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Supporting Information

Broadband Near-Infrared Persistent Luminescence of $Ba[Mg_2Al_2N_4]$ with Eu^{2+} -Tm^{3+} after Red Light Charging

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Tm-L_3 edge X-ray absorption near edge structure (XANES)

The Tm-L_3 edge was profiled from the synchrotron x-ray absorption near-edge structure in transmission mode at the BL17C1 beamline at NSRCC, Taiwan. The solid state approach involving high pressure and temperature under a reducing atmosphere could render the Tm_2O_3 input from Tm^{3+} to the reduced form Tm^{2+}, as Eu^{3+} is converted to Eu^{2+} in the reaction. The Tm-L_3-edge XANES reveals that the single Tm peak at 8650 eV corresponds to Tm^{3+} with no indication of having Tm^{2+}. Thus, emission of Tm^{3+} charged via energy transfer from Eu^{2+} account for the observed broadening to the NIR region of the observed emission.

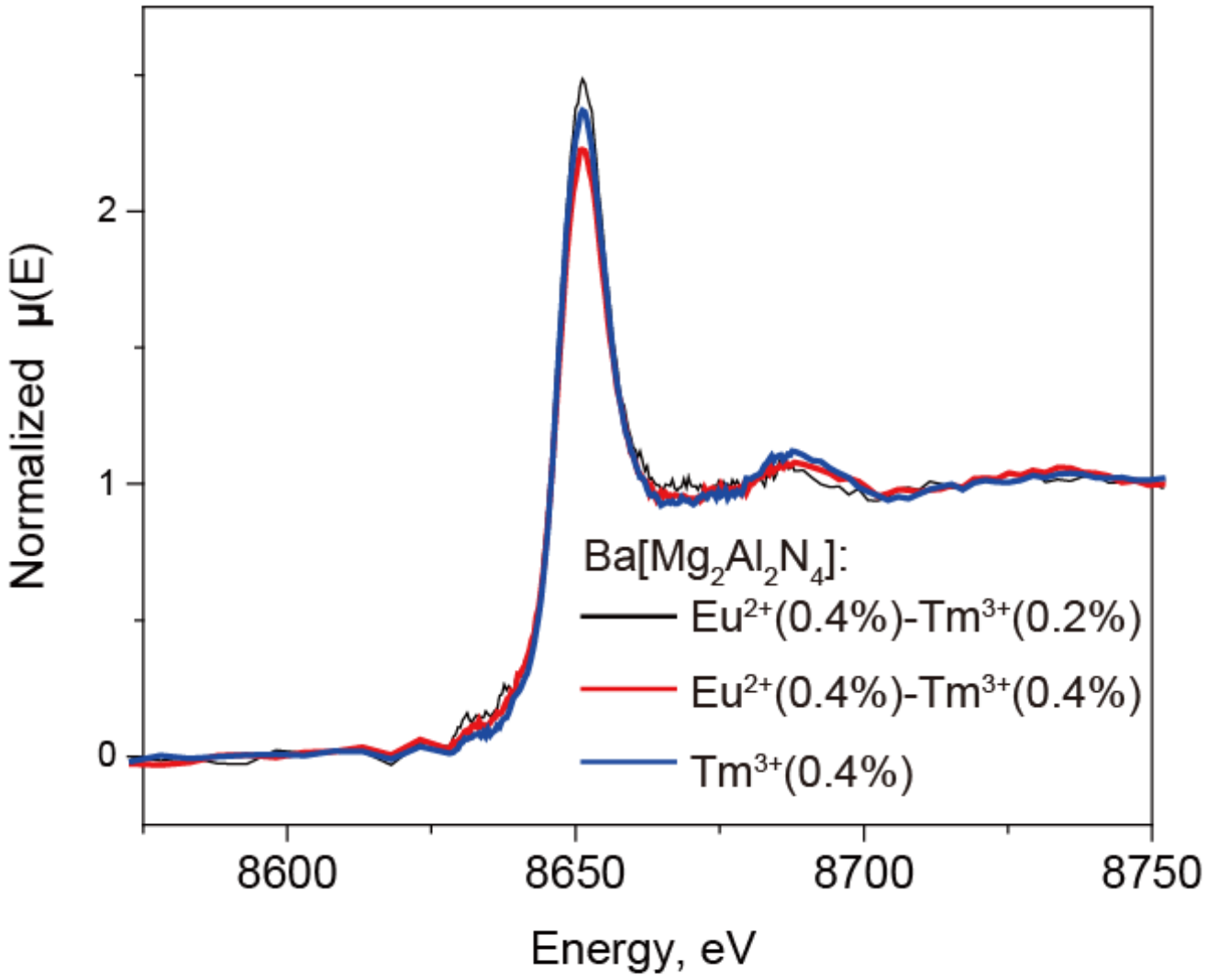

Figure S1. Tm L_3-edge X-ray Absorption at Near-Edge Spectra of $Ba[Mg_2Al_2N_4]:Eu^{2+}$, Eu^{2+}-Tm^{3+}

Luminescence decay curves for energy transfer.

Figure S2 shows luminescence decay curves of $Ba[Mg_2Al_2N_4]:Eu^{2+}$, Eu^{2+}-Tm^{3+}. The lifetime of Eu^{2+}:5d in Eu^{2+}-Tm^{3+}-doped samples is slightly shorter than Eu^{2+}-singly-doped sample.

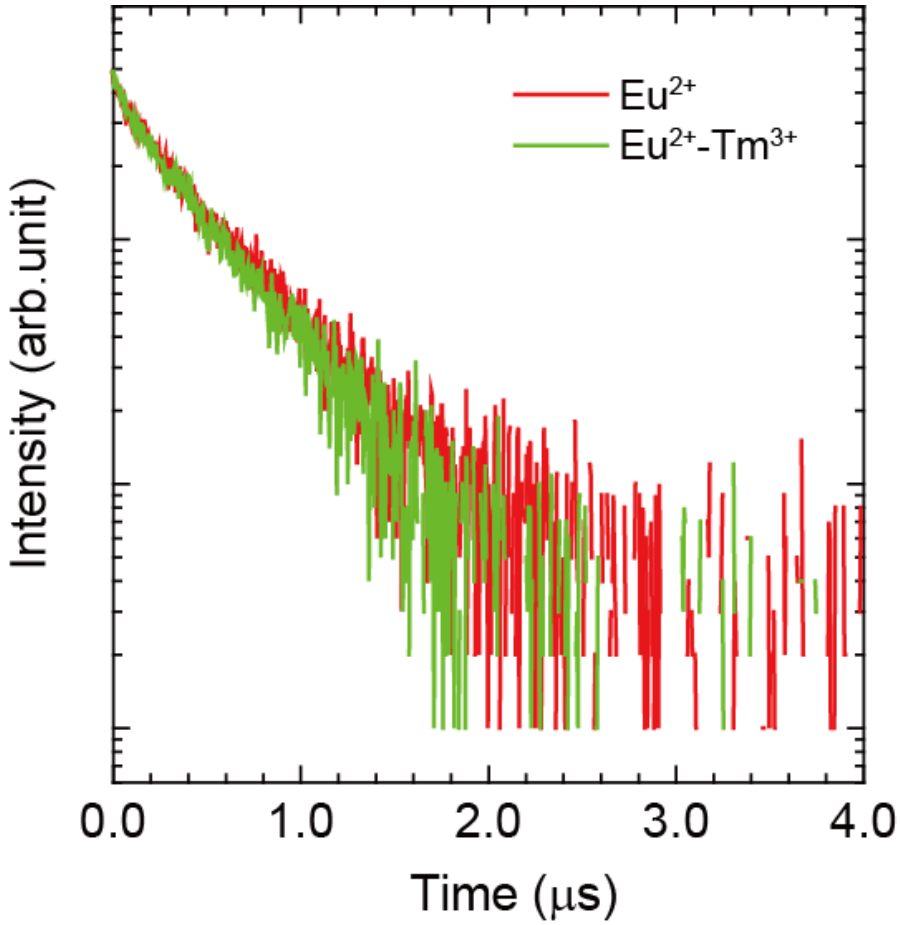

Figure S2. Luminescence decay curve monitoring 680 nm excited by 470 nm pico-second LED

Thermoluminescence (TL) glow curves

TL glow curves of $Ba[Mg_2Al_2N_4]:Eu^{2+}$, Eu^{2+}-Tm^{3+} were measured after UV excitation as shown in Figure S3. Both TL glow curves are almost the same as each other. The Tm^{3+} ion works as NIR luminescence, but not as trap center. The TL glow band has the peak temperature of 180 K and ranges up to around 350K. The peak temperature is not the best for the persistent phosphors at ambient temperature, but the small contribution at around 300 K in the TL glow curves is enough strong for detecting the persistent luminescence at room temperature for approximately 1 hour.

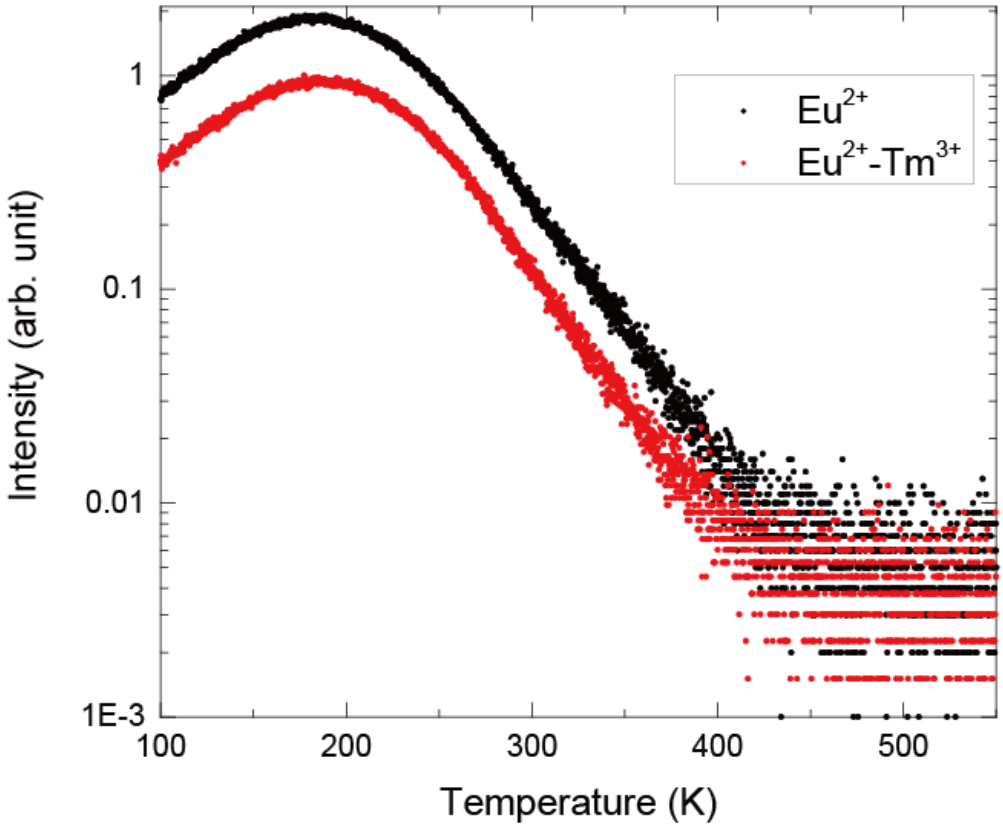

Figure S3. TL glow curves of $Ba[Mg_2Al_2N_4]:Eu^{2+}$, Eu^{2+}-Tm^{3+} after UV excitation

Time course of PersL spectra.

The contour plot of the persistent luminescence time versus the persistent luminescence wavelength. The *y*-axis of the plot is persL wavelength and the *x*-axis is time in seconds. The persistent decay profiles of the emission peaks at 700 and 800 nm are plotted in the graph (top) is almost the same as each other. In addition, the PersL spectra at 5, 50 and 100 sec after ceasing 660 nm excitation shows Eu^{2+} and Tm^{3+} persistent luminescence bands, and spectral shape does not change. These results show that Tm^{3+} PersL is caused by energy transfer from Eu^{2+}.

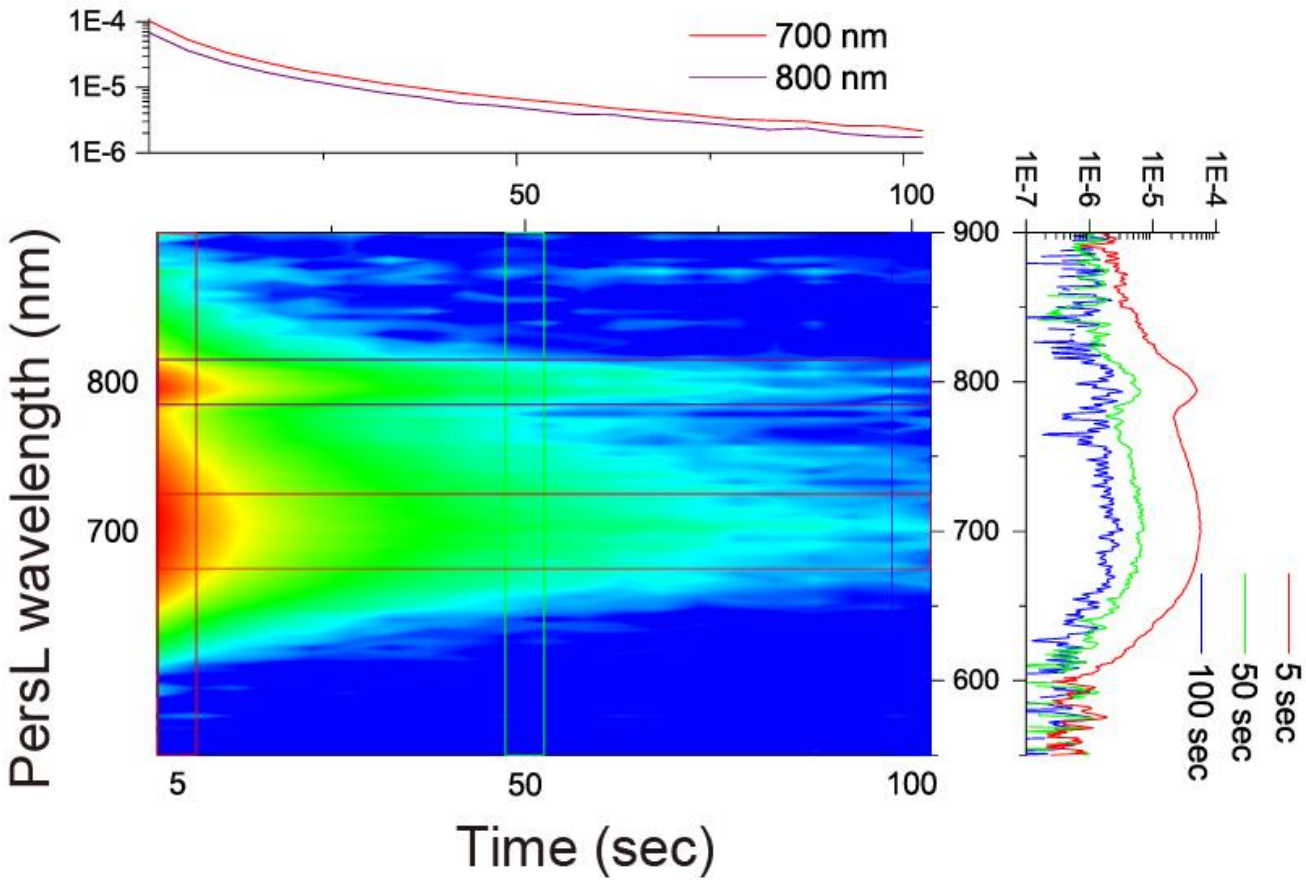

Figure S4. Time course of PersL spectra of $Ba[Mg_2Al_2N_4]:Eu^{2+}$-Tm^{3+} after 660 nm charging.

Charging properties for $Ba[Mg_2Al_2N_4]:Eu^{2+}$

The charging wavelength vs emission wavelength contour plot for persistent luminescence intensity in $Ba[Mg_2Al_2]N_4:Eu^{2+}$. The persistent luminescence of Eu^{2+}:5d-4f transition was observed after UV to red light charging. In the PersL excitation spectrum, the host exciton band below 400 nm and Eu^{2+}:4f-5d band in the ranger from 400 to 700 nm were observed.

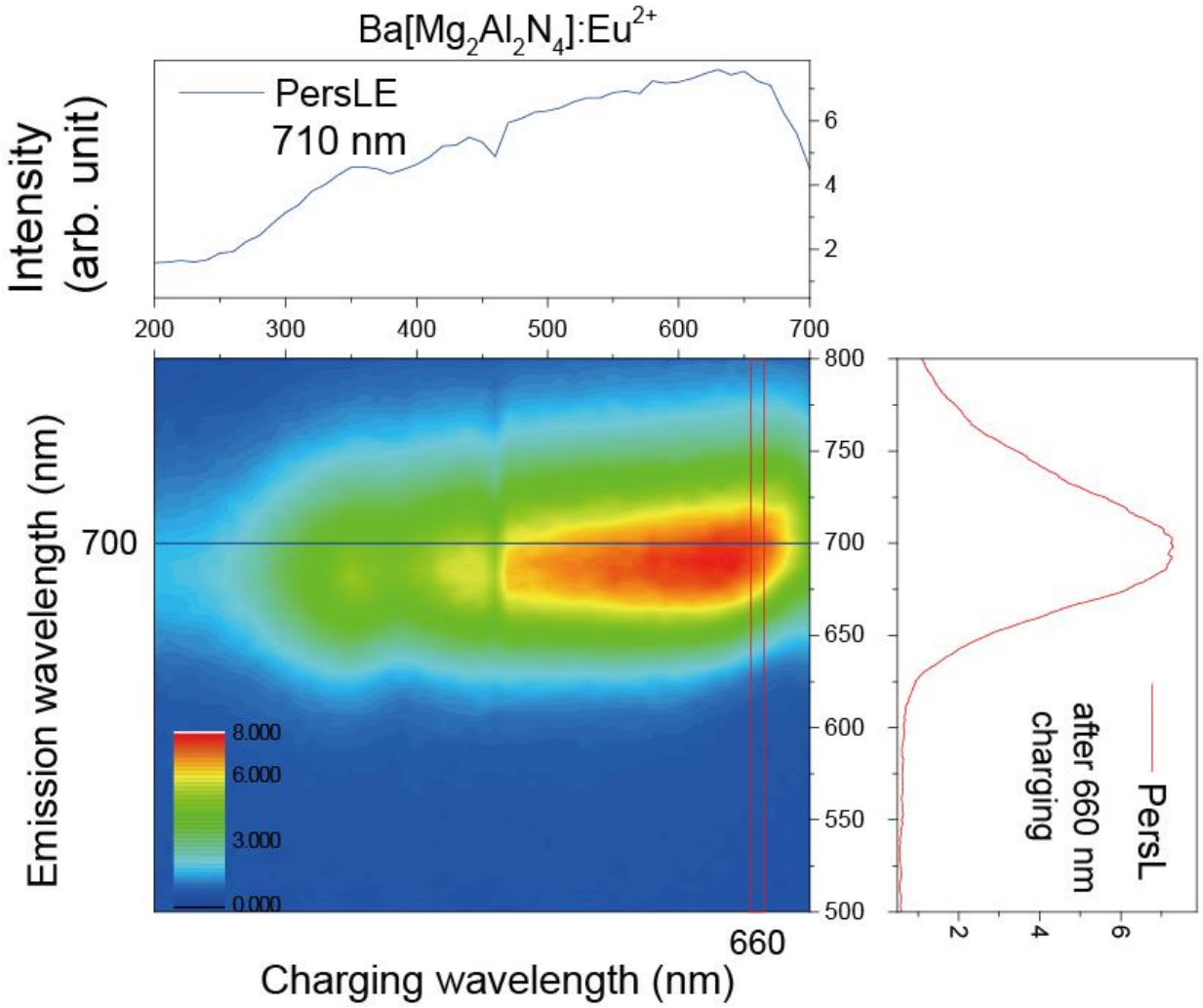

Figure S5. Charging wavelength vs emission wavelength contour plot for persistent luminescence intensity in $Ba[Mg_2Al_2N_4]:Eu^{2+}$.