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Microcavity top-emission perovskite light-emitting diodes

Doudou Qu[1 2 † *], Da miaomiao[2], and Martin Booth[3 † *]

[1]*Department of Electronic Engineering, Tsinghua University, Beijing 100084, China*
[2]*Frontier Science Center for Quantum Information, Beijing 100084, China*
[3]*Beijing National Research Center for Information Science and Technology, Beijing 100084, China*
[*]These authors contributed equally to this work.
[†]Correspondence to: Cun-ZhengNing: cning@tsinghua.edu.cn

Abstract

Light-emitting diodes (LEDs) based on perovskites show great potential in lighting and display applications. However, although perovskite films with high photoluminescence quantum efficiencies are commonly achieved, the efficiencies of perovskite LEDs are largely limited by the low light out-coupling efficiency. Here, we show that high-efficiency perovskite LEDs with a high external quantum efficiency of 20.2% and an ultrahigh radiant exitance up to 114.9 $mWcm^{(-2)}$ can be achieved by employing the microcavity effect to enhance light extraction. The enhanced microcavity effect and light outcoupling efficiency are confirmed by the study of angle-dependent emission profiles. Our results show that both the optical and electrical properties of the device need to be optimized to achieve high-performance perovskite LEDs.
Keywords: Algebra, geometry and analysis.

Metal halide perovskites are becoming promising candidates for planar light-emitting diode (LED) applications due to their unique optoelectronic properties such as high photoluminescence quantum efficiency (PLQE) and good color purity. During just 5 years, the external quantum efficiencies (EQEs) of perovskite lightemitting diodes (PeLEDs) have been enhanced from below 1% to over 20%. Many efforts have been made to develop high-efficiency PeLEDs with good stability, e.g., by employing multiple-quantum-well (MQW)-based perovskites. However, although perovskite films with high PLQEs are commonly achieved, the efficiencies of PeLEDs are largely limited by the low light out-coupling efficiency. Here, we demonstrate highefficiency perovskite LEDs by employing the microcavity effect to enhance light extraction. The enhancement of the light out-coupling efficiency is confirmed by comprehensive studies of angle-dependent emission profiles. Moreover, our results show that both the optical and electrical properties of the device need to be optimized to achieve high-performance PeLEDs.

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Methods

Synthesis and material preparation

Colloidal ZnO nanocrystals were synthesized by a solution-precipitation process2 . The perovskite precursor solution was prepared from N-methylacridinium iodide (NMAI), formamidinium iodide, and PbI2 with different molar ratios (from 2:1.9:2 to 1.3:1.9:2) in dimethylformamide (9 wt%) and stirred overnight at room temperature in a nitrogen-filled glove box. The NMAI was synthesized similar to the previously reported method3 .

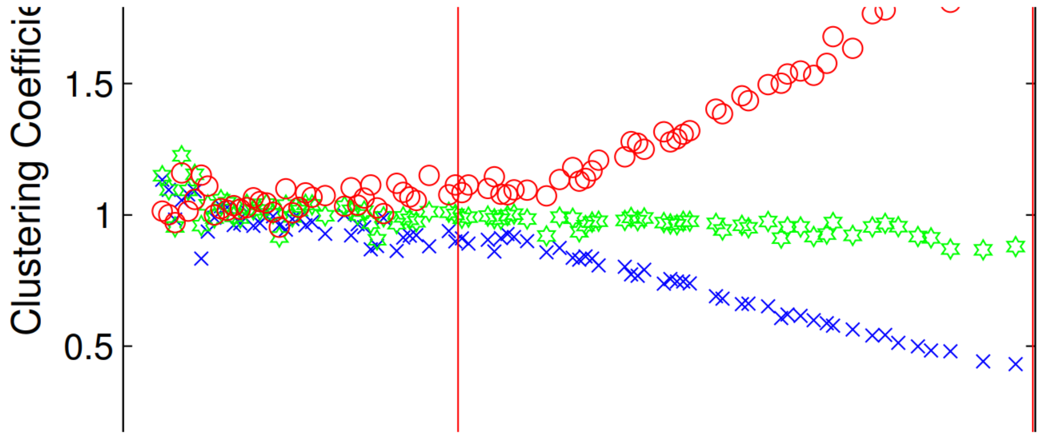

Fig. 1. Again with some vertical margin and thicker frame

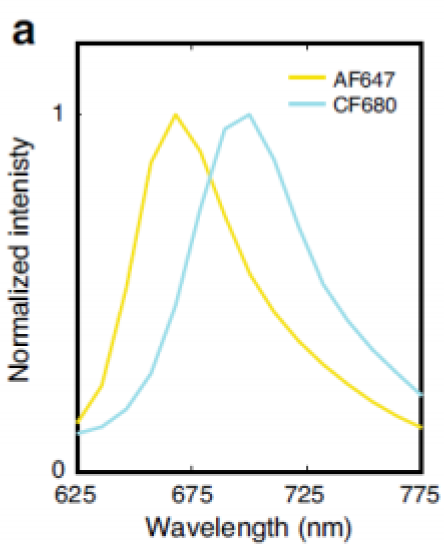

Fig. 2. The overview of delivery system.

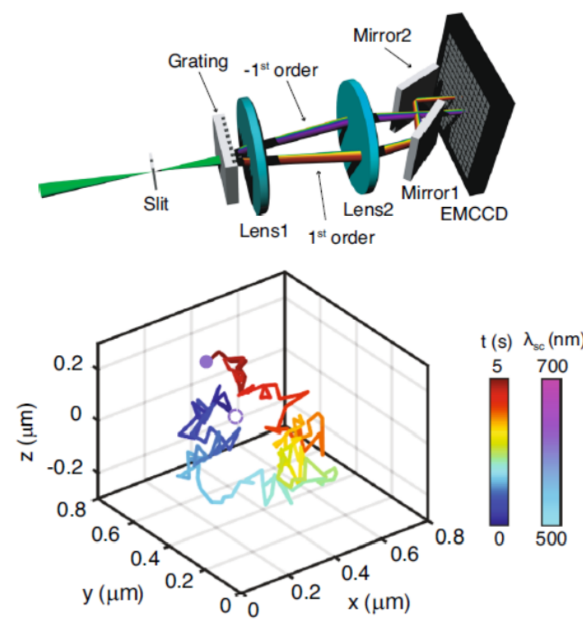

Fig. 3. The overview of delivery system.

Calculations

Resonant wavelength of the microcavity

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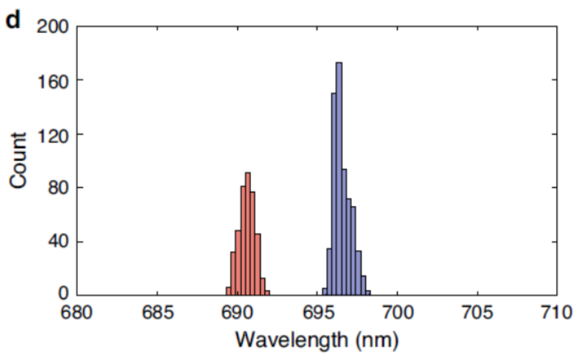

Fig. 4. The overview of delivery system.

Table 1: this is a table

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Emission intensity with changing emitter position

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Acknowledgement

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Conflict of interest

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Contributions

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