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$Tb^{3+} \rightarrow Ce^{3+}$ ENERGY TRANSFER IN $Y_3Ga_5O_{12}:Ce^{3+},Tb^{3+}$ GARNET

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The Ce^{3+} excitation spectrum, the Tb^{3+} fluorescence lifetimes and $Tb^{3+} \rightarrow Ce^{3+}$ energy transfer in $Y_3Ga_5O_{12}:Ce^{3+},Tb^{3+}$ have been studied under the excitation of ultra-violet radiation containing 266.0 nm laser pulses at room temperature.

1. INTRODUCTION

Yttrium aluminium($Y_3Al_5O_{12}$) and gallium ($Y_3Ga_5O_{12}$) garnets are the excellent host for luminescence and laser material. The $Y_3Al_5O_{12}$ and $Y_3Ga_5O_{12}$ garnet phosphors codoped with Ce(3+) and Tb(3+) are an interesting system in which a number of radiative, nonradiative and energy transfer processes can take place simultaneously.

In studing the fluorescence properties of the $Y_3Al_5O_{12}:Ce^{3+},Tb^{3+}$ garnet, energy transfer from Tb(3+) to Ce(3+) was observed by Liu and Ma of us[1]. Tb(3+)⟶ Ce(3+) energy transfer in $Y_3Al_5O_{12}$:Ce,Tb single crystaly films made by liquid phase epitaxy was studied under the excitation of the electron beam pulse[2]. Recently luminescence properties of the Ce(3+) ion in $Y_3Ga_5O_{12}$ garnet[3] have been reported just. Here new green luminescence material by Ce(3+) and Tb(3+) —coactivated yttrium gallium garnet phosphor and Tb(3+)⟶ Ce(3+) energy transfer in this system are investigated for the first time.

2. EXPERIMENTAL

The procedure used in preparing the phosphors studied was essentially a solid-state synthesis at high temperature. A part of the Y(3+) ions were replaced by Ce(3+) and Tb(3+) ions. The performance of the processes of the preparation and optical measurement of sample had been described previously[1].

The 266.0 nm laser pulses obtained by fourth-generation of YAG:Nd laser are used as the excitation source. The signal was analyzed by an BX-530 boxcar integrator.

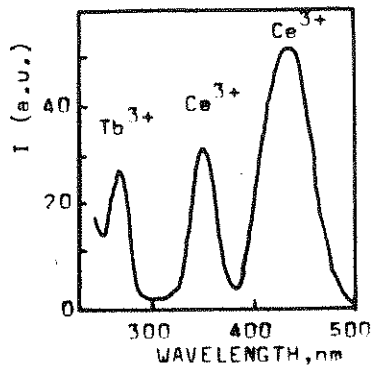

FIGURE 1
Excitation spectrum of the Ce(3+) 520 nm emission in $Y_3Ga_5O_{12}$:Ce,Tb phosphor.

3. RESULTS AND DISCUSSION

The strongest excitation band corresponding to the 4f-5d transition of the Tb(3+) is presented in the excitation spectrum of the Ce(3+) emission for $Y_3Ga_5O_{12}$:Ce,Tb when the Ce(3+) emission at 520 nm is monitored (see Fig. 1). In $Y_3Ga_5O_{12}$:Ce,Tb the excitation spectrum of the Ce(3+) ions coincides with the absorption spectra of the Ce(3+) and Tb(3+) ions. In the system $Y_3Ga_5O_{12}$:Ce,Tb between the Tb(3+) (donor) emission spectrum and the Ce(3+) (acceptor) excitation spectrum overlaps considerably.

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These results show that the energy obsorbed by Tb(3+) ions transfers to Ce(3+) ions by non-radiative and radiationless energy transfer mechanisms.

Another feature of the radiationless energy transfer is to exhibit a charge of the fluorescence lifetime observed of donor. In fact the donor fluorescence lifetimes observed of the $^5D_3$ and $^5D_4$ levels of the Tb^{3+} are decreased with Ce concentration when the $Y_3Ga_5O_{12}$:Ce,Tb samples are respectively excited by the 266.0 nm laser pulse with a width of 10 ns. For example, the intrinsic lifetimes τ_0 (418nm) and τ_0(544nm) of Tb^{3+} in $Y_3Ga_5O_{12}$:0.01Tb are 0.59 and 3.38 ms, respectively. The lifetimes τ(418nm) and τ(544 nm) of the donor in the present of the acceptor [Ce(3+), 0.5%], however, are 0.16 and 2.38 ms, respectively. The radiationless energy transfer efficiency η is given. The calculated values of η (418 nm) and η (544 nm) are 0.73 and 0.30, respectively.

This sensitization effect depends on the donor (Tb) concentration. Figure 2 shows that the emission intensities of the Ce(3+) depend on the concentrations of Tb in $Y_3Ga_5O_{12}$ under 263 nm UV excitation at room temperature.

It has been established that the energy transfer from the $^5D_3$ and $^5D_4$ levels of Tb(3+) to the Ce(3+) ions takes place in the system $Y_3Ga_5O_{12}$:Ce,Tb, which results in to enhance the emission. Under excitation of short wavelength UV, Tb(3+) ions in YGG:Ce, Tb system are excited into $f^7$5d state which lies in the region from 250 to 285 nm and then rapidly nonradiatively decay to $^5D_3$ and $^5D_4$ levels. A part of the excitation energy directly transits from $^5D_3$ and $^5D_4$

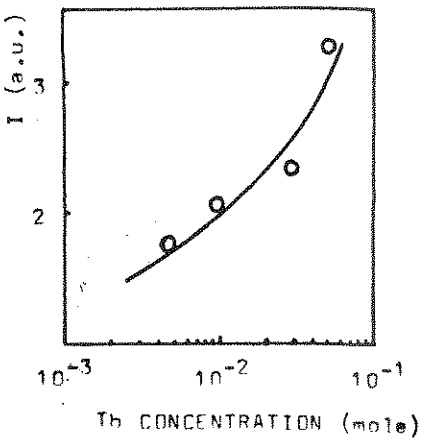

FIGURE 2
Relative intensity of the Ce(3+) 5d($^2D_{3/2}$)-4f(^2F_J) emission as a function of Tb concentration (X) under 263 nm UV excitation at RT.

to ^7F_J levels and results in Tb(3+) characteristic emissions; and other part of energy transfers from $^5D_3$ and $^5D_4$ levels to Ce(3+) ions by nonradiative energy resonance. Radiative energy transfer from Tb(3+) to Ce(3+) is not important in the system $Y_3Ga_5O_{12}$.

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