SIZE-DEPENDENT PROPERTIES OF YTTERBIUM DOPED CESIUM LEAD HALIDE PEROVSKITE PARTICLES

Daniel Rodz[1], Simona Streckaitė[1], Vidmantas Gulbinas[1]

[1]Department of Molecular Compound Physics, Center for Physical Sciences and Technology, Vilnius, Lithuania
rodz.daniel@yahoo.com

Perovskites have shown to be promising materials in the field of photovoltaics, where an efficiency of 25.5% for perovskite solar cells [1]. Perovskites are also promising materials in some other applications, for example 23% for light emitting diodes [2] was reached. Ytterbium doped lead halide perovskites, show an interesting quantum-cutting phenomenon where one high energy photon absorbed by the perovskite is down-converted into two low energy photons emitted by Yb^{3+} ions. Such materials have been shown to be efficient in luminescent solar concentrators which applied on top of conventional Si solar cells they may enhance their efficiency [3].

Although ytterbium doped perovskites are already being tested in various applications [3,4], many methods for their fabrication are still not easy or environmentally friendly. This is mainly due to the complicated nature of preparation methods [5] and the use of volatile and/or dangerous solvents [5]. In this work we apply facile mechanosynthesis method for the synthesis of $CsPbCl_3$ doped with Yb^{3+} [6]. This method requires only simple grinding and heating to produce samples with high photoluminescence quantum yield (PLQY) of ytterbium in near infrared (NIR) region. We investigate structural and optical properties of the powders, most importantly NIR PLQY and how efficiently ytterbium is incorporated in the fabricated samples, depending on the grain size by applying steady-state and time-resolved absorption and other techniques.

After grinding and annealing of precursor materials, the prepared Yb^{3+} -doped $CsPbCl_3$ perovskite powders (with 5% of Pb^{2+} ions exchanged by Yb^{3+} ions) were sieved into 3 grain size groups: smallest <25 µm, medium 75-100 µm and largest >200 µm particles. For biggest particles of >200 µm size, we observe fastest excitonic decay which should indicate efficient energy transfer to Yb^{3+} ions (Fig. 1b). However, QY of ytterbium emission explored with relation to the particle size show that smaller particles of less than 100 µm exhibit higher NIR PLQY than the largest particles (Fig. 1b). The processes which limit the energy conversion efficiency are yet to be defined with additional structural and spectroscopic studies.

We are also exploring ways of synthesising ytterbium doped perovskite quantum dots (QDs). For now synthesis of non-doped perovskites were achieved using simple grinding method, opposed to the standard hot injection method [5]. New experiments are under way, which may help develop a methodology for easy synthesis of high NIR PLQY perovskite QDs.

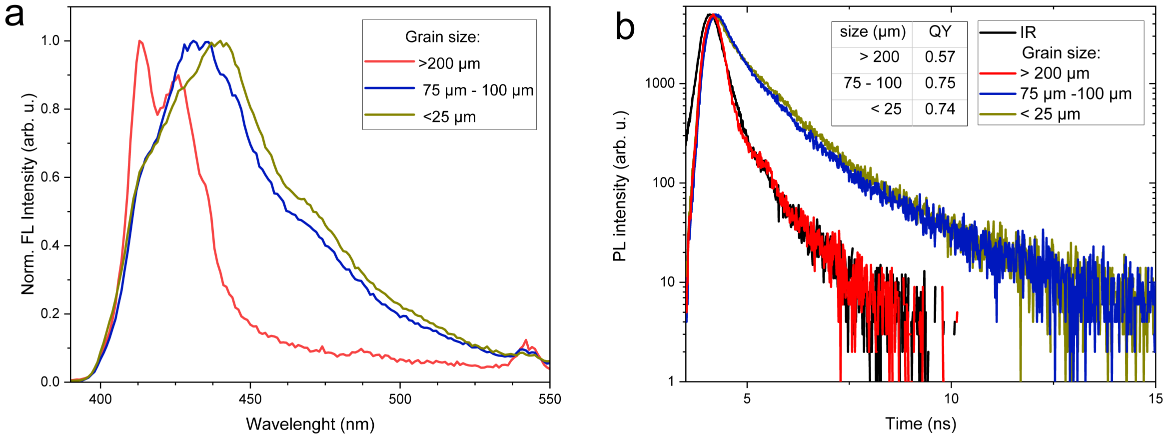

Fig. 1. Fig. 1. Fluorescence (FL) spectra (a) and kinetics at emission (b) of $CsPb_{0.925}Yb_{0.05}Cl_3$ powder depending on the grain size. Inset in (b) shows QY of the samples.

[1] Min, H., Lee, D.Y., Kim, J. et al. Nature,2021 598, 444–450
[2] Fakharuddin, A., Gangishetty, M.K., Abdi-Jalebi, M. et al. Nat Electron 5, 203–216 (2022)
[3] Xiao Luo, Tao Ding, Xue Liu et al. Nano Letters 2019 19 (1), 338-341
[4] Huang, H.; Li, R.; Jin, S. et al, ACS Appl. Mater. Interfaces 2021, 13 (29), 34561– 34571
[5] Huang, H.; Li, R.; Jin, S. et al, ACS Appl. Mater. Interfaces 2021, 13 (29), 34561– 34571
[6] Streckaitė Simona, Miklušis Lukas, Maleckait˙ e Karolina et al. Journal of Materials Chemistry (2023) C. 11. 10.1039/D3TC02631K