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2017

Qian, C., Yin, T., Yan, J., & Shen, Z. X. (2017). Different carrier recombination processes in CsPbBr3 quantum dots and microcrystals. 2017 12th Conference on Lasers and Electro-Optics Pacific Rim (CLEO-PR).

https://hdl.handle.net/10356/83771

Different carrier recombination processes in $CsPbBr_3$ quantum dots and microcrystals

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Abstract— **Good understanding of carrier generation and recombination is crucial for applications in LEDs, lasers, single photon sources and so on. In this work, we studied and compared charge generation and recombination processes of $CsPbBr_3$ QDs and microcrystals (MCs) in order to obtain clearer pictures for their photoluminescence. Power dependent photoluminescence experiments show that excitation species and recombination process are quite different in $CsPbBr_3$ QDs and MCs, where the MCs contain non-radiative dark states resulting a superlinear power dependence of the PL intensity at low excitation power while the QDs materials show linear dependence. At high excitation power, trions are generated in the QDs samples.**

Keywords- ***Perovskites, Quantum dots, Photoluminescence, Carriers recombination, bound excitons, trions***

BACKGROUD AND MOTIVATION

Colloidal $CsPbBr_3$ quantum dots (QDs) have emerged as the versatile materials for the promising applications including LEDs,[1] lasing gain materials,[2] low-cost nonlinear absorbers,[3] single photon sources.[4] and so on. Nevertheless, good understanding of charge generation and recombination in $CsPbBr_3$ QDs still remains lagging.

In this work, we studied and compared charge generation and recombination process of $CsPbBr_3$ QDs and microcrystals (MCs) in order to obtain a clearer picture of differences between them. X-ray diffraction (XRD) patterns and temperature-dependent Raman scattering indicate all samples crystalized in orthorhombic phase at ambient temperature. Power dependent photoluminescence experiments show that non-radiative trap states play important roles for emission process in MCs. Besides, trions formation is easier in $CsPbBr_3$ QDs, probably because of quantum confinement effect. Our results shed light on the mechanisms of optical behaviors in $CsPbBr_3$.

HIGHLIGHTS OF THIS WORK

In $CsPbBr_3$ MCs, we observed exciton emission peak (X band) and bound exciton emission peak (B band) at 78K. Both exciton and bound exciton emission behave superlinearly at low excitation power density and linearly at higher power. Such power dependence can be explained as due to the presence of a non-radiative carrier recombination pathway via a trap state. (Fig. 1)

No trap states emission peak or bound exciton emission peak were observed in $CsPbBr_3$ QDs. Instead, we observed trion emission peak under higher excitation intensity. Exciton emission increases linearly at first and become sublinear after appearance of trion emission while the trion emission peak show superlinear dependence. (Fig. 2).

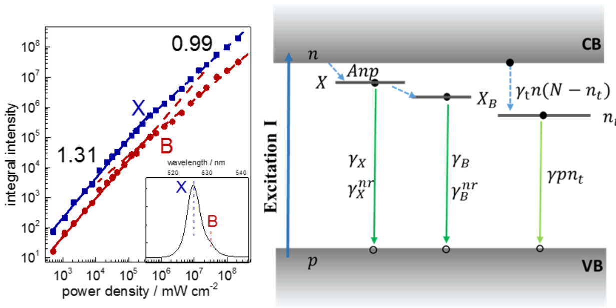

Figure 1. Photoluminescence (PL) of $CsPbBr_3$ Microcrystals (MCs). Left panel: Photoluminescence (PL) spectrum and integral PL intensity of X emission band and B emission band at different excitation intensity at 78 K. Right panel: Schematic of carrier recombination process in $CsPbBr_3$ MCs.

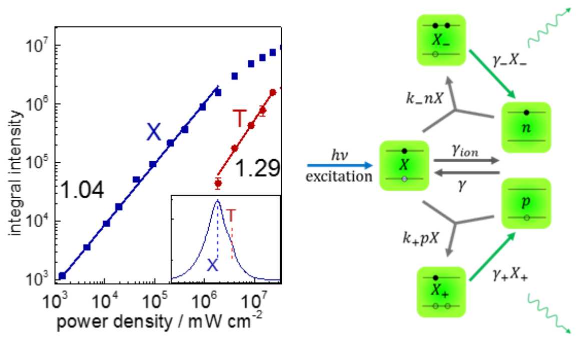

Figure 2. . Photoluminescence (PL) of $CsPbBr_3$ quantum dots (QDs). Left panel: Photoluminescence (PL) spectrum and integral PL intensity of X emission band and T emission band at different excitation intensity at 78K. Right panel: Schematic of carrier recombination process in $CsPbBr_3$ QDs.

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