Enhanced X-ray-Excited Persistent Luminescence in $CaF_2:Tb^{3+}$ via Interstitial Li^+ Incorporation

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Experimental section

Chemicals and Materials: CaF_2(99.9%), TbF_3 (99.9%), LiF (≥99.9%), were purchased from Aladdin. PDMS were purchased from Dow Corning.All the chemicaI reagents were used as received without further purification.

Methods

Synthesis of $CaF_2:Tb^{3+},Li^+$ Phosphors: $CaF_2:Tb^{3+},Li^+$ phosphors were synthesized via a high-temperature solid-state reaction. Stoichiometric amounts of raw materials were weighed according to the target composition, thoroughly ground with anhydrous ethanol to ensure homogeneity. The resulting mixture was transferred into an alumina crucible and calcined in air at 1100 °C for 6 h in a tube furnace. After natural cooling to room temperature, the product was reground with anhydrous ethanol and dried to obtain the final $CaF_2:Tb^{3+},Li^+$ phosphor powder.

Fabrication of $CaF_2:Tb^{3+},Li^+$@PDMS Composite Films: To prepare flexible scintillator films, 1.0 g of polydimethylsiloxane (PDMS) base, 0.1 g of curing agent, and 0.5 g of $CaF_2:Tb^{3+},Li^+$ phosphor powder were uniformly mixed in a vial. The homogeneous mixture was then blade-coated onto a clean glass substrate. The film was cured at 60 °C for 2 h to complete crosslinking, yielding a flexible $CaF_2:Tb^{3+},Li^+$@PDMS composite film.

Characterizations: X-ray diffraction (XRD) analysis was carried out by a powder diffractometer (Bruker D8 Advance) with a Cu-Kα (λ = 1.5405 Å) radiation. TESCAN VEGA3 S-4300 field-emission electron microscope was executed by a Scanning electron microscope (SEM), with electron energy of 30 keV. The X-ray photoelectron spectroscopy (XPS) test was completed by Thermo Scientific Nexsa. XEOL spectra were measured by a spectrometer (OmniFluo960) with an X-ray tube (target material: W, voltage 50 kV, tube current 200 μA) and a photon counter (DCS210PC-9S). X-ray

imaging was performed using a home-made setup comprising a miniature X-ray tube and camera (ORCA-Fusion BT, C15440-20UP). Thermoluminescence (TL) measurements were performed using an LTTL-3DS type thermoluminescence 3D spectrometer with a heating rate of 1 K/s.

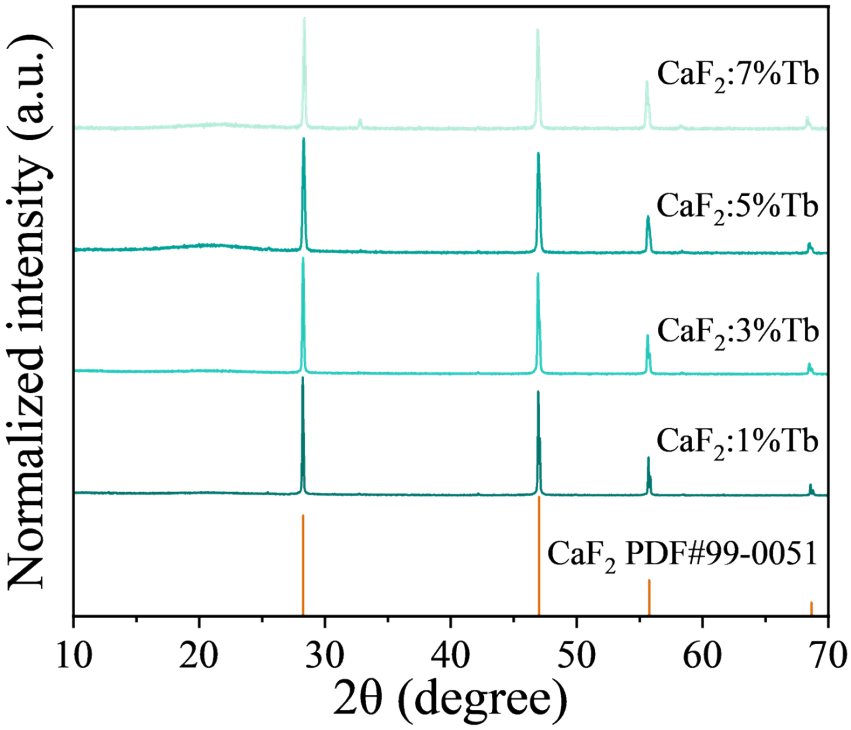

Figure S1. XRD patterns of CaF_2: Tb^{3+} with different Tb doping concentration.

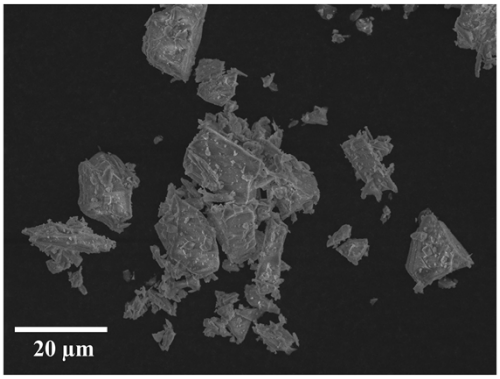

Figure S2. SEM images of CaF_2:Tb,Li phosphors.

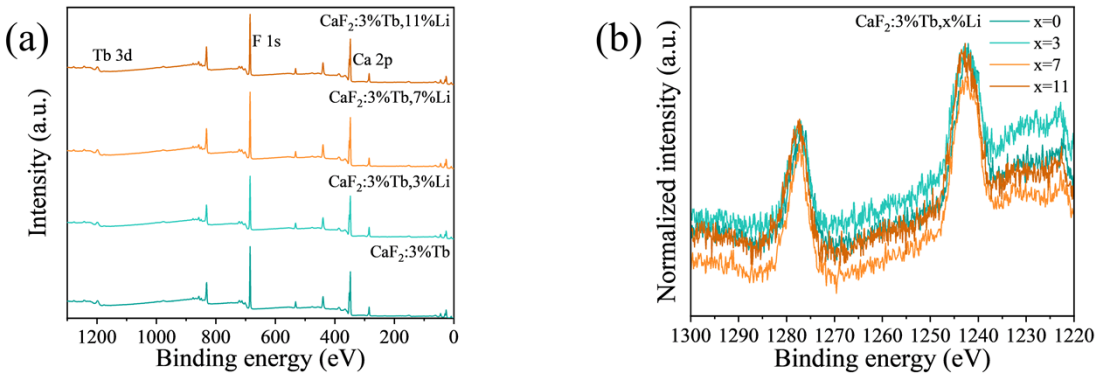

Figure S3. (a) XPS survey spectra of CaF_2:Tb,Li. (b) High-resolution XPS spectra of Tb 3d orbit.

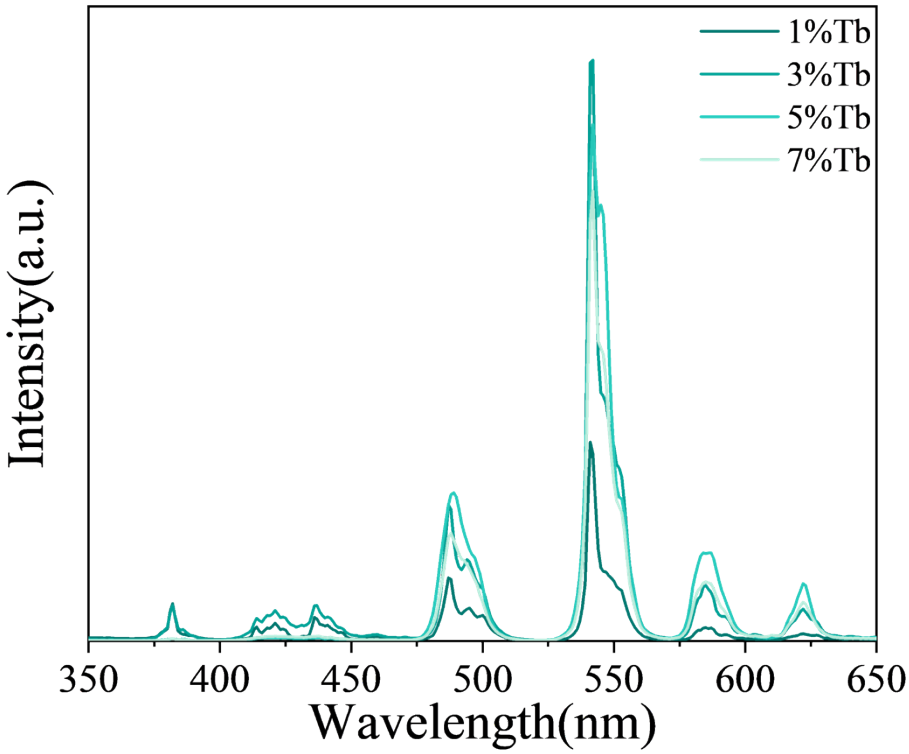

Figure S4. XEOL intensity plot of CaF_2:Tb^{3+} with different Tb doping concentration.

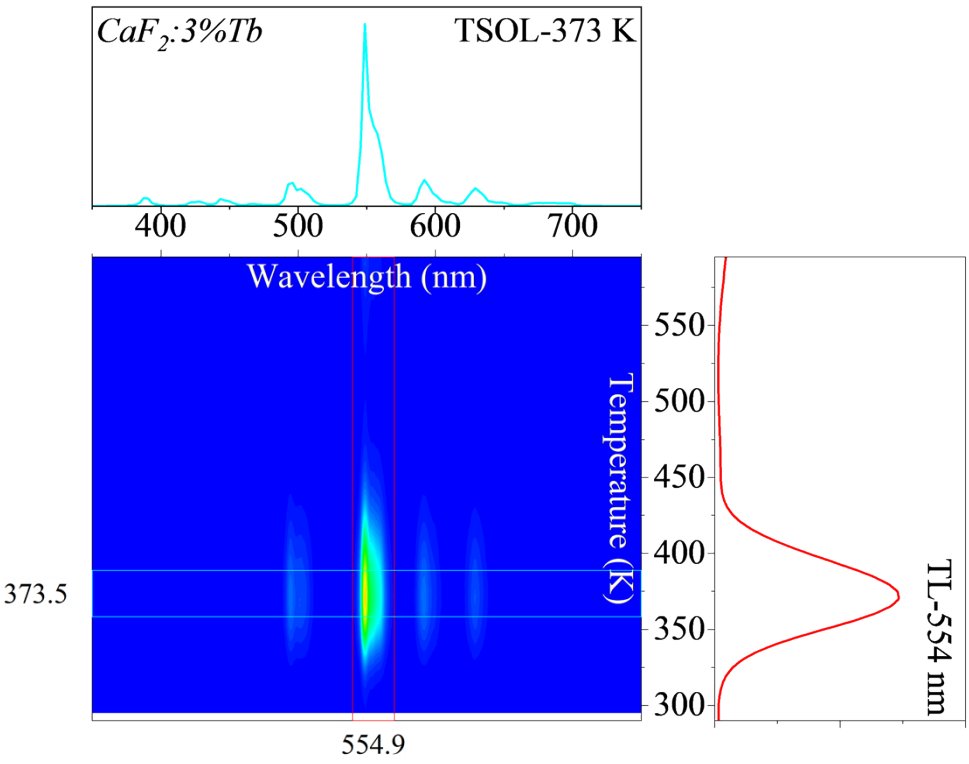

Figure S5. Pseudo-color TL spectra of CaF_2:3%Tb^{3+} during the heating process;

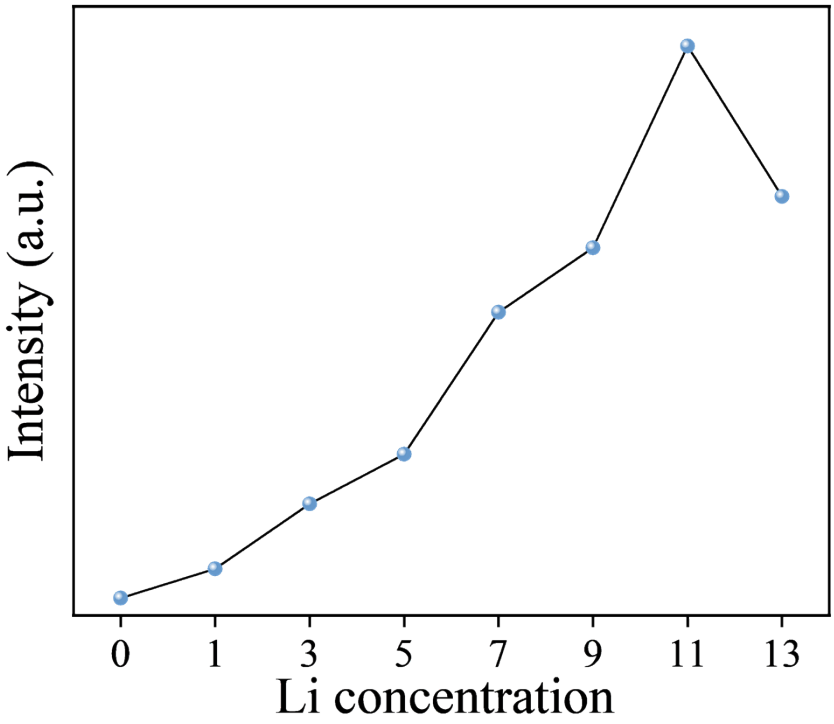

Figure S6. The dot-dash line of TL integrated intensity dependence with the Li concentration.

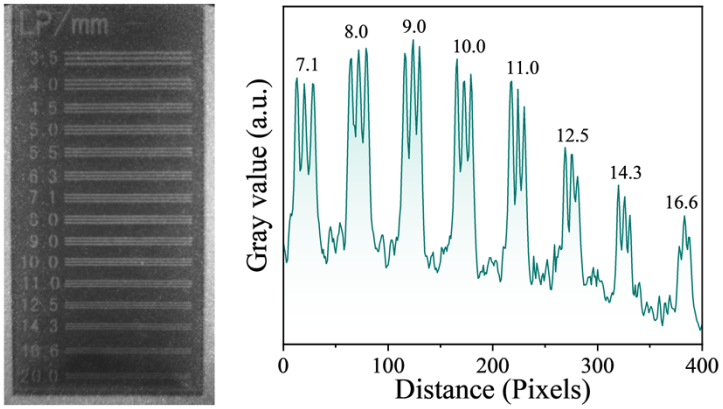

Figure S7. Spatial resolution of real-time X-ray imaging.

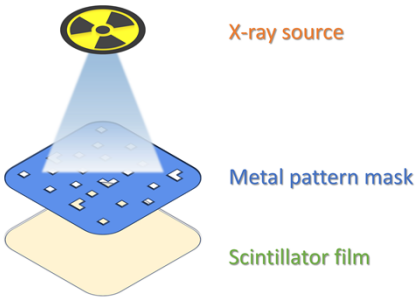

Figure S8. Schematic diagram for X-ray stimulated information storge system.

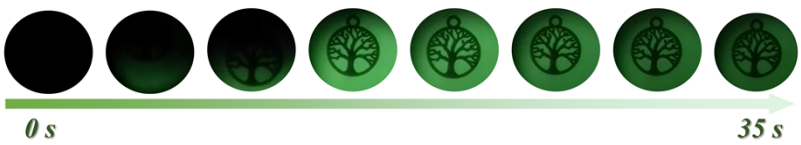

Figure S9. A tree pattern written by X-ray into a scintillator film and read out via hot water adding.