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Electronic Supplementary Information

Concentration quenching behavior of Stokes and upconversion luminescence for Pr^{3+}-doped $Y_3Al_5O_{12}$

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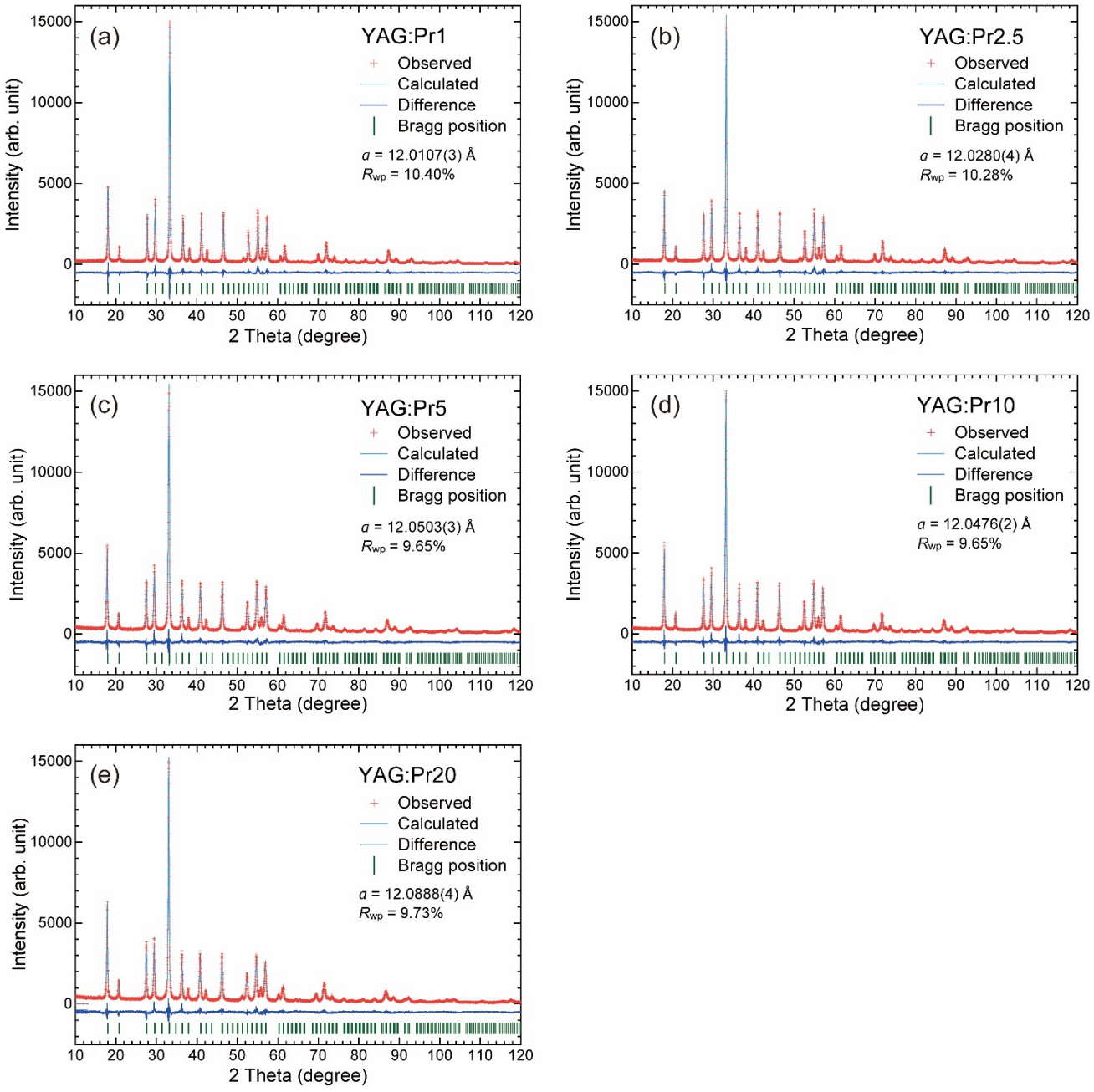

Fig. S1 XRD patterns of the YAG:Pr^{3+} samples with different Pr^{3+} concentrations (1–20%) and the refined plot through the Rietveld method.

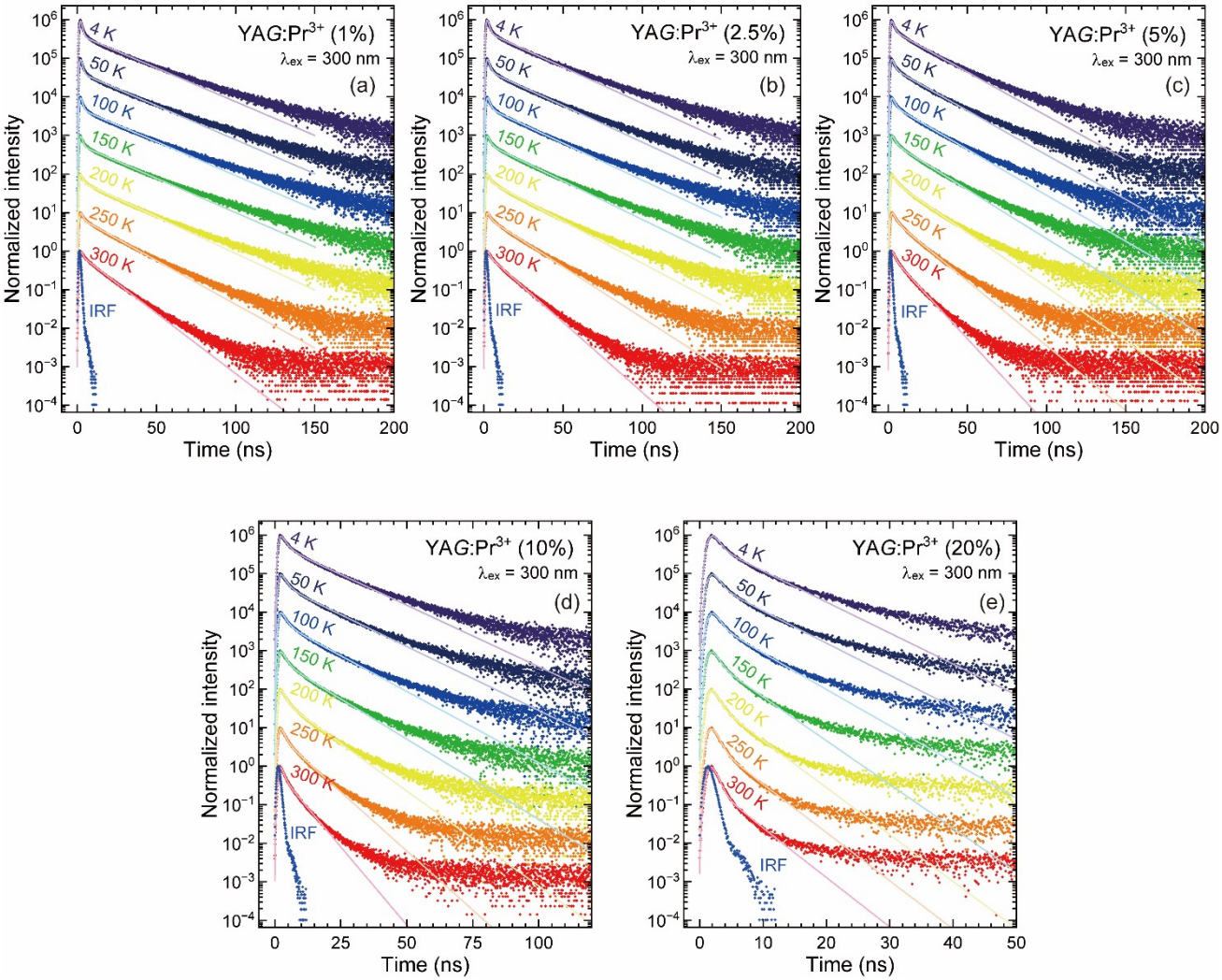

Fig. S2 Temperature dependence of luminescence decay curves of the YAG:Pr^{3+} samples with different Pr^{3+} concentrations (1–20%) and fitting curves using two-component exponential functions. The instrument response functions (IRF) are plotted in blue.

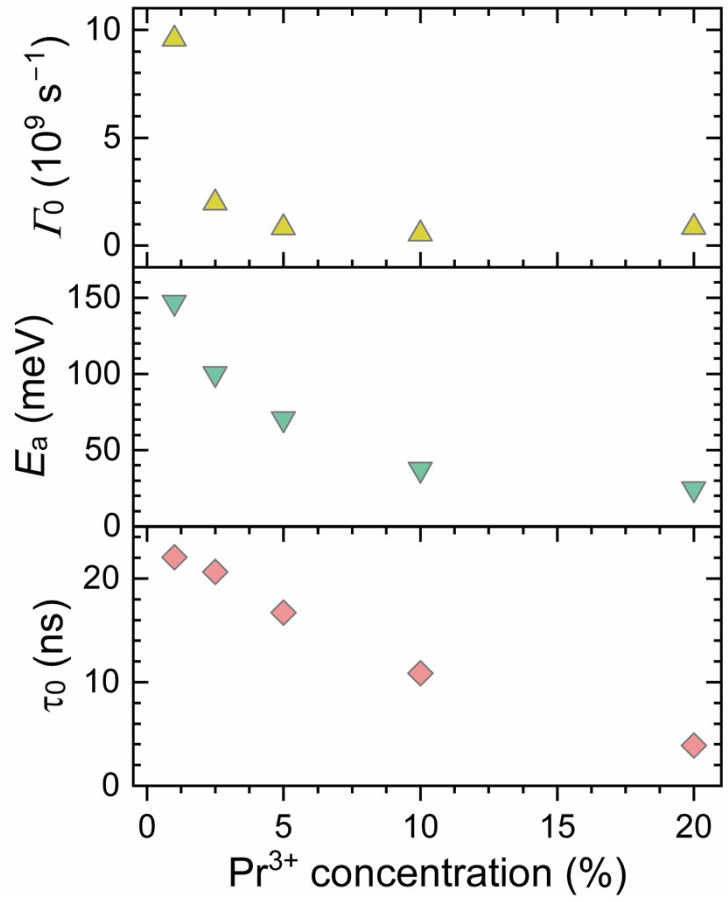

Fig. S3 Pr^{3+} concentration dependence of the attempt rate for the nonradiative transition Γ_0, the activation energy for thermal quenching E_a, and the fluorescence lifetime τ_0, which is the reciprocal of the radiative rate Γ_v.

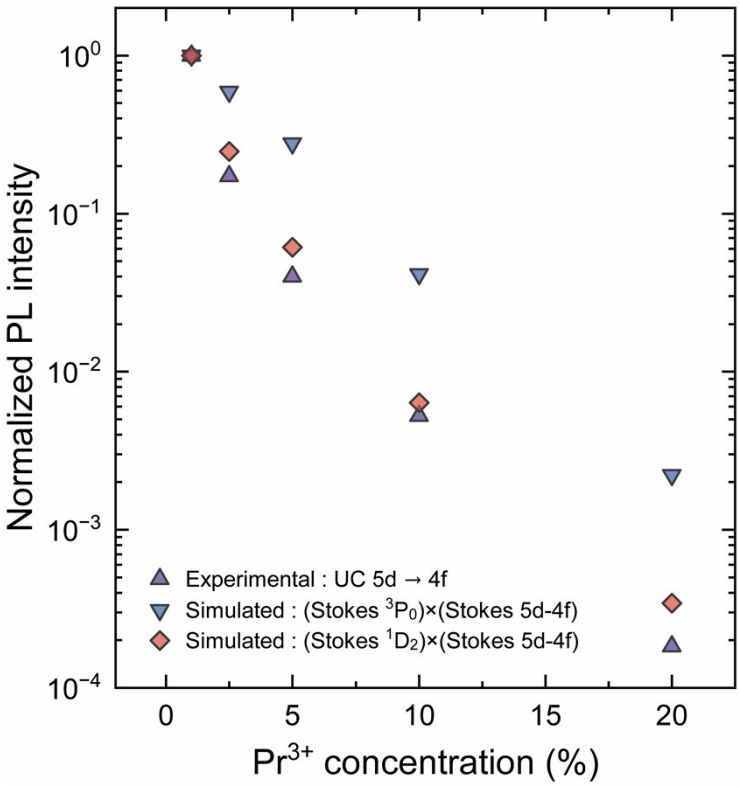

Fig S4 Concentration dependence of Pr^{3+}: 5d-4f upconversion luminescence, obtained with the spectroscopic measurements. The simulated plots were the products of the Stokes PL intensities of the 5d-4f and 4f-4f ($^3P_0 \rightarrow {}^3H_4$ and $^1D_2 \rightarrow {}^3H_4$) luminescence, which consider the influence of the cross-relaxation of the intermediate $^3P_0$ and $^1D_2$ states on the upconversion 5d-4f luminescence.

Table S1 Refined structural parameters of the YAG:Pr samples

Sample	YAG:Pr1	YAG:Pr2.5	YAG:Pr5	YAG:Pr10	YAG:Pr20
Chemical formula	$Y_{2.97}Pr_{0.03}Al_5O_{12}$	$Y_{2.925}Pr_{0.075}Al_5O_{12}$	$Y_{2.85}Pr_{0.15}Al_5O_{12}$	$Y_{2.7}Pr_{0.3}Al_5O_{12}$	$Y_{2.4}Pr_{0.6}Al_5O_{12}$
Crystal System	Cubic	Cubic	Cubic	Cubic	Cubic
Space group	$Ia\bar{3}d$	$Ia\bar{3}d$	$Ia\bar{3}d$	$Ia\bar{3}d$	$Ia\bar{3}d$
Lattice constant [Å]	12.0107(3)	12.0280(4)	12.0503(3)	12.0476(2)	12.0888(4)
Z	8	8	8	8	8
R_{wp} [%]	10.40	10.28	9.65	9.65	9.73
R_B [%]	2.76	2.63	2.14	1.93	2.03
S	1.87	1.93	1.99	1.88	2.02

Atom	Site	x	y	z	g	U_{eq} [Å^2]
YAG:Pr1						
Y, Pr	24*c*	0.125	0	0.25	Y: 0.99 Pr: 0.01	0.0358(4)
Al1	16*a*	0	0	0	1.0	0.0290(7)
Al2	24*d*	0.375	0	0.25	1.0	0.0322(6)
O	96*h*	0.4658(1)	0.0481(2)	0.3522(1)	1.0	0.0271(7)
YAG:Pr2.5						
Y, Pr	24*c*	0.125	0	0.25	Y: 0.975 Pr: 0.025	0.0319(4)
Al1	16*a*	0	0	0	1.0	0.0256(7)
Al2	24*d*	0.375	0	0.25	1.0	0.0274(6)
O	96*h*	0.4642(1)	0.0472(2)	0.3530(2)	1.0	0.0205(8)
YAG:Pr5						
Y, Pr	24*c*	0.125	0	0.25	Y: 0.95 Pr: 0.05	0.0340(4)
Al1	16*a*	0	0	0	1.0	0.0279(7)
Al2	24*d*	0.375	0	0.25	1.0	0.0294(7)
O	96*h*	0.4667(1)	0.0479(2)	0.3528(2)	1.0	0.0241(8)
YAG:Pr10						
Y, Pr	24*c*	0.125	0	0.25	Y: 0.9 Pr: 0.1	0.0363(4)
Al1	16*a*	0	0	0	1.0	0.0287(7)
Al2	24*d*	0.375	0	0.25	1.0	0.0323(6)
O	96*h*	0.4669(1)	0.0483(2)	0.3525(2)	1.0	0.0267(8)
YAG:Pr20						
Y, Pr	24*c*	0.125	0	0.25	Y: 0.8 Pr: 0.2	0.0380(5)
Al1	16*a*	0	0	0	1.0	0.0257(8)
Al2	24*d*	0.375	0	0.25	1.0	0.0341(8)
O	96*h*	0.4663(1)	0.0483(2)	0.3532(2)	1.0	0.0256(9)