**Microcontact printing-based patterning techniques for OLED displays and other microelectronic devices**

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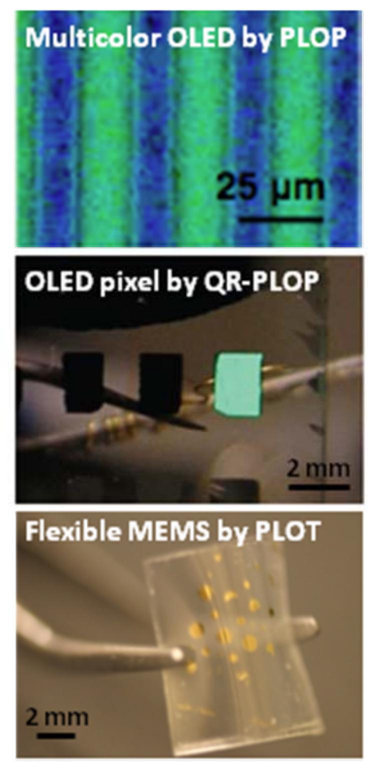
Displays based on OLED technology promise increased efficiency, contrast ratio, and response time; however, integration of these organic materials to produce large area displays presents challenges, as presently used commercial patterning techniques are limited in resolution and scalability. Microcontact printing-based methods have been proposed as a potential patterning solution for OLED materials, since these techniques offer high resolution and adaptability to roll-to-roll or wave printing processes over large areas. Additionally, heat- and pressure-free patterning routes remain desirable for these materials. Here, we present several complementary ambient temperature patterning techniques for the OLED materials set based on microcontact printing with an elastomeric poly(dimethylsiloxane) (PDMS) stamp. These methods include PDMS Lift-Off Patterning (PLOP) for organic small molecule films, Quick Release PLOP (QR-PLOP) for subtractive patterning of metal thin films, and PDMS Lift-Off Transfer (PLOT) for the transfer of thicker metal films. All three techniques are fully compatible with large area and flexible applications.




The PLOP process has the ability to simultaneously pattern an organic small molecule film in both lateral and vertical dimensions [1]. Patterning is achieved by placing a PDMS stamp in contact with an organic small molecule film such as Alq3 (aluminum tris(8-hydroxyquinoline)) or TPD (N,N'-diphenyl-N,N'-bis(3-methylphenyl)-(1,1'-biphenyl)-4,4'-diamine), then gently removing the stamp from the surface to remove an adhered film. Concurrent lateral patterning can be achieved by a stamp with a relief surface, formed by, e.g., molding against a silicon master. Multicolored OLEDs, with pixels defined using a single PLOP patterning step, are used to demonstrate the capabilities of the technique.

The QR-PLOP technique allows subtractive patterning of thin metal films [2]. Past attempts at metal film patterning by contact printing have required elevated pressure and/or temperature [3, 4]. Here, we require no applied pressure or elevated temperature; an elastomeric stamp is applied to the metal film and then rapidly removed, enhancing the adhesion between the patterned stamp surface and the metal enough to cause fracture along the features in thin metal films (~10 nm thick). To demonstrate this technique, we have applied QR-PLOP to pattern the top Mg:Ag electrode for an OLED pixel.

A final technique, PLOT, combines the kinetically enhanced adhesion of QR-PLOP with an organic release layer to transfer a thick (~100 nm) metal film to suspend a membrane over a predefined supports. This process allows the fabrication of microelectromechanical systems (MEMS) without requiring solvent or aggressive plasma etches to release mechanical structures. This technology has the potential to be easily integrated with the other patterning processes discussed here, leading to the integration of active elements in displays and other applications.

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[3] C. Kim, M. Shtein, S. R. Forrest, *Appl. Phys. Lett.* **2002**, *80*, 4051.
[4] Z. Wang, J. F. Yuan, J. Zhang, R. B. Xing, D. H. Yan, Y. C. Han, *Adv. Mater.* **2003**, *15*, 1009.