3.546-3.75eV which is near to other popularly known electronic as well as optical material GaN. whereas numerous preparation along with privilege methods like sputtering and spray pyrolysis, Chemical vapour deposition have been adopted used for preparing skinny films of technologically conducting oxides. The explore into nanoparticles and on quantum dot structure being very wide. Nanoparticles structure has a significant function in determination of their characteristics which has large no. of applications. To improve the presentation of appliance based on indium oxide, here are several geomorphologies of indium oxide through numerous changed dimensional nanostructures, like one dimensional (nanowire) 2dimensional (nanosheets), nanotubes, (3dimensional) nano plates, nano fibers.

II. THE PROPOSED WORK

Indium Oxide Nanoparticles Production: Nanoparticles of In_2O_3 were effectively synthesized via pulsed laser ablation method. Starter materials used in preparation were indium nitrate and Ammonium hydroxide. Indium nitrate of (0.2 M) be dissolve in 100 ml of distill H_2O and set aside on agitator nearly 2 hr. at 80 0C. after that 2 ml NH_4OH (Ammonium hydroxide) intermixed with 20 ml of distill water and subsequently kept exciting for 10 minutes and after that, the ammonium hydroxide solution was mixed gradually in the indium nitrate mixture until the pH was restricted. The mixed content was kept back stimulated for 3 hr at 80^0C and then the content was mixed for 10 min at 5000 rpm. After that, ethanol was used for washing it.

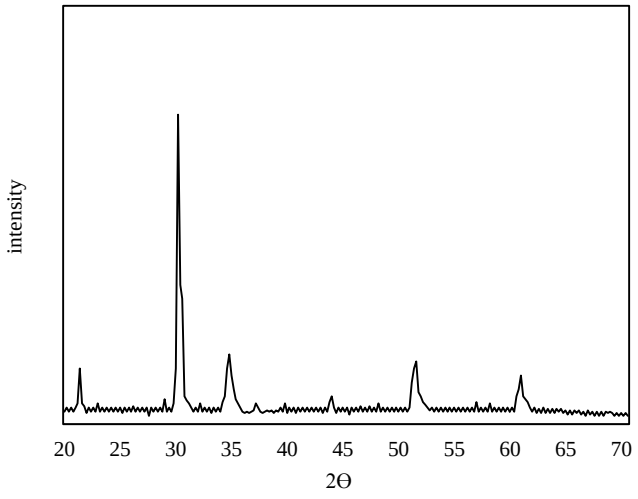
The content which is white colored was dried at 100^0C nearly 30 hr. and kept at 300^0C for 6 hr. The final content was grinded fine for getting fine particles for analysis. The opportunity of having nanostructures of technologically conducting oxides used for detectors and Ultra Violet lasers as gas sensors for nitrogen dioxide and ozone is quite interesting. The sensitivity of indium oxide towards gases has been observed to enhance considerably by reducing its constituent part size [6]. Characterization techniques used

are TEM (transmission electron microscopy), XRD (X-ray diffraction) and PL (photoluminescence).

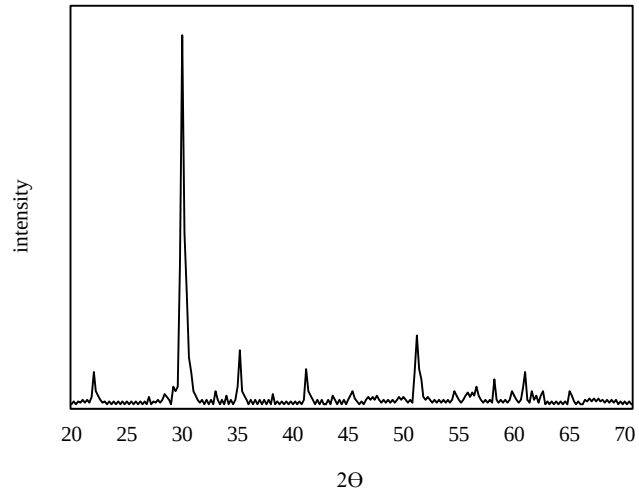
Indium metal having purity about 99.98 was ablated by laser in a chamber of stainless steel keeping pressure 25 Tor having flow rate of air nearly 0.6L/min .The source of laser used have characteristics like quartet harmonic of a pulsed Nd:YAG having wavelength λ = 266nm, recurrence rate of 10Hz, and a pulsation width of 10ns, and a pulse energy of 50mJ. For ablation laser ray was listening carefully on a spot of 1mm dia on target of indium. A micro porous cellulose nitrate membrane filter was used to collect reaction product [7-8]. The produce was characterized by XRD, TEM and PL spectroscopy.

III. RESULT AND DISCUSSIONS

Structural Analysis: The XRD spectra of synthesized In_2O_3 nanoparticles have been shown in figure 1. The nano ranged particles characterized by using XRD collection of X Ray Diffraction data was done with the help of XDS-2000 fine particles X-ray diffractometer by using radiations. For minimization of background signal quartz particular crystal nil surroundings specimen holders was adopted. Sample preparation was done by dispersion of powder on the quartz specimen holder. In XRD report of the sample crystalline peaks observed which matches with diffraction report of cubic indium oxide and with peaks of commercial indium oxide powders can be seen in figure 1. All these reports show that the product obtained by laser ablation was indium oxide .morphological and structural analysis of the produce was studied with help of transmission electron microscopy (TEM). The sample preparation was done by ultrasonic dispersion of powder in methanol for about 2 minutes. A holey carbon-coated copper grid was used for dispersing mixture of methanol powder. Then methanol was evaporated and distribution of particles on carbon film left which is then analyzed with the help of TEM which showed that the diameter of indium oxide nano crystal was about 6.5nm and standard deviation of 3.4nm.



(a)



(b)

Fig. 1 The proposed topologies showing positions of single wall and multi wall CNTs (a-b)

UV- Visible Spectrophotometer: Optical property of Indium oxide nano ranged particles which are in range of 272 -705 nm were studied with the help of UV-visible absorption spectroscopy as shown in Fig 2(a).The synthesized Indium oxide (In_2O_3) have absorbance peak near about at 351 nm. Immersion usually based on a variety of factor like band gap, particle size, oxygen scarcity, lattice twist, and face unevenness along with impurity [15]. The Tauc correlation [16] was implemented to compute the optical energy gap of the indium oxide nanoparticles which is given away in Fig. 2(b) and it was observed near at 3.6eV.

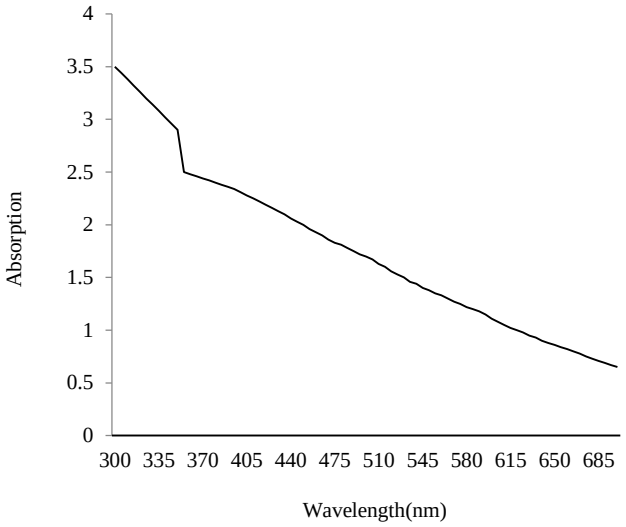


Fig. 2(a) Absorption spectrum of indium oxide nanoparticles

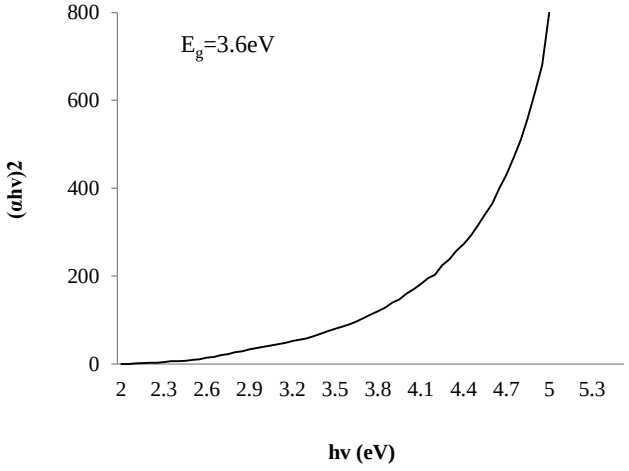


Fig. 2(b) Energy gap of indium oxide nanoparticles

PL Spectra: The Photoluminescence (PL) emission spectrum of the (In_2O_3) nanoparticles was measured at room hotness having exciting wavelength closely 350 nm. Photoluminescence (PL) emission crest of indium oxide nanoparticles (NPs) at 380 nm are depicted in figure 3.This can be due to contact of the oxygen vacancy as studied in the earlier writing. To obtain outcome of the Photo Luminance emission of indium oxide nanoparticle formed from irradiative reunite of photo excited hole with electron occupying oxygen gap. the present work, oxygen vacancies will frequently work as deep imperfection provider and be the cause for the generation of new energy level in the energy gap of indium oxide sample.

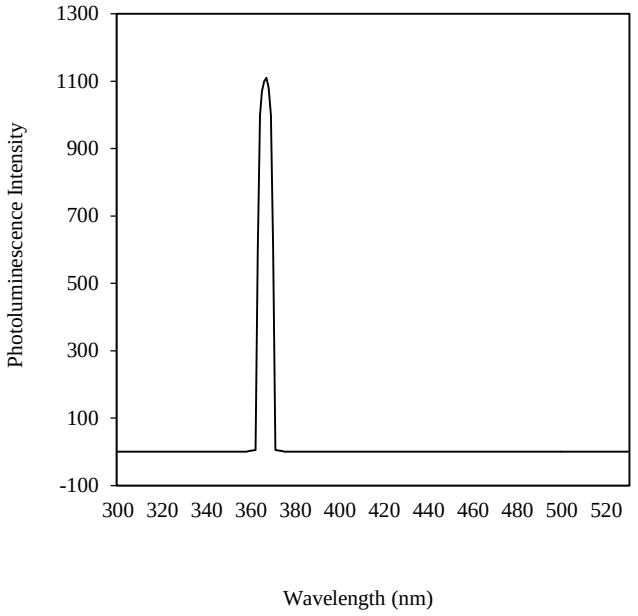


Fig. 3 PL spectra of In_2O_3 nanoparticles

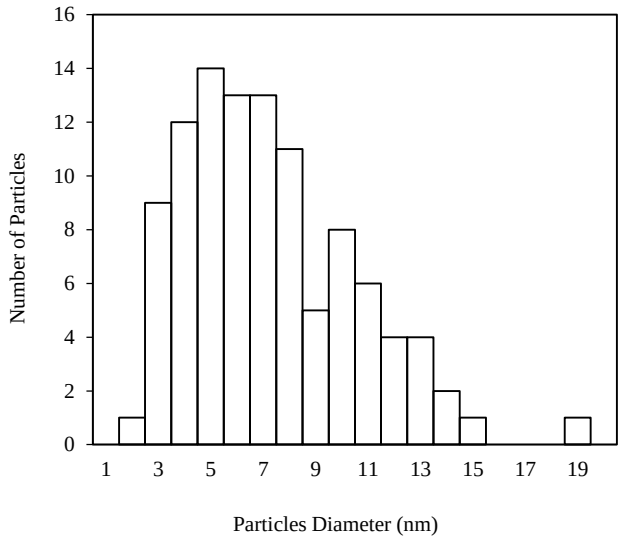


Fig. 4 Characteristic subdivision histogram from the TEM image having mean particle dia 6.5nm with a standard deviation of 3.4nm

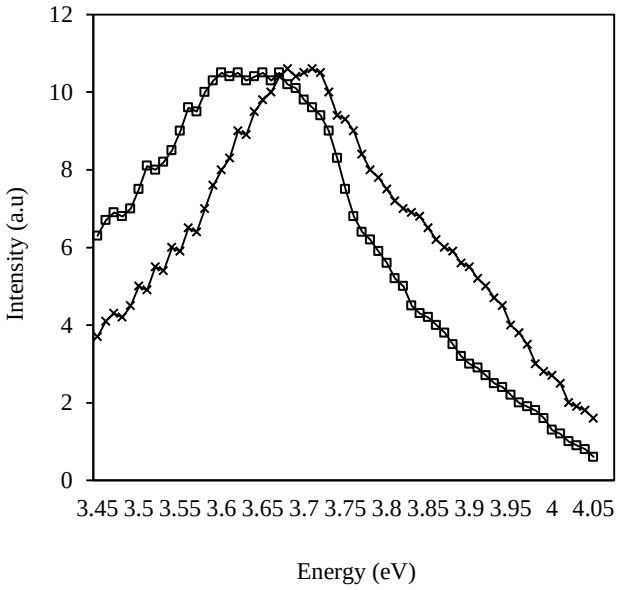


Fig. 5 (PL) Photoluminescence spectra of the laser-ablated sample and the marketable powder. The laser-ablated sample show a weak blue shift of 110 meV, consistent with particle dimension on the order of the Bohr excitation dia

Particle size distribution of indiumoxidesample histogram is shown in figure 4 and Bohr diameter estimation of indium oxide was done which was in range between 2.5nm to 5nm [9-10]. Oxide particles of Indium of sample show weak size dependency because diameter of prepared indium oxide was of order of Bohr excitation diameter. Sample also contains large particles of diameter, about 1 μm with small particles having diameter about 30nm to 100nm as confirmed by TEM ablation [11]. Photoluminescence spectra of prepared sample and marketable indium oxide fine particles were observed which were excited at 250 nm as shown in figure 5. Observed PL spectrum of commercial indium oxide powder have peak at about 3.64eV and ablated sample peak has been observed blue shifted to 3.76eV about 110meV shift which can be estimated using

$$\Delta E = \hbar^2/8MR^2$$

where ΔE = shift in energy =110 meV,

M = (me / + mh /) = $0.3m_0 + 0.6m_0$,

R = the particle radii

By putting the value in the used equation, the standard size of the particle is obtained 4nm in diameter which is within accord with the TEM outcome for the prepared indium oxide sample (6.5 nm in dia), which indicate that blue shift have a poor size reliance.

IV. CONCLUSION

We have prepared indium oxide nano sized particles, an important Transparent Conducting oxide material, its structural, morphological, and optical properties weredemonstrated. The structures confirmation of indium oxide nanoparticles was done with the help of XRD results which demonstrate the major peaks .X-Ray Diffraction and TEM analysis determined that particle were cubic, having signify dia of 6.5 nm. The poor size reliance is discovered by a shift in blue region of about 110 meV in the Photoluminescence spectrum which is constant with a particle size on the order of the Bohr exciton diameter. The optical energy gap of indium oxide which was measured by Tauc correlation was established to be 3.6 eV.

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