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SYNTHESIS AND CHARACTERIZATION OF STRUCTURAL AND OPTICAL PROPERTIES OF Al_2O_3 DOPED SnO_2 NANO COMPOSITES

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Abstract:- The morphological and optical bandgap ofAl2O3 dopped SnO2 Nano materials of metal oxides are studied here. The subjected nano composites nano particles of metaloxides were synthesized using chemical route method i.e., microwave assisted chemical co-precipitation method. The synthesized samples were characterized by the methods of X-Ray Diffraction, FTIR Spectroscopy and UV-VIS Spectroscopy for the morphological and optical characteristics of the samples. The result suggests that samples are of nano size and are wide bandgap semiconductors in nature. The X-Rays Spectrum a, UV-Visible Spectrum and Tauc Plots of the samples results were analyzed and size, absorption peaks and band gaps of the samples were calculated and compared. The comparative study suggests the applications of the samples as per their properties of wide band gap semiconductors behavior.
Keywords: BandGap, Wide BandGap, Nano-Materials, Nano-Composites,

1. Introduction:- Nano-composite and nano-materials have recently been the focus of intense investigation. The interest in the heterogeneous systems made of nanoparticles due to their current and future utility applications to the thrust zone/s. The high surface-to-volume (s/r) ratio and the large total interfacial area of the proposed nanoparticles/nanocomposites are reasons why they are so promising. In addition, advanced properties based on size were communlatwely depending on nature of host and gest materials (Bashir&Liu,2015).Structural and semiconducting properties of the nano composites and nanoparticles are the most popular functional nano fillers (Bousiakou et al., 2022; Chavali & Nikolova, 2019) for the thrust area. The structural andsemiconductor'sbandgappropertiesoftheresultantNano-composites the various factors such as calcination temperature $P_{H,}$ size of metal oxide NPs and conc. of dopant were effective role to enhanced the optical and morphological, semiconducting and magnetic of NSM nanoparticle's structures and band gap (Allia et al., 2014; Joschko et al., 2021). The degree to which nanocomposites interact remains unclear, among other things.

And nanoparticles will affect the structural and semiconducting properties and the givenen closure influences their properties (Bagheri-Mohagheghietal.,2008;GnanaprakasamDhinakar et al., 2016).Density of holes & electrons in metal oxides can be adjusted and controlled to a large extent by doping small amounts of impurities. Atoms that intentionally replace atoms to any degree in a crystal are called dopants and the cognitive process is called doping. Therefore, by doping, we can create intermediate states in the bandgap of metal oxide nanomaterials. In this way, doping will significantly increase the imperfection of the surface and cause a change in the electrical properties of the metal oxide. The dopant atoms presented can be interstitially dissolved or ionized or replaced in crystalline sites, resulting in deformation in the lattice, affecting the neutrality of the charge and the properties of the parent compound. The ionsand cations that are doped have a unique effect on the network of metal oxide nanomaterials(MONS). Metal oxide nanomaterials (MONS) which generally act as a recombination center forexcited electrons, while anionic doping results in cationic doping in the localized D states in the bandgap of deepening the donor levels in the P states near the valence band. Therefore, during doping, specific behaviors such as the ionization energy of impurities, absorption edge, state density and fundamental energy differences of metal oxide nanomaterials change due to the highconcentration of impurity or due to the high concentration of charge carriers. It's no secret that metal oxide semiconductors are essential in the sensor industry. (Wang et al., 2010). Nanocomposites are formed by mixing oxides that depend on the concentration of the material (Shaba et al., 2021;Zhu et al., 2020). Nanocomposites are very important for a variety of applications, such as– gassensors, photovoltaic devices and solar cells (Ates et al., 2020; Doagou-Rad et al., 2020). Aluminiumoxide is one of the N-type semiconductors (Egbo et al., 2020). SnO**2** is also N-type semiconductorwidely used in electronics. Solar cells and gas sensors (Hashim& Hamad, 2020; Li et al., 2001; Mahmoodetal.,2020),nano-campsitesandtheoptimalproperties,whicharesignificantlysuperiortosimpleoxides,improvepropertiesinnanocompositeelectricalandelectronicapplications, where the physical properties of nanocomposites are mainly influenced by the chemical composition of materials used in nanoscale and applications (El-Sharkawy et al., 1997;Mahmoodetal.,2020). Tin oxide, nickel oxide, Magnesium oxide, cadmium dioxide, aluminum oxide, and tungsten oxide are some of the most prevalent oxides. Carbon dioxide, organic alcoholic gas vapors such methanol ethanol, ammonia, and hydrogen sulphides have all been detected using these materials (Akhtar et al., 2021).

In this work, the authors$Al2O_3$-SnO_2nano composite nano structures by microwave assisted chemical co-precipitation method. The goal of this work is to synthesize $Al2O_3$-SnO_2 nanocomposites with different concentration at different calcination temperatures. The effect of different physical parameter on the nano composites structures for the most part focusing on the resulting structural and optical properties were compared and discussed in this report. The properties will be shown here which critically depends upon the types of the host enclosure and on the preparation proficiency.

1. Research Methodology

Experimental Synthesis Techniques:-The Fe-doped SnO_2nano composites formation was carried out using microwave-assisted chemical coprecipitation method in which $SnCl_2.5H_2O$ and $Fe(NO_3)2$ were dissolved in 100 ml of deionized water with a suitable 10% molar concentration. The resulting solution was flexed again using magnetic stirrer for 1 hour at room temperature to obtain a clear solution of an acidic nature continuously and regularly. Then, an ammonium solution (NH_4OH) was added drop-drop with constant stirring to the solution so that its pH remained at a value between 8 and 9,which was confirmed using the electrode pH meter(the pH

Meter was calibrated using the buffer solution). The resulting precipitated solution was maintained for the aging process to stabilize the same size of the crystal for about 24 hours. Now the precipitate is filtered using qualitative Whatman filter paper which has a pore size (20-25micrometers). The precipitate that formed was then washed with ethanol and purified water to remove contaminants like nitrate and chloride. The precipitated cake was heated from 4 hours to 6 hours at 100 °C using a hot plate to remove the water contents. Now, part of the resulting sample is grinded in the agate mortar and pastel and samples the "synthesized samples" and another part was then calcined to 200°C, 400°C & 600°C,respectively & as powder form samples using the agate mortar and pestle. The samples as synthesized, calcined sample and various calcined samples were placed in an airtight container and used for structural, optical and other characterization techniques.

Sample Characterization:-The various techniques were employed to examine morphology & magnetic properties of calcinated samples X- ray diffraction method Pw-17/10 with nickel filter having Cu Kr- 1.5418A^Oat 50 KV/40MA condition were applied during study and data were recorded as2θ∼10º-80° . The IR-spectrum were examined by Perkin Elmer 1600º and ranging of recorded rats 400-4000cm. The IR spectrum tell us about present in given sample

2. Results and Discussion

XRD Analysis:- Crystalline phase was determined at room temperature using a Rigaku Mini flex diffractometer and a radiation wavelength of 1.54 angstroms in a powder X-ray diffraction study. In the x ray analysis, one matched Phases was obtained for the 10%doping of $Al2O_3$ with the SnO_2.the corresponding spectra shows the well-matched peaks as tinoxide which is indexed for the different calcination temperatures. The observed XRD pattern revealed the formation of nano-composites of tin oxide with Aluminium oxide, further with no change inphaseoftinoxidesuggeststhattinisreplacedbytheAlions.Theexperimentalandcalculatedpeaks are well matched which signifies the formation of single phase nano-composites. Thefigure5.1 shows the comparative study of Aluminum oxide nano-composites.

Optical Properties:-The optical properties are an important property of the nano particles and for the nano composites are very useful for gas sensors, electronics and in optoelectronics.Thesepropertiesincludeabsorbanceandenergydeviationofthetargeted samples.

Absorbance Properties:-In the figure number 5.2, which shows pure $Al2O_3$dopped withSnO_2:andnanocompositesaresynthesized.Accordingtofigurenumber5.2and5.3,the value of the absorbance at a wavelength of 250 nm to 310 nm is having peak in UV region, and these decreases with increasing calcination temperatures, the decrement are in very small amount. This is due to the effect of an increase in the density of oxygen voids, crystal defects/voids and strainas it affects the crystal structure of the nano composites and causes changes in the nature of the surfaces

Electronic Band Gap Properties:-The optical energy difference is of great importance indeterminingthepossibilityofusingnanocompositesintheapplicationofsensorsandoptoelectronics as it gives a clear idea of the optical absorption, since the nano composites are transparent to radiation whose energy is less than the bandgap energy i.e. $Eg>h\upsilon$ and an absorptive radiation whose energy is greater than that $Eg<h\upsilon$. The value of the energy deviationin allowing

direct electronic transitions of Al2O_3-SnO_2: The band gap energy differences are calculated by drawing the graphical relation between $(\alpha h\nu)^{1/2}$ and the energy of the photons, so we get the value of the energy difference for the allowed indirect transition. Which are shown in figure number 5.4 shows the permissible indirect energy deviation of the nano composites, it was found that the bandgap differences are shown in thefigurenumber5.4.

4. FiguresandTables

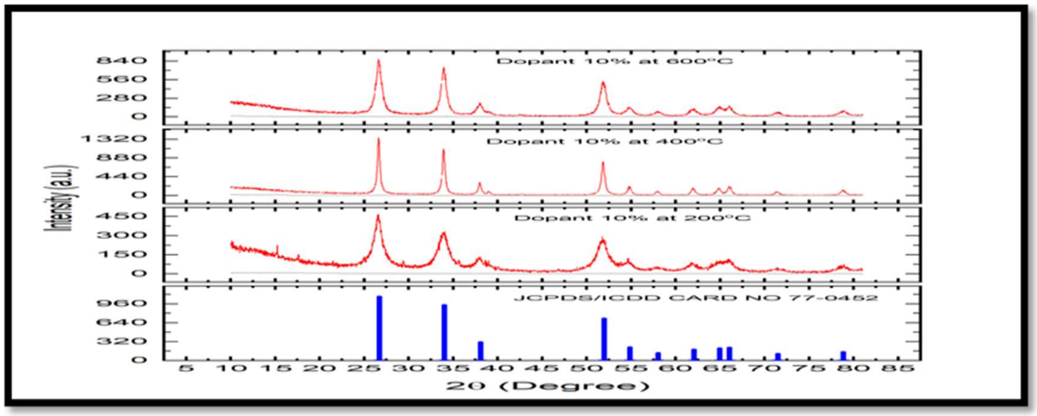

Figure 1 XRD Pattern of Al2O3 DopedSnO2 Nano Composites with 10% Dopant Concentration on Different Calcination Temperatures Calcined for 2 Hours. (a)200oC (b) 400oC (c) 600oC.and Compared with its JCPDS/ICDD data of SnO2 Nanoparticles.

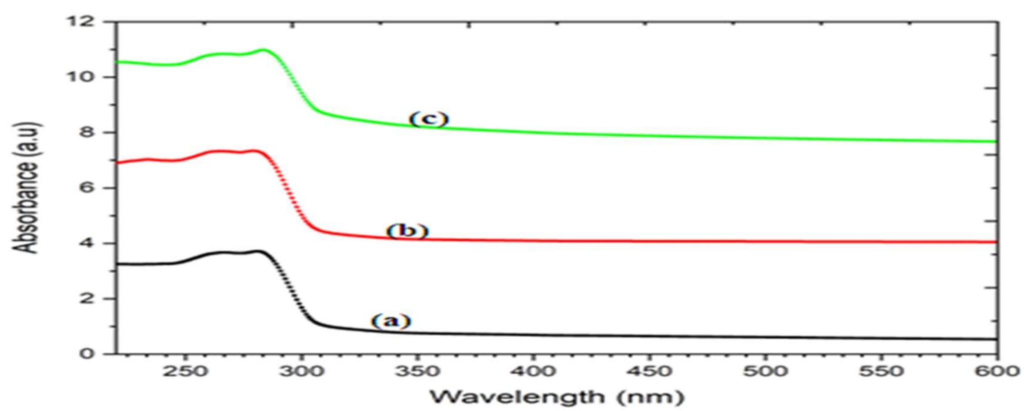

Figure 2 UV-Visible Spectra of Al2O3 Doped SnO2 Nano Composites with 10% Dopant Concentration on Different Calcination Temperatures and Calcinated for 2 Hours. (a) 200oC (b) 400oC (c) 600oC

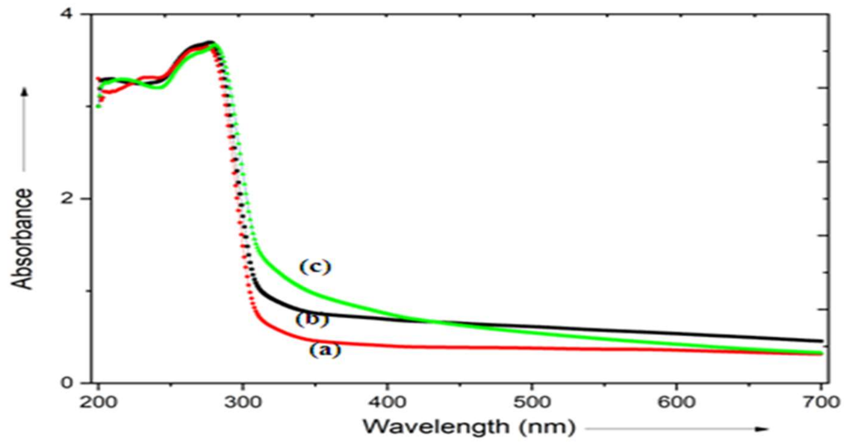

Figure 3 UV-Visible Spectra ofAl2O3 Doped SnO2 Nano Composites with10% Dopant Concentration on Different Calcination Temperatures and Calcinated for 2 Hours (a)200oC (b)400oC (c)600oC

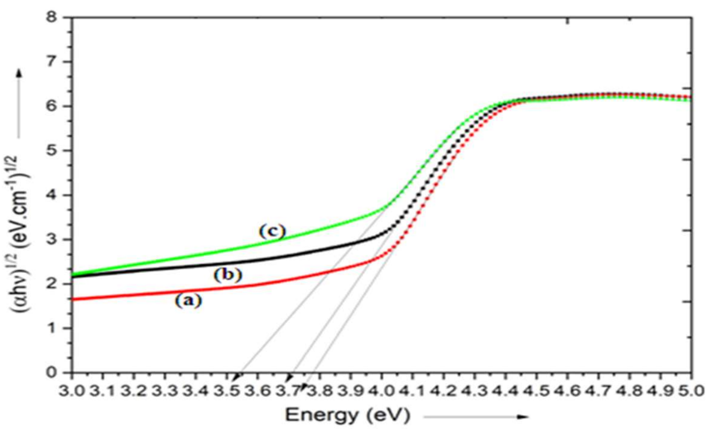

Figure 4 Tauc Plots of Al2O3 Doped SnO2 Nano Composites with 10% Dopant Concentration on Different Calcination Temperatures and Calcinated for 2 Hours. (a)200oC (b)400oC (c)600oC.

3. Conclusion:-The experimental and calculated peaks x-ray diffraction results are well matched and signify the formation of nano-composites. The figure 5.1 shows that x ray analysis, one matched Phases was obtained for the 10% doping of $Al2O_3$ with the SnO_2.the corresponding spectra shows the well-matched peaks as tin oxide which is indexed for the different calcination temperatures.According to figure number 5.2, the value of the absorbance at a wavelength of 250 nm to 310 nm is having peak in UV region, and these decreases with increasing calcination temperatures, the decrement are in very small amount.The figure number 5.3 shows the permissible indirect energy deviation of the nano composites, it was found that the band gap differences are shown in the figure number 5.3 are 3.71 eV, 3.77 eV and 3.53 eV for the calcinated temperatures.

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