Lanthanide-doped $KMgF_3$ upconversion nanoparticles for photon avalanche luminescence

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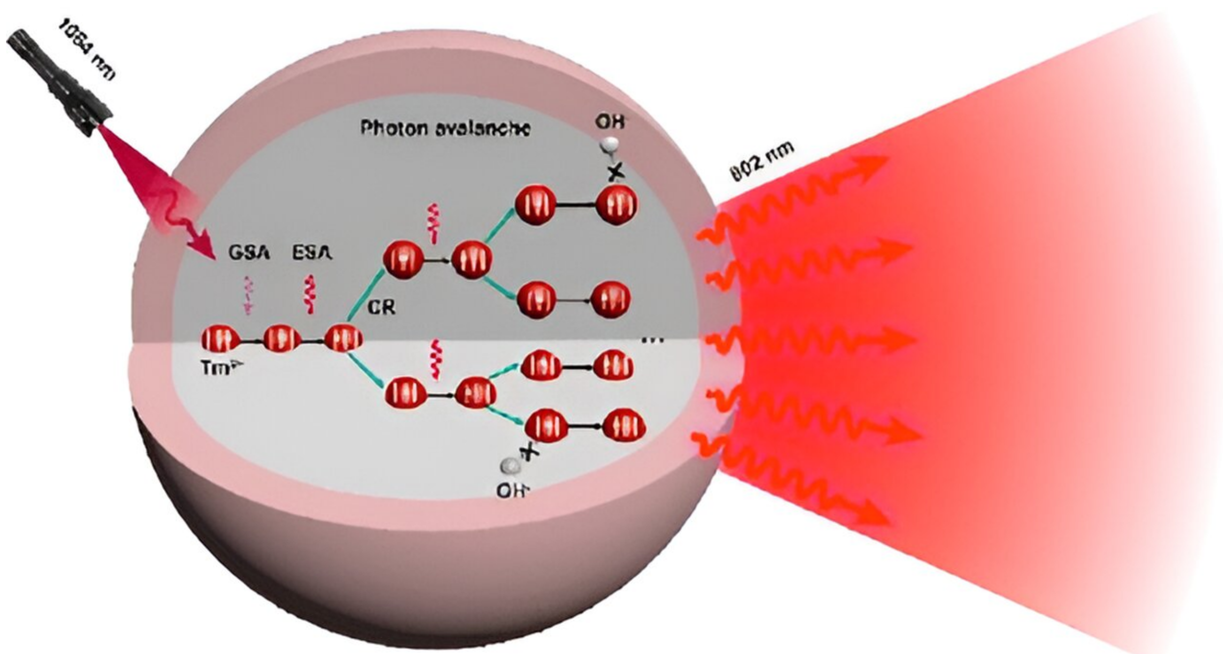

Credit: *Nano Letters* (2023). DOI: 10.1021/acs.nanolett.3c02377

Lanthanide (Ln^{3+})-doped photon avalanche (PA) upconversion nanoparticles (UCNPs) can be applied in super-resolution bioimaging, miniaturized lasers, single-molecule tracking and quantum optics.

However, it remains challenging to realize photon avalanche in colloidal

Ln^{3+}-doped UCNPs at room temperature due to the deleterious quenching effect associated with surface and lattice OH^{-} defects.

A research group led by Prof. Chen Xueyuan from the Fujian Institute of Research on the Structure of Matter of the Chinese Academy of Sciences has developed a novel approach based on the pyrolysis of KHF_2 for controlled synthesis of Ln^{3+}-doped $KMgF_3$ UCNPs, which can effectively protect Ln^{3+} from luminescence quenching by surface and internal OH^{-} defects, and thereby boost upconversion luminescence.

The study was published in *Nano Letters* on Sept. 8.

The researchers demonstrated that the KHF_2 precursor could effectively prevent the generation of OH^{-} defects during the growth of UCNPs, which resulted in highly efficient upconversion luminescence in Yb^{3+}/Er^{3+} and Yb^{3+}/Ho^{3+} co-doped $KMgF_3$ UCNPs, with upconversion quantum yields of □3.8% and □1.1%, respectively, under 980 nm excitation at a power density of 20 W cm^{-2}.

Specifically, due to the suppressed OH^{-} defects and enhanced cross-relaxation rate between Tm^{3+} ions in the aliovalent Tm^{3+}-doped system, the researchers realized efficient photon avalanche luminescence from Tm^{3+} at 802 nm in $KMgF_3$: Tm^{3+} UCNPs upon 1,064 nm excitation at room temperature, with a giant nonlinearity of □27.0, a photon avalanche rise time of 281 ms, and a threshold of 16.6 kW cm^{-2}.

Additionally, the researchers revealed the distinctive advantages of KHF_2 for the controlled synthesis of $KMgF_3$: Ln^{3+} UCNPs, which endowed the UCNPs with tunable size, improved crystallinity, a reduced number of surface and lattice defects (typically OH^{-}), and concomitantly improved upconversion luminescence and near-infrared-II downshifting luminescence efficiencies.

This study provides an approach for the development of highly efficient photon avalanche UCNPs with huge nonlinearities through aliovalent Ln^{3+} doping and crystal lattice engineering.

More information: Meiran Zhang et al, Lanthanide-Doped KMgF3 Upconversion Nanoparticles for Photon Avalanche Luminescence with Giant Nonlinearities, *Nano Letters* (2023). DOI: 10.1021/acs.nanolett.3c02377

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