Supporting information

Red emitting Eu:ZnO nanorods for highly sensitive fluorescence intensity ratio based optical thermometry

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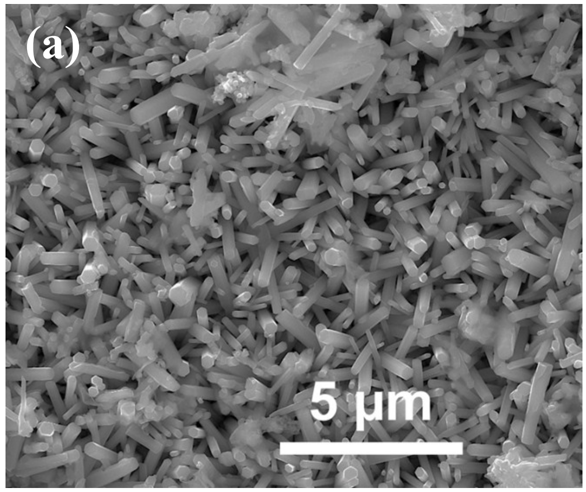


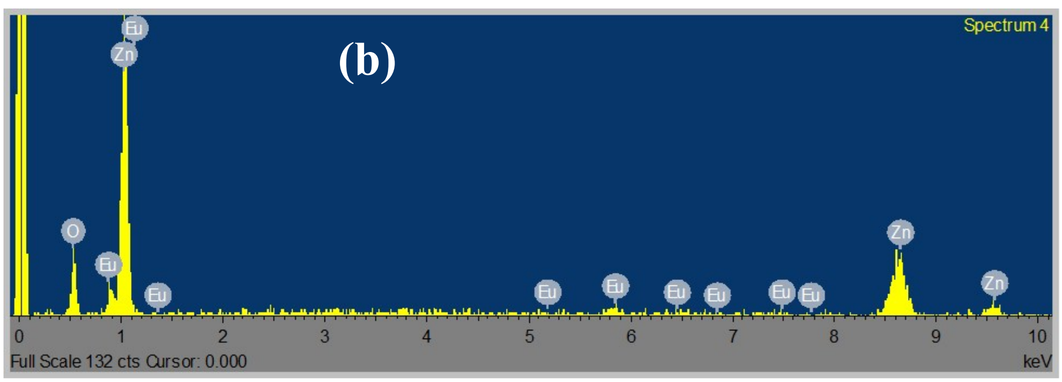
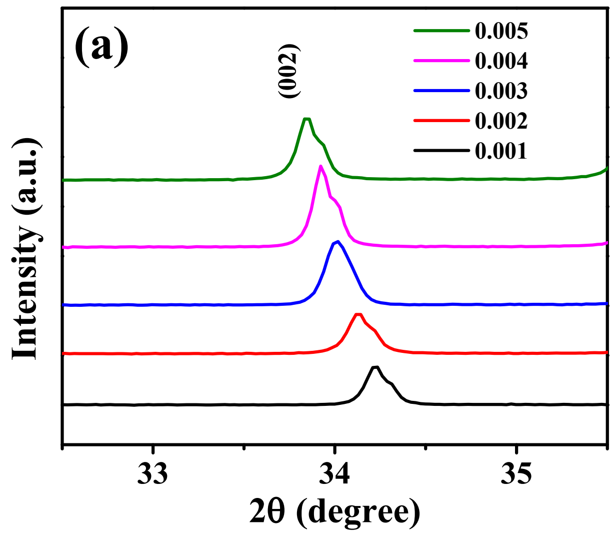


Figure S1. (a) FESEM image of Eu:ZnO (Eu-0.005) and (b) corresponding EDX spectrum (Eu-0.005) showing presence of Eu, Zn and O.



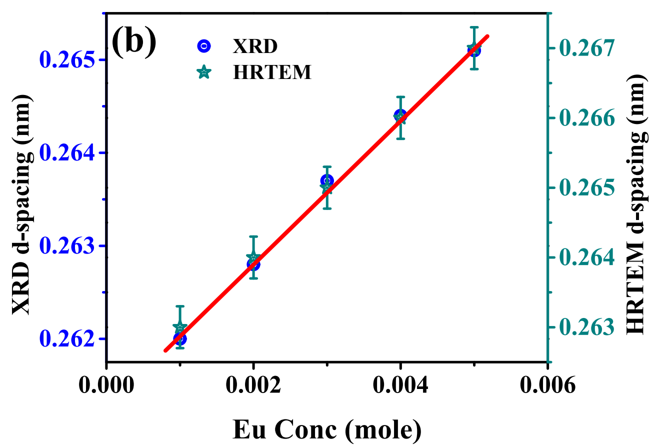


Figure S2. (a) XRD pattern of (002) peak of Eu:ZnO sample for different Eu doping contentand (b) variation of d-spacing obtained from XRD and HRTEM measurement with Eu doping concentration.

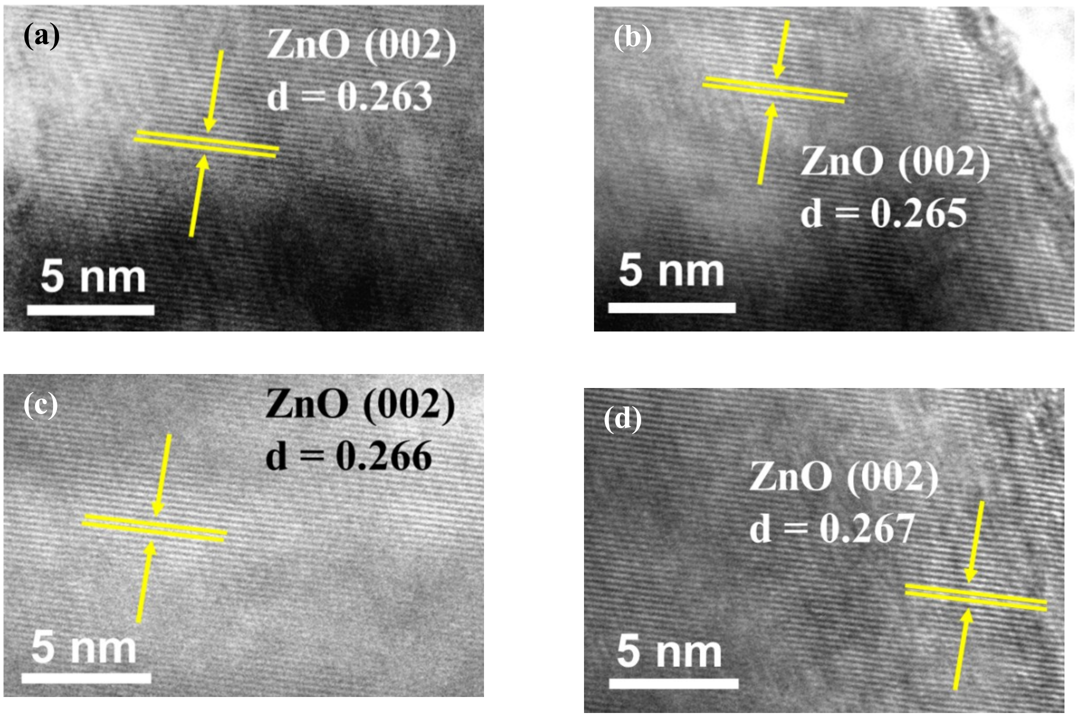


Figure S3. (a-d) HRTEM images of EuZnO samples for Eu doping of 1, 3, 4 and 5%, respectively.

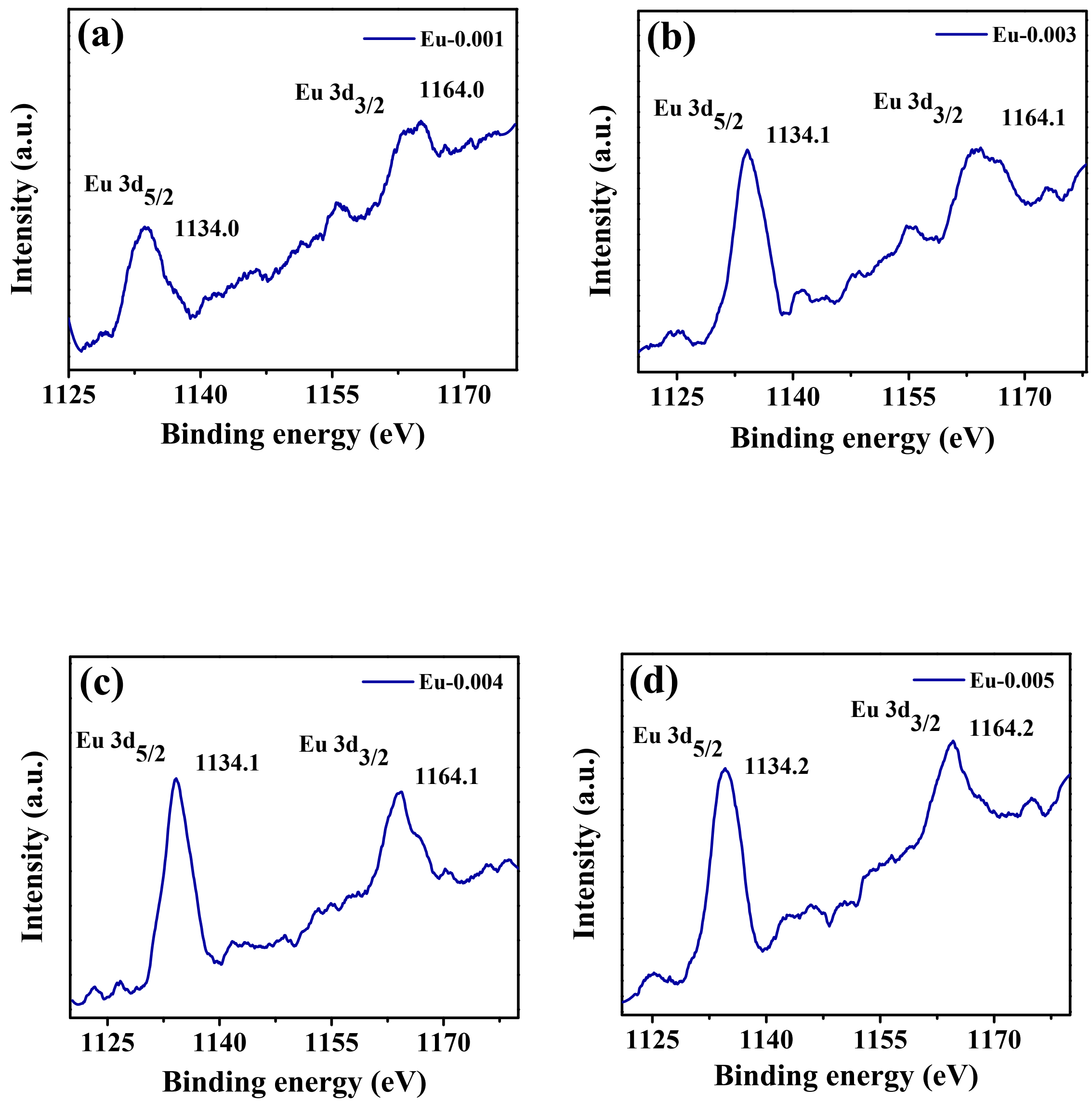


Figure S4. (a–d) High resolution XPS spectra of Eu–3d of Eu:ZnO for different Eu doping 1, 3, 4 and 5%, respectively.

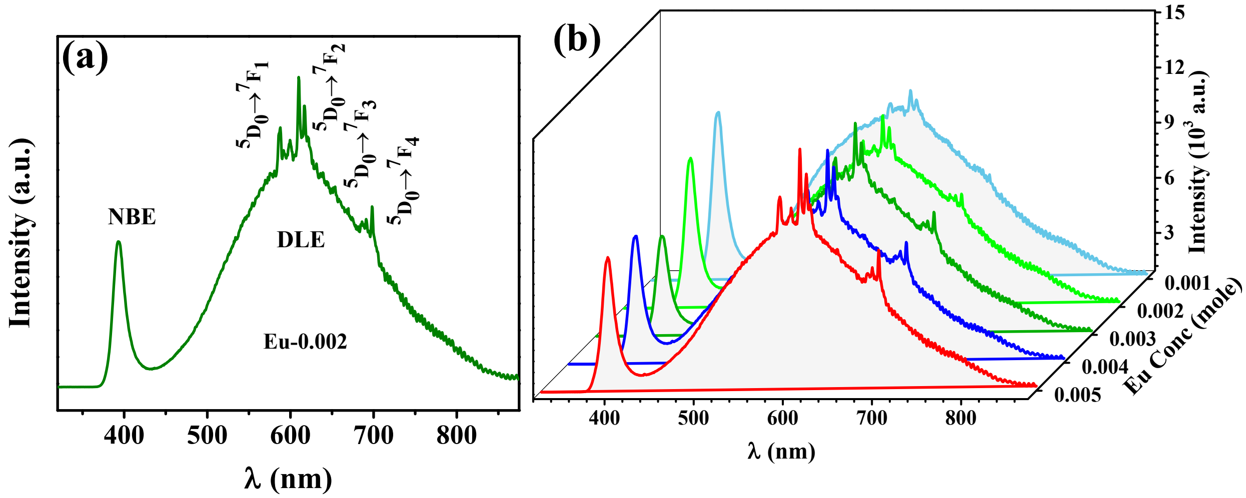


Figure S5. Room temperature PL spectra of Eu:ZnO for different Eu doping. The excitation wavelength is 355 nm.

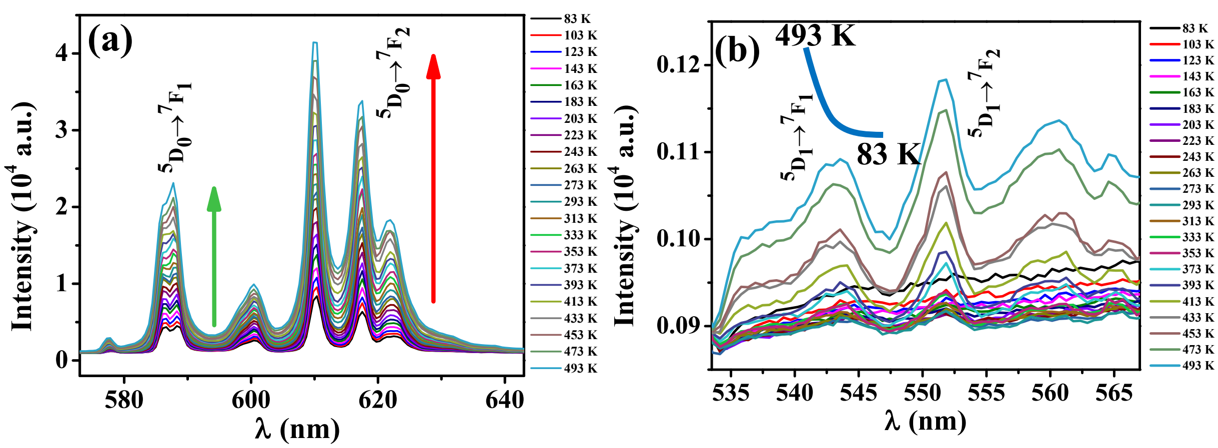


Figure S6. Temperature dependent PL spectra of Eu:ZnO (Eu-0.004) for (a) $^5D_0 \rightarrow {}^7F_1, {}^7F_2$ transitions and (b) $^5D_1 \rightarrow {}^7F_1, {}^7F_2$ transitions respectively.

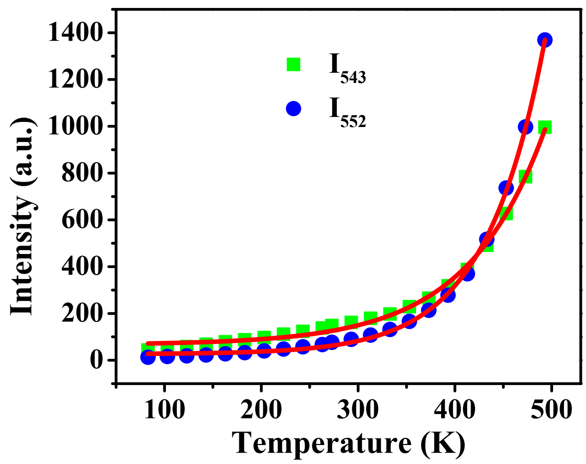


Figure S7. Variation of 543 and 552 nm integral PL intensity with temperature of Eu:ZnO (Eu-0.004).

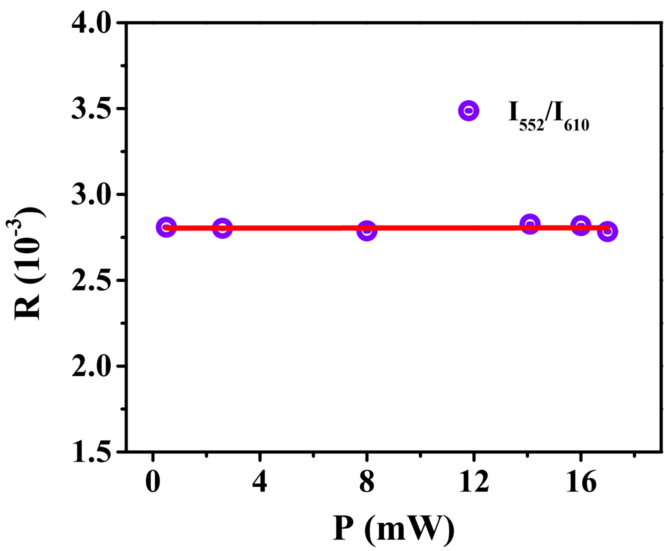


Figure S8. Power dependent FIR (I_{552}/I_{610}) variation.

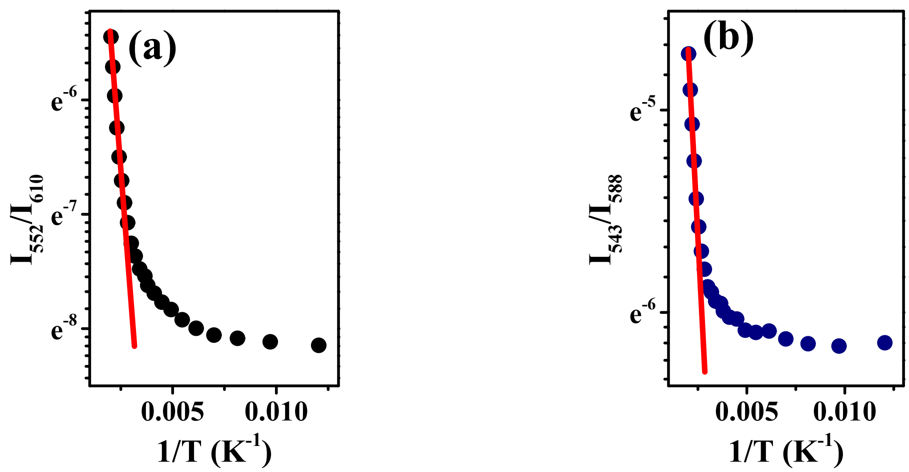


Figure S9. Variation of intensity ratio with temperature in logarithmic scale for (a) case-1 (I_{552}/I_{610}) and (b) case-2 (I_{543}/I_{588}). The linear part is fitted to ln I_{552}/I_{610}=-0.04-2676/T and ln I_{543}/I_{588}=-1.05-1815/T for case-1 and 2 respectively and the deviation increases at lower temperature. This suggests that the degree of population (η) is equal to 1 at higher temperature, which is only due to the thermal population process,[1] and η< 1 at lower temperature.[1]

Table S1. Comparison of sensitivity for different rare earth doped materials.

Rare earth ions	Host Materials	Temp range (K)	Excitations (nm)	S_R (K^{-1})	Ref.
Eu^{3+}	$YNbO_4$	303-803	395	$2331/T^2$	2
Eu^{3+}	$(Y_{0.75}Gd_{0.25})_2O_3$	293-873	393	$2350/T^2$	3
Tm^{3+}, Yb^{3+}	$NaNbO_3$	293-353	976	$93/T^2$	4
Tm^{3+}, Yb^{3+}	PbF_2	293-703	980	$2829/T^2$	5
Er^{3+}, Yb^{3+}	$LiNbO_3$	285-453	980	$1250/T^2$	6
Er^{3+}, Yb^{3+}	$NaBiTiO_3$	93-613	980	$827/T^2$	7
Er^{3+}, Yb^{3+}	Phosphate glass	283-333	980	$0.009/T^0$	8
Ho^{3+}, Yb^{3+}	$CaMoO_4$	303-543	980	$693/T^2$	9
Nd^{3+}, Yb^{3+}	$CaWO_4$	303–873	980	$1336/T^2$	10
Dy^{3+}	$BaYF_5$	293–773	355	$1507/T^2$	11
Eu^{3+}	ZnO	83 – 493	532	$3013/T^2$	Present study

Reference

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