Supporting Information for

Hydrothermal Tm^{3+}-Lu_2O_3 Nanorods with Highly Efficient 2 μm Emission

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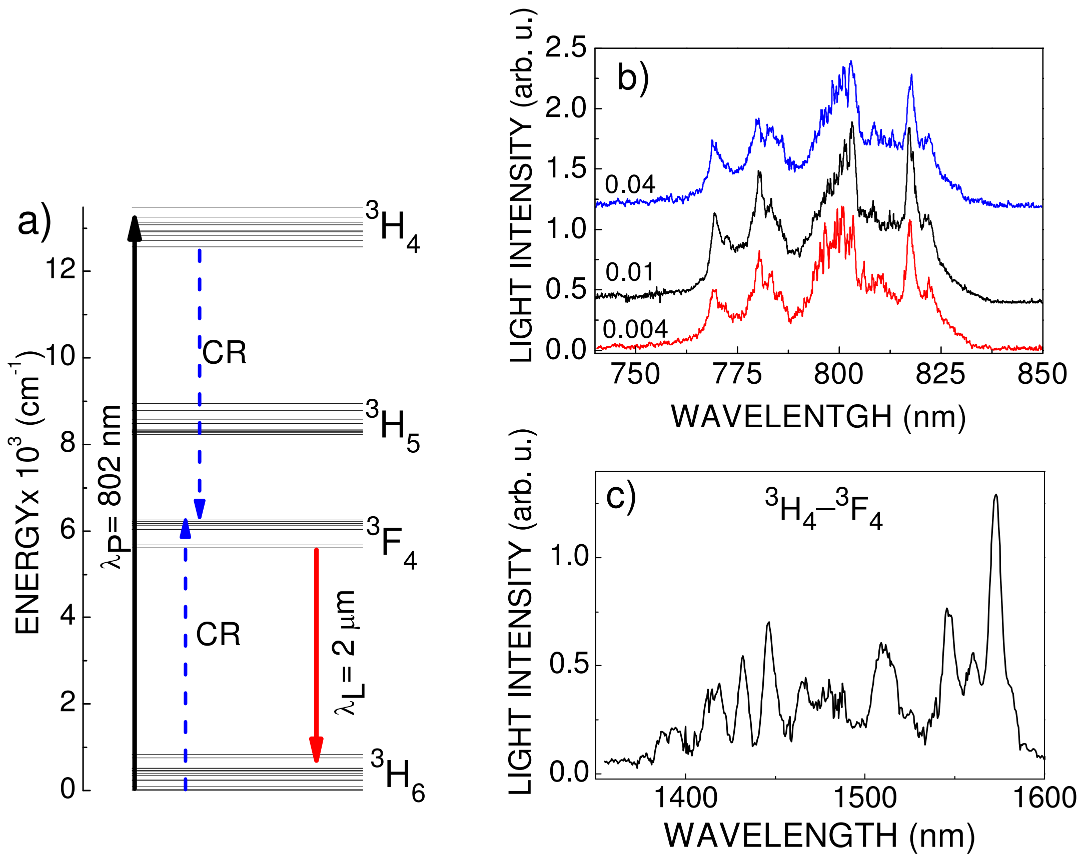

Figure S1. (a) Scheme of energy levels of Tm^{3+} in Lu_2O_3, showing relevant energy transfer processes for the $^3F_4 \rightarrow ^3H_6$ laser emission operating at ~2 μm. Tm^{3+} ions can be efficiently excited around 800 nm through the optical absorption from the $^3H_6$ ground state to the $^3H_4$ multiplet. The laser multiplet $^3F_4$ is populated by a cooperative cross-relaxation (CR) process that occurs through the interaction of two neighboring Tm^{3+} ions, $^3H_4 + ^3H_6 \rightarrow 2\times^3F_4$, thus the process yields two excited ions for each absorbed pump photon. The efficiency of the CR process depends on the Tm^{3+} doping concentration, being very efficient if the Tm-Tm distance is short enough. This laser channel can be directly and efficiently pumped with commercially available powerful semiconductor AlGaAs laser diodes around 800 nm, with little photon energy transferred as heat to the crystal host; (b) 300 K excitation spectrum (λ_{EMI}=1962 nm) of the $^3H_4$ multiplet of Lu_{2-x} Tm_xO_3 nanorods; (c) 300 K $^3H_4 \rightarrow ^3F_4$ photoluminescence (λ_{EXC}=802 nm) spectra of $Lu_{1.996}Tm_{0.004}O_3$ nanorods.

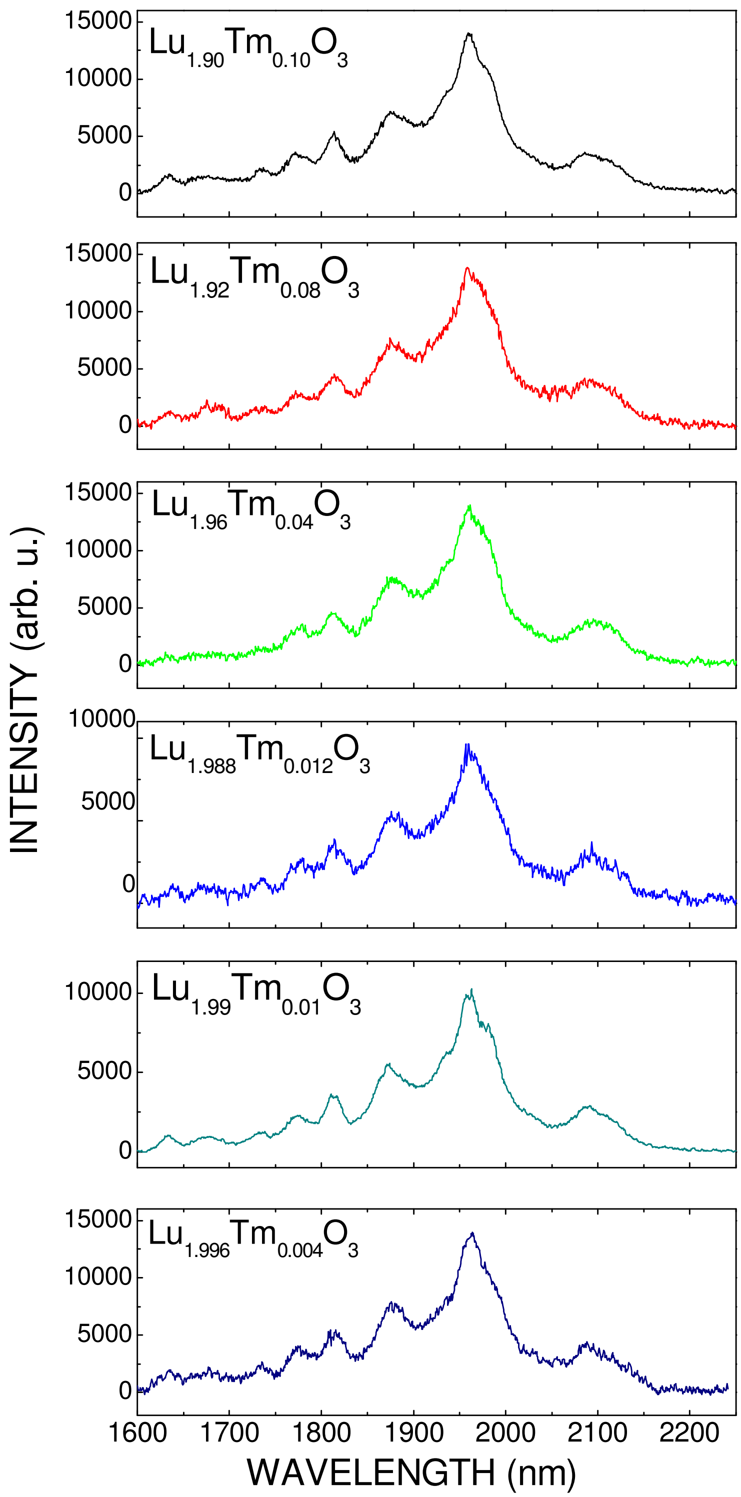

Figure S2. 300 K $^3F_4 \rightarrow ^3H_6$ photoluminescence (λ_{EXC}=802 nm) spectra of $Lu_{2-x}Tm_xO_3$ nanorods ($0.004 \leq x \leq 0.1$).