Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Development of cyan blue-emitting $Ba_3La_2(BO_3)_4:Ce^{3+},Tb^{3+}$ phosphor for use in dental glassing materials: color tunable emission and energy transfer

Gyu Jin Jeong,[1,2] Tae Wook Kang,[1,*] Young Ji Park,[1] Ye Jin Park,[1,3] Younki Lee,[2] Byungseo Bae,[4,*] and Sun Woog Kim[1,*]

[1] Electronic Convergence Materials Division, Optic & Electronic Component Materials Center, Korea Institute of Ceramic Engineering and Technology, Jinju 52851, Korea.

[2] Division of Materials Science and Engineering & Convergence Technology, Gyeongsang National University, Jinju 52828, South Korea

[3] Department of Chemistry, Pusan National Univeristy, Busan 46241, Korea

[4] Advanced Resources Team, Yeongwol Industrial Promotion Agency, 21-28 Palgoe 1 nonggongdanji, Yeongwolgun 26240, Korea

*Corresponding author:

Dr. Tae Wook Kang

E-mail: ktwcj@naver.com

Dr. Byungseo Bae

E-mail: bsbae@yipa.or.kr

Dr. Sun Woog Kim

E-mail: skim80@kicet.re.kr

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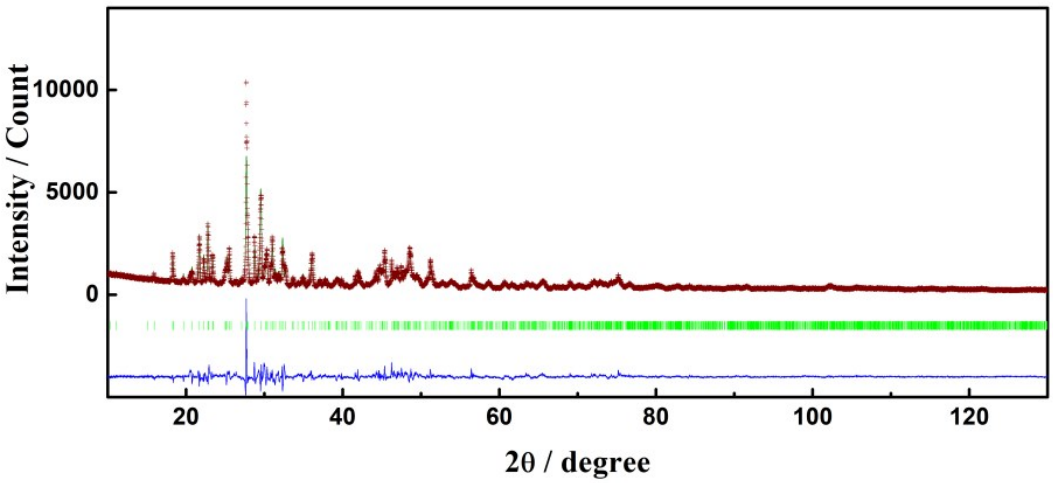

Figure S1. Rietveld refinement result for X-ray powder diffraction data of $Ba_3La_2(BO_3)_4$:0.05Ce^{3+}. Red symbol: measured pattern, green solid line: calculated pattern, blue solid line: difference between their intensities.

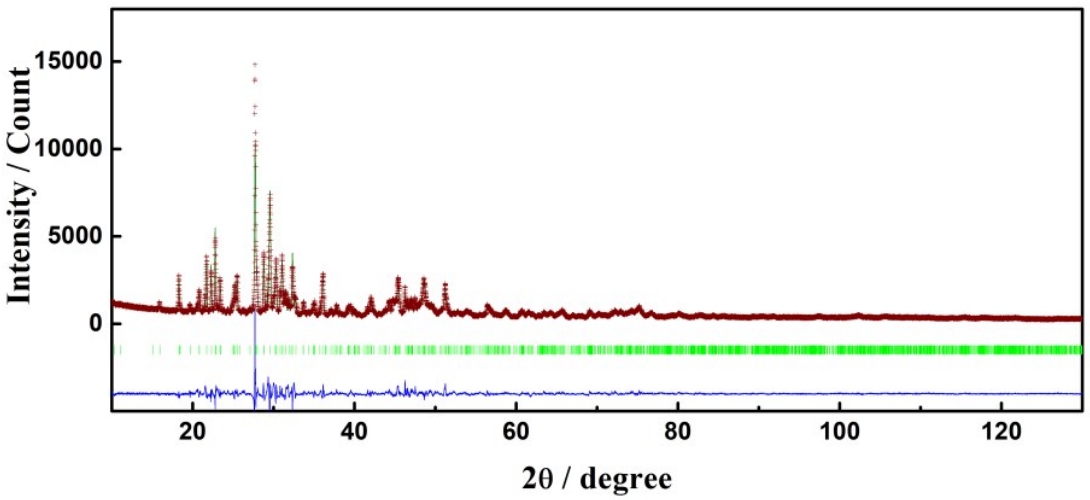

Figure S2. Rietveld refinement result for X-ray powder diffraction data of $Ba_3La_2(BO_3)_4$:0.03Tb^{3+}. Red symbol: measured pattern, green solid line: calculated pattern, blue solid line: difference between their intensities.

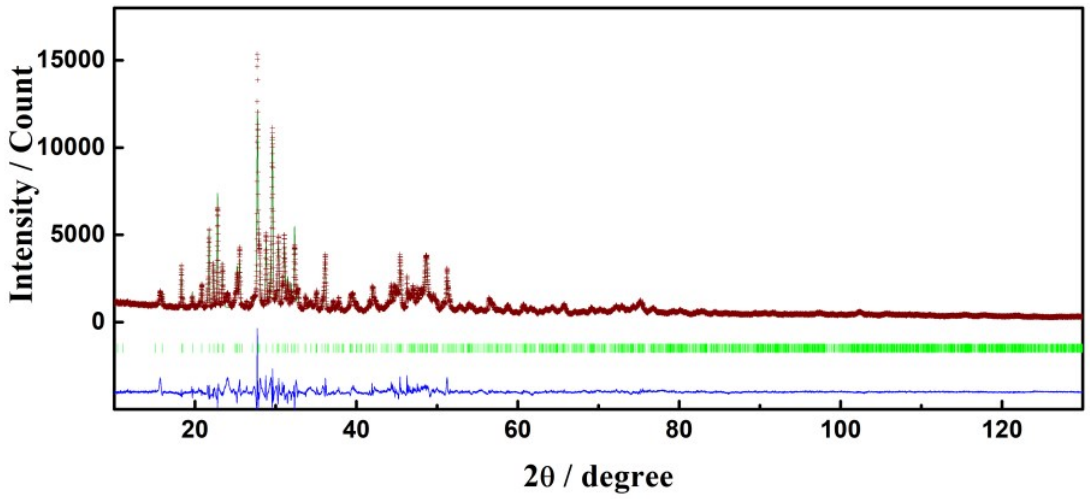

Figure S3. Rietveld refinement result for X-ray powder diffraction data of $Ba_3La_2(BO_3)_4$:0.05Ce^{3+},0.03Tb^{3+} Red symbol: measured pattern, green solid line: calculated pattern, blue solid line: difference between their intensities.

Table S1. Refined structural parameters of the $Ba_3La_2(BO_3)_4$ host material from the Rietveld refinement using XRD data obtained at room temperature.

Atom	Site	Occ.	*x*	*y*	*z*	Beq
La1	*4c*	0.67	0.3113(7)	0.25	0.5299(5)	1.0
Ba1	*4c*	0.33	0.3113(7)	0.25	0.5299(5)	1.0
La2	*8d*	0.33	0.1828(3)	0.1250(2)	0.1493(1)	1.0
Ba2	*8d*	0.67	0.1828(3)	0.1250(2)	0.1493(1)	1.0
La3	*8d*	0.33	0.4813(6)	0.5825(5)	0.1769(3)	1.0
Ba3	*8d*	0.67	0.4813(6)	0.5825(5)	0.1769(3)	1.0
B1	*4c*	1	0.6473(5)	0.25	0.1616(9)	1.0
B2	*4c*	1	0.4140(7)	0.75	0.3093(1)	1.0
B3	*8d*	1	0.3216(0)	0.4167(6)	0.4138(6)	1.0
O1	*8d*	1	0.5466(1)	0.3100(3)	0.0909(8)	1.0
O2	*4c*	1	0.3613(5)	0.25	0.2450(9)	1.0
O3	*4c*	1	0.6470(2)	0.25	0.5304(5)	1.0
O4	*8d*	1	0.7525(8)	0.6804(8)	0.1845(0)	1.0
O5	*8d*	1	0.6658(1)	0.6165(8)	0.4068(8)	1.0
O6	*8d*	1	0.2377(9)	0.4967(4)	0.9932(4)	1.0
O7	*8d*	1	0.3546(1)	0.4579(0)	0.3369(2)	1.0

Table S2. Refined structural parameters of the $Ba_3La_2(BO_3)_4$:0.05Ce^{3+} phosphor from the Rietveld refinement using XRD data obtained at room temperature.

Atom	Site	Occ.	*x*	*y*	*z*	Beq
La1	*4c*	0.62	0.3104(8)	0.25	0.5340(3)	1.0
Ba1	*4c*	0.33	0.3104(8)	0.25	0.5340(3)	1.0
Ce1	*4c*	0.05	0.3104(8)	0.25	0.5340(3)	1.0
La2	*8d*	0.28	0.1809(8)	0.1268(6)	0.1526(8)	1.0
Ba2	*8d*	0.67	0.1809(8)	0.1268(6)	0.1526(8)	1.0
Ce2	*4c*	0.05	0.1809(8)	0.1268(6)	0.1526(8)	1.0
La3	*8d*	0.28	0.4809(9)	0.5816(3)	0.1760(0)	1.0
Ba3	*8d*	0.67	0.4809(9)	0.5816(3)	0.1760(0)	1.0
Ce3	*4c*	0.05	0.4809(9)	0.5816(3)	0.1760(0)	1.0
B1	*4c*	1	0.6268(5)	0.25	0.1571(4)	1.0
B2	*4c*	1	0.4143(0)	0.75	0.3325(0)	1.0
B3	*8d*	1	0.3276(5)	0.4839(8)	0.4198(3)	1.0
O1	*8d*	1	0.5978(7)	0.3236(4)	0.0896(6)	1.0
O2	*4c*	1	0.3787(6)	0.25	0.2266(5)	1.0
O3	*4c*	1	0.6734(5)	0.25	0.5190(5)	1.0
O4	*8d*	1	0.7310(5)	0.6880(9)	0.1817(3)	1.0
O5	*8d*	1	0.6649(8)	0.6236(8)	0.4164(7)	1.0
O6	*8d*	1	0.2675(0)	0.4915(4)	1.0030(1)	1.0
O7	*8d*	1	0.3486(6)	0.4610(6)	0.3347(7)	1.0

Table S3. Refined structural parameters of the $Ba_3La_2(BO_3)_4$:0.03Tb^{3+} phosphor from the Rietveld refinement using XRD data obtained at room temperature.

Atom	Site	Occ.	*x*	*y*	*z*	Beq
La1	*4c*	0.62	0.3068(1)	0.25	0.5291(5)	1.0
Ba1	*4c*	0.33	0.3068(1)	0.25	0.5291(5)	1.0
Tb1	*4c*	0.05	0.3068(1)	0.25	0.5291(5)	1.0
La2	*8d*	0.28	0.1818(0)	0.1250(0)	0.1503(1)	1.0
Ba2	*8d*	0.67	0.1818(0)	0.1250(0)	0.1503(1)	1.0
Tb2	*4c*	0.05	0.1818(0)	0.1250(0)	0.1503(1)	1.0
La3	*8d*	0.28	0.4802(1)	0.5837(7)	0.1763(8)	1.0
Ba3	*8d*	0.67	0.4802(1)	0.5837(7)	0.1763(8)	1.0
Tb3	*4c*	0.05	0.4802(1)	0.5837(7)	0.1763(8)	1.0
B1	*4c*	1	0.4548(4)	0.25	0.0868(2)	1.0
B2	*4c*	1	0.3802(8)	0.75	0.4089(2)	1.0
B3	*8d*	1	0.2815(4)	0.4528(5)	0.4142(5)	1.0
O1	*8d*	1	0.6002(9)	0.3135(9)	0.1019(7)	1.0
O2	*4c*	1	0.3812(1)	0.25	0.2269(0)	1.0
O3	*4c*	1	0.6476(5)	0.25	0.5383(3)	1.0
O4	*8d*	1	0.7651(2)	0.6877(5)	0.1805(7)	1.0
O5	*8d*	1	0.6649(7)	0.6230(6)	0.4032(7)	1.0
O6	*8d*	1	0.2786(7)	0.4944(9)	0.9956(8)	1.0
O7	*8d*	1	0.3749(4)	0.4537(8)	0.3384(7)	1.0

Table S4. Refined structural parameters of the $Ba_3La_2(BO_3)_4$:0.05Ce^{3+}, 0.03Tb^{3+} phosphor from the Rietveld refinement using XRD data obtained at room temperature.

Atom	Site	Occ.	*x*	*y*	*z*	Beq
La1	*4c*	0.59	0.3054(9)	0.25	0.5337(3)	1.0
Ba1	*4c*	0.33	0.3054(9)	0.25	0.5337(3)	1.0
Ce1	*4c*	0.05	0.3054(9)	0.25	0.5337(3)	1.0
Tb1	*4c*	0.03	0.3054(9)	0.25	0.5337(3)	1.0
La2	*8d*	0.25	0.1842(8)	0.1260(6)	0.1541(0)	1.0
Ba2	*8d*	0.67	0.1842(8)	0.1260(6)	0.1541(0)	1.0
Ce2	*4c*	0.05	0.1842(8)	0.1260(6)	0.1541(0)	1.0
Tb2	*4c*	0.03	0.1842(8)	0.1260(6)	0.1541(0)	1.0
La3	*8d*	0.25	0.4794(3)	0.5830(4)	0.1778(7)	1.0
Ba3	*8d*	0.67	0.4794(3)	0.5830(4)	0.1778(7)	1.0
Ce3	*4c*	0.05	0.4794(3)	0.5830(4)	0.1778(7)	1.0
Tb3	*4c*	0.03	0.4794(3)	0.5830(4)	0.1778(7)	1.0
B1	*4c*	1	0.6405(1)	0.25	0.1472(1)	1.0
B2	*4c*	1	0.3929(6)	0.75	0.3855(0)	1.0
B3	*8d*	1	0.2665(8)	0.4911(5)	0.4303(5)	1.0
O1	*8d*	1	0.5964(7)	0.3235(0)	0.0868(8)	1.0
O2	*4c*	1	0.4057(7)	0.25	0.2249(1)	1.0
O3	*4c*	1	0.6575(9)	0.25	0.5172(0)	1.0
O4	*8d*	1	0.7411(6)	0.6944(0)	0.2060(5)	1.0
O5	*8d*	1	0.6530(7)	0.6097(0)	0.4441(8)	1.0
O6	*8d*	1	0.2716(7)	0.4910(8)	1.0159(3)	1.0
O7	*8d*	1	0.3720(2)	0.4620(7)	0.3480(3)	1.0

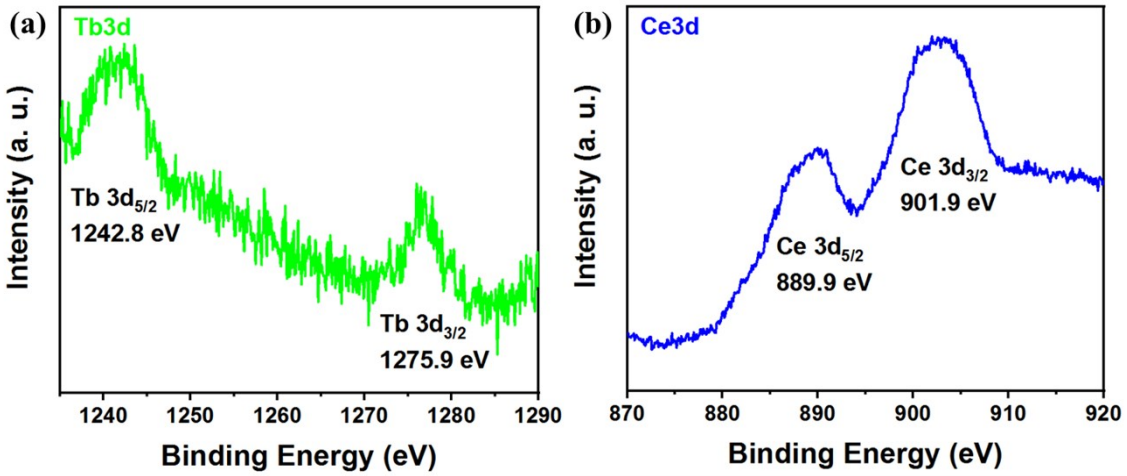

Figure S4. The (a) Ce3d and (b) Tb3d XPS spectra of $Ba_3La_2(BO_3)_4$:0.05Ce^{3+},0.13Tb^{3+} phosphor.