# Supporting Information for

# Photoluminescence Detection of Symmetry Transformations in Low-dimensional Ferroelectric $ABO_3$ Perovskites

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## Figures

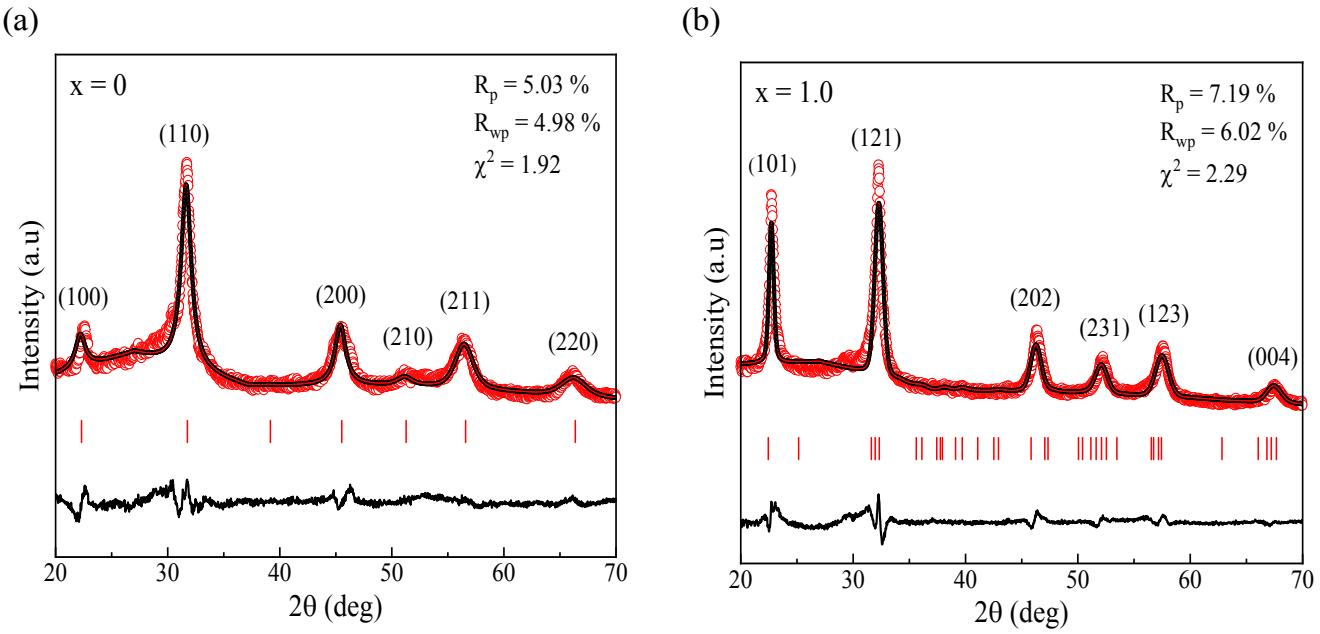


**Fig. S1** (a-b) Rietveld refinement of $Ca_xSr_{1-x}NbO_3$:Eu (2 mol%) NPs. The x = 0 ($Sr_{1-x}NbO_3$) and x = 1.0 ($Ca_{1-x}NbO_3$) compositions are references for the C and O phases. Reported spectra were collected at room temperature with λ = 1.541 Å. The upper symbols illustrate the observed data (circles) and the calculated pattern (solid line). The vertical markers show calculated positions of Bragg reflections and the lower curve represents the difference between observed and calculated intensities.

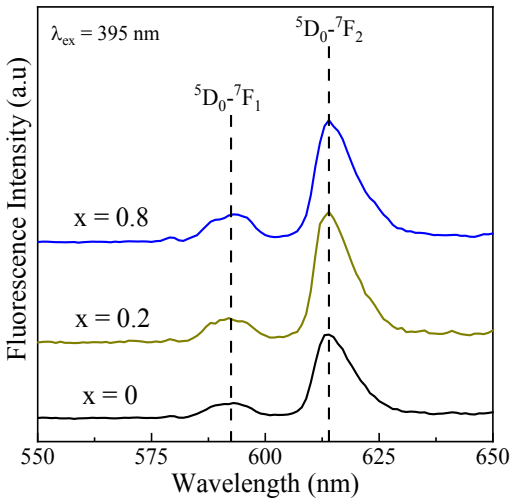


**Fig. S2** PL emission spectra for $Ca_xSr_{1-x}NbO_3$:Eu (2 mol%) nanoparticles. Spectra are offset for clarity.

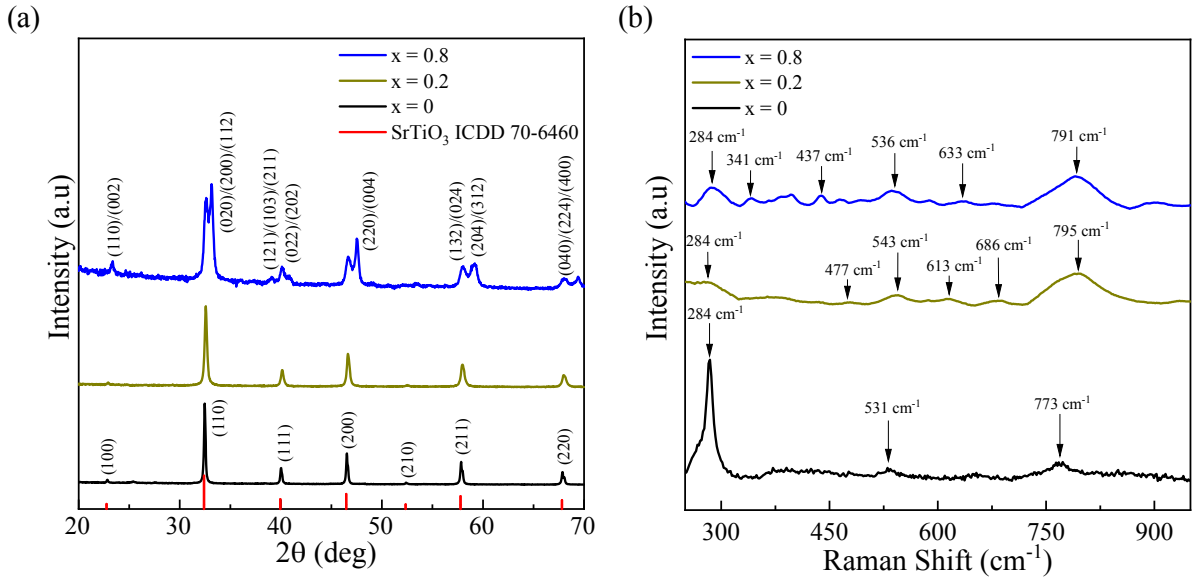


**Fig. S3** (a) XRD pattern and (b) Raman spectra for CSTO:Eu (2 mol%, x = 0, 0.2 and 0.8) nanoparticles.

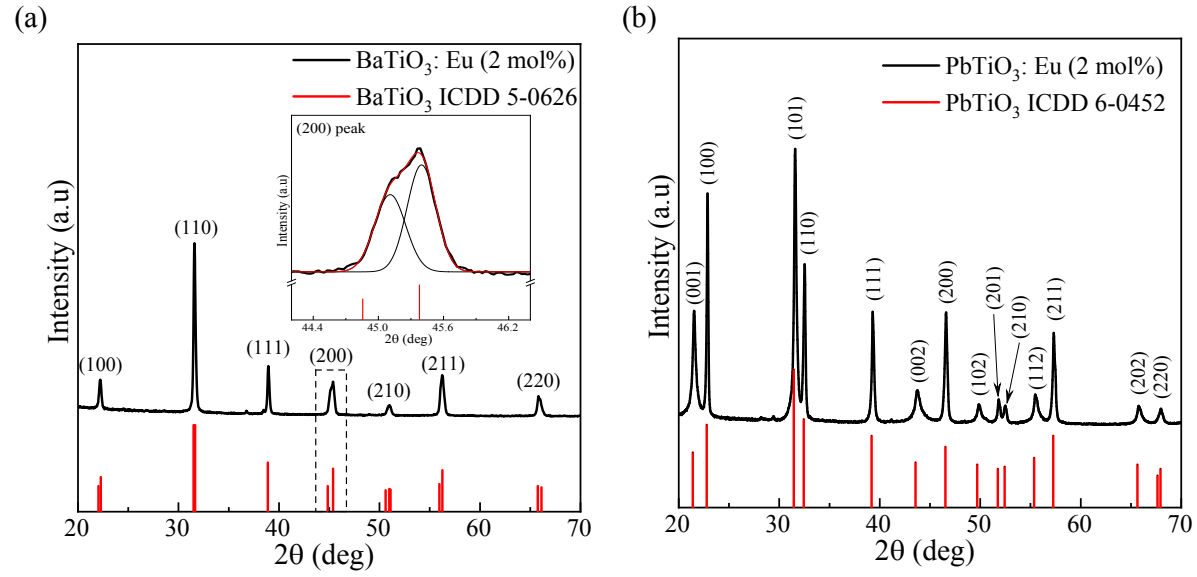


**Fig. S4** Diffraction pattern for Eu-doped (a) BTO and (b) PTO NPs.

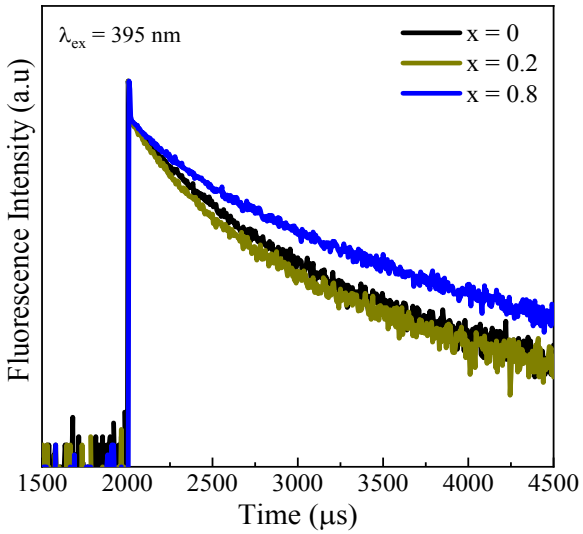


**Fig. S5** Room-temperature lifetime measurements for $Ca_xSr_{1-x}NbO_3$:Eu (2 mol%) nanoparticles.

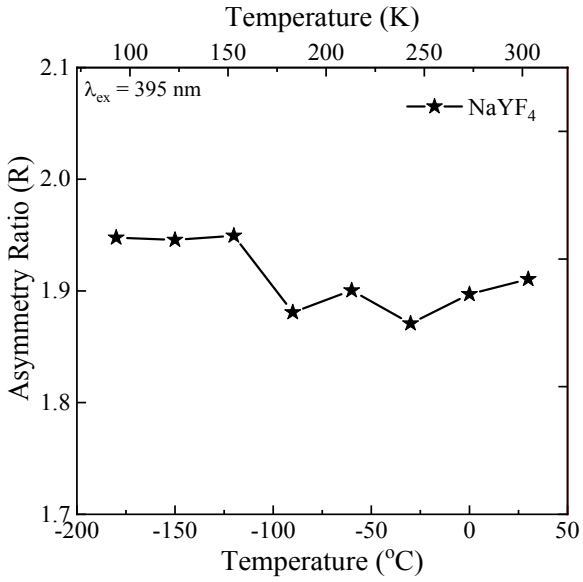


**Fig. S6** Asymmetry ratio for $NaYF_4$: Eu (2 mol%) nanoparticles in C phase. The plot highlights the absence of structural transformations in $NaYF_4$ at low-temperatures.

## Tables

**Table S1** Crystallographic Data and Refined Lattice Parameters for $Ca_xSr_{1-x}NbO_3$ Nanoparticles based on X-ray Diffraction Data

| **Parameters** | **x = 0** | **x = 1.0** |
|---|---|---|
| wavelength (Å) | 1.541 | |
| temperature (K) | 300 | |
| 2θ range (˚) | 20-70 | |
| space group | Pm-3m (No. 221)[a] | Pnma (No. 62)[b] |
| | Lattice Parameters | |
| a (Å) | 3.988(0) | 5.591(6) |
| b (Å) | 3.988(0) | 7.873(2) |
| c (Å) | 3.988(0) | 5.526(7) |
| α, β, γ (˚) | 90 | 90 |
| V ($Å^3$) | 63.411 | 243.306 |
| | Atomic Coordinates | |
| Sr/Ca (x,y,z) | 0.5, 0.5, 0.5 | 0.02602, 0.25, 0.02512 |
| Nb (x,y,z) | 0, 0, 0 | 0, 0, 0.5 |
| O1 (x,y,z) | 0.5, 0, 0 | 0.03976, 0.25, 0.54792 |
| O2 (x,y,z) | - | 0.19040, -0.022, 0.73890 |

[a-b] space group ref.: ICSD 19-2410, ICSD 47-1668. The occupancy was fixed to 0.7 at the Sr site and 1 at Nb and O sites for the $Sr_{1-x}NbO_3$ structure and to 1 at all atom sites for the $Ca_{1-x}NbO_3$ structure. For the $Sr_{1-x}NbO_3$, the isotropic displacement parameter $U_{iso}$ is 0.021(0), 0.017(9), and 0.044(5) $Å^2$ for Sr, Nb, and O sites, respectively. For the $Ca_{1-x}NbO_3$, the isotropic displacement parameter $U_{iso}$ is 0.060(7), 0.003(9), 0.025(2), and 0.043(0) $Å^2$ for Ca, Nb, O1, and O2 sites, respectively.

**Table S2** Lattice Parameter and Crystal Structure for $Ca_xSr_{1-x}NbO_3:Eu^{3+}$ (2 mol%) Nanoparticles

| x | a (Å) | b (Å) | c (Å) | V ($Å^3$) | Crystal Structure |
|---|---|---|---|---|---|
| 0 | 3.98 | 3.98 | 3.98 | 63.13 | C |
| 0.1 | 3.98 | 3.98 | 4.04 | 64.03 | C and T |
| 0.2 | 3.98 | 3.98 | 4.03 | 63.85 | C and T |
| 0.5 | 5.67 | 7.97 | 5.33 | 241.06 | Mixture |
| 0.8 | 5.75 | 7.91 | 5.29 | 240.81 | O |
| 1.0 | 5.75 | 7.88 | 5.28 | 239.49 | O |

**Table S3** Lifetime for $Ca_xSr_{1-x}NbO_3:Eu^{3+}$ (2 mol%) Nanoparticles Fit to a Double-Exponential Decay Curve

| x | $\tau_1$ (μs) | $\tau_2$ (μs) | $R^2$ (%) |
|---|---|---|---|
| 0 | 179.03 | 571.99 | 99.8 |
| 0.2 | 174.46 | 629.20 | 99.8 |
| 0.8 | 211.04 | 798.55 | 99.8 |