

A Synergy Approach to Enhance Upconversion Luminescence Emission of Rare Earth Nanophosphors with Million-Fold Enhancement Factor

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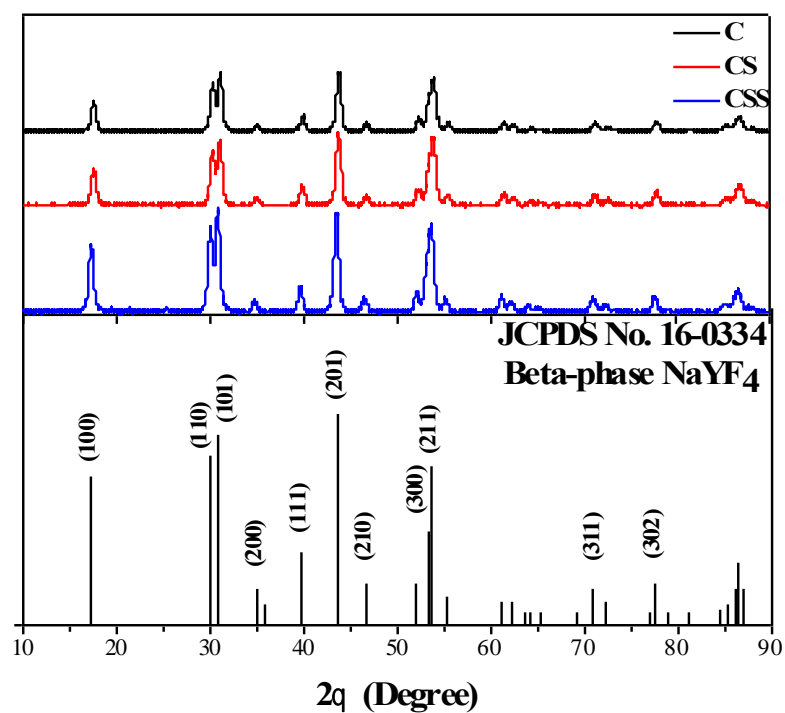


Figure S1. XRD pattern of C, CS, CSS UCNPs and standard β -phase NaYF_4 data (JCPDS file no. 16-0334).

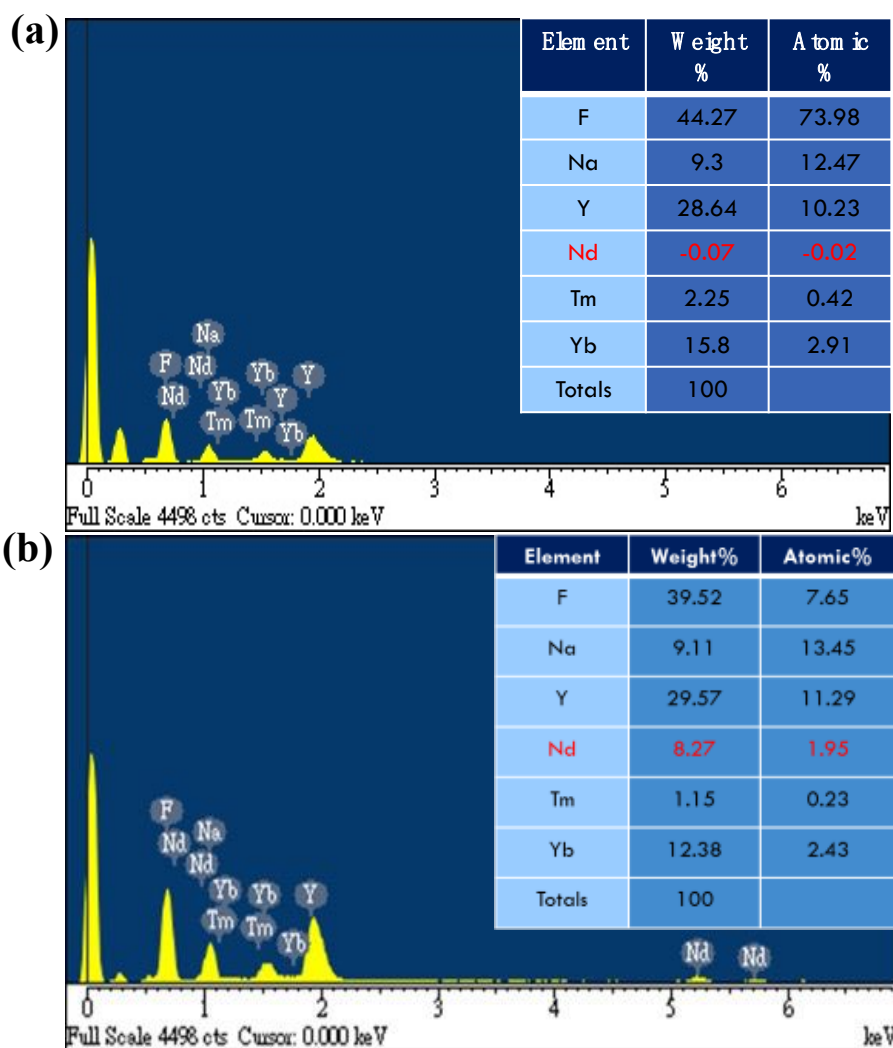


Figure S2. EDX spectra of (a) $\text{NaYF}_4:\text{Yb}^{3+},\text{Tm}^{3+}$ core UCNPs, (b) $\text{NaYF}_4:\text{Yb}^{3+},\text{Tm}^{3+}@\text{NaYF}_4:\text{Yb}^{3+},\text{Nd}^{3+}$ CS UCNPs.

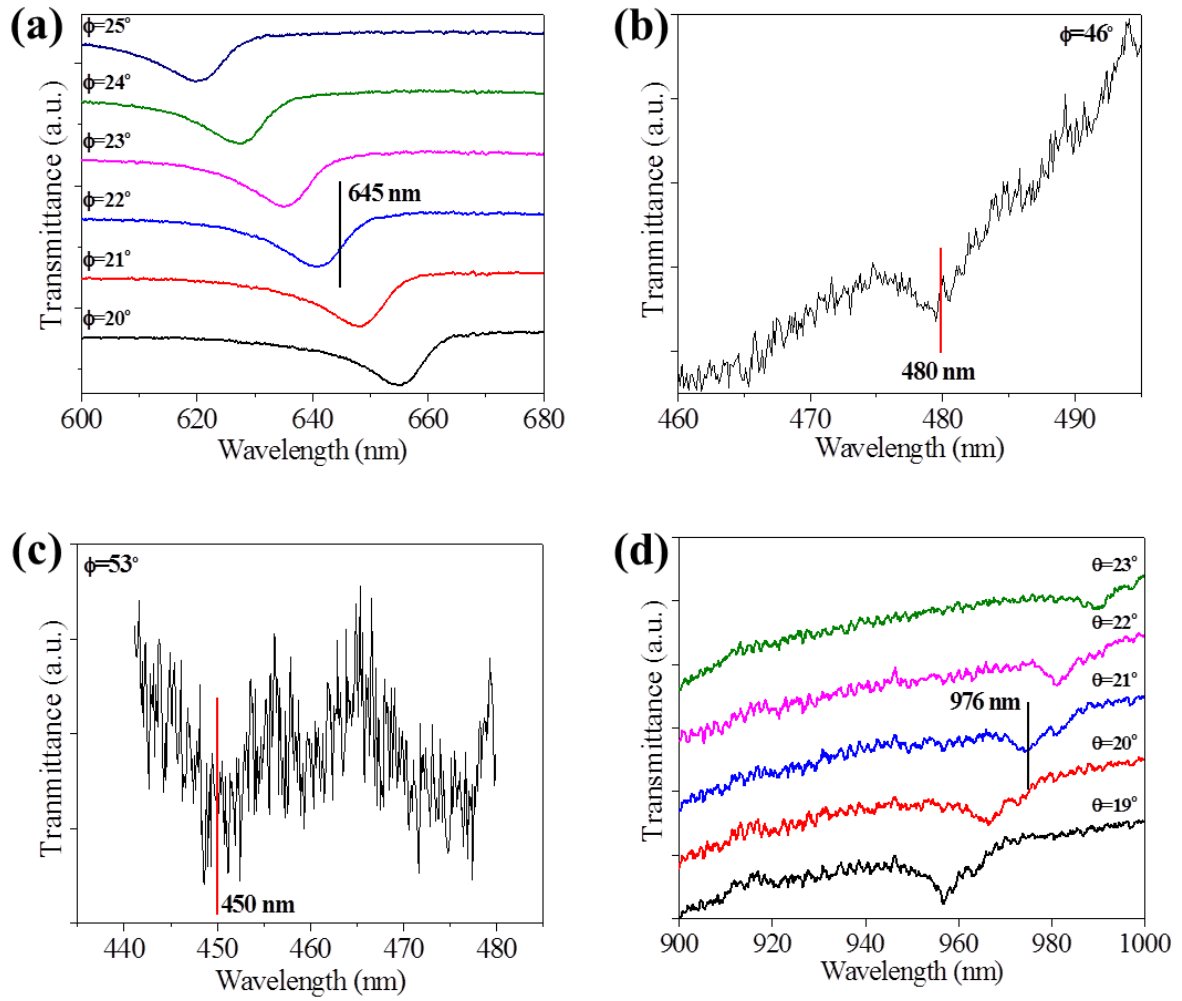


Figure S3. Angle-resolved transmission spectra of the low-n RWG deposited with CSS UCNP, (a) in the detection angle (ϕ) range of 20-25°, at the detection angle of (b) 46°, (c) 53°, and (d) in the excitation angle range of 19-23°. Vertical solid lines present three UCL emission peaks (645, 480, 450 nm) of CSS UCNP and excitation wavelength of 976 nm.

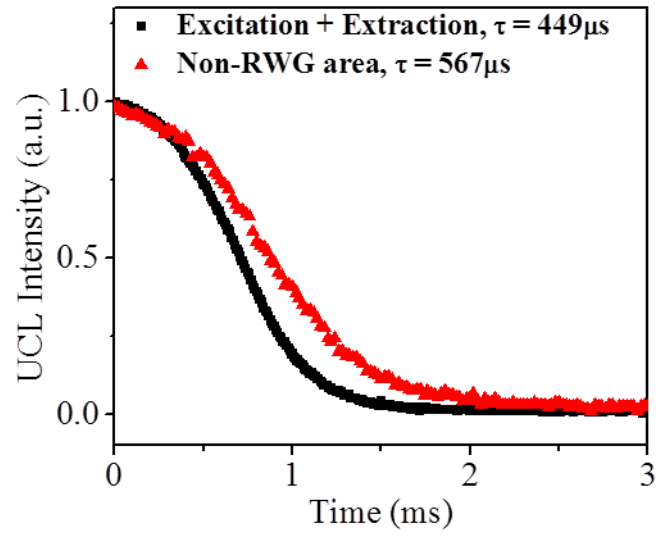


Figure S4: UCL lifetime measurement of the UCL emission at 450 nm obtained from the non-RWG area and the RWG area under *excitation + extraction resonance*.

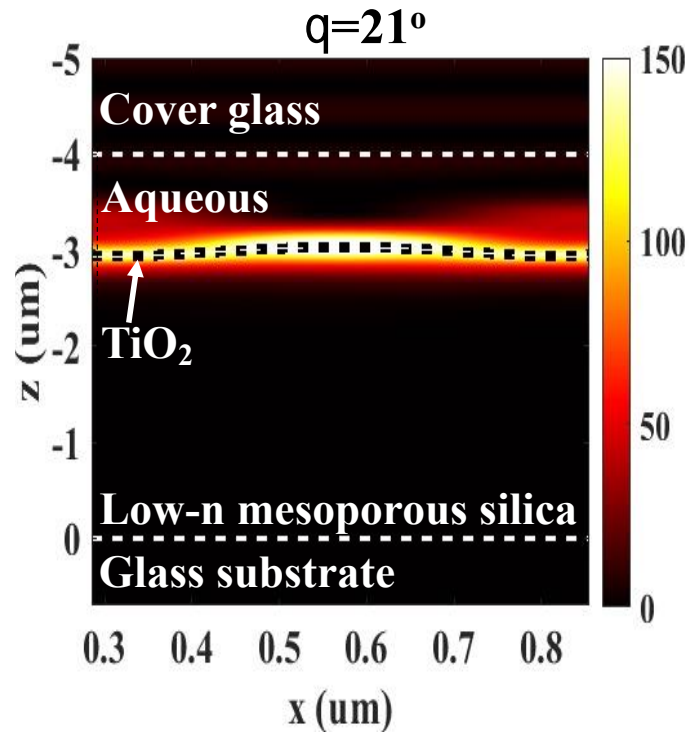


Figure S5. Calculated TE mode electric-field intensities ($|E|^2$) under *resonant excitation* condition ($\lambda = 976 \text{ nm}$, $\theta = 21^\circ$) of the low-n RWG covered with aqueous solution.