Electronic Supplementary Material (ESI) for New Journal of Chemistry

†Electronic supplementary information (ESI)

Up/down conversion luminescence properties of $Na_{0.5}Gd_{0.5}MoO_4:Ln^{3+}$ (Ln= Eu, Tb, Dy, Yb/Er, Yb/Tm, Yb/Ho) microstructures: Synthesis, morphology and structural investigation

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Note added after first publication: This Supplementary Information file replaces the one originally published on 20th May 2014 due to an error in Fig. S5(c).

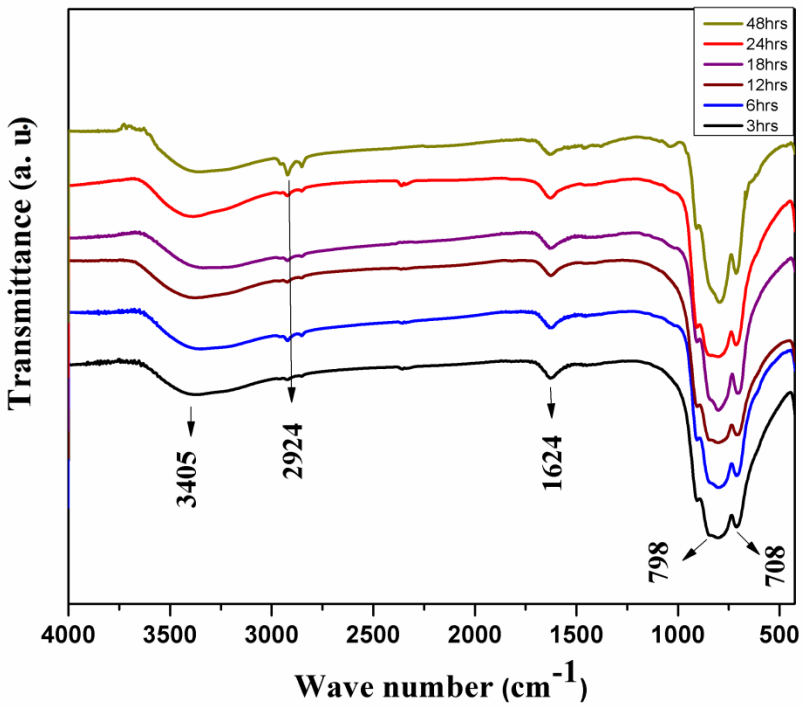

Fig. S1 FTIR spectra of $Na_{0.5}Gd_{0.5}MoO_4:Eu^{3+}$ synthesized with different reaction time intervals.

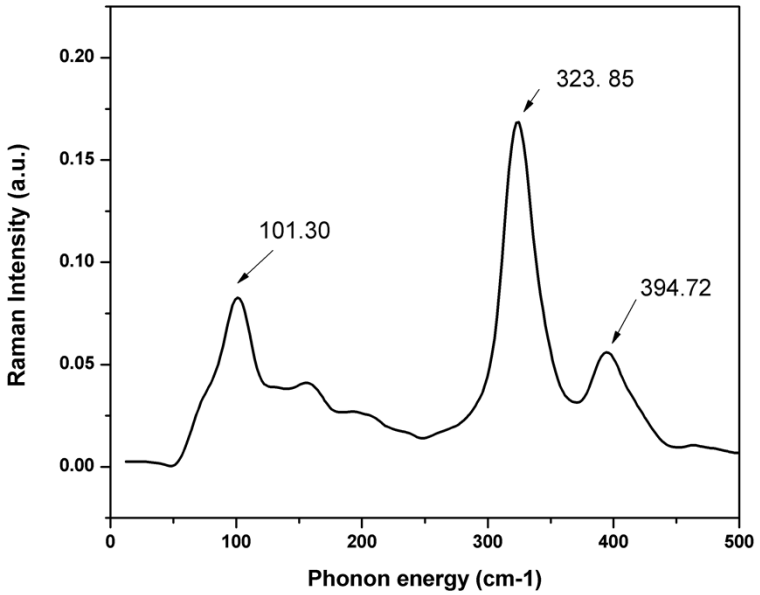

Fig. S2 Raman spectra of microstructures focusing on the $Na_{0.5}Gd_{0.5}MoO_4$ phonon region.

For representative analysis, the phonon bands of the $Na_{0.5}Gd_{0.5}MoO_4:Eu^{3+}$ were identified by using Raman spectroscopy and shown in fig. S2. The phonon energy of Eu^{3+} doped $Na_{0.5}Gd_{0.5}MoO_4$ is found to be maximum at 323 cm^{-1} which is assigned due to the symmetric bending vibrations within the $[MoO_4]^{2-}$ clusters.

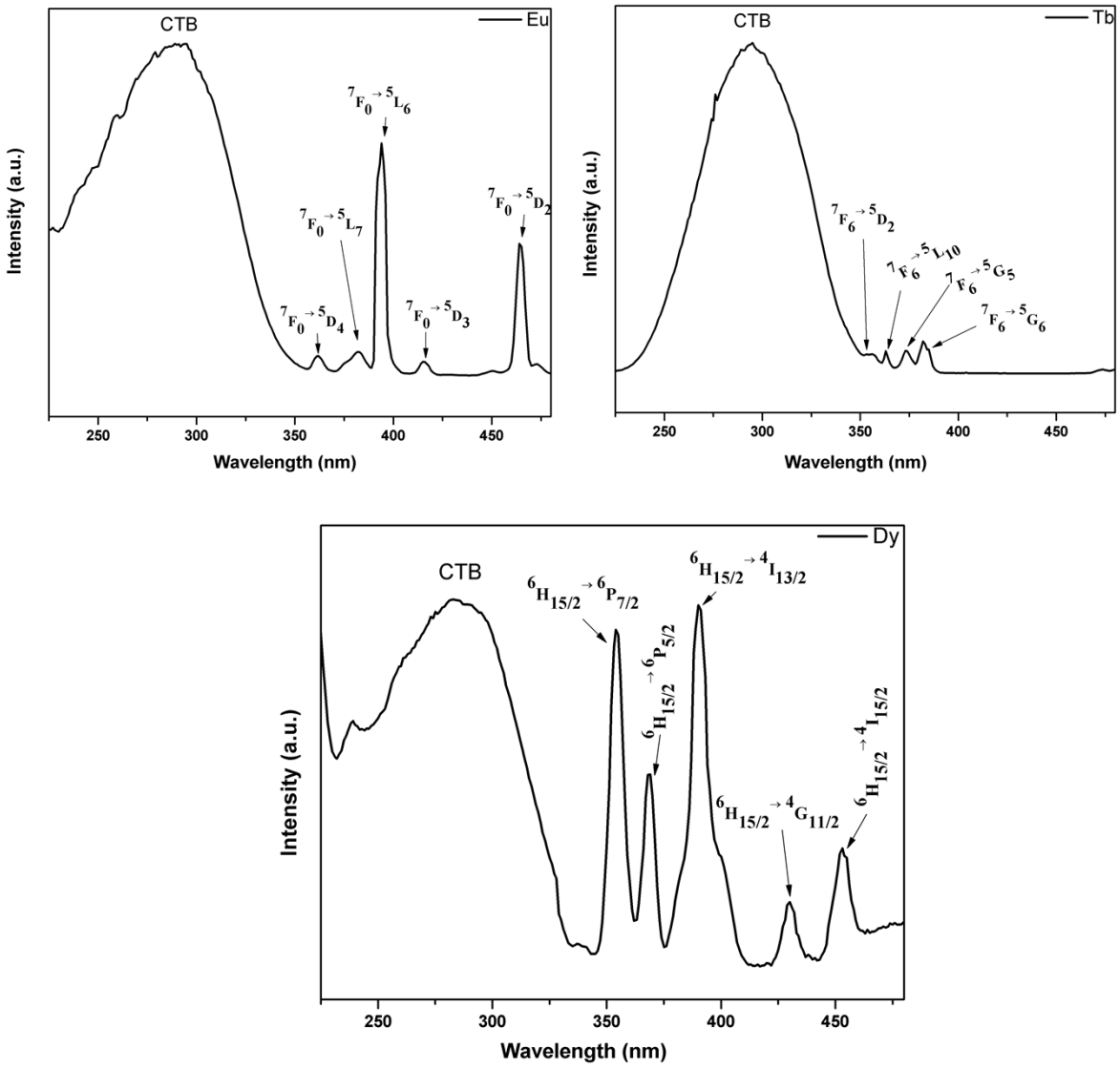

Fig. S3 Excitation spectrum of $(Na_{0.5}Gd_{0.5})MoO_4$ doped with Ln^{3+} (Eu, Tb, Dy).

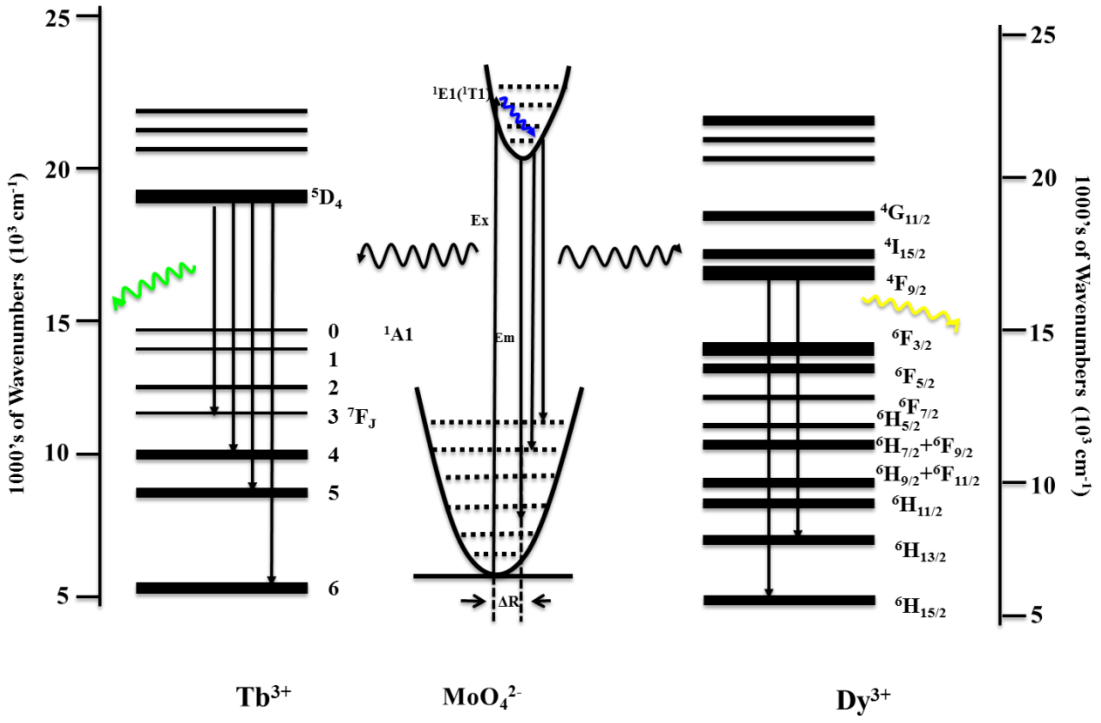

Fig. S4: The energy level diagram and the energy transfer process in the $Na_{0.5}Gd_{0.5}MoO_4:Ln^{3+}$ (Ln= Tb^{3+}, Dy^{3+}).

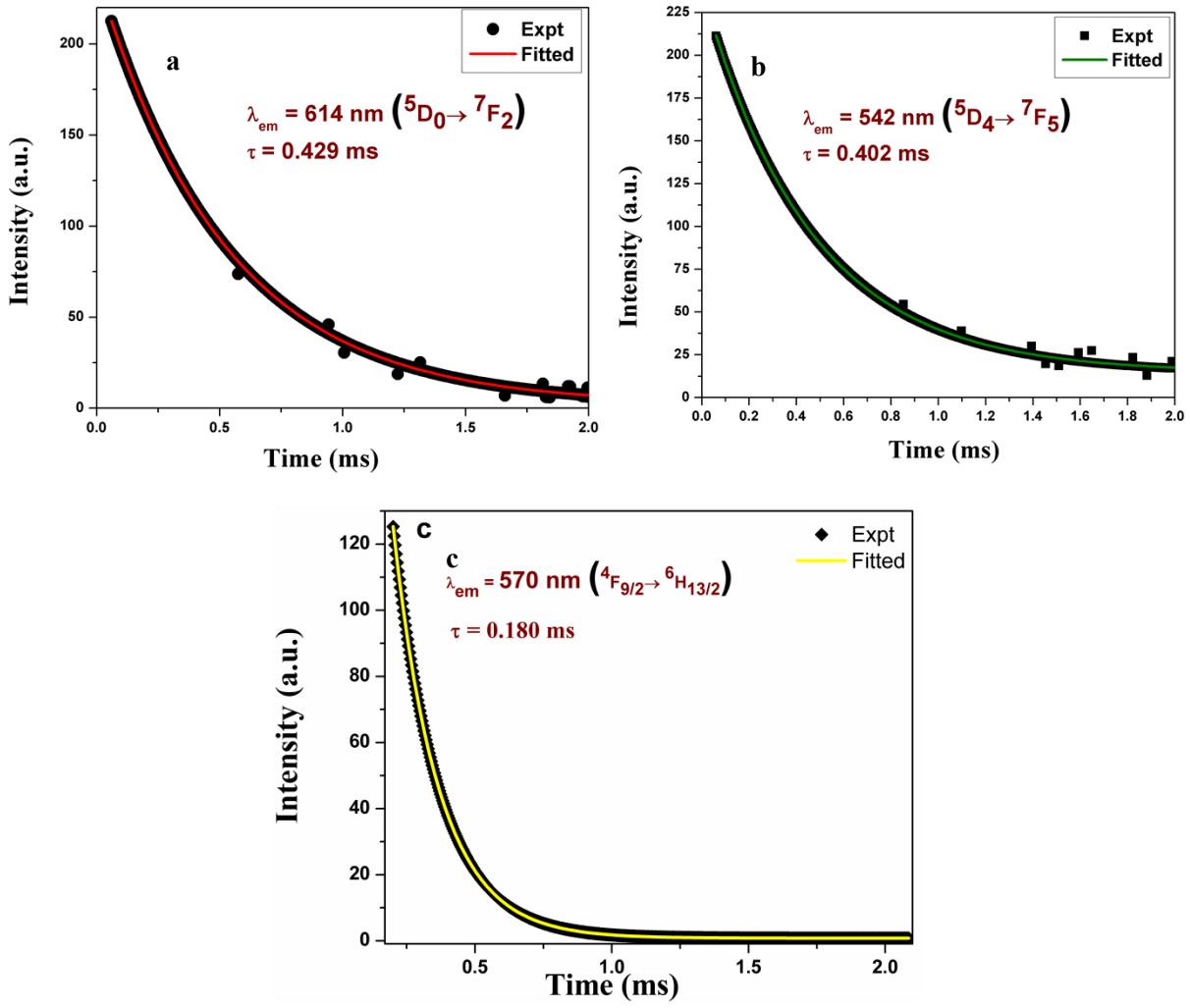

Fig. S5: Fluorescent life time of (a) $^5D_0 \rightarrow {}^7F_2$ transition in Eu^{3+}, (b) $^5D_4 \rightarrow {}^7F_5$ transition in Tb^{3+}, (c) $^4F_{9/2} \rightarrow {}^6H_{13/2}$ transition in Dy^{3+}.

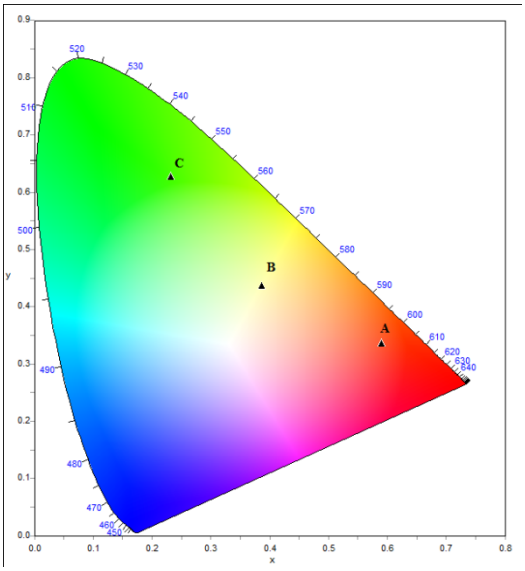

Fig. S6 CIE diagram of $Na_{0.5}Gd_{0.5}MoO_4$ microstructures doped with Eu^{3+}, Tb^{3+}, Dy^{3+} (A, B, C, respectively).

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Table S1: Photometric characteristics of $(Na_{0.5}Gd_{0.5-x})MoO_4:xEu^{3+}$

Phosphor	Eu^{3+} concentration in moles	CCT (K)	CRI	Colour coordinates		LER (lm W^{-1})
				x	y	
$(Na_{0.5}Gd_{0.5-x})MoO_4 : xEu^{3+}$	x = 0.02	1534	57	0.511	0.318	178
	x = 0.04	1489	53	0.521	0.321	182
	x = 0.06	1204	47	0.589	0.334	198
	x = 0.08	1326	51	0.555	0.326	192
	x = 0.10	1447	52	0.528	0.321	189

Table S2: Photometric characteristics of $(Na_{0.5}Gd_{0.5-x-y})MoO_4:xYb^{3+}/yEr^{3+}$

Phosphor	Er^{3+} Concentration in moles	CCT (K)	CRI	Colour coordinates		LER (lm W^{-1})
				x	y	
$(Na_{0.5}Gd_{0.5-x-y})MoO_4$: xYb^{3+}/yEr^{3+} (x=0.05 moles of Yb^{3+})	y = 0.01	Undefined	24	0.185	0.780	447
	y = 0.02	Undefined	19	0.182	0.775	457
	y = 0.03	Undefined	12	0.178	0.766	482
	y = 0.04	Undefined	16	0.181	0.732	475
	y = 0.05	Undefined	14	0.183	0.756	473

Table S3: Photometric characteristics of $(Na_{0.5}Gd_{0.5})MoO_4$: Ln^{3+}(Ln=Tb, Dy, Yb/Tm, Yb/Ho) under optimized condition (200°C for 24 h)

Phosphor	CCT (K)	CRI	Colour coordinates		LER (lm W^{-1})
			x	y	
$(Na_{0.5}Gd_{0.5})MoO_4:Eu^{3+}$	1204	47	0.589	0.334	198
$(Na_{0.5}Gd_{0.5})MoO_4:Tb^{3+}$	Undefined	8	0.232	0.625	278
$(Na_{0.5}Gd_{0.5})MoO_4:Dy^{3+}$	4208	7	0.386	0.433	283
$(Na_{0.5}Gd_{0.5})MoO_4:0.05Yb^{3+}/0.03Er^{3+}$	Undefined	12	0.178	0.766	482
$(Na_{0.5}Gd_{0.5})MoO_4:0.05Yb^{3+}/0.03\ Tm^{3+}$	>100000	Undefined	0.153	0.145	96
$(Na_{0.5}Gd_{0.5})MoO_4:0.05Yb^{3+}/0.03Ho^{3+}$	Undefined	33	0.394	0.510	281