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Superhydrophobicity and Oleophobicity of Transparent Glass Prepared by Plasma Etching

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Extended Abstract

It is well known that superhydrophobic surfaces, showing an apparent contact angle higher than 150° and low contact angle hysteresis, have a self-cleaning property, i.e. lotus effect as shown by Barthlott and Neinhuis (1997). However these surfaces are vulnerable to oil contamination such as fingerprint, and if contaminated, they lose self-cleaning property as well as hydrophobicity. Therefore, it is necessary for the surfaces to be oleophobic in order to gain full practical values. The preparation methods of oleophobic glass suggested thus far require many additional steps such as sol-gel and lithography processes. Furthermore, the additionally added nanostructure and the substrate are not of the identical materials, leading to intrinsic problem of durability.

Here we fabricate, optimize and test superhydrophobic and oleophobic glass by modifying a method proposed by Yu et al. (2015), where nanostructured glass is fabricated by non-lithographic, anisotropic etching. A sacrificial SiO_2 layer is deposited on soda-lime glass using plasma enhanced chemical vapor deposition (PECVD) with a mixture of N_2O gas and SiH_4 gas. Subsequently, the substrate is etched by a glow discharge of CF_4 gas using PECVD. To remove metal fluorides from the surface, the substrate is immersed in water for the hydrolysis. Since it is well known that silane, a low-surface-energy material, reacts with the surface hydroxyl group (-OH), the substrate is immersed in piranha solution to further functionalize the surface with hydroxyl group. Subsequently, we modify the surface with perfluorooctyl trichlorosilane (PFOTS) using vapor deposition. The result is glass exhibiting not only superhydrophobicity but also oleophobicity.

We observed nanostructured glass with various CF_4 plasma duration with the scanning electron microscope (SEM) to find that solid fraction increases with CF_4 plasma duration. As shown by Cassie and Baxter (1944), the resulting contact angle can be expressed

$$\cos\theta_r = f\cos\theta_f + f - 1 \tag{1}$$

where θ_r and θ_f are the contact angle of rough and flat surface, respectively, and f refers to solid fraction in contact with liquid. To achieve high contact angles of water, ethylene glycol and hexadecane on the nanostructured glass, it is necessary to reduce solid fraction. Hence, it is natural to expect the contact angle of liquids on the nanostructured glass to increase with decreasing CF_4 plasma duration. The results of our experiments show good agreement with the theoretical prediction. In addition to CF_4 plasma duration, the contact angle of each liquid was found to increase with the PFOTS deposition time and to eventually saturate. The process we developed in this work can be used to fabricate such products as eyeglasses, solar panel and optical instruments, where minimization of contamination is crucial.

Barthlott, W., & Neinhuis, C. (1997). Purity Of The Sacred Lotus, Or Escape From Contamination In Biological Surfaces. *Planta*, 202, 1-8.

Cassie, A. B. D., & Baxter, S. (1944). Wettability Of Porous Surfaces. *T. Faraday. Soc.*, 40, 546.

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