Insights into the multi-site emission from $SrAl_2O_4:Eu^{2+}$-Dy^{3+} persistent phosphors by time-resolved streak imaging

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【Introduction】 Persistent phosphors with intense and long duration persistent luminescence (PersL, a "self-sustained" luminescence after ceasing external excitation) continuously stimulate the extensive research interest of material scientists, chemists, physicists, and even biologists because of their unique optical phenomena and potential widespread applications [1]. $SrAl_2O_4:Eu^{2+}$-Dy^{3+}, as one of the most successfully persistent phosphors since its discovery by Nemoto & Co., LTD at the beginning of 1990s [2], gives nearly perfect PersL properties: (i) extremely bright and long duration in the dark (over 30 hours before the emission intensity dropping upon 0.32 mcd/m^2); (ii) green emission band peaking at ~530 nm that matches well with the human's photopic vision; (iii) broad excitation band suitable for the charging process *via* conventional fluorescent lamps and large absorption cross-section of the parity-allowed Eu^{2+}: $4f^7 \rightarrow 4f^6 5d^1$ transition; (iv) highly chemical and physical stability without any radioactive elements. It was reported that an additional broad band emission at ~450 nm can be clearly observed at low temperatures (*i.e.*, 100 K) [3], which is attributed to the Eu^{2+} emission from that occupying the other Sr site. Here, in order to clarify the relationship between the two kinds of Sr sites, low temperature time-resolved spectroscopy of commercial $SrAl_2O_4:Eu^{2+}$-Dy^{3+} is investigated.

【Experimental procedure】 Commercial $SrAl_2O_4:Eu^{2+}$-Dy^{3+} powder phosphors (Nemoto & Co., LTD, LumiNova@, G-300M) are used as target samples. The detailed setup of time-resolved streak imaging system with microscope spectrometer and OPO femtosecond (fs) laser will be explained during the conference.

【Results and discussion】 Fig. 1 gives time-resolved streak imaging of the $SrAl_2O_4:Eu^{2+}$-Dy^{3+} sample under 365 nm laser excitation. At low temperature (4 K), besides the well-known green emission from the Sr2 site, an additional emission in the blue region from the Sr1 site is clearly observed, which exhibits much faster decay kinetics (~0.44 μs) compared with that from the Sr2 site (~1.28 μs). However, at room temperature, the blue emission from the Sr1 site is almost quenched, while the green emission from the Sr2 site becomes dominant. The nonexponential decay profile of Eu^{2+} from the Sr1 site suggests the possible energy transfer (ET) process between Eu^{2+} in two sites, which contributes to the fast quenching behavior of Eu^{2+} emission at the Sr1 site.

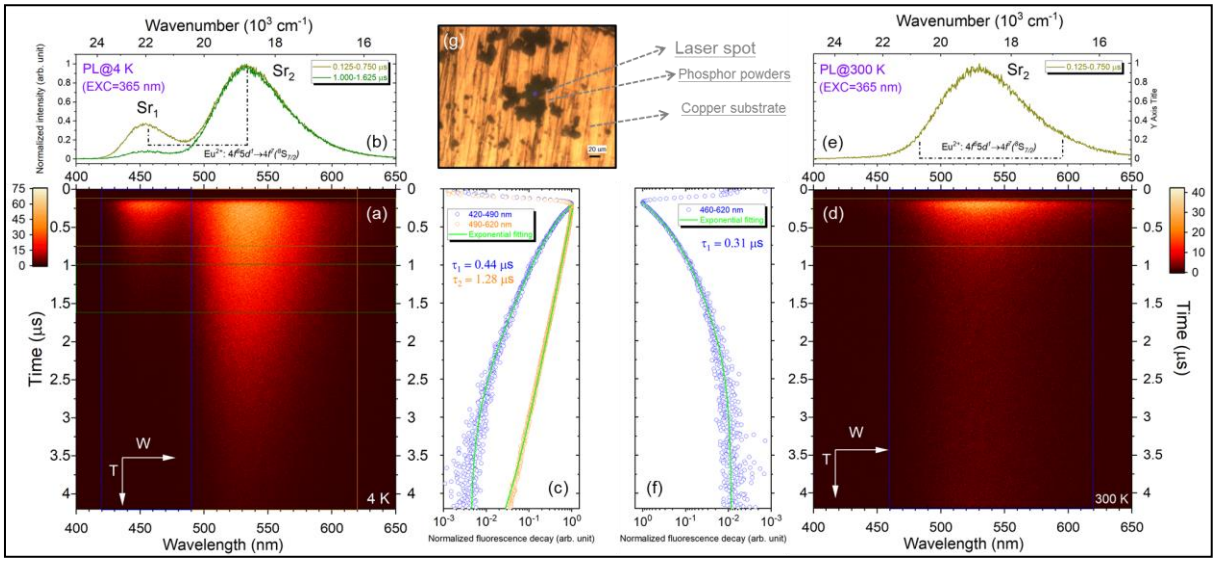

Fig. 1. Time-resolved streak imaging under 365 nm laser excitation of the commercial $SrAl_2O_4:Eu^{2+}$-Dy^{3+} powder phosphors (LumiNova@, G-300M) recorded at (a) 4 K and (d) 300 K; PL spectra at (b) 4 K monitoring the time range from 0.125 μs to 0.75 μs as well as from 1 μs to 1.625 μs (e) 300 K monitoring the time range from 0.125 to 0.75 μs; fluorescence decay curves at (c) 4 K monitoring the wavelength range from 420 to 490 nm as well as from 490 nm to 620 nm (f) 300 K monitoring the wavelength range from 460 to 620 nm; (g) the photograph of powder samples dispersed above a copper substrate, and the performed laser excitation spot is <1 μm.

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