Fabrication of super-lyophobic surface on thermoplastic substrates with hybrid micro/nano-scale overhang structures

H. Feng, W. Shu, J. Pang, B. Zhang, X. Chen and Y. Chen
Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, China, 518005
yan.chen@siat.ac.cn

Super-lyophobic surfaces, which are simultaneously surperhydrophobic and superoleobic, exhibit excellent nonwetting performance for almost any liquid[1]. These surfaces have huge potentials in a variety of self-cleaning surface applications such as lens, displays, anti-fog glass, and electronic equipments, etc. Many of the studies of super-lyophobic surfaces are based on optically non-transparent substrates. In particular, super-lyophobic surfaces with high optical transmission in visible wavelengths are of great interests in the self-cleaning applications of optical components. Here we propose a simple, versatile, and low-cost approach to create super-lyophobic surfaces with hybrid micro/nano-scale overhang structures on highly transparent thermoplastic substrates such as COC or COP.

It has been reported that a combination of hybrid micro-scale and nano-scale overhang structures can facilitate the formation of super-lyophobic surfaces[2]. Such combination exhibits great super-lyophobic effect, due to the fact that liquid droplets touch on the apex of the nano-scale structure, and air pockets can be filled in both the void of micro and nano-scale structures, resulting in low contact area of droplets, high contact angle, and low adhesive force.

The fabrication procedure of the master mold with hybrid micro/nano-scale overhang structures is illustrated in Figure 1. Standard photolithography, metal deposition and lift-off process were used to pattern an array of Cr disks on top of Si substrate. ICP etching followed by wet etch was used to form the micro overhang pillar structures. After that, we perform nanoimprint process on the micro-pillar structure using a double layer resist method. Since two resist layers have different etching resistivity, with carefully selected anisotropic etching parameters, nano-scale mushroom shaped posts can be formed on the Si substrate. Figure 2 shows a SEM image of the nano-scale mushroom structure after nanoimprint lithography. As the master mold of micro/nano-scale overhang structures is fabricated, a rigid polymer stamp was used to replicate the master mold and then worked as the hot embossing mold to duplicate the structure onto the thermoplastic substrates. Various surface tests were conducted on the embossed thermoplastics, showing excellent nonwetting performances.

[Reference]
1. A. Tuteja, W. Choi, J. M. Mabry, G. H. McKinley and R. E. Cohen, Proc. Natl. Acad. Sci. U. S. A., 2008, 105, 18200-18205.
2. L. Yuan, T. Wu, W. Zhang, S. Ling, R. Xiang, X. Cui, Y. Zhu and Z. Tang, Journal of Materials Chemistry A, 2014, 2, 6952-6959.

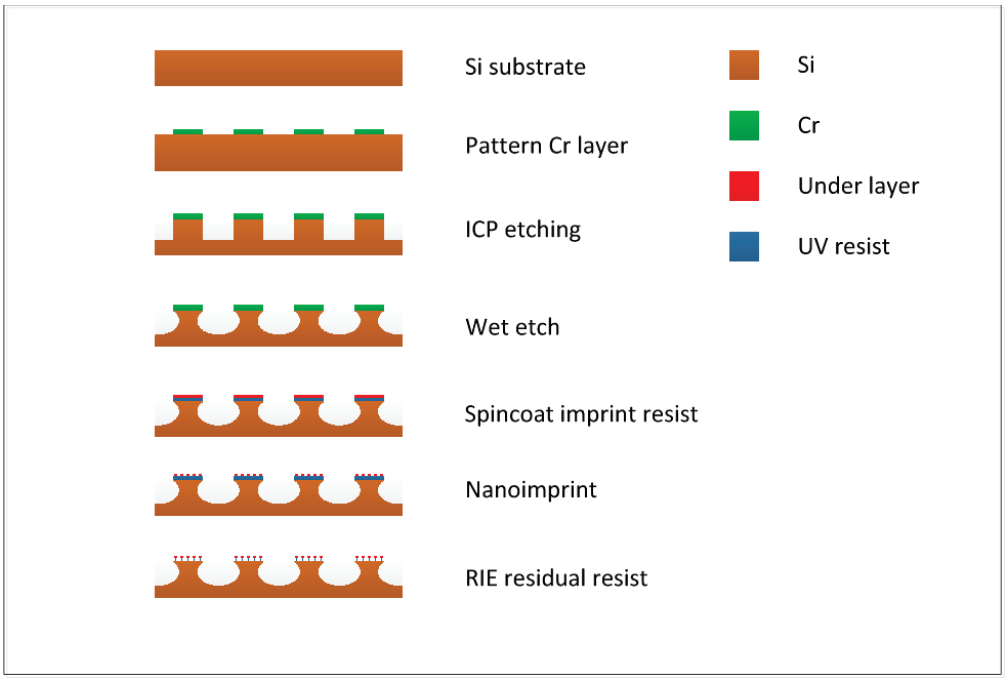

Figure 1: The fabrication process of a master mold with hybrid micro/nano-scale overhang structures.

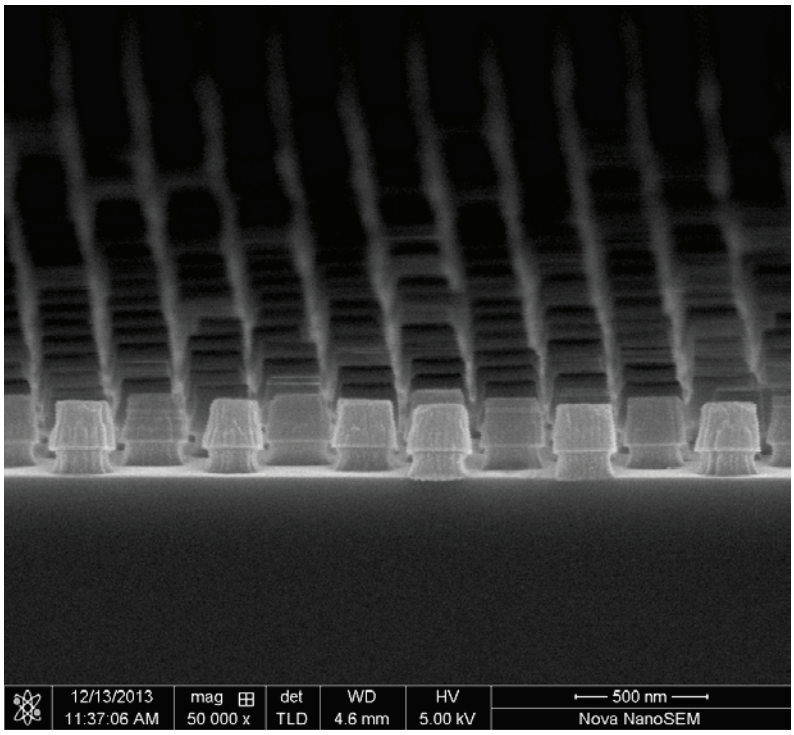

Figure 2: The SEM image of nano-scale mushroom shaped structure on top of a Si micro-pillar. The micrograph shows an array of 250 nm height mushroom posts with a diameter of 230nm and a periodicity of 400 nm.