Improved upconversion luminescence in β-$NaGdF_4$: Er^{3+}, Yb^{3+} nanoparticles: A new microwave-assisted synthesis in anhydrous ionic liquids

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A new microwave assisted synthesis of β-$NaGdF_4$: Er^{3+}, Yb^{3+} nanoparticles was investigated in ethylene glycol (EG) and ionic liquids (IL). Sub-10 nm nanoparticles with an intense green upconversion (UC) luminescence were synthesized. The UC intensity was strongly enhanced by changing the solvent from EG/IL mixture to pure IL, as well as the design from core to core/shell nanoparticles. The reaction in hydroxyl-free conditions reduces the number of oxygen impurities in the fluoride material. Protecting the particle surface by an undoped shell limits surface defects and shields the active core from contact with surface ligands which are required for solubility. Both decrease non-radiative losses and concomitantly yield a stronger UC emission. The UC emission is visible by eye already for low excitation power in sub-5 nm β- $NaGdF_4$: 2%Er^{3+}, 18%Yb^{3+} nanoparticles, see the Fig. below. These results are unique for such small particle size. The new synthesis is robust, scalable, and economically favourable, involving low temperatures and well accessible chemicals.

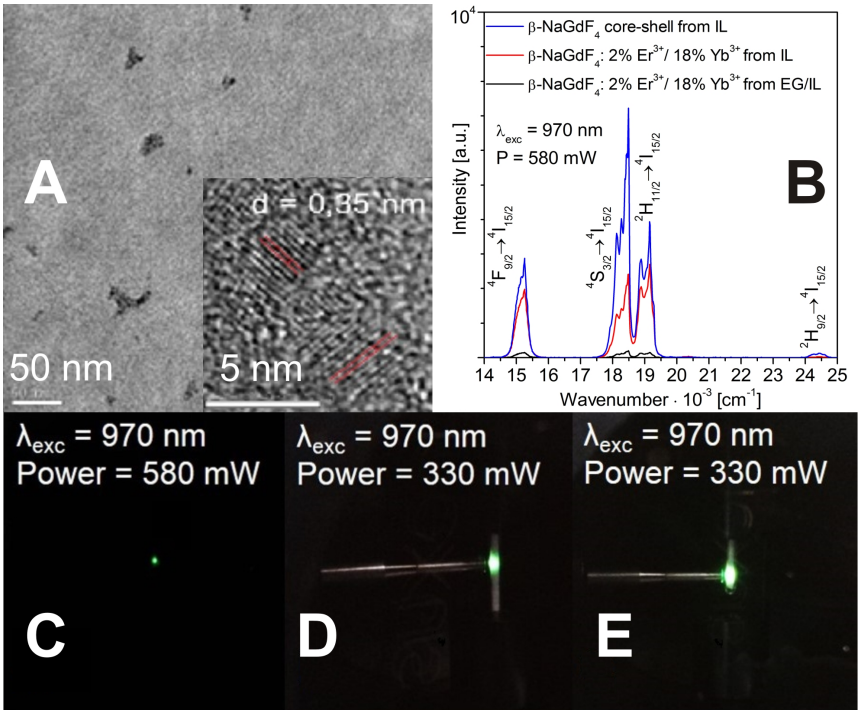

Figure: (A) HR-TEM picture of sub-5 nm nanoparticles. (B) Upconversion luminescence spectra of nanoparticles from ethylene glycol / ionic liquid (IL) synthesis (black trace), from IL synthesis (red trace), and core-shell nanoparticles from IL synthesis (blue trace). (C-E) Photos of the green upconversion luminescence from the samples in Fig. (B) under 580 mW (C) and 330 mW (D,E) excitation at 970 nm.