Microlens Array Enhanced Upconversion Luminescence at Low Excitation Irradiance

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Figure S1 TEM images of (a) core NaYF₄:20%Yb³⁺,2%Er³⁺, (b) core-shell NaYF₄:20%Yb³⁺, 2%Er³⁺@20%Yb³⁺,30%Nd³⁺, (c) core NaYF₄:20%Yb³⁺,0.5%Tm³⁺, (d) core-shell NaYF₄:20%Yb³⁺, 0.5%Tm³⁺@20%Yb³⁺,30%Nd³⁺ nanoparticles. Scale bars: 50 nm.
Figure S2 (a) Upconversion emission spectra of NaYF₄:20%Yb³⁺, 2%Er³⁺@20%Yb³⁺,30%Nd³⁺ nanoparticles under CW 980 nm and 808 nm excitation. Excitation power density for both lasers was 1.3 W/cm². Excitation power-density response of NaYF₄:20%Yb³⁺, 2%Er³⁺@20%Yb³⁺,30%Nd³⁺ under (b) CW 980 nm excitation and (c) CW 808 nm excitation. (d) Upconversion emission spectra of NaYF₄:20%Yb³⁺, 0.5%Tm³⁺@20%Yb³⁺,30%Nd³⁺ nanoparticles under CW 980 nm and 808 nm excitation. Excitation power density for both lasers was 14.5 W/cm². Excitation power-density response of NaYF₄:20%Yb³⁺, 0.5%Tm³⁺@20%Yb³⁺,30%Nd³⁺ under (e) CW 980 nm excitation and (f) CW 808 nm excitation. Laser beam diameter for both lasers: ~1.0 mm.
Figure S3 Transmission spectrum of the microlens array

Figure S4 Upconversion luminescence spectra of NaYF₄:20%Yb³⁺, 2%Er³⁺ @ 20%Yb³⁺, 30%Nd³⁺ nanoparticles under 980 nm CW excitation (Average excitation intensity: 3.9 W/cm²) without and with the addition of microlens array (MLA), using different solvents as the interface medium (ethanol, water, methanol).