Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

Role of Ln^{3+} (Ln=Eu, Yb) on persistent red luminescence in $MgGeO_3$: Mn^{2+}

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Fig. S1 shows photoluminescence (PL) spectra of MGO:Mn^{2+}-Eu^{3+} and MGO:Mn^{2+}-Yb^{3+} under 290 nm excitation. The PL lines due to 4f-4f transitions of Ln^{3+}(Eu and Yb) ions were observed approximately at 620 nm (Eu^{3+}) and at 980 nm (Yb^{3+}). With increasing Yb concentration, The PL intensity of Mn^{2+} decreased and that of Yb^{3+} increased.

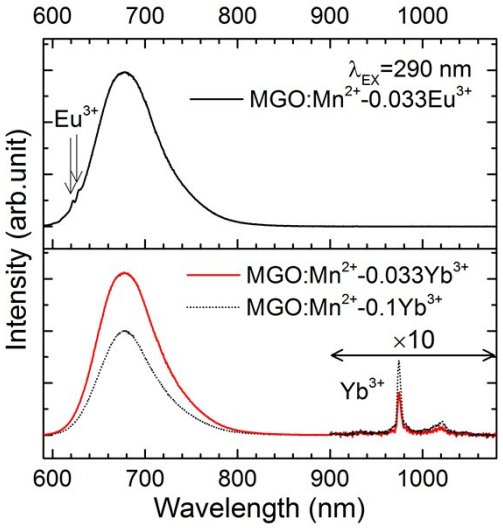

Fig. S1 PL spectra of MGO:Mn^{2+}-Eu^{3+} (upper) and MGO:Mn^{2+}-Yb^{3+} with different Yb concentration (lower) under 290 nm excitation. PL lines due to 4f-4f transitions of Ln^{3+}(Eu and Yb) ions were observed. With increasing Yb concentration, PL intensity of Mn^{2+} decreased and that of Yb^{3+} increased.

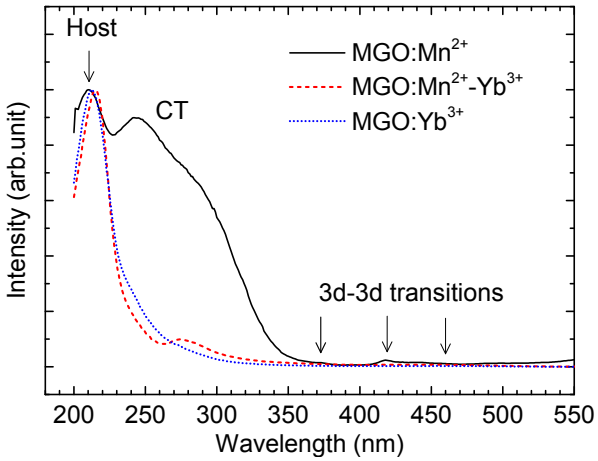

Fig. S2 PLE spectra of MGO:Mn^{2+} monitoring Mn^{2+} luminescence, MGO:Mn^{2+}-Yb^{3+} and MGO:Yb^{3+} samples monitoring Yb^{3+} luminescence.

The PLE spectra of the MGO:Mn^{2+}, MGO:Mn^{2+}-Yb^{3+}, and MGO:Yb^{3+} samples monitoring Mn^{2+} or Yb^{3+} luminescence are shown in Fig. S2. For all the spectra, host related PLE band was observed at 210 nm, as well as the bands due to the charge transfer at 250 nm and 3d-3d transitions of Mn^{2+}.

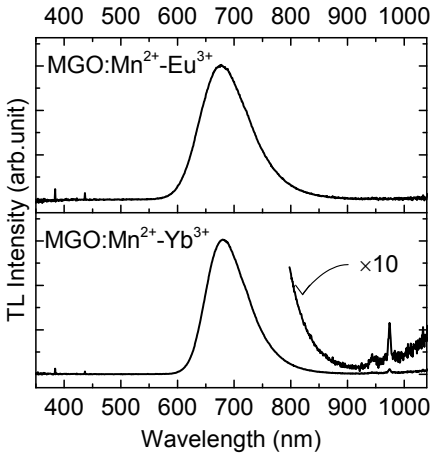

Fig. S3 TL spectra for MGO:Mn^{2+}-Eu^{3+} and MGO:Mn^{2+}-Yb^{3+} samples at the TL glow maxima, 496 K for MGO:Mn^{2+}-Eu^{3+} and 326 K for MGO:Mn^{2+}-Yb^{3+}. (a horizontal cross section in Fig.5).

Fig.S3 shows the TL spectra for MGO:Mn^{2+}-Eu^{3+} and MGO:Mn^{2+}-Yb^{3+} samples at the TL glow maxima. Both samples show a luminescence band peaking at 677 nm due to the Mn^{2+}. For the MGO:Mn^{2+}-Yb^{3+} sample, weak Yb^{3+} luminescence approximately at 1000 nm is also observed. The spectrum is similar to the persistent luminescence spectrum shown in Fig.2.

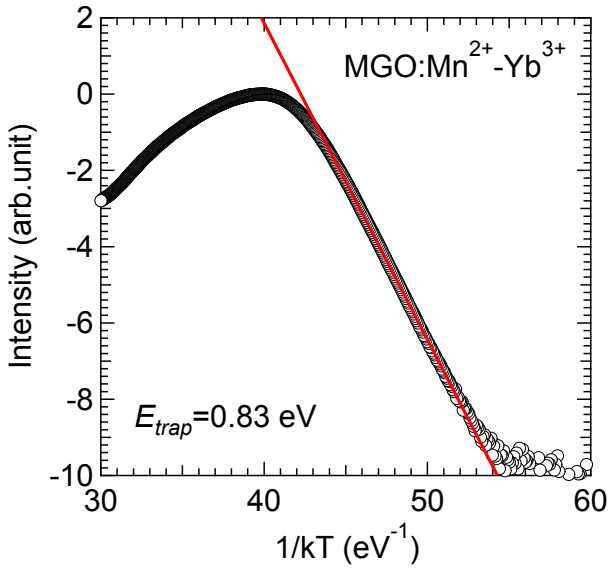

Fig.S4 Initial rise plot of the TL glow curve of MGO:Mn^{2+}-Yb^{3+} and corresponding fitted curve. TL was recorded by thermal cleaning method with thermal cleaning temperature at 230 K.

Fig.S4 shows initial rise plot of the TL glow curve of MGO:Mn^{2+}-Yb^{3+} recorded by thermal cleaning method. Trap depth was estimated by using a following equation.

$$I(T) \propto \mathrm{s} \cdot \exp\left(-\frac{E_{trap}}{kT}\right)$$

Here, s is a frequency factor, E_{trap} represents trap depth, k is Boltzmann constant and T is temperature. The estimated E_{trap} was 0.83 eV. When the trap depth distribution obeys Gaussian, trap depth created by Yb co-doping has an average value of 0.99 eV with 0.05-0.08 eV uncertainty.