High-Resolution Non-Destructive Patterning of Isolated Organic Semiconductors

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Patterning organic semiconductors is an important issue for organic electronic applications, for example, organic thin-film transistors (OTFTs) and organic light-emitting diodes (OLEDs). To achieve this goal, many techniques have been employed, such as photolithography, inkjet printing, screen printing, and nanoimprint lithography (NIL). However, these techniques have their own limitations. Patterning organic semiconductors by photolithography degrades the device performances[1]. Inkjet printing and screen printing are limited by their patterning resolution[2]. NIL can provide high-resolution patterns but removing residue layer by reactive ion etching (RIE) damages organic semiconductors. Hence, the current patterning techniques need to address how to avoid damaging organic semiconductors and achieve high-resolution patterns.

A nondestructive patterning method for organic semiconductors by nanoimprint is investigated in this work. There are two advantages of this proposed method. First, it is nondestructive to organic semiconductors during the patterning process. Second, by using NIL, this approach is capable of fabricating nanoscale structures. The process is schematically illustrated in Figure 1. A 210 nm thick Teflon AF was deposited on a silicon dioxide substrate as a NIL resist and patterned by applying a thermal NIL with a mold (350 nm wide line pattern with 350nm depth) to generate a TEFLON AF grating template. After fabricating the TEFLON AF template, oxygen RIE was used to remove the TEFLON AF residue layer to make the grating isolated. Since the oxygen RIE process converts the TEFLON AF surface from hydrophobic property into hydrophilic property, a thermal treatment at 170^{o}C was applied to resume its hydrophobic state. After spin-coating P3HT solution, P3HT can be deposited in the trench area of the TEFLON AF template because of hydrophilic nature of exposed silicon oxide. The grating pattern was then immersed in the FC-40 solvent to dissolve TEFLON AF. Since the FC-40 is a fluorinated solvent, it doesn't damage organic semiconductors[3]. After dissolving TEFLON AF template, isolated sub-micron P3HT structures were achieved. Figure 2(a) shows the TEFLON AF template and the patterned P3HT with two TEFLON AF strips peeled off. Figure 2(b) shows the P3HT pattern after removing the TEFLON AF template. P3HT square patterns were also demonstrated in fluorescent images. Figure 3(a) is the P3HT square pattern before TEFLON AF template removal and figure 3(b) is the P3HT pattern after dissolving TEFLON AF template. The isolated organic semiconductor patterns can be used to fabricate high-resolution OLED or high-performance OTFT arrays for advanced organic integrated systems.

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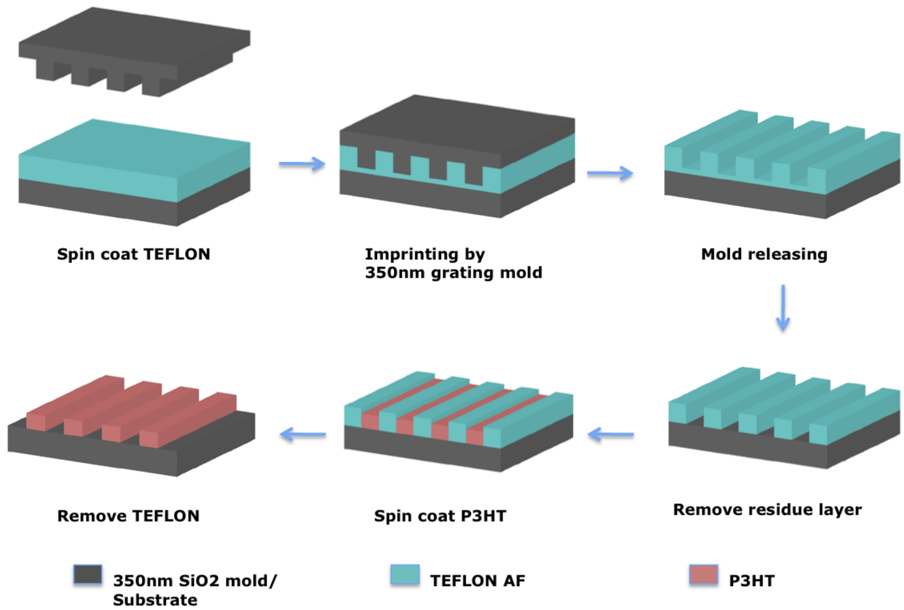

Figure 1. Schematics of the patterning process.

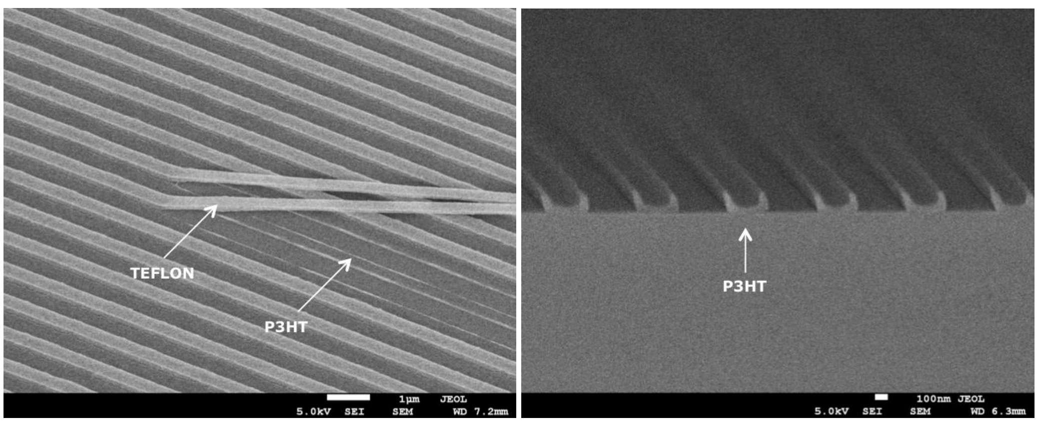

Figure 2. (a) left: TEFLON AF template and patterned P3HT; (b) right: P3HT pattern after removing TEFLON AF.

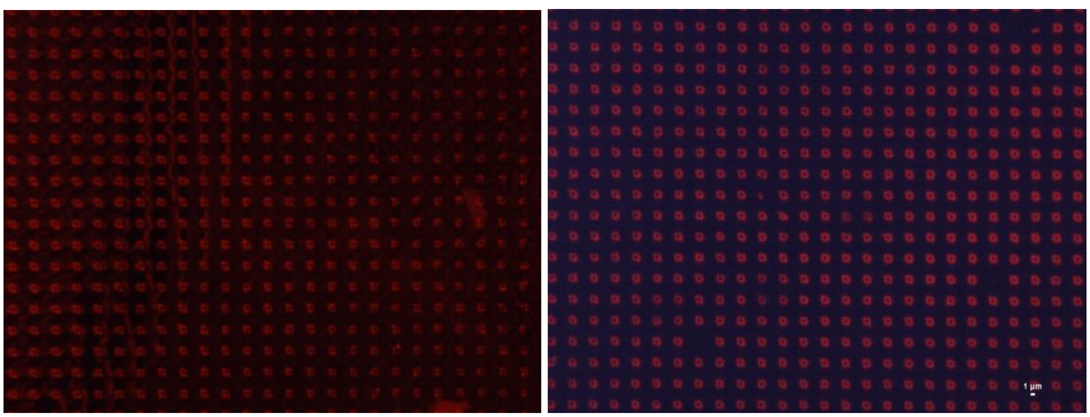

Figure 3. Fluorescent images of P3HT square patterns: (a) left: before dissolving TEFLON AF template; (b) right: after dissolving TEFLON AF template.