3.4 $\rightarrow$ 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$_3$Al$_5$O$_{12}$) and gallium (Y$_3Ga_5O_{12}$) garnets are the excellent host for luminescence and laser material. The Y$_3$Al$_5$O$_{12}$ 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 studying the fluorescence properties of the $Y_3Ga_5O_{12}:Ce^{3+}, Tb^{3+}$ garnet, energy transfer from Tb$^{3+}$ to Ce$^{3+}$ was observed by Liu and Ma of us. Tb$^{3+}$ $\rightarrow$ Ce$^{3+}$ energy transfer in Y$_3Ga_5O_{12}:Ce,Tb$ single crystal 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 we report the luminescence material by Ce$^{3+}$ and Tb$^{3+}$--doped yttrium gallium garnet phosphor and Tb$^{3+}$ $\rightarrow$ 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 optimization of the processes of the preparation and optical measurement of sample had been described previously$^1$. The 266.0 nm laser pulses obtained by

![Figure 1](image-url)

**FIGURE 1**
Exciitation spectrum of the Ce$^{3+}$ 520 nm emission in $Y_3Ga_5O_{12}:Ce,Tb$ phosphor.

Fourth-generation of YAG:Nd laser are used as the excitation source. The signal was analyzed by an BK-530 boxcar integrator.

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.
These results show that the energy absorbed 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 change 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$_2$O$_3$:Ce:Tb samples are respectively excited by the 266.0 nm laser pulse with a width of 10 ns. For example, the intrinsic lifetimes $\tau_0$ (418 nm) and $\tau_0$ (544 nm) of Tb$^{3+}$ in Y$_2$O$_3$:0.01% Tb are 0.59 and 3.58 ms, respectively. The lifetimes $\tau_0$ (418 nm) and $\tau_0$ (544 nm) of the donor in the present of the acceptor [Ce(3+), 0.5%], however, are 0.15 and 2.38 ms, respectively. The radiationless energy transfer efficiency $\eta$ is given. The calculated values of $\eta$ (418 nm) and $\eta$ (544 nm) are 0.73 and 0.30, respectively.

This sensitization effect depends on the donor (Th) concentration. Figure 2 shows that the emission intensities of the Ce(3+) depend on the concentrations of Tb in Y$_2$O$_3$ 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$_2$O$_3$:Ce:Tb, which results in to enhance the emission. Under excitation of short wavelength UV, Tb(3+) ions in Y$_2$O$_3$:Ce:Tb system are excited into $^4F_9$ 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 $^5D_4$ 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$_2$O$_3$:Ce:Tb.

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REFERENCES