Ligand Engineering and Self-Assemble Recrystallization of Perovskite Nanocrystals for High-Quality Patterning and Single-Mode Lasing

School of Engineering, The University of Tokyo¹,

International Graduate Program of Molecular Science and Technology (NTU-MST) National Taiwan University²,

Department of Materials Science and Engineering National Taiwan University³,

Center of Atomic Initiative for New Materials (AI-MAT) National Taiwan University⁴,

Department of Chemistry National Taiwan Normal University⁵,

Di Xing¹, Cheng-Chieh Lin^{2,3}, Ya-Lun Ho¹, A. Syazwan A. Kamal¹, I-Ta Wang^{2,3}, Chia-Chun Chen⁵,

Cheng-Yen Wen^{2,3,4}, Chun-Wei Chen^{2,3,4}, Jean-Jacques Delaunay¹

E-mail: jean@mech.t.u-tokyo.ac.jp

Lead halide perovskites exhibiting extraordinary performances in optoelectronics are promising media for the next-generation photonic devices. The practical application of photonic devices requires that they can be integrated on chip in arbitrary shape and position. However, a significant bottleneck in perovskite lasers is their chemical reactivity, which leads to instability issues and currently prevents manufacturing by well-established semiconductor top-down lithography process resulting in high-roughness, low-defect, and high-quality perovskite devices. Here, a top-down and etching-free fabrication technique assisted by ligand engineering and self-assemble recrystallization of CsPbBr₃ nanocrystals is demonstrated for large-area patterning and single-mode laser arrays. The ligand engineering and self-assemble recrystallization process greatly improve the lasing property (single mode lasing with a high quality-factor ~ 1700 and a low threshold ~ 3.8 μ J/cm²) of the laser arrays. With the precise control of the high-quality laser cavity scale, a modulation of wavelengths is realized up to \approx 8 nm. These results report a strategy for top-down fabricated high-quality perovskite devices on-chip and enable research on the development of large-area and low scattering loss perovskite integrated optical circuits.

