Accepted Manuscript

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PII: S1001-8417(17)30422-9
DOI: https://doi.org/10.1016/j.cclet.2017.10.005
Reference: CCLET 4278

To appear in: *Chinese Chemical Letters*

Received date: 24-3-2017
Revised date: 15-9-2017
Accepted date: 11-10-2017

Communication

Carrier dynamics in $CsPbI_3$ perovskite microcrystals synthesized in solution phase

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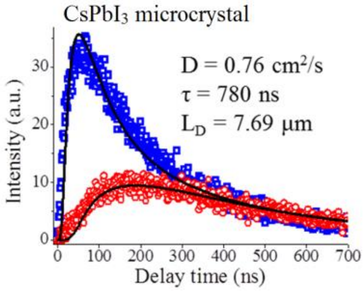
Graphical abstract



Carrier diffusion and recombination kinetics in all-inorganic $CsPbI_3$ perovskite microcrystals directly synthesized in solution phase are reported.

ARTICLE INFO

Article history:
Received 24 March 2017
Received in revised form 19 September 2017
Accepted 22 September 2017
Available online

Keywords:
Carrier dynamics
$CsPbI_3$
Solution process
Perovskite

ABSTRACT

All-inorganic cesium lead halide perovskites ($CsPbX_3$, X = Cl-, Br-, I-) could provide comparable optoelectronic properties as a promising class of materials for photovoltaic cell (PV), photodetector and light-emitting diode (LED) with enhanced thermal and moisture stabilities compared to organic-inorganic lead halide species. However, fabrication of $CsPbI_3$ perovskite *via* facile solution process has been difficult due to instability of $CsPbI_3$ in the perovskite cubic phase in ambient air. Herein, we report the synthesis of $CsPbI_3$ perovskite microcrystals by low-temperature, catalyst-free, solution-phase method. By applying the time-resolve spectroscopic technique, we determine the carrier diffusion coefficient of 0.6-1.2 $cm^{-2}s^{-1}$, the intrinsic carrier lifetimes of 200-1300 ns and diffusion length of 4-10 μm in different individual $CsPbI_3$ perovskite microcrystals. Our results suggest the $CsPbI_3$ perovskite microcrystals synthesized by solution process exhibit high quality feature and are suitable for applications in optoelectronic devices.

Organic-inorganic metal halide perovskites ($CH_3NH_3PbX_3$, X = I^-, Cl^-, Br^-) have received great attentions due to excellent optoelectronic properties such as high charge mobility, long carrier diffusion distance, direct-bandgap semiconductor, tunable bandgap, strong light harvesting ability [1]. These properties have led to their potential applications in the photovoltaic solar cells, light emitting diodes, photodetectors, and lasers [2-17]. Especially, high-efficiency perovskite solar cells have reached power conversion efficiency (PCE) over 22% in 2016 [18]. Despite the exciting progress, the organic-inorganic metal halide perovskite materials still face a huge challenge in practical applications, for that the family of organic-inorganic halide perovskite compounds are unstable, volatile, and hygroscopic in ambient air and are sensitive to the processing conditions on account of their intrinsic structural and thermal instability [19,20]. To expand the practical applications of perovskite materials, the fabrication of more stable perovskites in the atmospheric environment should be explored.

One strategy to make stable perovskites is to replace the organic cation ($CH_3NH_3^+$) with inorganic metal ions cesium (Cs^+) having similar size to organic component, forming all-inorganic cesium lead halide perovskites $CsPbX_3$ (X = Cl^-, Br^-, I^-) [21]. Compared to the