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Effect of Different Excitations on Photoluminescence Behaviour of the Tb^{3+} Gd_2O_3 Phosphor

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Abstract

Gd_2O_3:Tb^{3+} phosphor was prepared by combustion synthesis method using glycerin as a fuel and annealed it for further studies at 900°C. The XRD result confirms the formation of monoclinic phosphor. The photoluminescence behavior was determined by recording the excitation and emission spectra of the prepared phosphor. The excitation spectra have intense peaks at 229, 277 and 314 nm. Emission spectra were recorded under different excitation. The most intense peak was found in the green region. All the spectra have emission peaks at the same positions only they differ in their intensities. The maximum intensity was found under 277 nm excitation.

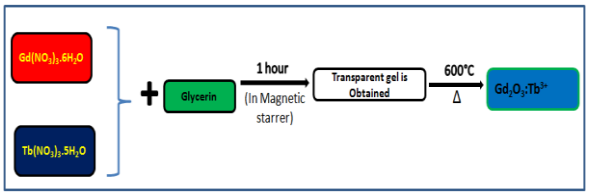
Keywords:- Gd_2O_3: Tb^{3+}, Photoluminescence

Introduction:- Rare earth elements have partially field d and f orbitals, which gives rise to spectrally narrow localized electronic transitions in the ultra violet to far infrared region [1]. Rare earth oxide phosphors were found suitable for field emission display, plasma panel display devices, electroluminescence devices etc [2-4]. Gd_2O_3 is a member of rare earth oxide host. Gd^{3+} ion has a longest excited level and gives emission lines in UV region and the luminescence is altered by addition of other rare-earth ions [5]. Among the rare earths, Tb^{3+} ions in different hosts could show an intense green emission and hence those have been used in the development of efficient green emitting phosphors and scintillator materials [6,7]. Several reports have also confirmed the use of Tb^{3+} as an active ion in laser glasses [8,9]. In present paper we have synthesized Gd_2O_3:Tb^{3+} codoped phosphors by combustion method.

The structural, morphological and optical properties of the prepared phosphor were determined. The photoluminescence excitation and emission spectra were recorded. The emission spectra were recorded for three different excitations present in excitation spectra.

Synthesis:

Tb^{3+} doped Gd_2O_3 phosphor was synthesized by solution combustion synthesis method using $Gd(NO_3)_3.6H_2O$, $Tb(NO_3)_3.6H_2O$ as precursor materials and urea as fuel. The synthesis process was carried out by using the steps of our previous reported method [10]. The obtained sample was annealed at 900°C (Scheme 1).



Scheme 1. Synthesis of $Gd_2O_3:Tb^{3+}$ phosphor

The phase of prepared phosphor was determined by recording X-ray diffraction pattern of the prepared sample. The Pattern is in good agreement with JCPDS card No. 43-1015 [11] of pure Gd_2O_3, and shows no impurity peaks due to Tb^{3+} ion. The crystal size was determined by Scherer's formula [12,13] and it was found around 18 nm.

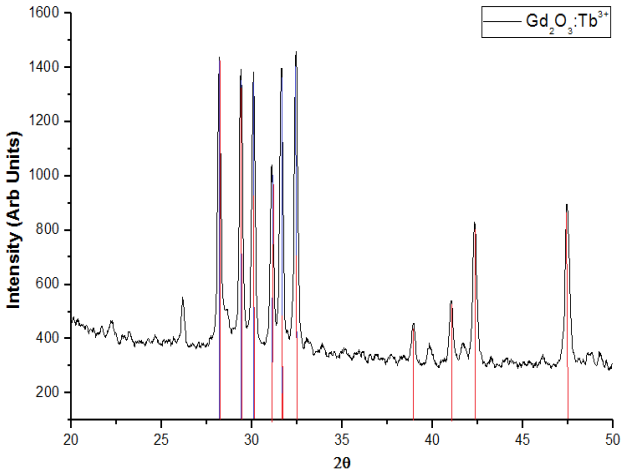


Figure 1. XRD pattern of annealed $Gd_2O_3:Tb^{3+}$ phosphor

The structure and crystal size of the phosphor was further confirmed by TEM analysis. The average particle size of the sample was found around 15 nm, which is in good agreement with XRD results (Fig 2).

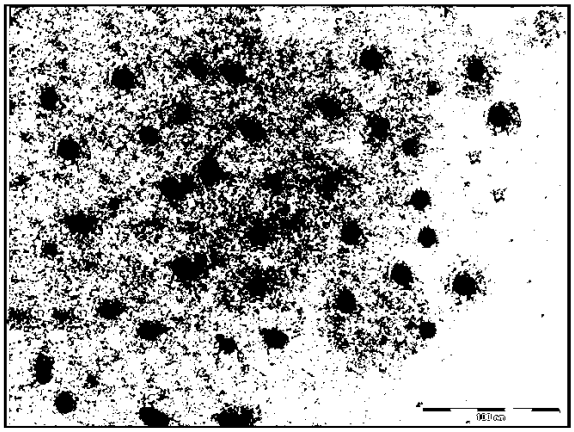


Figure 2 TEM Image of $Gd_2O_3:Tb^{3+}$ (1 mol%)

Crystal size distribution of the prepared phosphor was determined by using 100 crystals and represented in fig 3. The average crystal size from this analysis was also found around 15nm.

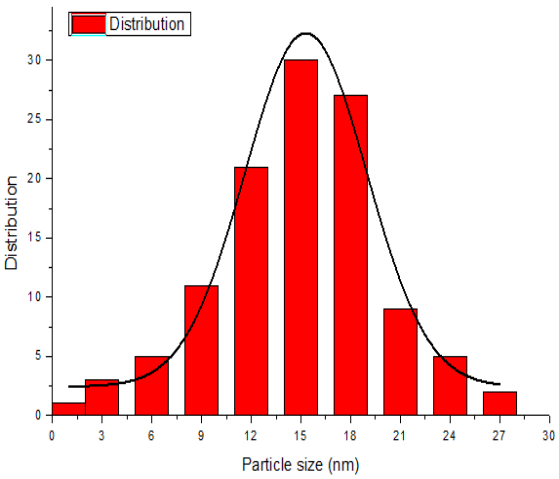


Figure 3. Crystal size distribution for $Gd_2O_3:Tb^{3+}$ from TEM image

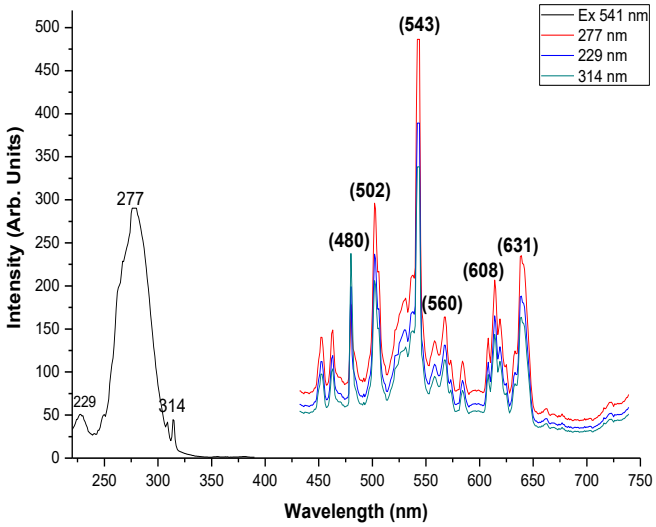


Figure 4. Excitation and emission spectra of $Gd_2O_3:Tb^{3+}$ under different excitations

An excitation spectrum of the phosphor was recorded under 574 nm wave length. The excitation spectrum has three peaks at 229 nm, 277 nm and 314 nm. Emission spectrum of the phosphor was recorded under all these three excitations. The emission spectra contain same emission peaks only differ in their intensities and excitation mechanism. The emission spectra have intense emission peak in green region centered at 543 nm along with small peaks at 502 nm, 560 nm, 608 nm and 631 nm. It also have emission peak at blue region at 480 nm.

Under different excitations 8S7/2 of Gd3+ excites at different levels and shows slight variation in energy transfer. By absorbing 229 nm photon 8S7/2 excites to 6Dj level, by 277 nm photon it excites to 6Ij level and by absorbing 314 nm photon it excites to 6Pj level.

The electrons from 6Dj and 6Ij levels de-excites non radiatively and populates 6Pj level. The energies from excited levels of Gd^{3+} will transfer to the $4f^7$ 5d level, $^5H_5$ and $^5D_2$ levels of Tb^{3+} respectively.

Transitions between energy levels of Tb^{3+} ion are responsible for all the visible transitions. The emission at 480 nm attributed due to $^5D_4 \rightarrow {}^7F_6$, the intense green emission at 543 nm along with weak emission peaks at 502 nm, 560 nm are corresponding to the $^5D_4 \rightarrow {}^7F_5$, $^5D_4 \rightarrow {}^7F_2$, $^5D_4 \rightarrow {}^7F_4$ transitions respectively. The red emission at 631 nm is due to $^5D_4 \rightarrow {}^7F_3$ transition [14] (Fig 5). The emission spectrum under 277 nm excitation shows maximum intensity then other two excitations.

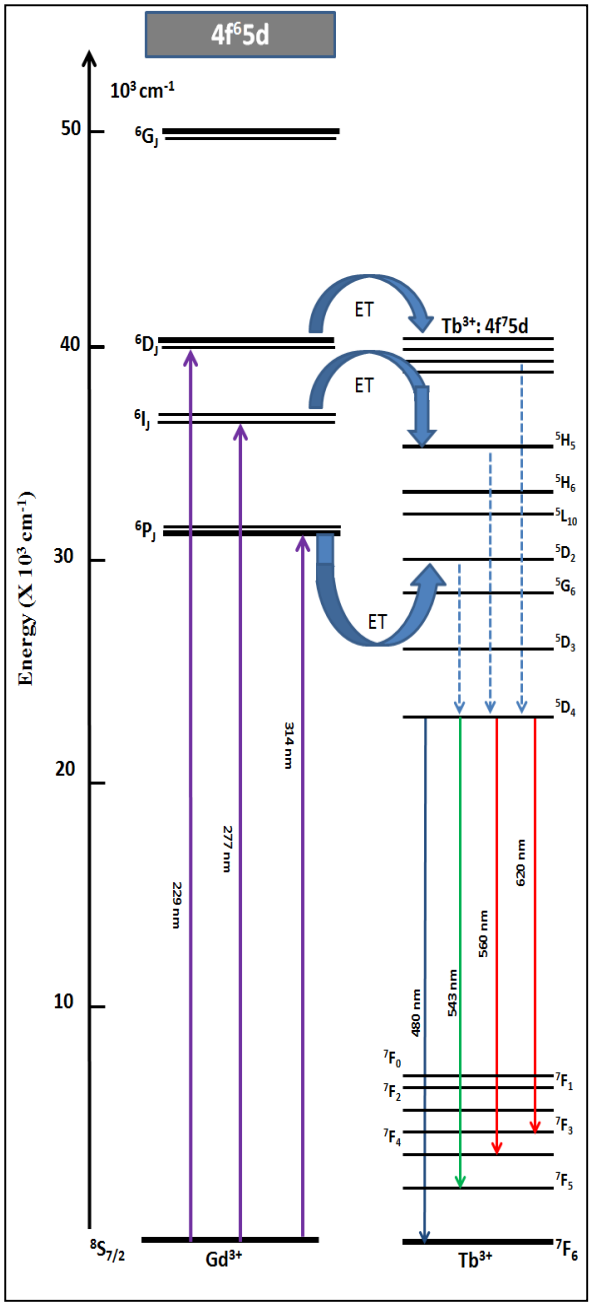


Figure 5. energy level diagram of Gd_2O_3:Tb^{3+} phosphor

Conclusion:

Tb^{3+} doped Gd_2O_3 phosphor was synthesized by solution combustion method. Structural characterization confirms monoclinic phase with crystal size 18 nm, which further confirmed by TEM analysis. The emission spectra recorded under three different excitations 229 nm, 277 nm and 314 nm have emission peaks centered at green region at 543 nm the most intense one and weak emissions at 502 nm, 560 nm, 480 nm, and weak red emission at 631 nm. The most intense emissions were found for 277 nm excitation.

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