Studies of Two Cerium Sites in Mixed $(Lu,Y,Gd)_2SiO_5$:Ce Crystals

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Photoluminescence spectra of Gd_2SiO_5:Ce, Lu_2SiO_5:Ce, and Y_2SiO_5:Ce were investigated thoroughly by Suzuki *et al.* [1,2]. They distinguished two crystallographic sites (denoted as Ce1 and Ce2) occupied by Ce^{3+} ions and assigned to them two emission bands, peaking in GSO:Ce at 425 and 480 nm, respectively. Both the efficiency and the decay time of the shorter wavelength luminescence (Ce1) were almost temperature-independent between 10 and 300 K. On the contrary, in case of the Ce2 luminescence reduced intensities and shorter decay time constants were observed at higher temperatures.

In 2002 at the Superlumi station of HASYLAB we studied the role of the two cerium sites in Lu_2SiO_5:Ce and Y_2SiO_5:Ce [3]. In this year we have extended our studies by including three mixed crystals, i.e. $(Lu_xY_{1-x})_2SiO_5$:Ce (LYSO:Ce), $(Lu_xGd_{1-x})_2SiO_5$:Ce (LGSO:Ce), and $(Lu_xY_yGd_{1-(x+y)})_2SiO_5$:Ce (LYGSO:Ce). All the crystals have been grown at CTI MI, Inc. In this report we summarize all the results.

Fig. 1 shows the low temperature excitation spectra of both cerium emissions in LYGSO:Ce which is very similar to the spectra of other studied crystals (LSO:Ce, YSO:Ce, LYSO:Ce, LGSO:Ce). It is clear that the Ce1 luminescence can be efficiently excited at about 180, 260, and 290 nm. Although the maximum of the second curve (Ce2) is located at about 190 nm, the 325 nm peak turns out to be a better choice for selective excitation of the Ce2 luminescence, as there is also a local minimum in the Ce1 excitation spectrum at this wavelength. We note that the room temperature excitation spectra (not shown) are characteristic of the Ce1 center despite the 500 nm observation wavelength (see ref. [3]). Thus in this report we concentrate on the low temperature spectra and time profiles.

In *Fig. 2* we present the luminescence spectra of LYSO:Ce, LGSO:Ce, and LYGSO:Ce. For the 290 nm excitation the spectra consist of the Ce1 bands (the spin-orbit split $^2F_{5/2}$ and $^2F_{7/2}$ levels of the Ce^{3+} 4*f* configuration are resolved) with almost no contribution from the Ce2 sites. Additionally, some remnants of intrinsic emissions characteristic of the undoped $(Lu_xY_yGd_{1-(x+y)})_2SiO_5$ crystals occur below 370 nm. The spectra excited at 325 nm look quite different: although both cerium emissions can be observed, the Ce2 band with maximum close to 465 nm clearly dominates.

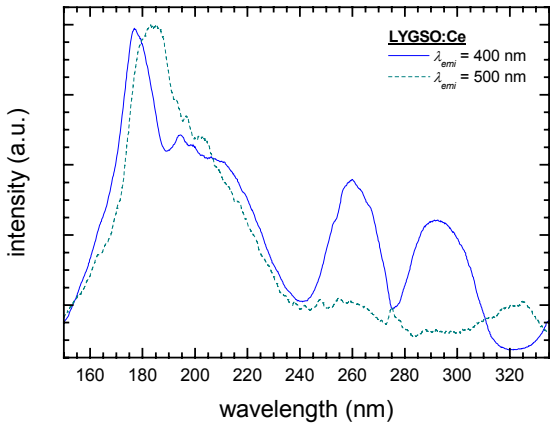

Figure 1: Low temperature excitation spectra of the Ce1 and Ce2 emissions in LYGSO:Ce

Fig. 3 shows the low temperature time profiles of photoluminescence coming from the two cerium sites in LYGSO:Ce. The Ce1 emission excited at 290 nm and observed at 400 nm decays single-exponentially with a time constant of about 35 ns. The Ce2 emission profile is also single-exponential, but the decay time constant is longer (above 50 ns). The time profiles recorded for the other crystals are similar, although decay time constants from fits vary slightly between 35 to 38 ns (Ce1) and from 51 to 57 ns (Ce2). We note here that at room temperature the Ce1 luminescence time profiles of different crystals are practically the same. The quenched Ce2 luminescence decays

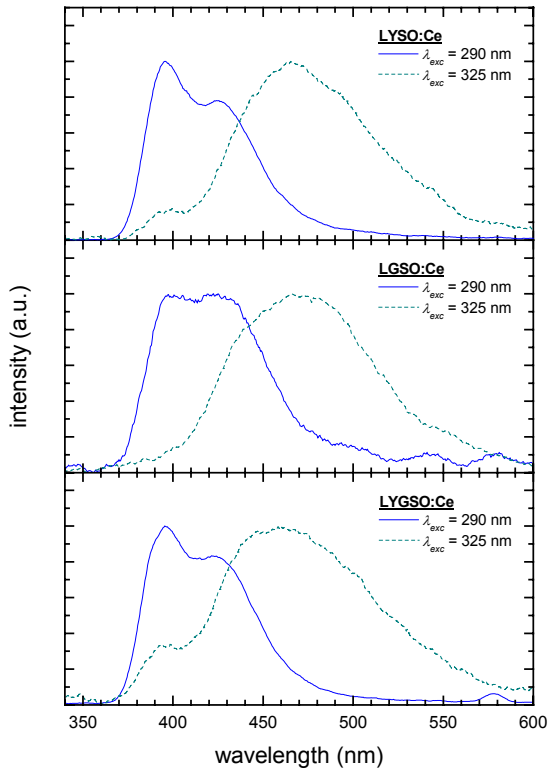

Figure 2: Low temperature emission spectra of LYSO:Ce, LGSO:Ce, and LYGSO:Ce

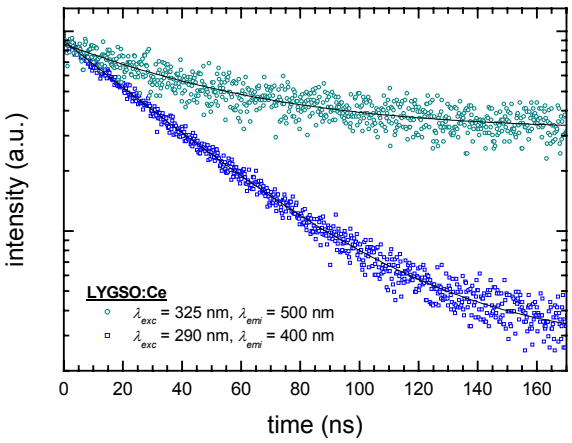

Figure 3: Low temperature time profiles of the Ce1 and Ce2 emissions in LYGSO:Ce

much faster but, as expected, its contribution is much less significant [3].

The summary of the results discussed above is presented in *Table 1*. We conclude that the major cerium sites in all of the studied crystals (LSO:Ce, YSO:Ce, LYSO:Ce, LGSO:Ce, and LYGSO:Ce) and the role they play in the mechanism of light production in those crystals are very similar.

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Table 1: Band maxima (±2.5 nm) and photoluminescence decay times of both cerium emissions at low temperature in all studied materials (τ_1: λ_{exc} = 290 nm, λ_{emi} = 400 nm; τ_2: λ_{exc} = 325 nm, λ_{emi} = 500 nm)

crystal	Ce1		Ce2	
	λ_{max1} (nm)	τ_1 (ns)	λ_{max2} (nm)	τ_2 (ns)
LSO:Ce	395, 425	36	465	57
YSO:Ce	390, 420	38	470	56
LYSO:Ce	395, 425	35	465	57
LGSO:Ce	395, 425	35	465	52
LYGSO:Ce	395, 425	36	460	51

References

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