Studies of Two Cerium Sites in Lu_2SiO_5:Ce and Y_2SiO_5:Ce

W. Drozdowski, A.J. Wojtowicz, D. Wisniewski, and P. Szupryczynski

Institute of Physics, N. Copernicus University, Grudziadzka 5/7, 87-100 Torun, Poland

Photoluminescence spectra of Gd_2SiO_5:Ce (GSO:Ce), Lu_2SiO_5:Ce (LSO:Ce) and Y_2SiO_5:Ce (YSO:Ce) were investigated thoroughly by Suzuki *et al.* [1,2]. They reported the existence of two distinct crystallographic sites (denoted as Ce1 and Ce2) occupied by Ce^{3+} ions. These sites were responsible for 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 in the 10-300 K range. On the contrary, in case of the Ce2 luminescence reduced intensities and shorter decay time constants were observed while reaching room temperature.

The Lu_2SiO_5:Ce and Y_2SiO_5:Ce crystals, however, received much less attention in the studies of Suzuki *et al.* [1,2]. Moreover, their measurements were performed at excitation wavelengths longer than 240 nm. These facts explain our decision to record several photoluminescence spectra and time profiles of LSO:Ce and YSO:Ce samples cut from boules grown by Photonic Materials Limited, Scotland, at the Superlumi station of HASYLAB.

The low temperature excitation spectra of both cerium emissions in Lu_2SiO_5:Ce are presented in *Fig. 1a*. The Ce1 luminescence can be efficiently excited below 130 nm (this region is discussed in detail in another report [3]), and also at 180, 260, and 290 nm, whereas the best choice for the Ce2 luminescence excitation is the 320 nm peak, which is not only a local Ce2 maximum, but a local Ce1 minimum as well. In agreement with expectations, the excitation spectra at room temperature (not shown) are dominated by the Ce1 emission even if observed at 500 nm.

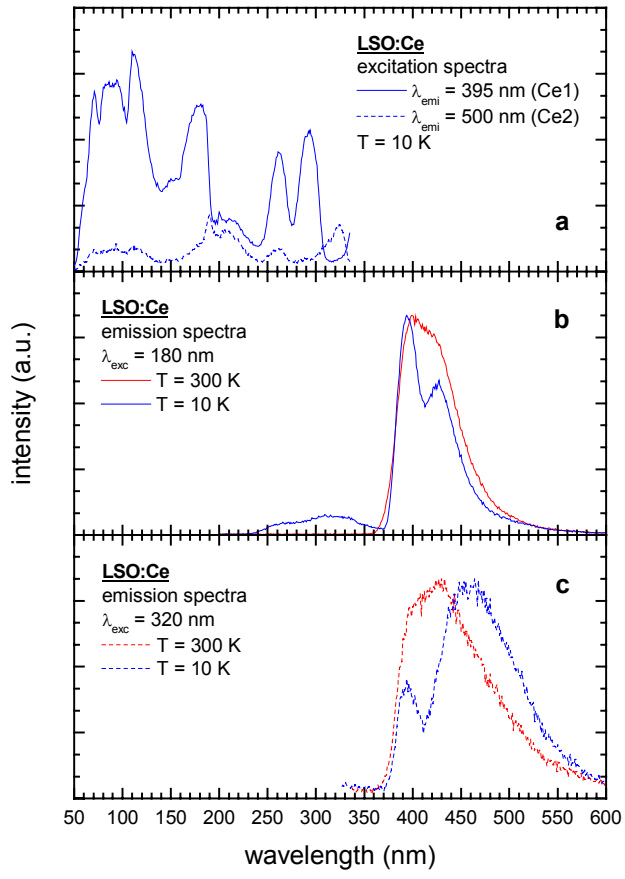

Figure 1: Excitation and emission spectra of LSO:Ce

In *Fig. 1b* we show the luminescence spectra of LSO:Ce at 180 nm excitation. They consist of the Ce1 emission (at low temperature the spin-orbit split $^2F_{5/2}$ and $^2F_{7/2}$ levels of the Ce^{3+} $4f$ configuration are resolved) with almost no contribution from the Ce2 emission. An additional band between 230 and 370 nm, which can be ascribed to the Lu_2SiO_5 host, appears at 10 K.

The spectra excited at 320 nm (*Fig. 1c*) look quite different, particularly at low temperature. The maximum is shifted to 460 nm, but it is still rather not the real maximum of the Ce2 luminescence, as the contribution from the Ce1 luminescence is evident. At room temperature the significance of the Ce2 sites clearly decreases in favour of the Ce1 ones.

In *Fig. 2* we present the time profiles of photoluminescence coming from the two cerium sites in Lu_2SiO_5:Ce. The Ce1 emission excited at 180 nm and observed

at 395 nm (*a*) decays single-exponentially with a time constant of about 40 ns both at low and room temperature. In case of the 320 nm excitation and the 500 nm detection (*b*) a bit slower (~50 ns) single-exponential decay at 10 K turns into a double-exponential one at 300 K. The short component (~5 ns) is most probably due to some remains of the Ce2 luminescence, which is indeed expected to be much faster at room temperature [1,2]. The longer component can be then associated with the Ce1 luminescence, the intensity of which at 500 nm is high enough to contribute to the time profile.

As the results obtained for theY_2SiO_5:Ce crystal are very similar, we limit ourselves to show a few representative spectra measured at low temperature (*Fig. 3*). Both the excitation (*a*) and the emission (*b*) bands characteristic of the Ce1 and Ce2 sites in YSO:Ce resemble those observed in LSO:Ce (*Fig. 1*). The most apparent difference is the weaker VUV response of YSO:Ce, what correlates well with the lower scintillation light yield of this particular YSO:Ce sample comparing to the LSO:Ce one (see another report [3]).

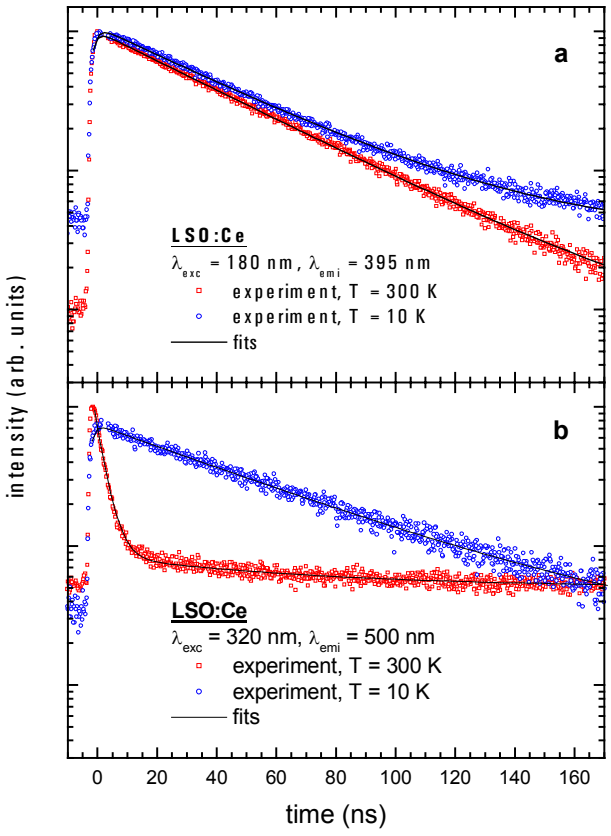

Figure 2: Time profiles of the Ce1 and Ce2 emissions

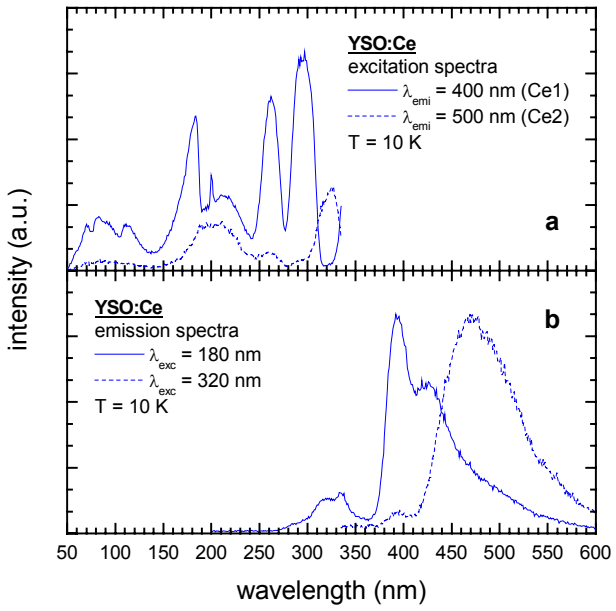

Figure 3: Excitation and emission spectra of YSO:Ce

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References

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