Time-Resolved Photoluminescence Measurement of One-Dimensional Lead Bromide Organic- Inorganic Hybrid Perovskites

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One-dimensional (1D) lead halide hybrid perovskites are attractive materials because they are expected to show high and fast optical nonlinear effects owing to the enhanced electron density of states and electron-phonon interaction. The 1D perovskites are a low dimensional class of hybrid perovskites in which octahedrons are connected in a chain and surrounded by organic cations[1]. Thus, they can be considered as the crystalline bulk assemblies of 1D quantum confined materials. In our previous report, the structural dependence of the photoluminescence spectra of 1D lead bromide perovskites with three different structures was examined, where broadband luminescence due to self-trapped excitons was observed in all the materials[2]. To understand the detailed mechanism of the photoluminescence we performed the time-resolved photoluminescence (PL) measurements of 1D lead bromide hybrid perovskite crystals with 4-ethylpyridine organic molecules. The orange curve in Fig. 1 shows the photoluminescence spectrum of the specimen at 300 K. The absorption spectrum is also presented as a blue curve, showing that the absorption edge is around 3.4 eV. The luminescence looked yellow and the spectrum was very broad with a large Stokes shift, which are characteristic for luminescence from self-trapped excitons (STE). In addition, at a temperature the same decay profiles were observed for the peak at 2.0 eV (620 nm) and 1.9, 1.8 eV, indicating that the photoluminescence of the specimen due to STE with single nature. Fig. 2 depicts the decay profiles at the peak around 2.0 eV at temperatures of 5, 100, and 200 K. As seen from the figure the experimental data were well fitted using a single-exponential function: $I(t)=I_0\exp(-t/\tau)$, where I is the phosphorescence intensity, I_0 is the constants, and τ is the decay constant. As temperature increases the decay constant decreases, which were 4.9, 3.6, and 0.8 μs, at 5, 100, and 200 K, respectively. This behavior is similar to other 1D lead halide perovskites[1].

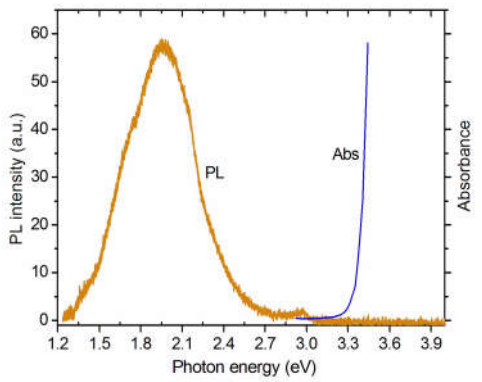

Fig. 1 Photoluminescence spectrum (orange) of a triple chain lead bromide crystal excited at 3.5 eV. Absorption spectrum is also presented as a blue curve.

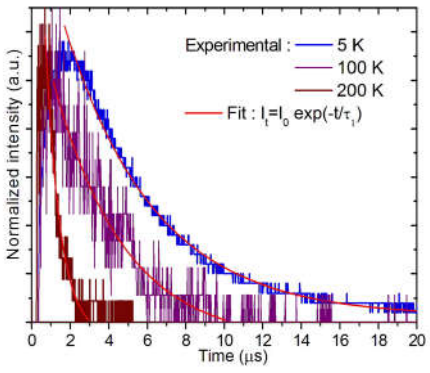

Fig. 2 Photoluminescence decay profiles around the peak at 2.0 eV (620 nm) at 5 K (blue), 100 K (purple), and 200 K (brown). The intensity was normalized.

[1] Z. Yuan et al., Nat. Comm., 8, 14051, 2017.
[2] Thi-Mai Huong Duong et al., JSAP Fall Meeting, Nagoya, Japan, 2018; MRS Fall Meeting and Exhibit, Boston, 2018.