Lead Halide Perovskite Micro-arrays Fabricated by Reusable Metal Mesh Templates

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Halide perovskites have attracted tremendous interest due to their superior optoelectronic properties, including high absorption coefficients, tunable bandgap, high color purity, and long-ranged balanced electron and hole transport, which makes perovskite materials promising for diverse optoelectronic applications.[1-2] However, high-resolution patterning of perovskite arrays is challenging owing to their extreme instability in general photolithography solvents. In this work, a novel patterning process for perovskite arrays is performed, where the high-resolution, large-scale metal mesh template film is adopted to pattern perovskite arrays through drop casting. This approach is based on photolithography to manufacture a reusable metal mesh template, and the metal mask film can be easily attached to the arbitrary substrate as a mask with the assistance of capillary force and be detached after the coating. Using this approach, we successfully fabricated highly crystalline perovskite micro-disk arrays. The morphological characterization illustrates the excellent fidelity of the perovskite micro-disks to the metal mesh template. The crystallinity and optical properties of the patterned perovskite arrays are characterized by transmission electron microscopy (TEM) and photoluminescence (PL) tests. This method enables the patterning of perovskite micro-arrays on versatile substrates with reusable metal mesh templates and can be further applied to other materials to facilitate the development of micro-structured optoelectronic devices.

Figure 1 schematically demonstrates the fabrication of a perovskite array through this method. A metal mesh pattern is first created in the photoresist on a conductive ITO glass substrate by photolithography. Next, the photoresist is used as an electrodeposition mask for the deposition of metal. After the photoresist is gently dissolved in solvent, the 4-um thick metal mesh is left on the surface of the ITO glass and mechanically separated from the substrate. A toluene droplet was dripped on the target substrate, and the metal mesh film was placed on the toluene. After the evaporation of toluene under the heating of 80 ℃, the metal mesh is tightly attached to the substrate by capillary force. Finally, a solution of CsBr and PbBr2 in Dimethyl sulfoxide (DMSO), which serves as the first-step precursor, was dripped on the prepared substrate. After complete wetting, the precursor solution filled the micro-arrays defined by the metal mesh template. Crystalline perovskite micro-disks were obtained after baking at 100 °C for 30 min, and the reusable metal mesh template was mechanically peeled off. **Figure 2(a)** and **(b)** display the morphological characterization of the photoresist pattern on ITO glass and the electroplated metal mesh, respectively. **Figure 2(c)** shows the perovskite array on a piece of glass after peeling off the metal mesh film.

References

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[2] Wu, C. Y., Wang, Z., Liang, L., Gui, T., Zhong, W., Du, R. C., Luo L. B. *Small*, **2019**, 15, 1900730.

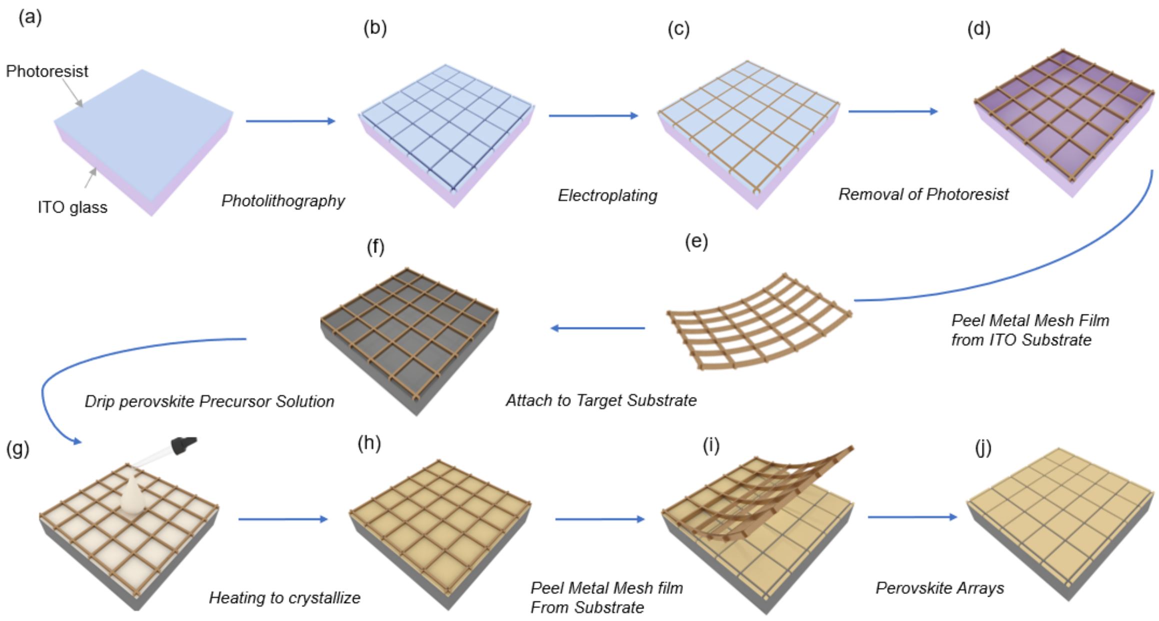

Figure 1. Schematic illustration of the perovskite micro-array fabrication process.

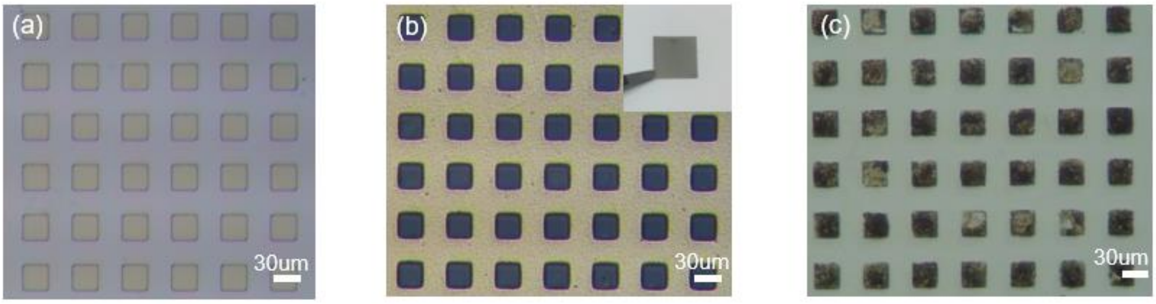

Figure 2. (a) Optical microscope image of mesh patterns formed in the photoresist layer on the ITO glass by lithography. **(b)** Electrodeposition of metal inside the resist trench to form a uniform metal mesh (inset is the photograph of a free-standing metal mesh film). **(c)** Microscope image of perovskite arrays after peeling off the metal mesh film.