Optically pumped lasing from single-crystal perovskite of $CH_3NH_3PbBr_3$

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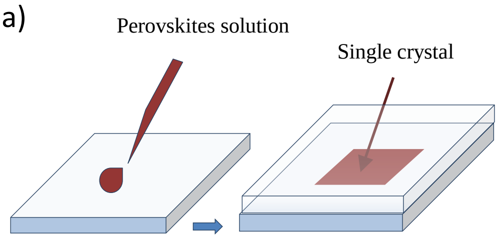
Along with outstanding photovoltaic performances, organometallic halide perovskites represent one of the most promising candidates for low-cost, efficient light emitting and lasing materials [1,2]. An advantage of perovskites for those applications is their tunability of emission colors by varying the halide composition [3]. Their low-temperature solution processability allows the growth of crystalline perovskites with excellent semiconducting and optical properties. In particular, high-quality single-crystal perovskites are required for effective light confinement and cavity formation for the laser application.

In this study, we introduce a new method, namely "cast-capping", to fabricate large size single-crystal perovskites of $CH_3NH_3PbBr_3$. There are only two simple steps as shown in Fig. 1a: casting a perovskite solution on a distributed Bragg reflector (DBR) substrate, then capping with another DBR substrate at ambient condition. Due to slow crystal growth, large size, high quality single crystals are successfully obtained between these substrates as shown in Fig. 1b. Our fabrication method is simple, low cost, but shows high quality and extremely large size compared to previous methods such as spin coating and vapor deposition. To investigate their lasing properties, we measured both edge and surface emissions from the sample at room temperature under optical pumping with a fs-pulsed laser (λ = 397 nm, 200 fs duration, 1 kHz).

Multimode lasing oscillations were observed in the edge emission from the DBR/$CH_3NH_3PbBr_3$/DBR cavity at λ= 553-563 nm when the excitation fluence is above a threshold of 11.9 $\mu J/cm^2$. This lasing is attributed to Fabry-Pérot resonation at the side facets of the single crystal. On the other hand, surface-emitting spectra taken through the DBR substrate indicated an amplified emission peak at λ= 540-590 nm above a threshold fluence of 24.6 $\mu J/cm^2$. The wavelength and intensity of this surface lasing varied depending on the excitation position of the crystal due to irregular crystal cavity thickness.

[1] Z. K. Tan et al., Nature Nanotech. **9**, 687 (2014).
[2] Q. Zhang et al., Nano Lett. **14**, 5955 (2014).
[3] G. Xing et al., Nature Mater. **13**, 476 (2014).

a)



b)

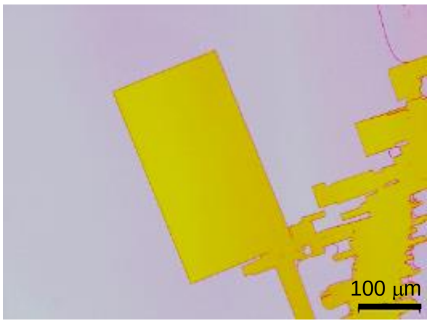


Figure 1. a) Schematic of cast-capping method. b) Optical micrograph of $CH_3NH_3PbBr_3$ crystal grown between DBR substrates.