Supporting Information for:

Single crystal growth and properties investigation of Dy^{3+} and Tb^{3+} co-doped $Gd_3Sc_2Al_3O_{12}$ (GSAG): multi-applications for GaN blue LD pumped all-solid-state yellow lasers and UV or blue lights chip excited solid-state lightings

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1. Effective segregation coefficient of Dy^{3+}

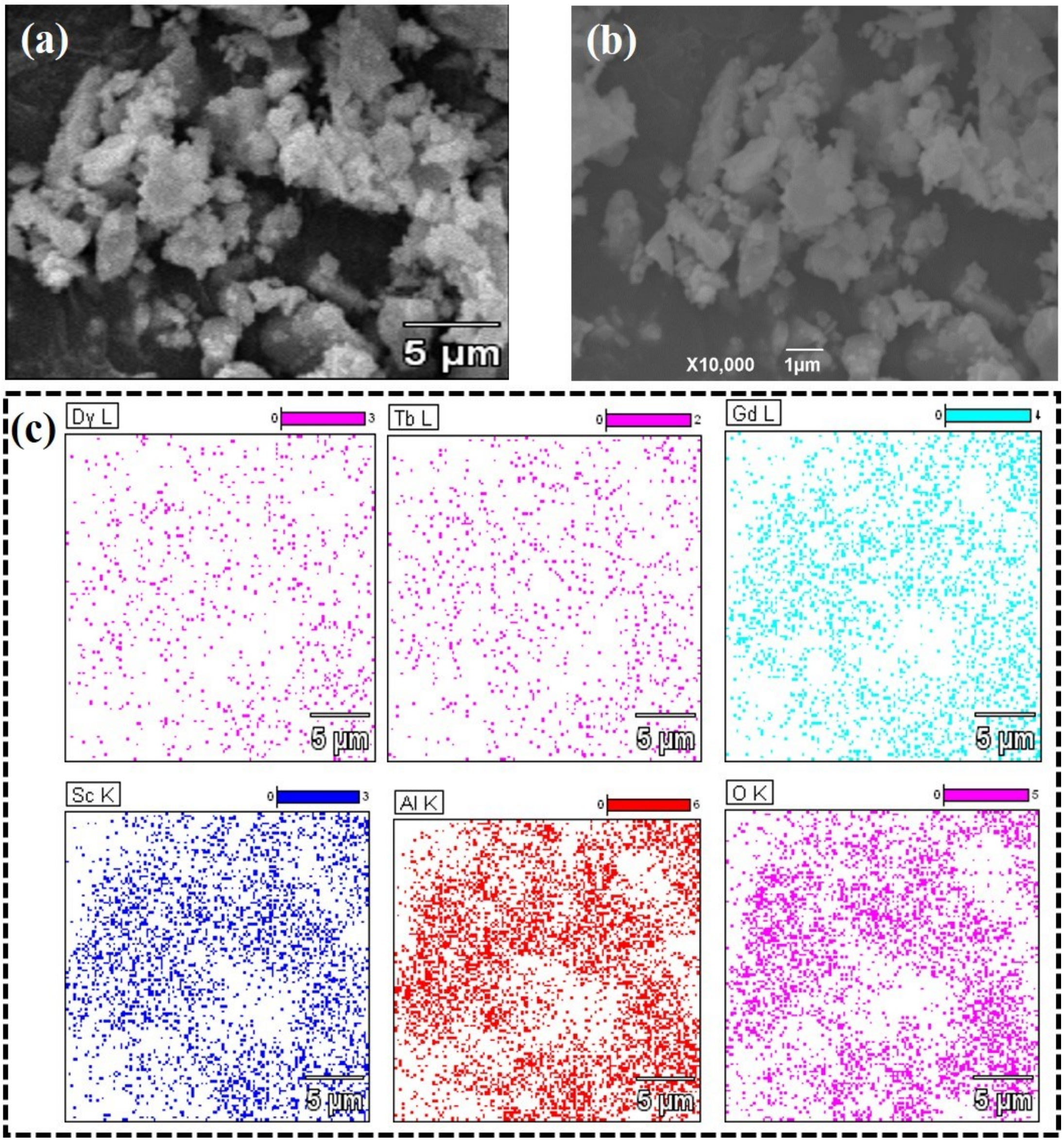

FIG.S1 (a) and (b) The morphology of the powder sample used to characterize the elements mapping; (c) The mapping of the elements in Dy,Tb:GSAG crystal.

2. Judd-Ofelt (J-O) calculation

The Judd-Ofelt (J-O) calculation is an effectively and widely used method to evaluating the 4f configuration radiative transitions of rare-earth ions in crystals or glasses[1-6]. In this work, the J-O calculation for Dy,Tb:GSAG crystal was conducted on the basis of the measured absorption spectrum in the range of 400~1700 nm (exclude the Tb^{3+} absorption). The detailed J-O calculation procedure is similar to that reported in our previous work. The square of the reduced matrix elements $U^{(t)}$ used for the J-O calculation has been described by Carnall et al [7]. The J-O parameters, including experimental line strength $S_{exp}(J^{''},J^{'})$ and calculated line strength $S_{cal}(J^{''},J^{'})$, were calculated and listed in Table S1. The relative square deviation R for the J-O calculation was fitted to be 9.77%, which indicates the high reliability of the calculated values. The intensity parameters Ω_t (t=2, 4, 6) were fitted to be 2.12×10^{-20} cm^2, 2.58×10^{-20} cm^2 and 2.46×10^{-20} cm^2, respectively. According to these calculated intensity parameters, the line strength of the electric-dipole transition S_{ed}, magnetic-dipole transition S_{md}, radiative transition rate $A(J^{''}\rightarrow J^{'})$, fluorescence branching ratio $\beta(J^{''}\rightarrow J^{'})$ and radiative lifetime τ_{rad} for the transitions of Dy^{3+} from its $^4F_{9/2}$ level to different lower levels were calculated, as listed in Table S2.

Table S1 The calculated spectral parameters of Dy,Tb:GSAG crystal

Transitions from $^6H_{15/2}$	λ (nm)	S_{exp} (10^{-20} cm^2)	S_{cal} (10^{-20} cm^2)
$^4G_{11/2}$	428	0.0319	0.0382
$^4I_{15/2}$	453	0.145	0.199
$^4F_{9/2}$	475	0.0378	0.0903
$^6F_{3/2}$	751	0.115	0.150
$^6F_{5/2}$	805	0.754	0.848
$^6F_{7/2}$	901	1.73	2.03
$^6F_{9/2}$+$^6H_{7/2}$	1095	2.02	3.07
$^6F_{11/2}$+$^6H_{9/2}$	1280	3.27	4.83
$^6H_{11/2}$	1690	2.30	1,77
Relative square deviation: R=9.77%; Ω_2=2.12, Ω_4=2.58, Ω_6=2.46			

Table S2 The calculated fluorescence line strengths, branching ratios, radiative lifetimes, and transition rates of Dy,Tb:GSAG crystal

$^4F_{9/2}\rightarrow^{2S+1}L_J$ transitions	λ (nm)	S_{ed} (10^{-20} cm^2)	S_{md} (10^{-20} cm^2)	A (s^{-1})	β (%)	τ_{rad} (ms)
$^6F_{1/2}$	1490	0.000119	0	0.01807	0.00142	0.784
$^6F_{3/2}$	1375	0.000644	0	0.1245	0.00976	
$^6F_{5/2}$	1239	0.0169	0	4.463	0.350	
$^6F_{7/2}$	1052	0.0101	0.0200	4.339	1.03	
$^6H_{5/2}$	941	0.00451	0	2.718	0.213	
$^6F_{9/2}$	873	0.00479	0.0120	3.621	1.01	
$^6H_{7/2}$	856	0.0237	0.00692	19.05	1.94	
$^6F_{11/2}$	799	0.0138	0.0781	13.65	7.26	
$^6H_{9/2}$	762	0.0153	0.00449	17.34	1.77	
$^6H_{11/2}$	667	0.0331	0.0150	55.93	6.43	

$^6H_{13/2}$	582	0.265	0	674.6	52.9
$^6H_{15/2}$	490	0.0810	0	345.6	27.1

3. Fig.S2

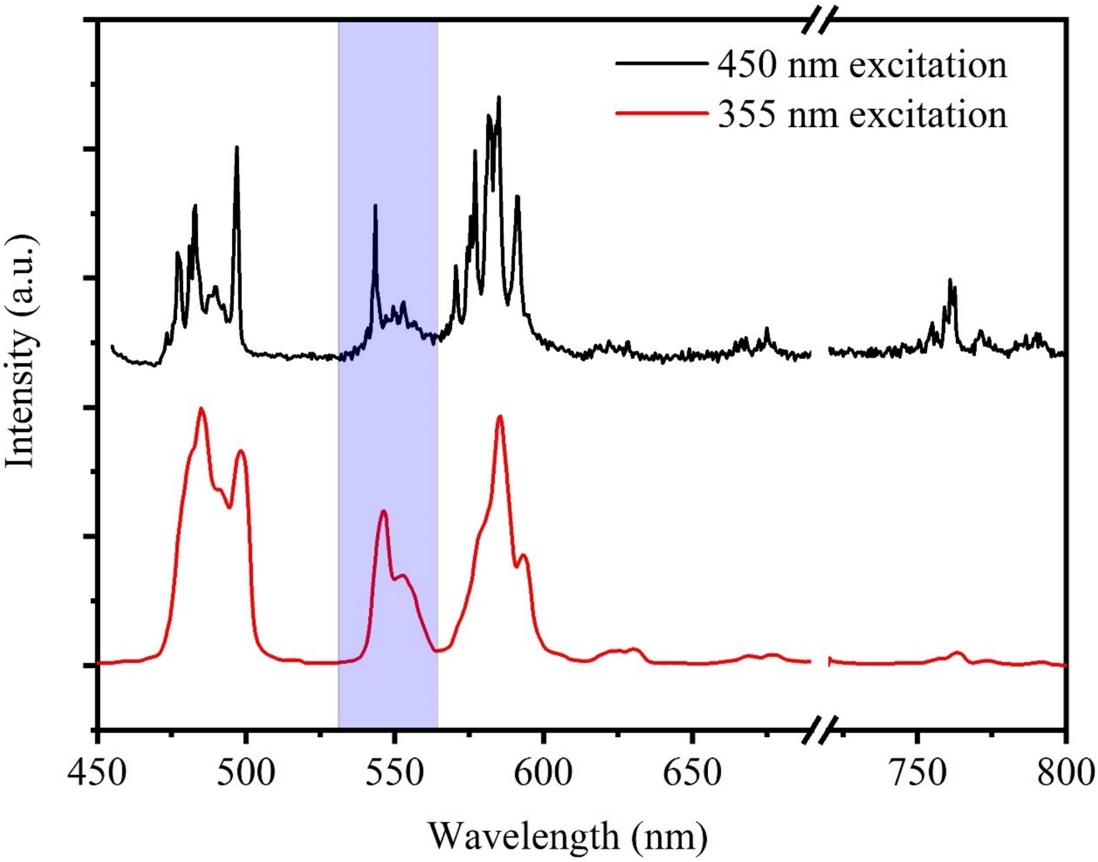

Fig.S2 The room temperature photoluminescence spectra of Dy,Tb:GSAG crystal with the excitation of 450 nm and 355 nm, respectively.

4. Fig.S3

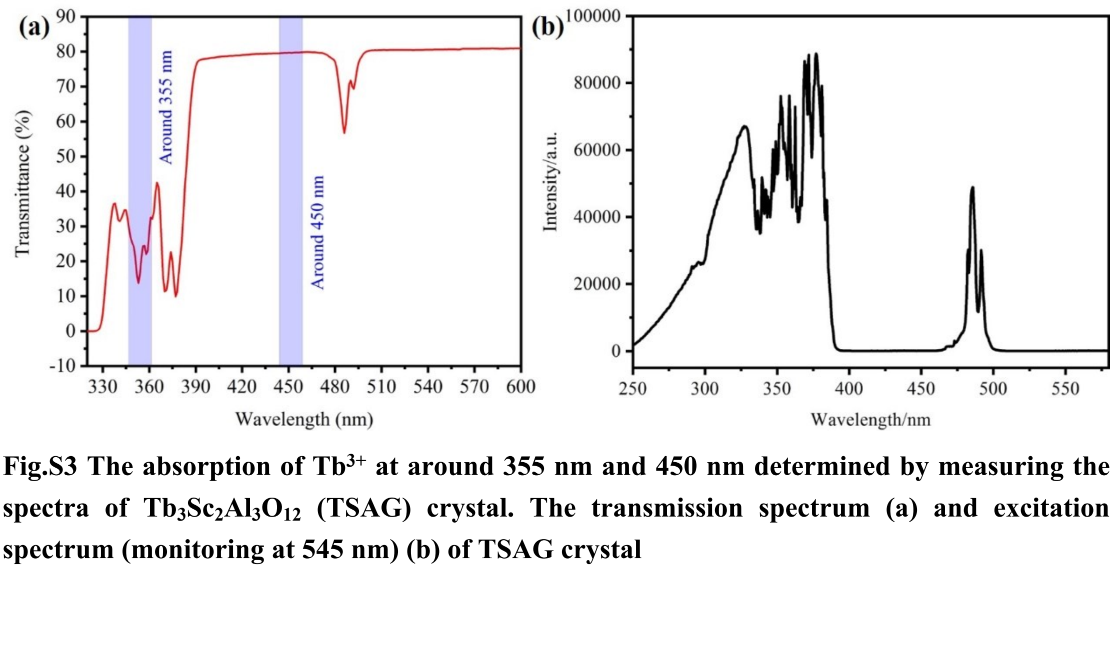

Fig.S3 The absorption of Tb^{3+} at around 355 nm and 450 nm determined by measuring the spectra of $Tb_3Sc_2Al_3O_{12}$ (TSAG) crystal. The transmission spectrum (a) and excitation spectrum (monitoring at 545 nm) (b) of TSAG crystal

REFERENCES

[1] B.R. Judd, Physical review 127 (1962) 750.

[2] G. Ofelt, The journal of chemical physics 37 (1962) 511.

[3] Y. Tian, B. Chen, R. Hua, J. Sun, L. Cheng, H. Zhong, X. Li, J. Zhang, Y. Zheng, T. Yu, Journal of Applied Physics 109 (2011) 053511.

[4] B. Tian, B. Chen, Y. Tian, X. Li, J. Zhang, J. Sun, H. Zhong, L. Cheng, S. Fu, H. Zhong, Journal of Materials Chemistry C 1 (2013) 2338.

[5] Y. Zhang, B. Chen, S. Xu, X. Li, J. Zhang, J. Sun, X. Zhang, H. Xia, R. Hua, Physical Chemistry Chemical Physics 20 (2018) 15876.

[6] C. Yu, B. Chen, X. Zhang, X. Li, J. Zhang, S. Xu, H. Yu, J. Sun, Y. Cao, H. Xia, Physical Chemistry Chemical Physics 22 (2020) 7844.

[7] W. Carnall, G. Goodman, K. Rajnak, R. Rana, The Journal of Chemical Physics 90 (1989) 3443.