Substrate patterning by NanoImprint for efficiency enhancement of organic light-emitting devices

N. Chaix, S. Landis, L. André, A. Mary, S. Boutami,
Y. Désières, H. Doyeux and R. Espiau de Lemaestre
CEA/LETI - Minatec, 17 rue des Martyrs
F-38054 Grenoble Cedex 9, France

The development of commercially available organic light-emitting diodes (OLEDs) places continuing demands to find ways to increase the efficiency of these devices. The internal efficiency of OLEDs has approached unit efficiency so that improvements to the optical out-coupling efficiency of these structures are becoming increasingly important.

The standard configuration of an OLED consists of an organic emissive material bounded on one side by a thick metallic cathode and on the other by a metallic or transparent anode. The decay of excitons within the emissive organic layer may result in power lost to non-radiative modes, including surface plasmon-polariton (SPP) modes associated with the dielectric-metal interfaces. Therefore, device efficiency can be significantly improved by incorporating periodic nanostructures to couple SPP modes to usefull far-field radiation.

In this paper we will address the whole process flow to manufacture nanostructured light emitting devices with NIL approach. Figure 1 shows Atomic Force Microscopy characterization and corresponding cross section profile of 250 nm dense line patterned substrates used for this study with then OLED coated over the reflowed topography. Figure 2 shows the good agreements between the experimental and simulated spectral and angular electro optical characterizations. First results show that up to 20% improvement, regarding light extraction was achieved with such patterned substrates. With 1mA/cm² current structured OLED emitted 17Cd/m² whereas a flat device emitted only 14Cd/m².

In this paper will present how NIL lithography coupled with reflow processes may be used to improve the OLED efficiency. Figure 3 shows SEM pictures of a wide range of periods and feature shapes used. Line, dot and trenches were manufactured with feature size as small as 50 nm. We will present results of dispersion curves measurements of electroluminescence from such diodes, which quantitatively compares to numerical simulations.

This work was partially supported by the EC-FP7 ‘NaPANIL’ project and the French National Research Agency (ANR) through Carnot funding.

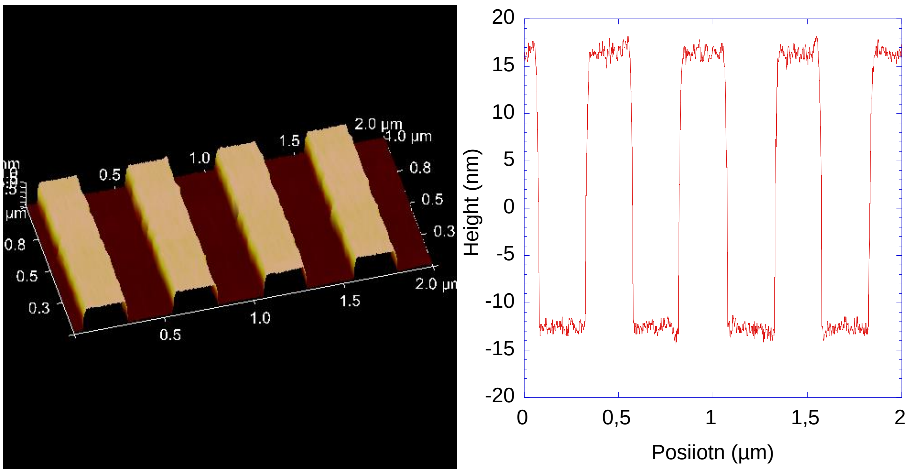

Figure 1: Atomic Force Microscopy and corresponding profile cross sections of 250 nm dense line array imprinted in thermoplastic resist

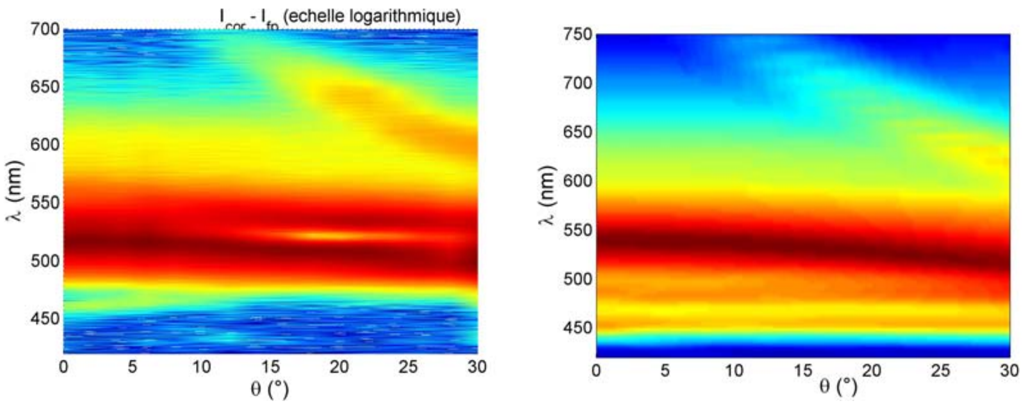

Figure 2: Spectral and angular electro optical characterization of patterned substrate (250 nm dense line array) covered with OLED material (left) and simulation (right)

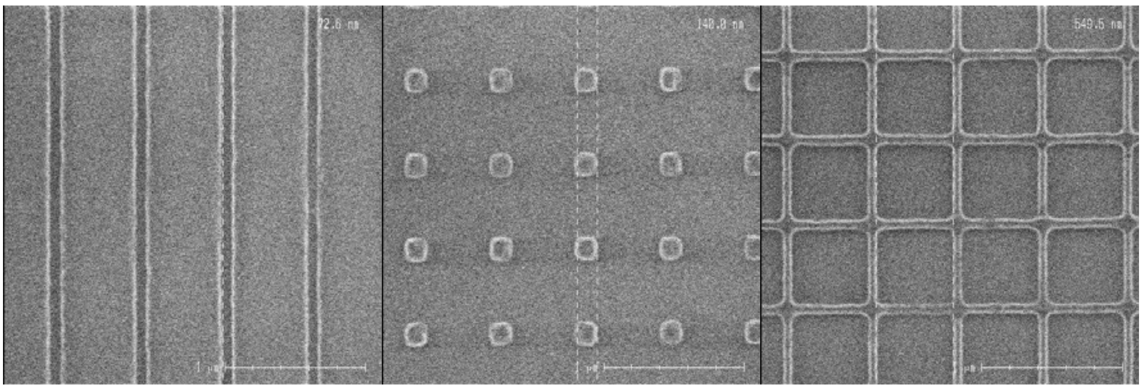

Figure 3: SEM pictures of patterned substrate with line array (left picture), dot arrays (middle picture) and trenches grid array (right picture) used to reinforce light extraction