Simultaneous generation of higher harmonics and upconversion luminescence in lanthanide-doped nanoparticles for optical coding and anti-counterfeiting applications

Jan Moszczyński[1#], Marcin Runowski[1], Przemysław Woźny[1], Inocencio R. Martín[2], Kevin Soler-Carracedo[1,2], Teng Zheng[3], Sascha Feldmann[4]

1. Faculty of Chemistry, Adam Mickiewicz University, Uniwersytetu Poznańskiego 8, Poznań 61-614, Poland
2. Departamento de Fisica, IUdEA, IMNand MALTA Consolider Team, Universidad de La Laguna, San Cristobal de La Laguna, Santa Cruz de Tenerife E-38200, Spain
3. School of Information and Electrical Engineering, Hangzhou City University, Hangzhou 310015, China
4. Rowland Institute, Harvard University, 100 Edwin H. Land Boulevard, Cambridge, MA 02142, USA

Nonlinear optical materials currently play very crucial role in various fields like nanophotonics, optical information processing, biomedical imaging, and anti-counterfeiting. However, the presently used nanomaterials for these applications are effective only for a single type of nonlinear optical activity. Here, we report for the first time a new type of materials based on the $LiNbO_3$:Ln^{3+}–doped nanoparticles [1]. Our nanoparticles exhibit multiple efficient nonlinear optical activities, including SHG and THG, along with up-conversion photoluminescence at the same time. They maintain high efficiency optical activity independently if they are in the form of powder or in the form of the aqueous colloidal solution. Their high stability allows for the formation of optically active biocompatible fibers, polymer-based 3D-printed objects, and fingerprint detection. Additionally, we demonstrate the first 8-bit coding platform solely relying on the multimodal nonlinear optical activities from various processes. Furthermore this lanthanide-doped nanomaterial platform represents a significant advancement in the field of photonics and materials engineering. It has high potential usage in such areas like biomedicine, anti-counterfeiting, and optical information processing.

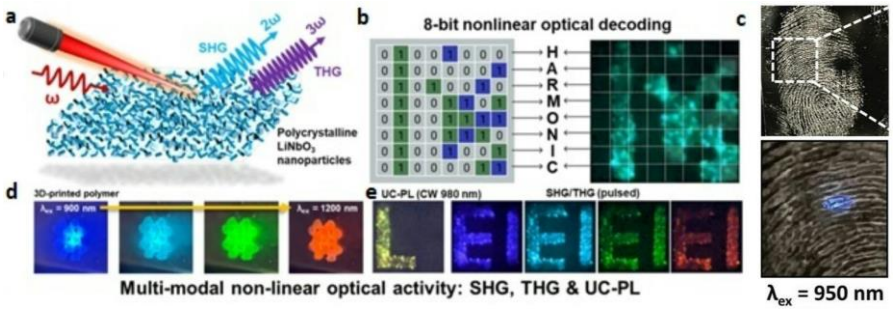

Fig. a. Generating Second and third Harmonic by LiNbO3 nanoparticles, b. 8-bit optical coding and decoding, c. Fingerprint disclosing d. 3D-printed polymer e. Up-conversion photoluminescence and SHG/THG encoding

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corresponding author: janmos1@st.amu.edu.pl