## Supplemental Information

# Defects induced tunable near infrared emission of Er - $CeO_2$ by heterovalent co - dopants

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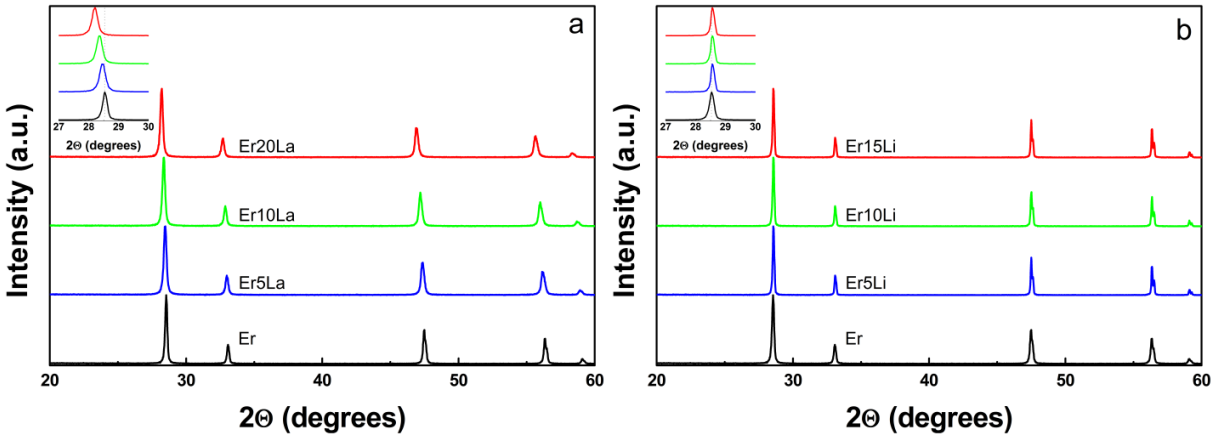


**Fig. S1**. Effects of La (a) and Li (b) co - doping on the phase and crystallite size (XRD patterns) of Er - $CeO_2$.

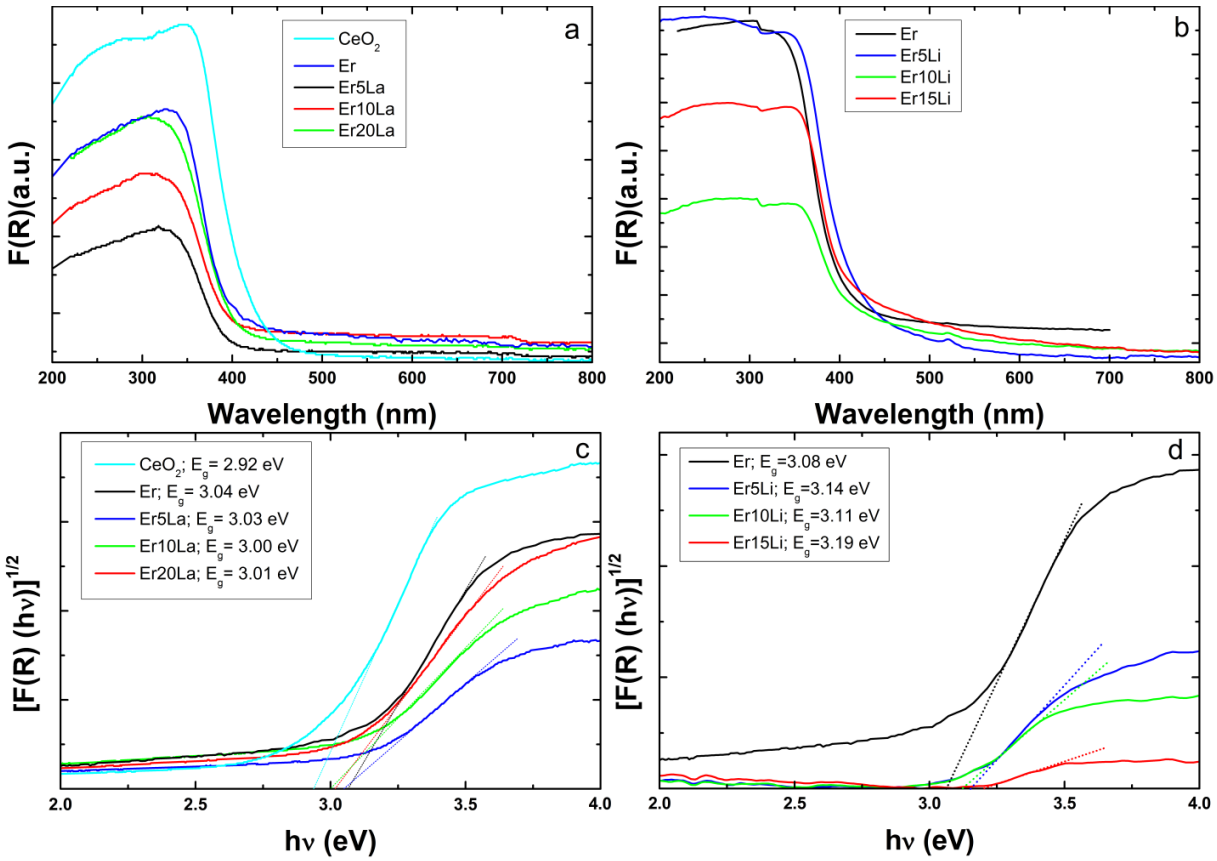


**Fig. S2**. Effects of La (a, c) and Li (b, d) co - doping on DR/UV-Vis spectra of Er - $CeO_2$

**Table S1.** Effects of La/Li co - doping on the intensity and peak value of charge –transfer band of Er - $CeO_2$

| Concentration of La/Li | Relative intensity of CT band intensity estimated form excitation spectra[a] | | Peak value of CT band |
|---|---|---|---|
| | $\lambda_{em}$= 545 nm | $\lambda_{em}$= 675 nm | |
| Er20La | 1.9 (7 %) | 20.0 (8 %) | ~374 nm |
| Er10La | 2.5 (9 %) | 27.1 (11 %) | ~363 nm |
| Er5La | 6.5 (23 %) | 54.2 (21 %) | ~365 nm |
| ***Er (1000)*** | ***28.8 (100 %)*** | ***259.0 (100 %)*** | ***~360 nm*** |
| ***Er (800)*** | ***21.8 (100 %)*** | ***118.4 (100 %)*** | ***~360 nm*** |
| Er5Li | 10.1 (46 %) | 69.9 (59 %) | ~370 nm |
| Er10Li | 14.0 (64 %) | 103.9 (88 %) | ~370 nm |
| Er15Li[b] | 21.4 (98 %) | 247.7 (209 %) | ~370 nm |

[a] All the excitation spectra were normalized to f - f absorption of Er at 488 nm.

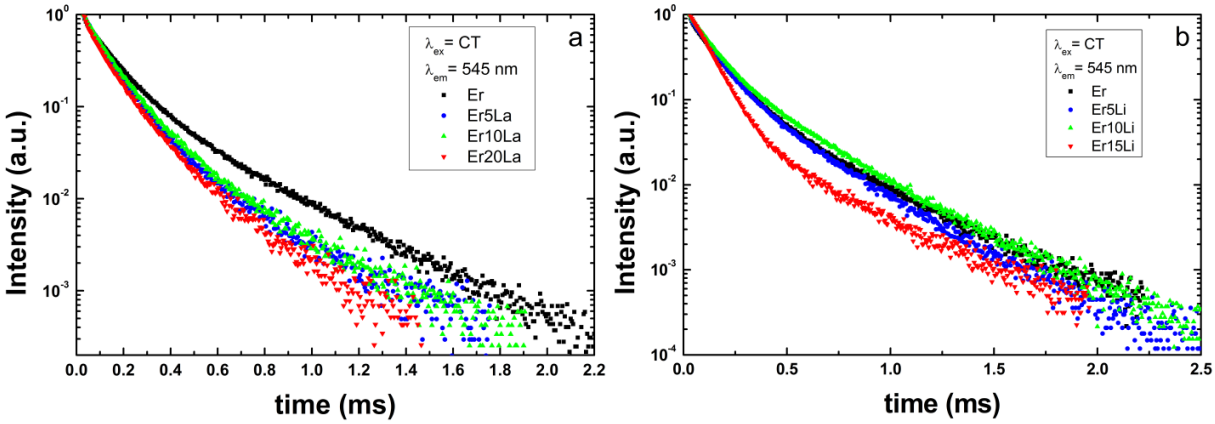


**Fig. S3** Effects of La (a) and Li (b) co - doping on the charge – transfer (CT) excited emission decays of Er - $CeO_2$ measured at 545 nm.

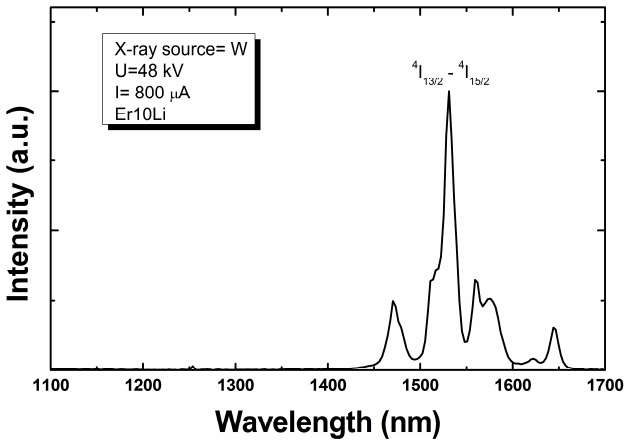


**Fig. S4**. Near - infrared emission at 1500 nm of Er10Li – $CeO_2$ measured under X-ray excitation.

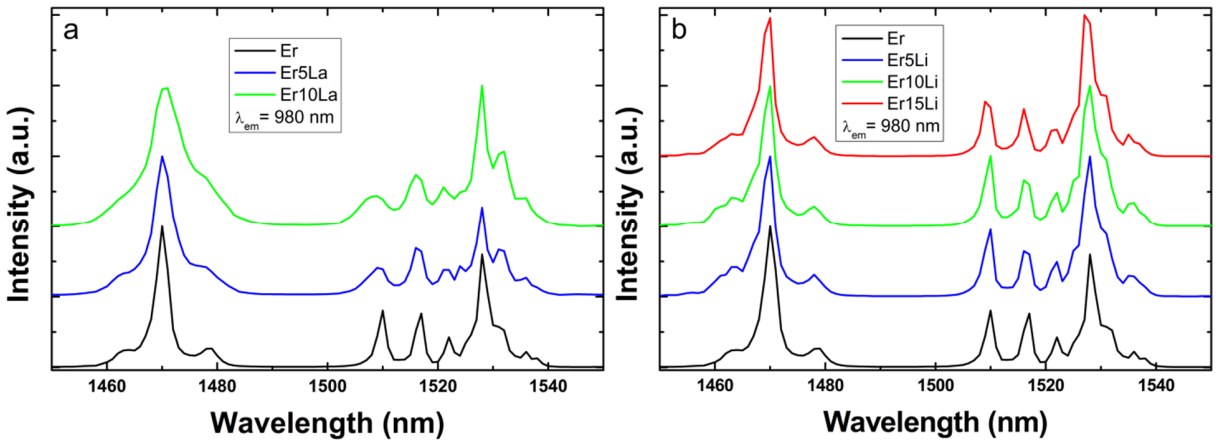


**Fig. S5**. Effects of La (a) and Li (b) co - doping on the up – conversion excitation spectra of Er - $CeO_2$ monitoring the near – infrared emission at 980 nm.

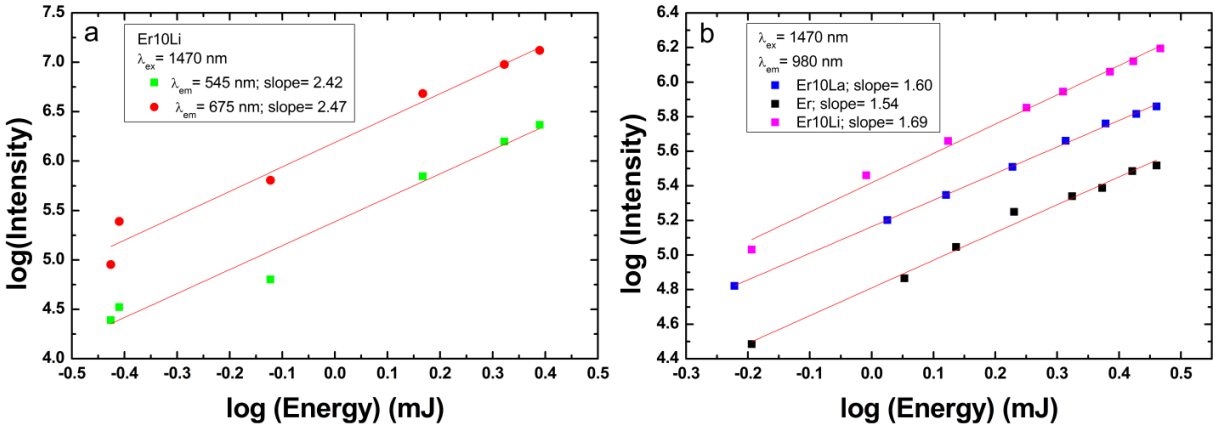


**Fig. S6** Integrated up - conversion emission intensities corresponding to 545, 675 and 980 nm based emission of Er as a function of laser energy pulse (excitation wavelength = 1470 nm)

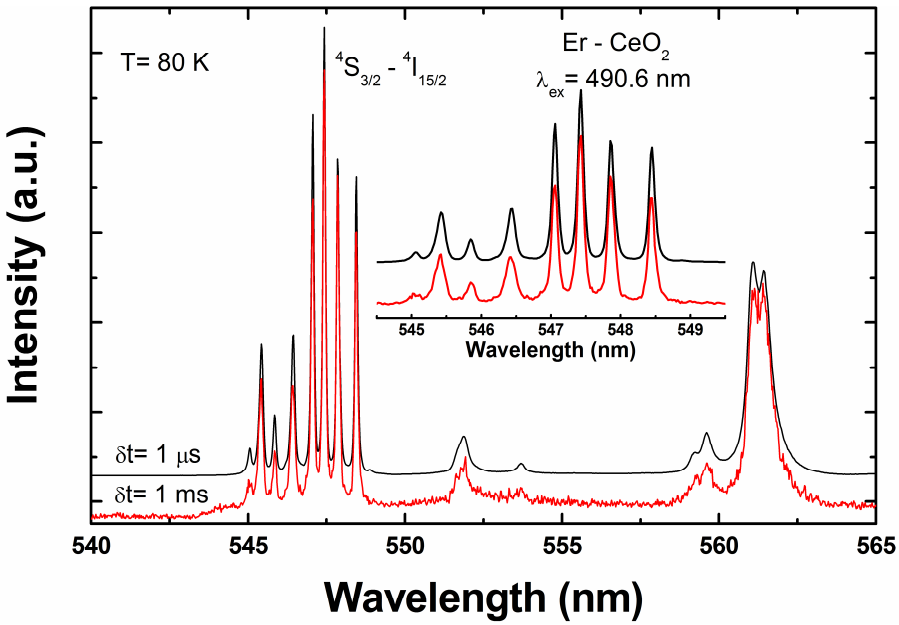


**Fig. S7** Time – gated emission spectra of Er – $CeO_2$ highlighting the $^4S_{3/2}$ – $^4I_{15/2}$ transition measured at 80 K.

Similar Stark splitting patterns and constancy of the (normalised) spectra with delay were found for the La/Li, Er co – doped $CeO_2$ samples.

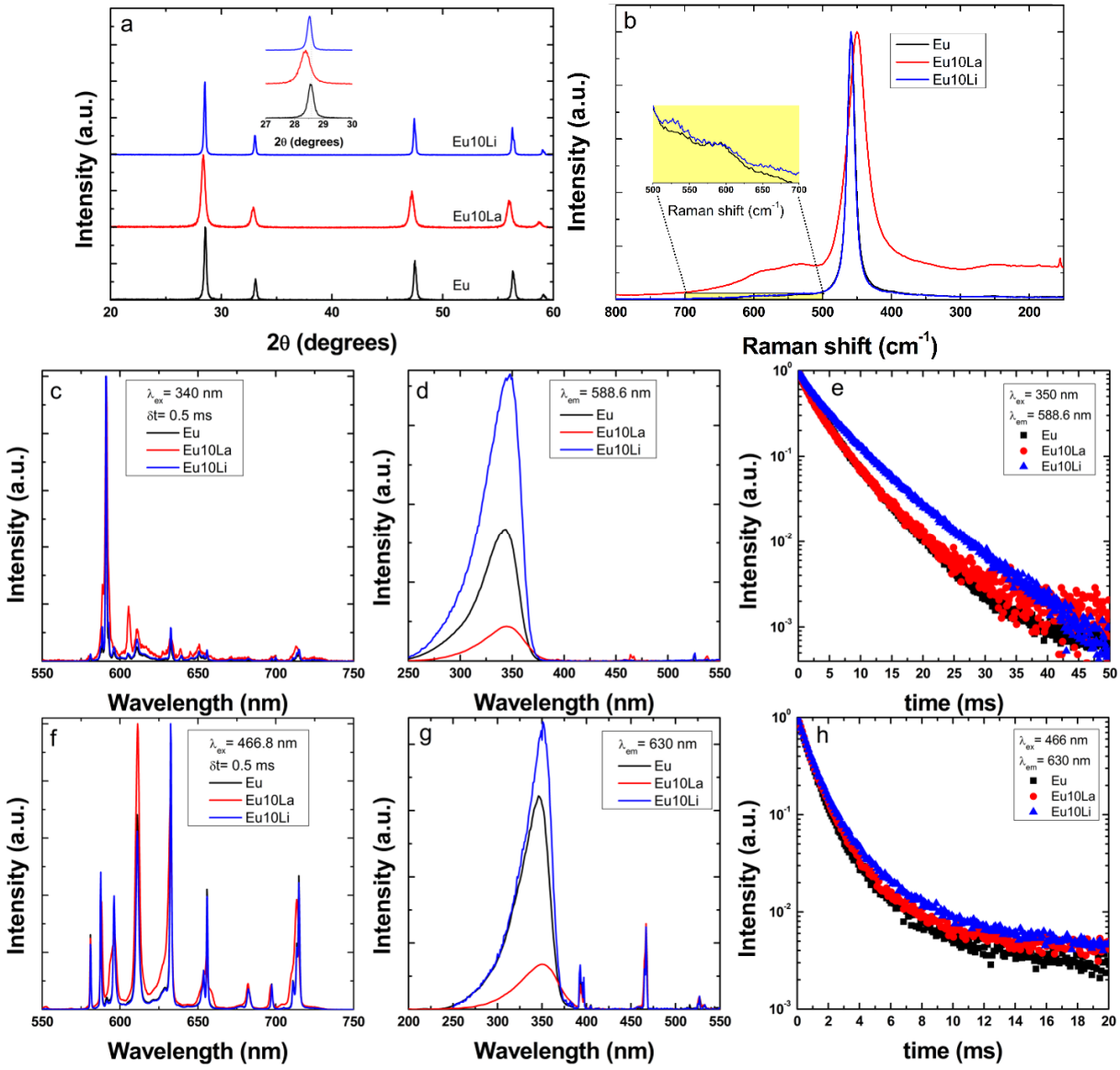


**Fig. S8.** Summary of the comparative analysis of the effects of La/ Li co - doping on XRD patterns (a), Raman spectra (b) emission (c,f)/excitation (d,g) spectra and emission decays (e,h) of Eu – $CeO_2$. Concentrations of Eu and La/ Li are 1 and 10%, respectively. Longer emission decay of Eu10Li – $CeO_2$ compared to those of Eu10La – $CeO_2$ and Eu – $CeO_2$ is due to improved separation of the longer lived isolated Eu center against the shorter – lived Eu - vacancy associate.