Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.


# An excellent cyan-emitting orthosilicate phosphor for NUV-pumped white LED application

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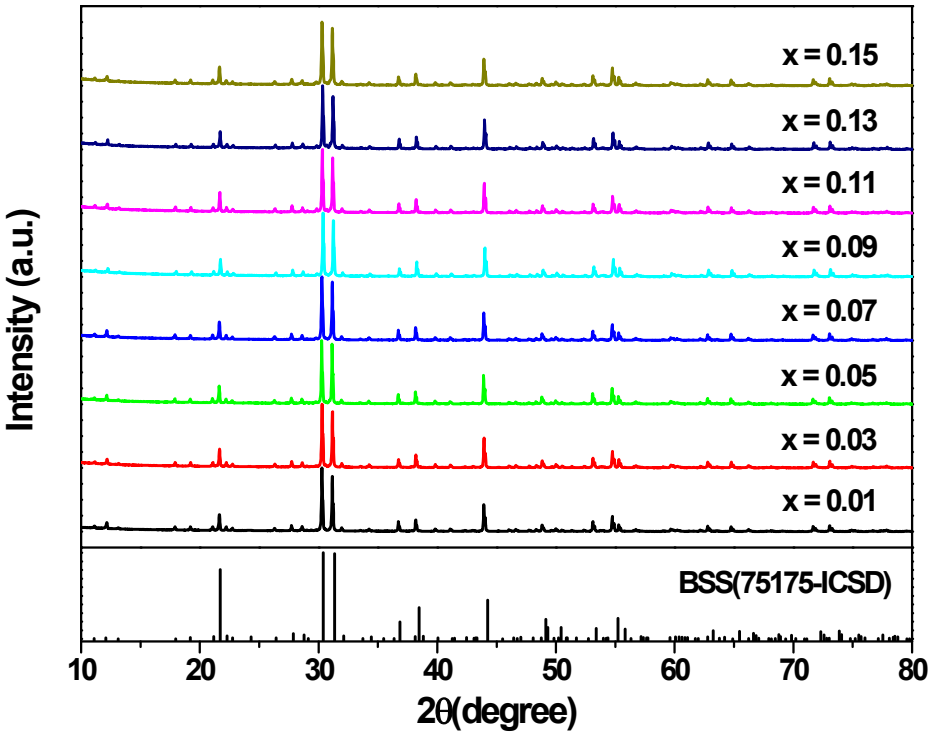


**Figure S1** XRD patterns for BLS:$x$Ce$^{3+}$ ($x$ = 0.01-0.15).

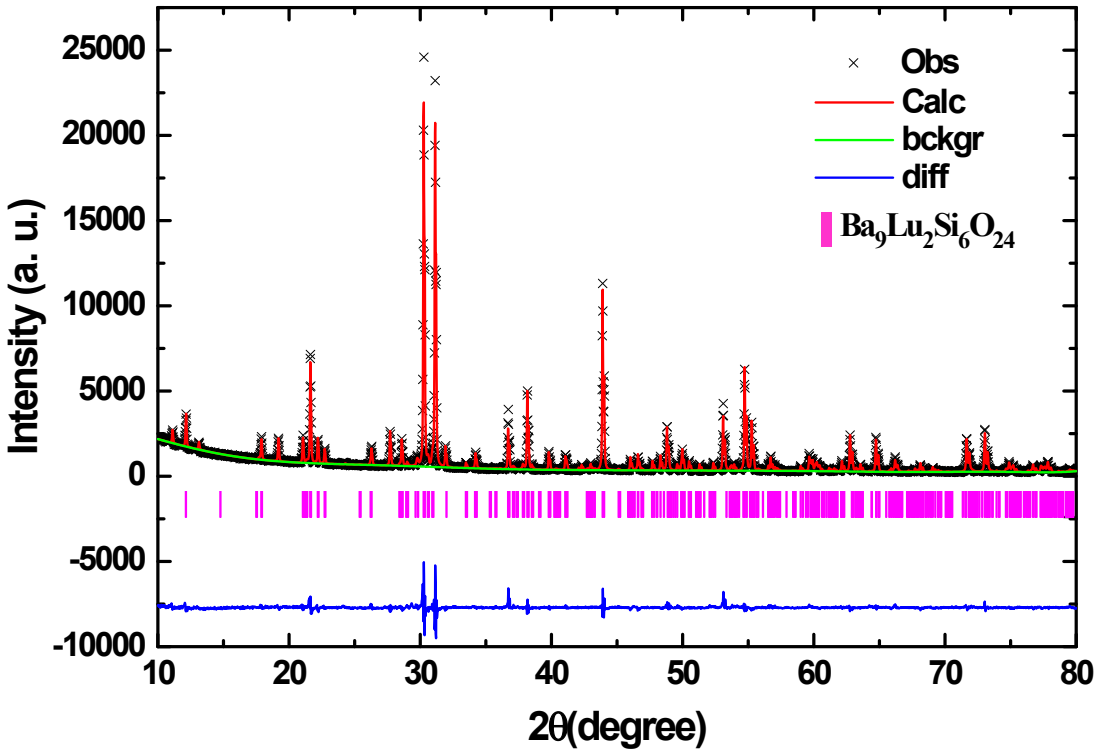


**Figure S2** Rietveld refinement of BLS:5%$Ce^{3+}$. Observed, calculated, background, difference and *hkl* of the XRD pattern are plotted in the same range. The pattern contains two phases: $Ba_9Lu_2Si_6O_{24}$ (magenta) and $Ba_2SiO_4$ (6246-ICSD, cyan).

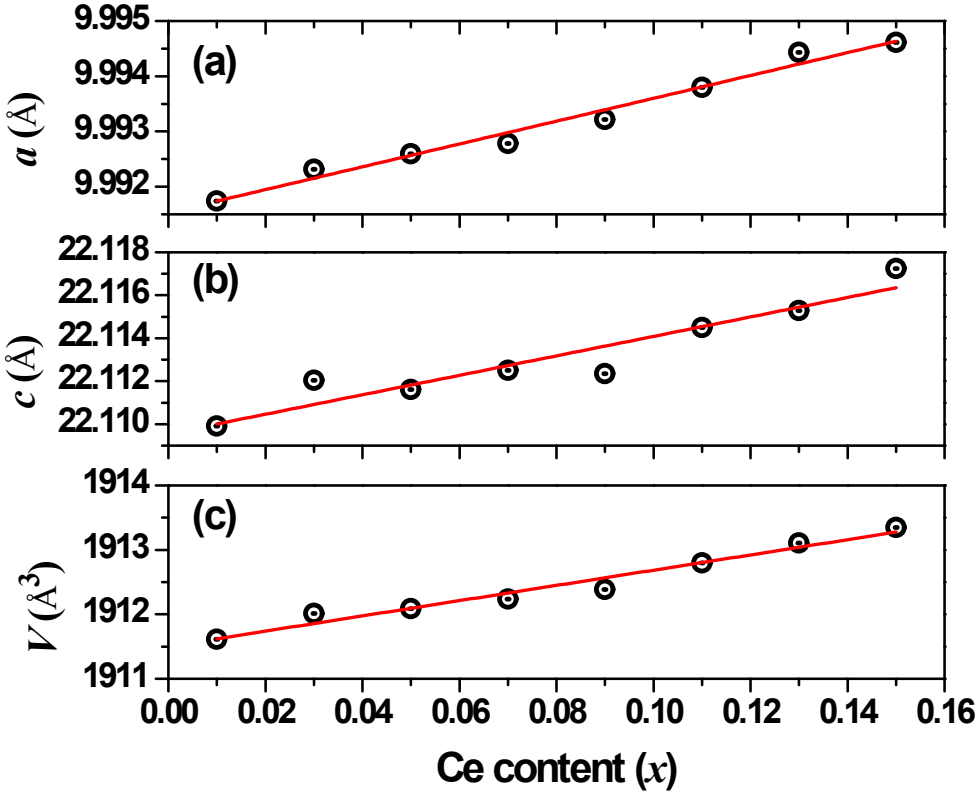


**Figure S3** Refined lattice parameters *a* and *c* and unit cell volume *V* for BLS:*x*$Ce^{3+}$ (*x* = 0.01-0.15).

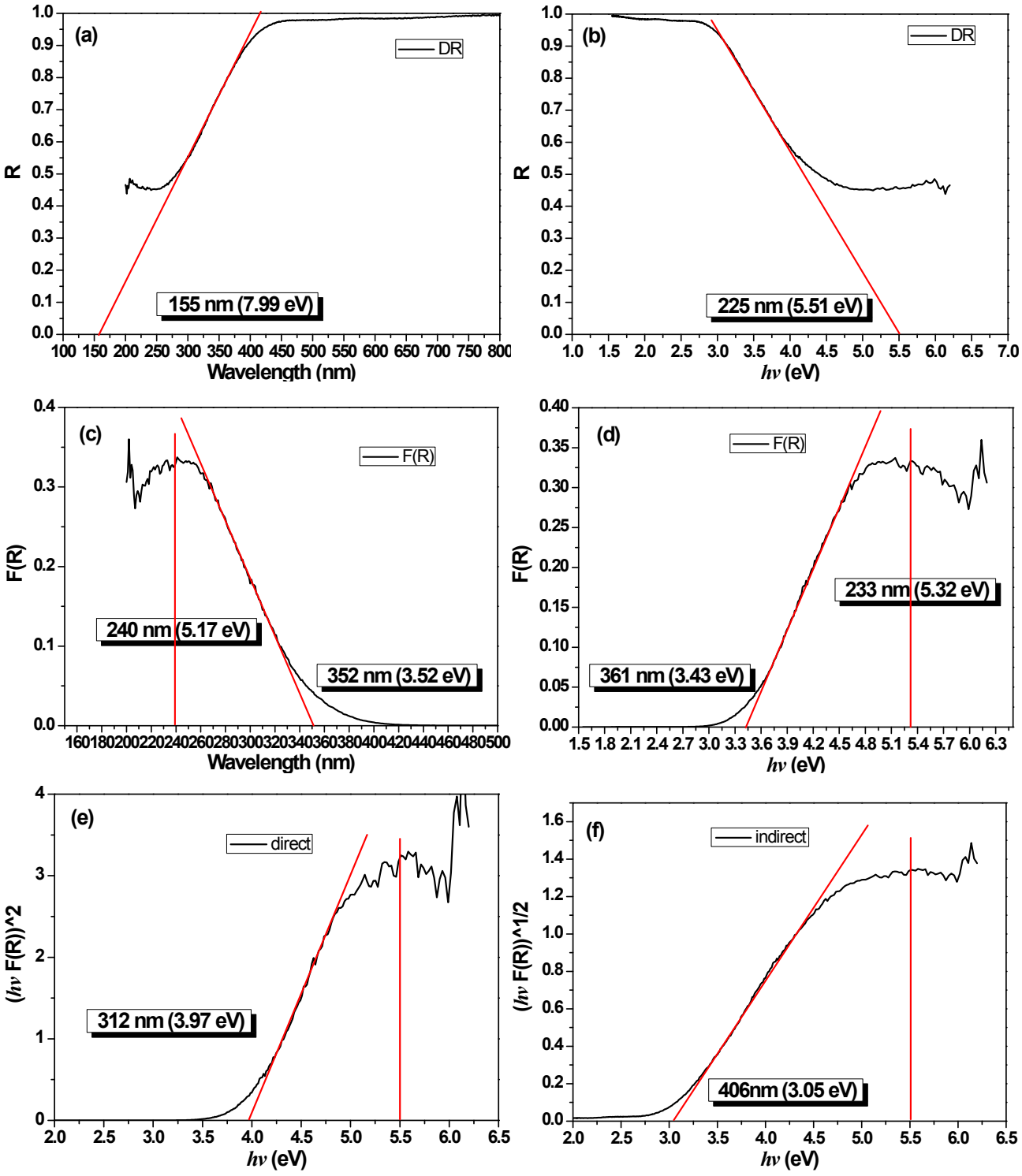


**Figure S4** Optical band gap of the BLS host determined by extrapolating the DR curve (M-1) against wavelength (a) and against energy (b), the F(R) curve (M-2) against wavelength (c) and against energy (d), (hvF(R))^2 for a direct band gap (e) and (hvF(R))^(1/2) for an indirect band gap (M-3).

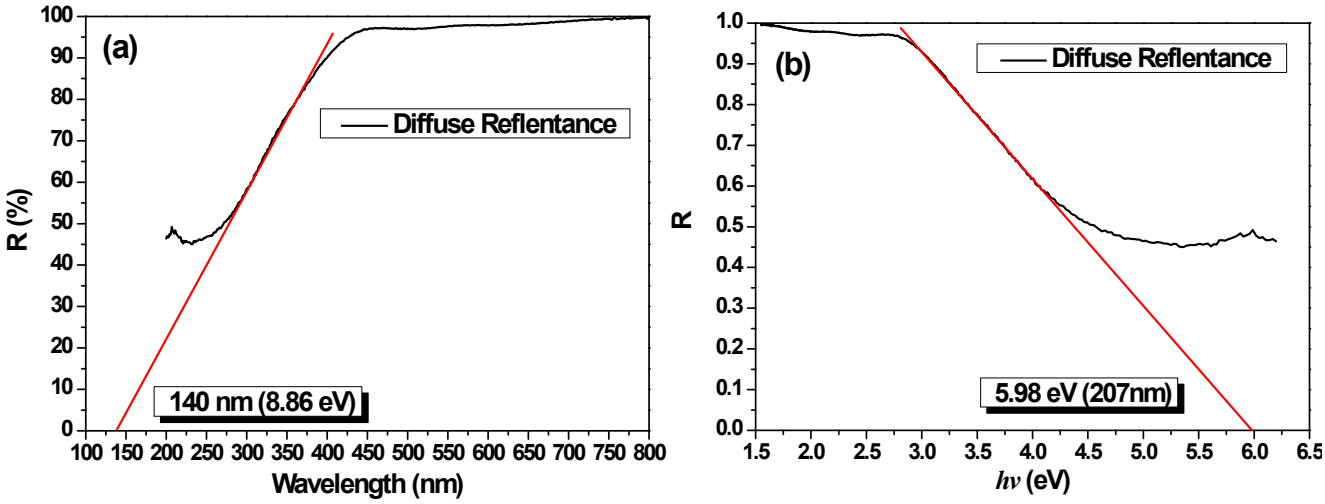


**Figure S5** Optical band gap of the BYS host determined by extrapolating the R curve (M-1) against wavelength (a) and against energy (b).

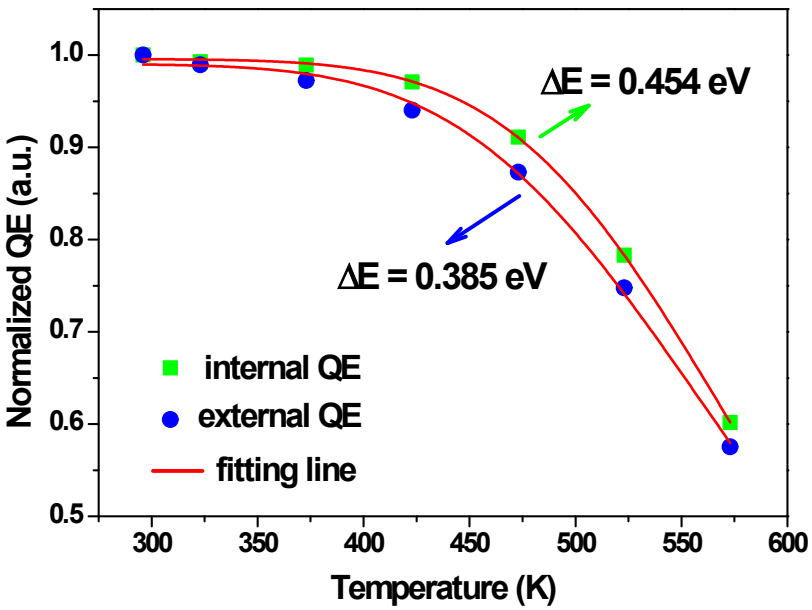


**Figure S6** Temperature-dependent of normalized internal and external QEs for BLS:11%$Ce^{3+}$ and fitting results by the Arrhenius equation.

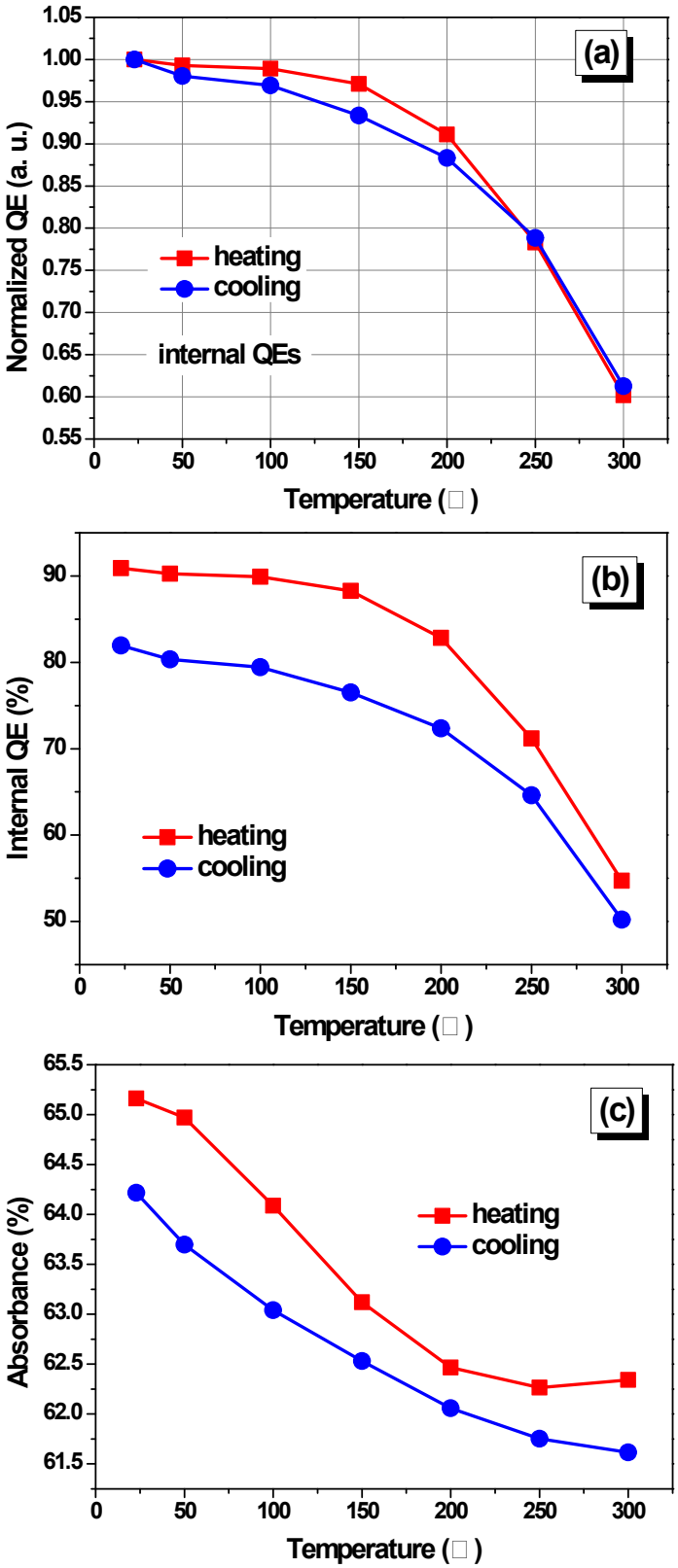


**Figure S7** Temperature dependence of normalized internal QEs (a), internal QEs (b) and absorbance (c) for BLS:11%$Ce^{3+}$.

**Table S1** Rietveld refinement and Crystal data for $Ba_9Lu_{2-x}Ce_xSi_6O_{24}$ ($x$ = 0.01-0.15).

| $x$ | $a$ | $c$ | $V$ | $R_{WP}$ | $R_P$ | $\chi^2$ |
|---|---|---|---|---|---|---|
| $x$ = 0.01 | 9.991742 | 22.109903 | 1911.613 | 7.87% | 5.89% | 5.104 |
| $x$ = 0.03 | 9.992314 | 22.112038 | 1912.016 | 10.4% | 7.55% | 8.682 |
| $x$ = 0.05 | 9.992594 | 22.111609 | 1912.086 | 7.74% | 6.07% | 4.416 |
| $x$ = 0.07 | 9.992785 | 22.112505 | 1912.236 | 9.05% | 6.68% | 6.658 |
| $x$ = 0.09 | 9.993217 | 22.112343 | 1912.388 | 9.23% | 7.25% | 6.268 |
| $x$ = 0.11 | 9.993797 | 22.114502 | 1912.797 | 10.9% | 8.58% | 8.946 |
| $x$ = 0.13 | 9.994432 | 22.115292 | 1913.108 | 10.8% | 8.71% | 9.958 |
| $x$ = 0.15 | 9.994613 | 22.117237 | 1913.346 | 11.4% | 8.90% | 8.961 |

**Table S2** Atomic Parameters, $x$, $y$, $z$, occupancy, Uiso and Wyckoff position for $Ba_9Lu_2Si_6O_{24}$:5%$Ce^{3+}$.

| atom | $x$ | $y$ | $z$ | Occupancy | Uiso*100 | Wyckoff position |
|---|---|---|---|---|---|---|
| Ba1 | 0.00000(0) | 0.00000(0) | 0.00000(0) | 1.0000 | 0.82(3) | 3a |
| Ba2 | 0.33330(0) | 0.66670(0) | 0.00420(1) | 1.0000 | 0.57(7) | 6c |
| Ba3 | 0.03203(0) | 0.67011(8) | 0.10848(5) | 1.0000 | 0.77(1) | 18f |
| Lu | 0.00000(0) | 0.00000(0) | 0.16383(5) | 1.0000 | 2.53(1) | 6c |
| Si | 0.33854(5) | 0.01357(8) | 0.07356(3) | 1.0000 | 2.86(4) | 18f |
| O1 | 0.35161(6) | 0.05826(1) | 0.00330(7) | 1.0000 | 6.72(6) | 18f |
| O2 | 0.49420(1) | 0.14148(0) | 0.10621(8) | 1.0000 | 2.04(4) | 18f |
| O3 | -0.03290(3) | 0.16891(2) | 0.10333(8) | 1.0000 | 0.40(0) | 18f |
| O4 | 0.16581(9) | 0.47469(8) | 0.09243(3) | 1.0000 | 0.69(2) | 18f |

**Table S3** Selected Bond Distances for $Ba_9Lu_2Si_6O_{24}$:5%$Ce^{3+}$.

| Bond | Distance (Å) | Bond | Distance (Å) |
|---|---|---|---|
| Ba1-O1 (6×) | 3.298(4) | Ba3-O1 | 2.548(7) |
| Ba1-O3 (6×) | 2.861(1) | Ba3-O2 | 2.981(6) |
| Ba2-O1 (3×) | 2.893(4) | Ba3-O2 | 3.065(7) |
| Ba2-O2 (3×) | 3.115(3) | Ba3-O2 | 3.086(8) |
| Ba2-O4 (3×) | 2.776(6) | Ba3-O3 | 2.929(7) |
| Lu-O2 | 2.163(0) | Ba3-O3 | 3.038(3) |
| Lu-O3 | 2.225(7) | Ba3-O3 | 3.176(6) |
| Si-O1 | 1.589(1) | Ba3-O4 | 2.703(2) |
| Si-O2 | 1.671(3) | Ba3-O4 | 2.718(5) |
| Si-O3 | 1.653(6) | Ba3-O4 | 3.113(1) |
| Si-O4 | 1.629(1) | | |