A superhydrophobic surface made from hydrophilic materials with micro-umbrella structures

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Superhydrophobic surfaces with a water contact angle (CA) larger than 150° and a roll-off angle less than 10° have recently attracted significant attention because of their unique water repellency which may lead to applications ranging from nonwetting micro/nanoelectronics to large area self-cleaning building products. It is generally assumed that superhydrophobicity can be achieved through a combination of two properties: extreme surface texture and low surface energy materials. A few recent papers have reported that some superhydrophobic surfaces can also be made from intrinsically hydrophilic materials. For some microfluidics applications, such as thermal management and micro inkjet printing, it is important to maintain the droplet in the superhydrophobic state during evaporation and manipulation. On superhydrophobic surfaces reported to date, a transition from the mobile, superhydrophobic (i.e. Cassie) state to a wetting (i.e. Wenzel) state always occurs as the droplet evaporates and becomes smaller than a critical value on a patterned superhydrophobic surface. [1]

In this paper, we report a superhydrophobic surface on which a water droplet remains in the Cassie state throughout the evaporation process. The surface is composed of a hydrophilic polymer with a special micro-umbrella structure that is fabricated on a silicon wafer by combination of dispensing and reactive ion etching (RIE), as shown in Figure 1. By controlled over-etching, the polymer cap with a tapered thickness overhangs the silicon post, forming a micro-umbrella structure. The surface shows good superhydrophobicity immediately after microfabrication without additional surface modification. The original hydrophilic phenolic surface is partially modified by the RIE process, but retains hydrophilic properties as demonstrated by the contact angle hysteresis which increases to 55° after etching. The static water CA of a water droplet positioned on the fabricated surface is as high as 155°, and the water droplets can be easily lifted off. More importantly, the water droplet remains in the Cassie-Baxter state during the entire evaporation process. A possible mechanism for the unique evaporation properties of water droplets on this surface is discussed.

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[1] McHale, G.; Aqil, S.; Shirtcliffe, N. J.; Newton, M. I.; Erbil, H. Y. Langmuir 2005, 21, 11053-11060

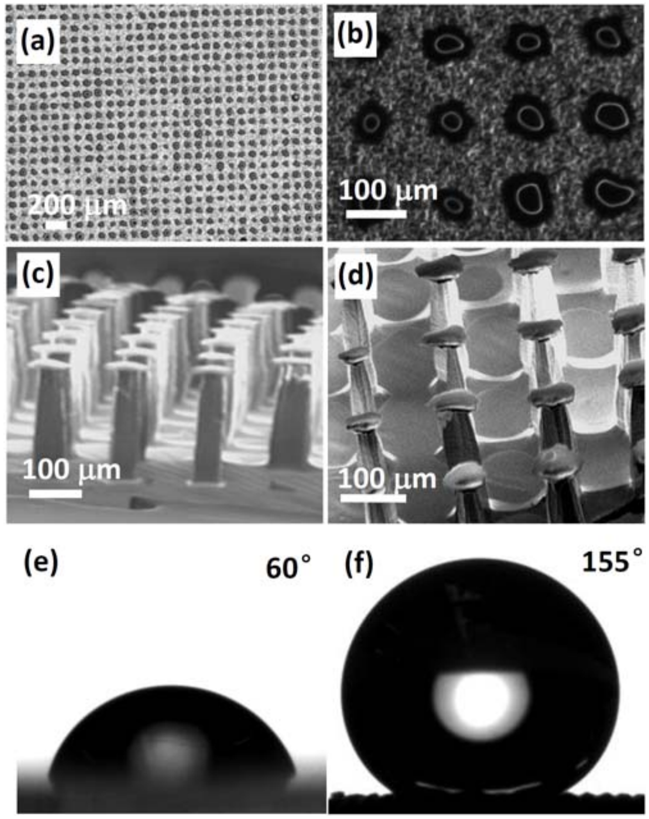

Figure 1: Optical images of the patterned silicon wafer at lower magnification (a) and higher magnification (b). SEM images of the fabricated micro-umbrella structures tilled at 80° (c) and 30° (d). Optical images of water droplets on flat phenolic surface (e) and fabricated surface (f).