Fabrication of omniphobic surfaces using deposited silicon dioxide layer and dry etching process

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Surfaces with special wetting characteristics have broad technical and industrial applications such as self cleaning glasses, solar cell panels, anti-reflection coatings, printing materials, and anti-bioadhesion surfaces. A surface is generally considered to be hydrophobic if the water contact angle is greater than 90^o. Surfaces with water contact angles greater than 150^o are usually referred to as superhydrophobic as they have very high water repellency. To get the superhydrophobic surface, numerous studies have shown that it is the combination of surface chemistry and surface roughness according to the Wenzel model and the Cassie–Baxter mode [1, 2]. Several research groups have used overhang or re-entrant structures that utilize the metastable Cassie–Baxter state for implementing superhydrophobic surfaces. The surface with overhang structures were able to repel both water and oil, thus inducing both the superhydrophobic and superoleophobic phenomena (superomniphobic state). In this study, various special SiO_2 nanopillar geometries have been produced by simple and advantageous low-temperature processing. For example, the process was applied to introduce SiO_2 nanopillars on a ultra-high-molecular-weight polyethylene plastic surface, with the processing temperature not exceeding 110°C. Substrates were spin-coated with a few micrometer thick layer of silicate-containing precursor. The sample was then baked to vaporize the solvent in the precursor layer,, which was subsequently etched by reactive ion etching process to create vertically aligned, ~100 nm diameter array of SiO_2 nanopillars on the substrate surface. A fluorine-containing hydrophobic material was then applied onto the SiO_2 nanopillar surface through a vaporization process in vacuum. The resultant sample exhibited excellent superhydrophobicity with a contact angle with water droplet greater than 160° and good oleophobicity with oleic acid droplet greater than 130°. The optical properties of the coated substrate remain excellent with the optical transparency in the visible spectrum range maintained with only ~5% level average loss compared with an uncoated soda lime glass.

[1] R. N. Wenzel, Ind. Eng. Chem., 28, 988 (1936).
[2] A. B. D. Cassie and S. Baxter, Trans. Faraday Soc., 40, 546 (1944).

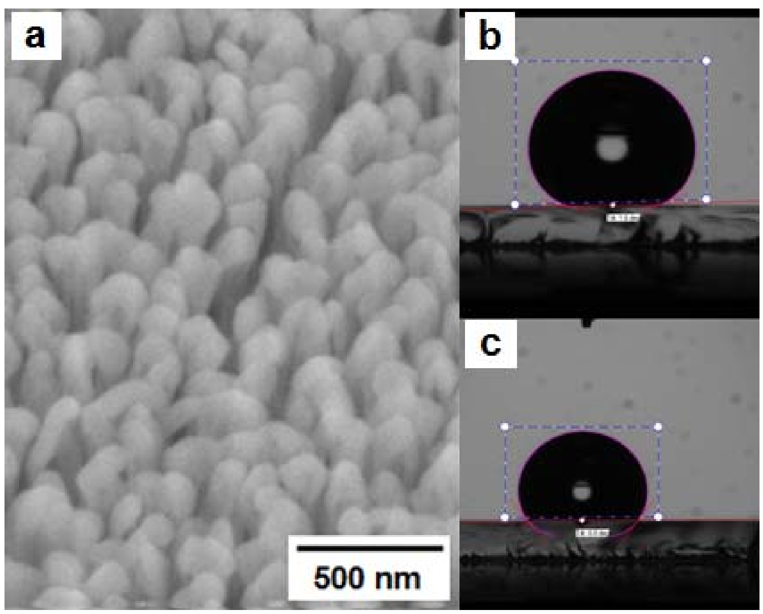

Figure 1. (a) SEM image of fabricated SiO_2 nanopillars with mushroom tip structure having omniphobic characteristics. The side-view photographs of (b) water droplet and (c) oleic acid droplet on the patterned omniphobic structure after fluorine-containing hydrophobic material is applied. The droplet was eluted from a syringe onto the sample surface.