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SYNTHESIS AND CHARACTERIZATION OF MANGANESE DOPED STRONTIUM OXIDE NANOPARTICLES

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ARTICLE INFO

Received : 25.03.2025
Revised : 11.05.2025
Accepted : 17.08.2025
Published : 15.09.2025

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Keywords:
SrO,
Sol – gel method,
XRD,
DRS,
PL.

ABSTRACT

The present work deals with the synthesis of manganese doped strontium oxide nanoparticles by sol - gel method. The manganese ion concentration was fixed at 0.05 mol. The synthesized samples are characterized by X-ray diffraction analysis (XRD), Diffuse reflectance spectroscopy (DRS) and photoluminescence (PL) spectroscopy respectively. XRD analysis confirmed the formation of cubic crystal structure. The DRS spectrum revealed the dopant absorption at UV region. The excitation spectrum confirmed the absorption at UV region from 250 nm to 450 nm and the emission spectrum showed the broad band covering the yellow- orange region with a maximum at 580 nm.

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1.INTRODUCTION

Nanotechnology with its nano - scale capabilities, that drive much of the dynamics of the natural and physical world, has the potential to make unprecedented advances in human history.Nanotechnology, which appeared in the last quarter of the 20thcentury, is rapidly developing.Usingnanotechnology,

materials can effectively be made stronger, lighter, more durable, more reactive, better electrical conductors among many other traits. Analkalineearthmetal, strontium is a soft silver-white yellowishmetallicelement that is highlychemicallyreactive. The metal forms a dark oxide layer when it is exposed to air. Strontium has physical and chemical propertiessimilartothoseofitstwovertical neighbours in the periodic table,calciumandbarium.

Strontium Oxide nanoparticles is an important nanomaterial with the wide range of applications like biomedical imaging of living tissues, fabrication of photovoltaic devices, gas sensors,-catalysts inchemicalreactions.Due to these applications, my present work deals with the synthesis of pure strontium oxide and strontium oxide doped with manganese nanoparticles by sol-gel method using distilled water as solvent. The synthesized samples were characterized by X-ray diffraction (XRD), Diffuse Reflectance Spectroscopy (DRS) and Photoluminescence (PL) spectroscopy respectively. Strontium oxide gained significant attention in recent years due to their unique physical, chemical, and optical properties. Composed of strontium and oxygen,thesenanoparticlesexhibit remarkable characteristics such as a high surface area, excellent stability, and enhanced reactivity compared to their bulk counterparts.

The main application of SrO: Mn nanomaterials issolid state lighting (W- LED). Manganese doping introduces energy levels within the band gap of SrO, enabling efficient light emission. By varying the Mn concentration andsynthesis conditions, the emission color can be tuned. Phosphor-Converted White LEDs (pc-WLEDs) are one of the most common approaches to produce white light. Manganese ions (Mn^{2+}) in the SrO lattice can produce broad green or red depending on the doping level and host lattice environment. SrO: Mnnanoparticles provide efficient light emission,enhancingthebrightness.

2. EXPERIMENTALPROCEDURE

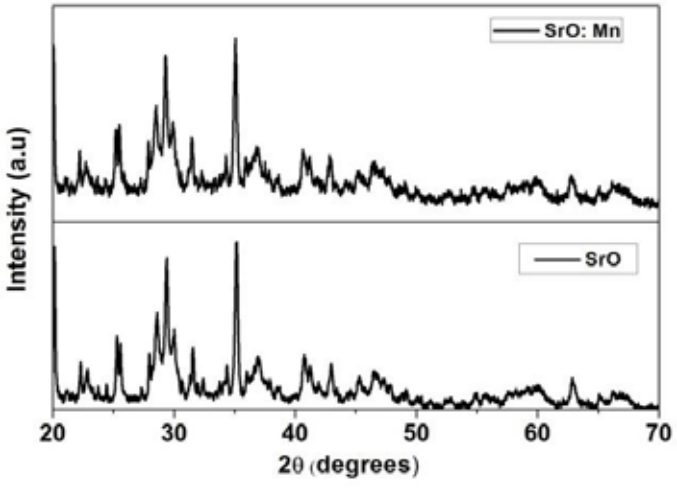
2.1 SOLGELMETHOD

Strontium oxide nanoparticles can be synthesized by various methods. In the presentworkwehaveattemptedtoprepare SrO nanoparticles by sol-gel method. The sol–gel process is a wet-chemical technique used for the fabrication of both glassy and ceramic materials. In this process, the sol (or solution) evolves gradually towards the formation of a gel- like network containing both a liquidphase and a solid phase. Typicalprecursors are metal alkoxides and metal chlorides, which undergo hydrolysis and polycondensation reactions to form a colloid. The basic structure or morphology of the solid phase can range anywherefrom discrete colloidal particles to continuous chain-like polymer networks. The sol-gel method involves the transition of a system from a liquid “sol” (a colloidal suspension) to a solid “gel” phase. It’s a versatile technique widely used for synthesizing metal oxides and doped nanoparticles. Strontium Nitrate doped with manganese dissolve in a suitable solvent like distilled water or ethanol. The pure and manganese doped strontiumoxide nanoparticles were synthesized by sol-gelmethodusingStrontiumnitrate

[$Sr(NO_3)_2$], Urea [CH_4N_2O], Manganese chloride [M n (- Cl_2).$4H_2O$]. The stoichiometric amounts of these chemical ingredients were taken into a beaker to which deionized water was added and allowed to stir for 5h to ensure the homogenous distribution of chemical species in ionic form. Finally, the solution was slowly heated at 110 ^oC until become dry massive solid. This step produces a xerogel (dried gel).Then the resultant gel mixture was heated at 800 ^oC for 3 h in muffle furnace so as to realize phase pure highly crystalline SrO nanoparticles. This step decomposes organic materials and crystallizes SrO: Mn nanoparticles. After synthesis, the nanoparticles are characterized using X-Ray Diffraction (XRD): Confirms crystalline structure and phase purity. Photoluminescence (PL) Spectroscopy: Assesses optical properties and emission spectra. DRS is a spectroscopic technique used to measure the optical absorption of powderedSrO: Mn samples by analyzing how light is reflected off the surface. It’s particularly useful for studying semiconductors, and doped nanoparticles.

3. RESULTS AND DISCUSSION

3.1 X-rayPowderDiffraction(XRD)



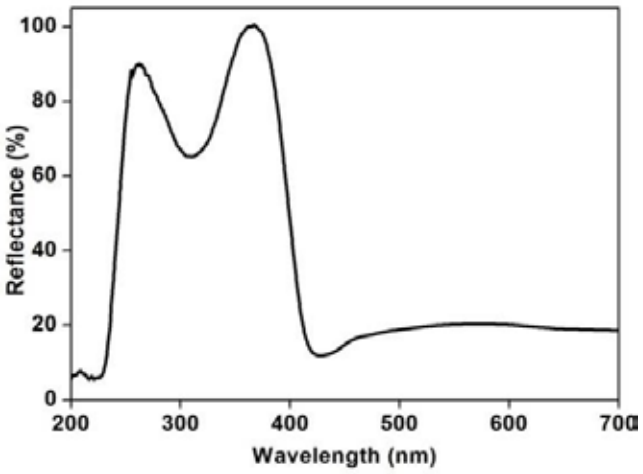
X-ray Powder Diffraction (XRD) is an efficient analytical technique used determinationofgrainsize,compositionof solid solution, lattice constants and degree of crystallinity in a mixture of amorphous and crystalline substances.

Fig3.1.XRDpatternofSrOand SrO:Mn nanoparticles

Figure shows the XRD pattern ofstrontium oxide and manganese doped strontium oxide nanoparticles. It indicates the presence of cubic crystal structure

3.2 DiffuseReflectanceSpectra-DRS

Diffuse reflectance spectroscopy is a type of absorption where the light reflected from the sample is recorded, rather than the beam transmitted through the sample. The Diffuse Reflectance Spectrum of SrO:Mn nanoparticles are shown in Fig. The tune of host bandgap as wellasexistenceofthechargetransferband (CTB) and dopant absorption are revealed from the diffuse reflectance spectral measurements. The Mn ion has absorption at 270 nm, 310 nm and 420 nm respectively.



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Fig 3.2: Diffuse Reflectance spectrum of SrO: Mn nanoparticles

3.3 PHOTOLUMINESCENCE

The excitation and emission spectra of SrO: Mn nanoparticles are shown in figure.

3.3.1 ExcitationSpectrum

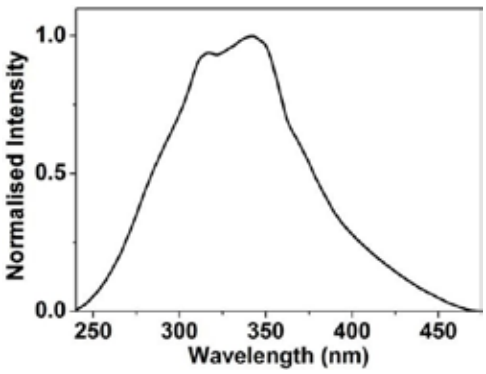


Fig3.3:ExcitationspectrumofSrO:Mn nanoparicles

The excitation spectra of SrO: Mn nanoparicles are shown in figure. The excitation spectrumshows a broad absorption band in the UV region with a maxima at 310 nm and 350 nm,which are dueto the $^6A_1$- $^4T_1$electronictransition of Mn^{2+}ion, respectively.

3.3.2 EmissionSpectrum:

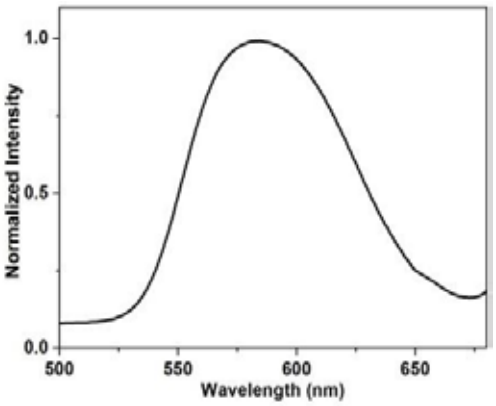


Fig3.4: Emission spectrum of SrO: Mnnanoparicles

Emission spectrum monitored at the excitation wavelength of 350 nm is shown in the above figure. The emission spectrum shows an asymmetric emission band covering the yellow- orange region with a maximum at 580 nm, which is due to the and$^6A_1$- $^4T_1$electronic transition of Mn ion.

4 . CONCLUSION

In the present work, we have attempted to prepare pure strontium oxide andstrontium oxide doped with manganese nanoparticlesbyusingsolgelmethod.

The prepared samples were characterized by XRD, DRS and PL analysis. The X- Ray Diffraction (XRD) pattern of SrO and SrO: Mn nanoparticles confirms the cubic crystal structure of the synthesized materials. The Diffuse Reflectance Spectrum of SrO: Mn nanoparticlesreveals absorption peaks at 270 nm, 310 nm, and 420 nm. The observed absorption indicates effective incorporation of Mn ions into the SrO matrix.Theexcitation spectrum of SrO: Mn nanoparticles displays a broad absorption band in theUV region with maxima at 310 nm and350 nm. These peaks are attributed to the ^{6}A1 - ^{4}T1 electronic transition of Mn^{2+} ions, signifying that the Mn dopant effectively introduces electronic states that respond to UV excitation. The emission spectrum, monitored at an excitation wavelength of 350 nm, shows an asymmetric emission band in the yellow- orange region, peaking at 580 nm. This emission is due to the ^{6}A1 - ^{4}T1 electronic transition of Mn ions. This analysis highlights the structural and optical properties of the synthesized SrO: Mn nanoparticles, confirming successful doping and potential applications in photonics and optoelectronics.

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