Supporting Information

Large-Area Nanopatterning Based on Field Alignment by Microscale Metal Mask for Etching Process

Jihye Lee[a,b], Jun-Young Lee[a,b] and Jong-Souk Yeo[a,b,*]

a School of Integrated Technology, Yonsei University, Incheon, 406-840, Rep. of Korea,

b Yonsei Institute of Convergence Technology, Yonsei University, Incheon, 406-840, Rep. of Korea

* Correspondence: jongsoukyeo@yonsei.ac.kr

Supporting Information 1

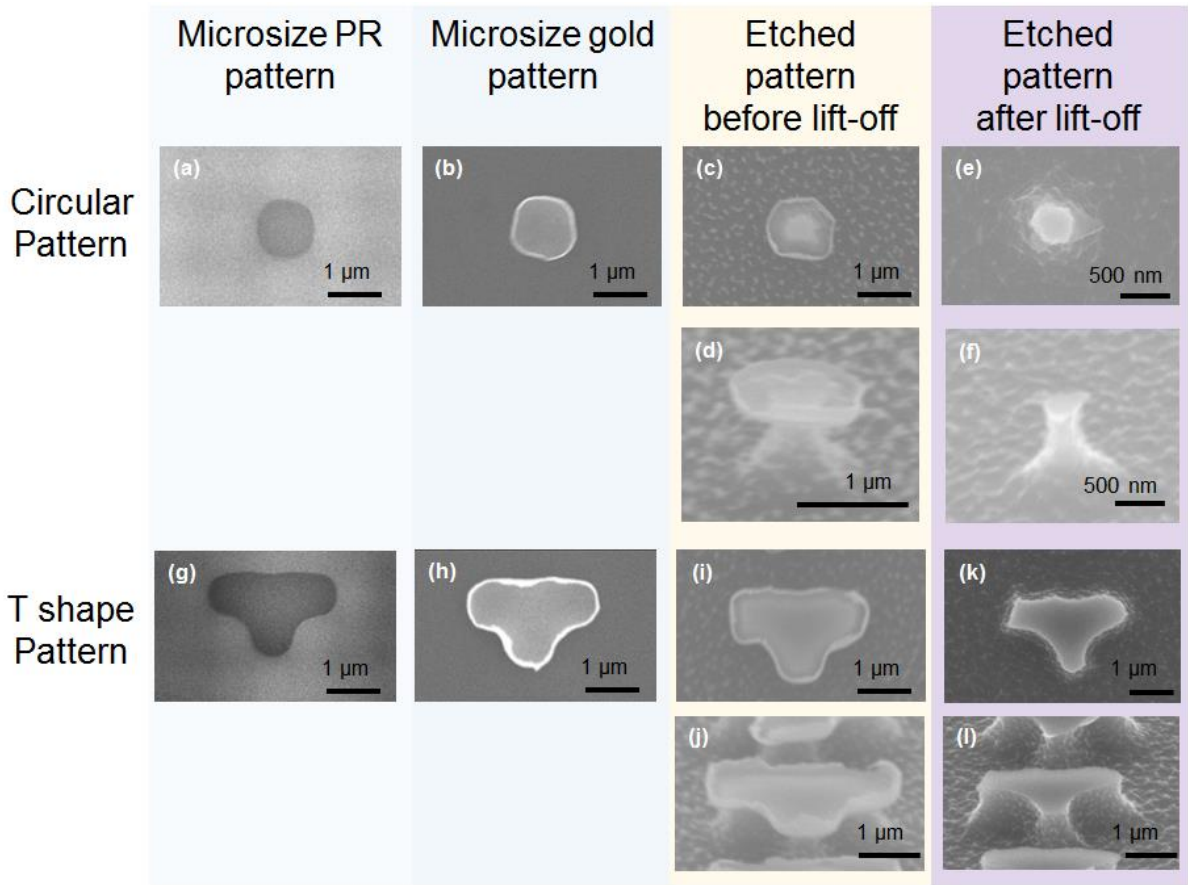

Figure S1 Fabrication of various shapes and size of nanostructures. Scanning electron microscope images of the circular and T shape patterns at each process step are shown as they follow the FAME process. (a), (g) microsize photoresist (PR) pattern, (b), (h) microsize gold pattern after deposition of gold, (c), (d), (i), (j) etched pattern before lift-off of gold mask layer, and (e), (f), (k), (l) etched pattern after lift-off of gold mask layer. The 60 degree tilted images in (d), (f), (j), (i) are provided in order to visualize the depth and shape of the sidewall profile after etching process.

In our experiment, we have tried different shapes and sizes of nanostructures such as circular and T shape patterns to support the versatility of our etching process and its potential applications. The circular pattern originally has 1 μm size with 3 μm pitch. The T shape pattern originally has 0.62 and 3 μm length simultaneously. The SEM images from photoresist pattern to etched pattern are shown in Figure S1. The images of the circular pattern indicate a size-reduction from 1 mm (microsize PR pattern, microsize gold pattern, and etched pattern before lift-off of the gold mask) to 380 nm (etched pattern after lift-off of the gold mask). For the T shape pattern, the long 3 μm pattern was reduced to 2.43 μm. These experiments also show the possibility of fabricating size-reduced circulars and other patterns by using a Field Alignment by Metal Mask for Etching (FAME) process.

Supporting Information 2

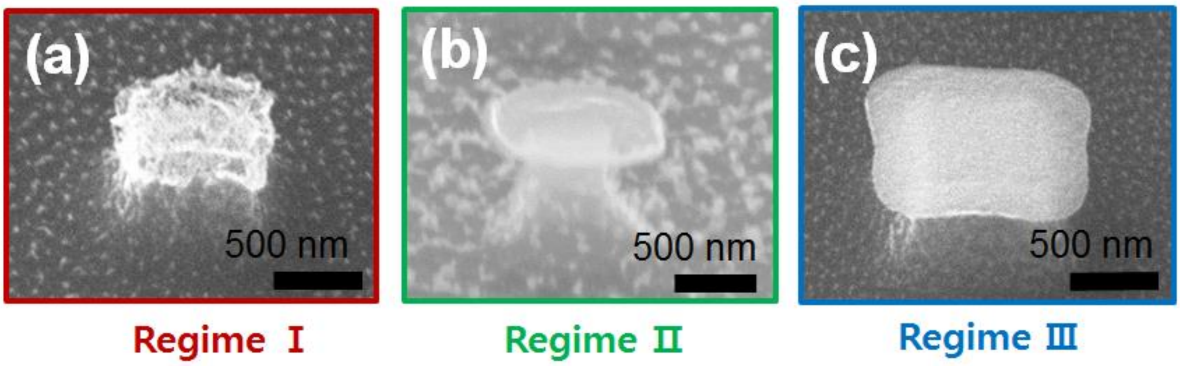

Figure S2 Cross-sectional scanning electron microscope (SEM) images of the gold mask layer after RIE process in order to show changes in the metal mask after etching process. (a) Regime I (gold mask thickness: 5 nm), (b) Regime II (gold mask thickness: 100 nm), and (c) Regime III (gold mask thickness: 150 nm).

During reactive ion etching (RIE), the sharp edge of the metal mask structure shows changes after etching process due to the damage of the gold mask layer. The cross-sectional SEM images shown in Figure S2 represent the edge roughness depending on the gold mask thickness. As shown in Figure S2 (a), the 5 nm thick gold mask is almost damaged since the thin gold layer is weak to endure the reactive etching gas. Hence, the mask in Regime I is not able to provide a control in etching a nanostructure. In Regime II shown in Figure S2 (b), the 100 nm thick gold layer leads to a smooth edge with a flare but a size-reduction is achieved with the field-enhanced bowing effect from a gold mask. The range of thickness in Regime II enables the fabrication of a nanostructure with controlled etching process as presented in Figure 3 of the Manuscript. In Regime III shown in Figure S2 (c), the 150 nm thick gold layer also shows a smooth edge but the ions affected by the field-enhanced bowing are now directed toward the edge of the thick mask, thus leading to a change in the shape of the mask.

Supporting Information 3

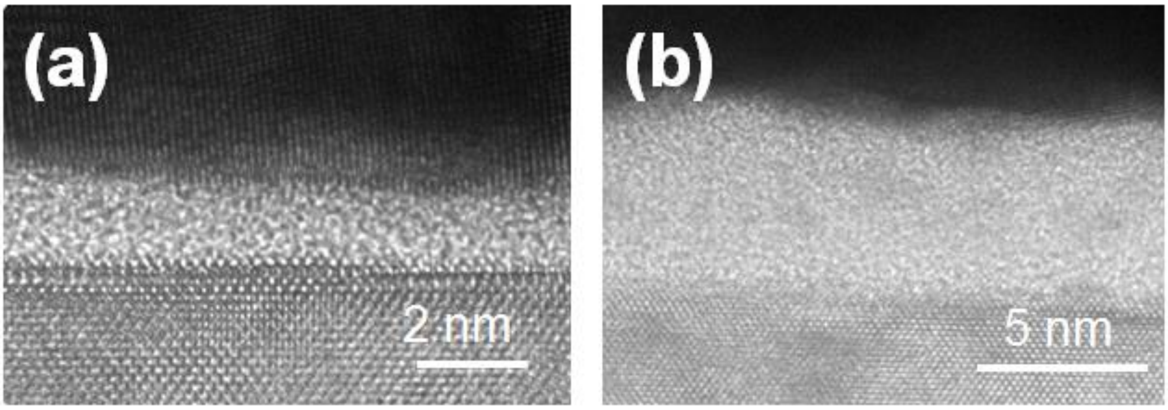

Figure S3. High-resolution transmission electron microscope (HRTEM) images of (a) a single FOTS layer on size-reduced silicon mold, (b) a few layer of FOTS on size-reduced silicon mold. This thick layer could be formed after several use of the silicon mold for transfer printing.

Traditionally, the anti-stick layer on silicon master could be formed by self-assembled layer (SAM) which has a 1-2 nm thickness shown in HRTEM Figure S3 (a). However, when the silicon mold is used repeatedly, the residue of the SAM polymer is not completely removed even with the several cleaning processes, thus 5-10 nm thick residual layer is shown in Figure S3 (b).