Fluorescence studies of Zinc Oxide Nanomaterial with Neodymium ion

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Abstract: The Fluorescence spectra have been recorded of Nd^{3+} doped ZnO nanomaterial using with intense absorption bands (400nm) at room temperature in visible region. The spontaneous emission probability (A) values have been calculated for the fluorescence bands at 882.2nm ($^4F_{3/2} \rightarrow {}^4I_{9/2}$), 1046 nm ($^4F_{3/2} \rightarrow {}^4I_{11/2}$), 1380 nm ($^4F_{3/2} \rightarrow {}^4I_{13/2}$) and 1403nm ($^4F_{3/2} \rightarrow {}^4I_{15/2}$) have been calculated for ZnONMNd and assigned to $^4F_{3/2} \rightarrow {}^4I_{9/2}$, $^4F_{3/2} \rightarrow {}^4I_{11/}$,$^4F_{3/2} \rightarrow {}^4I_{13/2,}$ and $^4F_{3/2} \rightarrow {}^4I_{15/2}$.transitions respectively. Radiative properties viz. spontaneous emission probability (A), fluorescence branching ratio (β), radiative life time (τ) and stimulated emission cross- section (σp) have been computed. The size range of the generated Nd^{3+} doped ZnO nanomaterial was approximately 50-20nm. The trend of stimulated emission cross-section (σ_P) has been shown like this $^4F_{3/2} \rightarrow {}^4I_{9/2}$, $^4F_{3/2} \rightarrow {}^4I_{11/}$,$^4F_{3/2} \rightarrow {}^4I_{13/2,}$ and $^4F_{3/2} \rightarrow {}^4I_{15/2}$.

Keywords: Neodymium Nd^{3+} doped ZnO nanoparticles, Judf-Ofelt Intensity Parameters Fluorescence Spectra, Radiative Properties and Emission Cross Section.

1. Introduction

ZnO is a wide band-gap semiconductor (3.37 eV) featuring peculiar physical and chemical properties, such as photo- and sono-catalytic activities [1,2,3], piezoelectricity [4,5] and pyroelectric [6] behaviors. The abovementioned properties can be combined together and even strengthened by selecting, among the numerous ZnO morphologies, the most appropriate one: thin films [7,8] nanowires (NWs) [9] nanorods (NRs) [10] nanobelts [11] nanoparticles (NPs) [13] and flower-like structures [14] can be easily synthesized by wet and dry preparation approaches such as sol-gel and hydrothermal routes, and chemical synthesis techniques. The rare earth ion doped ZnO has the potential to be a highly multifunctional material with coexisting semiconducting, electromechanical and optical properties.

Recent work is available on synthesis and studies of the ZnO Nanomaterial with Neodimium ions of 0.2mol% . The rare earth ions are better luminescent materials because of the sharp and intense emission due to their 4f intra shell transitions. Elements of the rare earth ions series are characterized by a partially filled 4f energy level, surrounded by full 5s and 5p orbitals. Shielding effects of the 5s and 5p orbitals allow the Photoluminescence (PL) spectra of rare-earth ions to show emission frequencies, which are relatively host independent. RE doped zinc oxide nanocrystals has turned out to be an important area of quest. The task of doping has been un-assailable due to easy formation of metal-aqua complex and its inability to merge into the ZnO crystal lattice [15]. The radiative efficiency of impurity-induced emission increases [16] when rare earth ions (RE) dopent is introduced into the crystal lattice of ZnO structure, enhancing its photo-luminescence phenomenon.

Experimental

ZnO nanoparticles will be tried in alcoholic media like ethanol, methanol or propanol. In alcoholic media growth of oxide particles is slow and controllable [17]. Different solutions will be prepared by dissolving 0.2725 g of $ZnCl_2$ (10^{-1} M, 20 ml), 0.525 g NaOH (10^{-1} M, 100 ml) and *X* M glycerol in ethanol. Glycerol slowly added to NaOH solution while it will be continuously stirred. The resulting solution will be stirred for one hour before adding $ZnCl_2$ and 0.2mol% Nd^{3+} solution to it. After three hours of constant stirring a milky white solution will be obtained. Size selective precipitation will be carried out using acetone as a non-solvent. The precipitate will be washed in methanol and ethanol will be allowed to evaporate at room temperature to obtain doped ZnO nanoparticles in white powder form.

Characterization of the Materials:

Scanning electron microscopy -SEM

The size of the ZnONM:Nd^{3+} nano particle around 100-200 nm. It demonstrates clearly the formation of nearly spherical ZnONM: Nd^{3+} nanoparticles, and change of the morphology

Transmission Electron Microscope- TEM

TEM images of ZnONM: Nd^{3+} nanoparticle have been recorded and collected in fig-2 The estimated average particle size to 0.2mol%, are 50 nm.

Radiative properties

Four fluorescence bands have been observed in ZnONMNd. They have been assigned to transitions $^4F_{3/2} \rightarrow {}^4I_{9/2}$, $^4F_{3/2} \rightarrow {}^4I_{11/}$,$^4F_{3/2} \rightarrow {}^4I_{13/2}$, and $^4F_{3/2} \rightarrow {}^4I_{15/2}$. Four fluorescence bands have been observed at room temperature. For laser applications, the value of emission cross-section is an important parameter and signifies the rate of energy extraction from the optical material. A large stimulated emission cross-section is of benefit for a low threshold and a high gain in laser operation. The various laser parameters like spontaneous emission probability (A), branching ratio (β), radiative life time (τ), and stimulated emission cross-section (σ_P) in table 6 have been calculated Neodymium is one of the most widely used elements for high power laser applications. Recently these lasers have shown their usefulness in inertia confined fusion Experiments. Furthermore, Nd^{3+} doping reduces the band gap energy and enhances the possibility of the photo degradation of dyes under visible light.

Transitions	λ(nm)	A(sec^{-1})	β	τ (μ sec)	$\sigma_p(10^{-20})$
$^4F_{3/2} \rightarrow {}_2{}^4I_{13/2}$	1.38E-04	1.97E+02	7.82E-02	5.09E-03	1.28E-21
$^4F_{3/2} \rightarrow {}^4I_{11/2}$	1.05E-04	1.08E+03	4.28E-01	9.29E-04	2.32E-21
$^4F_{3/2} \rightarrow {}^4I_{9/2}$	8.83E-05	1.23E+03	4.89E-01	8.13E-04	1.73E-20

Table-Emission cross section (σ_p) for various levels of ZnONM: Nd^{3+}nanoparticles

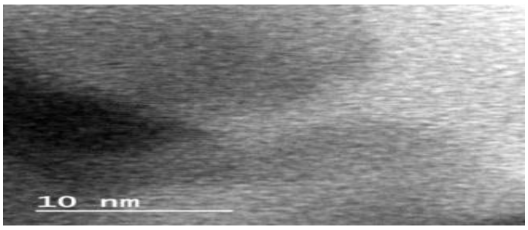

Fig1- SEM-0.2% Nd^{3+} -ZnONM

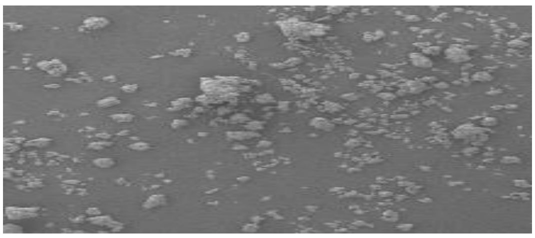

Fig2- TEM-0.2% Nd^{3+} -ZnONM

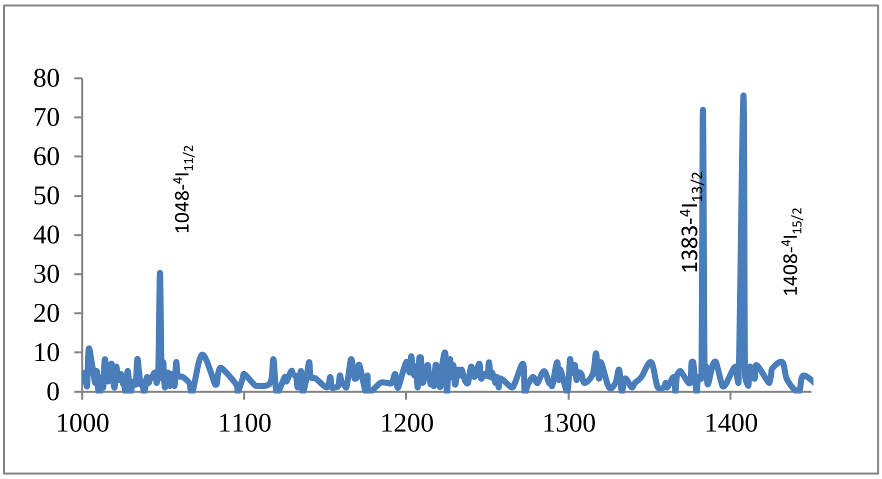

Fig3- : fluorescence spectrum of 0.2% Nd^{3+} -ZnONM

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