Supporting Information

Core-spacer-shell Structured NaGdF$_4$: Yb$^{3+}$/Er$^{3+}$@NaGdF$_4$@Ag Nanoparticles for Plasmon-enhanced Upconversion Luminescence

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Figure S1. Dynamic light scattering measurements (DLS) of core-spacer-shell UCNPs in deionized water.

Figure S2. FT-IR spectra of UCNPs-OA (black line) and UCNPs-TGA (red line).
Figure S3. Energy diagram and simplified mechanism for energy-transfer upconversion between Yb$^{3+}$ and Er$^{3+}$.

Figure S4. FDTD simulations of electric field intensity enhancement at 980 nm a single of core–spacer-shell structured UCNPs model: a 14 nm NaGdF$_4$ core (n = 1.29), with a 1.75 nm NaGdF$_4$ spacer layer (n = 1.29) and a 1.5 nm Ag shell (n = 0.20), color bar indicates E/E$_0$. 

Figure S5. Dotted line: FDTD simulated absorption of a hollow Ag shell, inset is the picture of hollow Ag shell; Solid line: absorption of core-spacer-shell UCNPs.