Fabrication of Organic Light Emitting Diode Arrays by Reversal Imprint Lithography

B. L. Cardozo and S. W. Pang
Department of Electrical Engineering and Computer Science
The University of Michigan, Ann Arbor, Michigan 48109-2122

Organic light emitting diodes (OLEDs) offer tremendous potential in optoelectronic applications such as high brightness, low power displays. Several techniques have been developed for the fabrication of OLED devices, including ink jet printing, spin casting with laser ablation, physical vapor deposition, and screen printing. These techniques, however, offer relatively low resolution, are relatively slow serial processes, or require significant chemical processing of the active polymer layers, resulting in damage and reduced efficiency. We have developed a new technique, based on reversal imprint lithography, which offers the advantages of low cost parallel processing, high resolution, and minimal polymer processing. The technique also simplifies the device processing, as multiple metal and polymer layers can be transferred in a single imprint. We have demonstrated the patterning of polymer and metal features down to 100 nm using reversal imprint, giving this technique the potential to rapidly produce extremely high resolution OLED arrays at low cost.

The devices consist of an Al cathode, a poly[9,9-dioctylfluorenyl-2,7-diyl)-co-1,4-benzo-{2,1'-3}-thiadiazole fluorine copolymer light emitting polymer (LEP) layer, a poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) hole conducting layer, and an indium tin oxide (ITO) anode. The polymer layers are patterned by reversal imprint lithography, as shown in Fig. 1. In this process, a mold, consisting of Si or SU-8 features defined by optical lithography on a Si substrate, is coated with a 500 nm thick Al layer. The polymers to be deposited are spin coated onto a polydimethylsiloxane (PDMS) pad and brought into direct contact with the mold at a pressure of 3 MPa and temperature of 70 °C. Upon removal of the mold from the polymer coated PDMS pad, the polymers are transferred from the pad to the mold and the polymer layers coat the plateaus of the SU-8 or Si features, as shown in Figs. 2 and 3. Finally the metal and polymer stack is transferred from the mold onto an ITO coated glass substrate, resulting in arrays of OLED devices. The diode characteristics for one such device is shown in Fig. 4. Using this technique, we can pattern OLED arrays with minimum features sizes ranging from 100 nm to millimeter dimensions. We will show that the quality of the pattern transfer of the OLED stack and the performance of the OLEDs can be optimized by controlling the step height, sidewall profile, surface treatment, mold coating method, layer thicknesses, and thermal treatments.

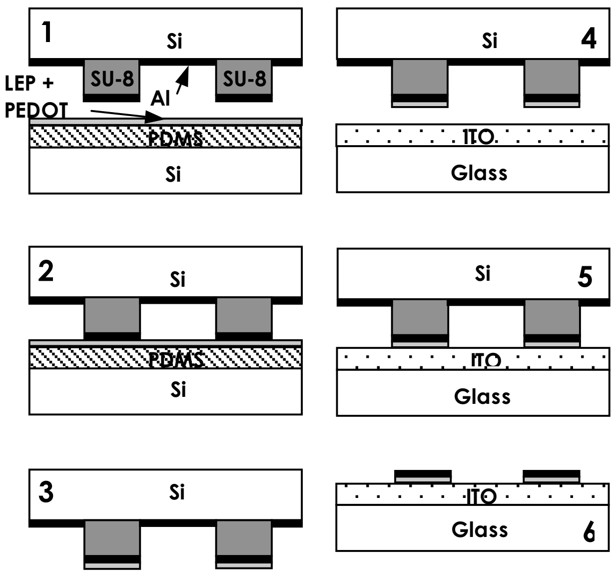

Figure 1: Schematic reversal imprint lithography process for fabrication of OLED arrays. A mold of SU-8 with Au/Al on Si is inked with the active polymer layers of the device which are then imprinted onto an ITO substrate.

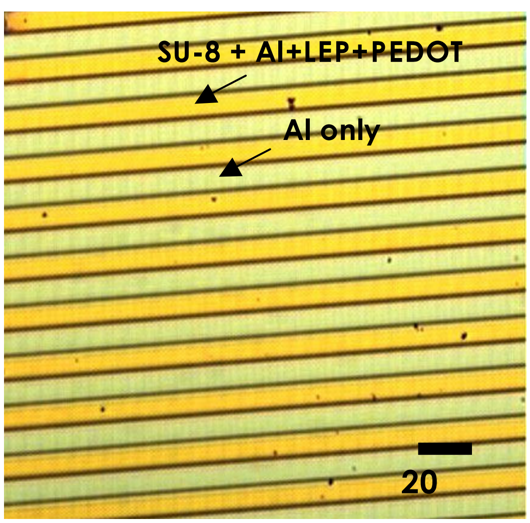

Figure 2: Optical micrograph of 10 µm wide, 1 µm deep SU-8 features after Al deposition and LEP/PEDOT inking (corresponds to part 3 of Figure 1).

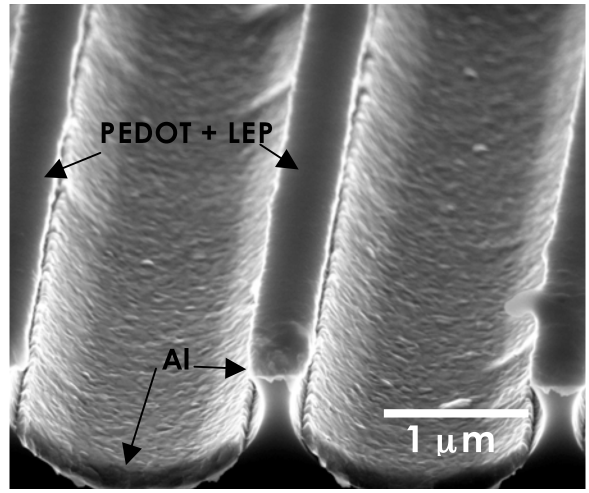

Figure 3: Cross section of Si mold with ~400 nm wide features after Al evaporation (visible in the lower sections but obscured on the raised features) and inking with LEP and PEDOT (visible on top of raised features).

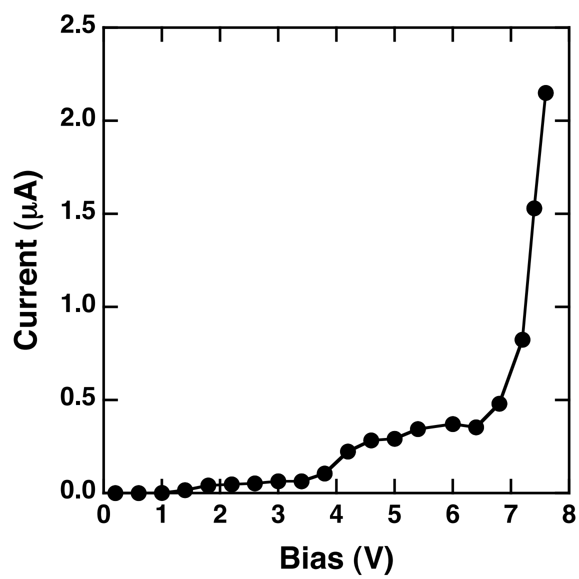

Figure 4: Diode characteristic of an OLED formed by reversal imprint lithography.