Oleophobic Surfaces with Low Adhesion from Stainless Steel (9Cr18) by Laser Processing and Chemical Etching

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A new method consisted of two steps of top-down fabrication method was proposed to fabricate oleophobic surfaces with low adhesion from stainless steel (9Cr18). Firstly, the femtosecond laser was used to process the micro-scale pillars. Secondly, HCl was used to etch the sub-micro scale asperities on the pillars, followed by a fluorination process. The results shown that the contact and rolling angles of PAO oil on the processed surface with 1min etching are 128° and 45°. The pillars and the asperities constituted a multi-scale pattern. It enabled the processed surfaces to have the properties of oleophobicity and low adhesion.

Keywords (from 3 to 5 max): oleophobic, stainless steel, laser processing, HCl etching

1. Introduction

Oleophobic surfaces with low adhesion have wide applications in the fields of oil-water separation, self-cleaning, and so on. The coating methods, which induced the binding property between membrane and basement becomes the main factor to influence the lifetime limit of the surfaces, were usually used to fabricate oleophobic surfaces from stainless steel. This study aims to fabricate oleophobic surfaces with low adhesion from stainless steel (9Cr18) by top-down fabrication methods to eliminate the influences of the membrane.

2. Methods

The process of manufacturing the oleophobic surface from stainless steel (9Cr18) is shown in Figure 1. The femtosecond laser is used to process the microscale pillars. Pillar height, pillar width, and interpillar distance are 30, 17, and 17μm. HCl is used to etch the sub-micro scale structures. Etching times are 1, 2, 3, 4, 5, and 6min. 1H, 1H, 2H, 2Hperfluorodecyltrimethoxysilane is used in the fluorination process to decrease the surface energy. Poly-alpha olefin synthetic base oil (PAO) is used to test the wettability of the processed surfaces.

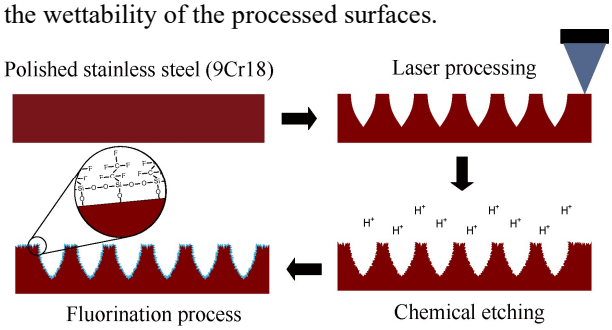

Figure 1: Process of fabricating the oleophobic surface.

3. Results and discussion

The influences of the etching time on the wettability and pattern of surfaces are shown in Figure 2. The contact angle (CA) of PAO increases initially, followed by a decrease, but then again increases with an increase of the etching time. The CA achieves the maximum value of 128° at 1min. Rolling angle (RA) achieves the minimum value of 45° at 1min and 6min. The results shown that the manufactured stainless steel has the properties of oleophobicity and low adhesion when the etching times are 1 and 6min.

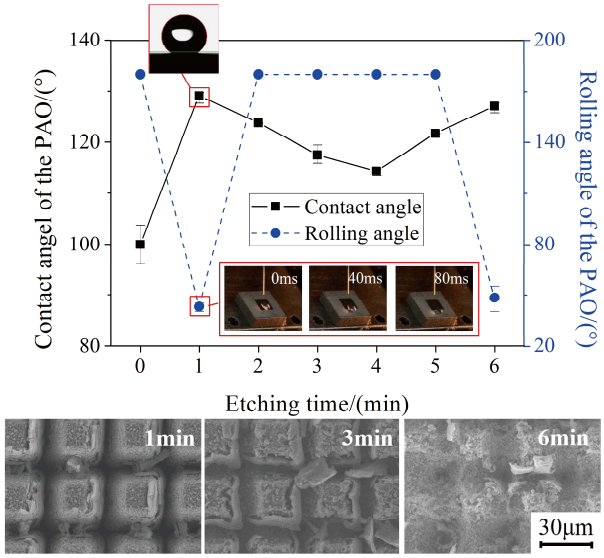

Figure 2: The influences of the etching time on the wettability and pattern of surfaces.

In Figure 2, the sub-micro scale asperities appear on the microscale pillars and they constitute a multi-scale pattern at 1min etching. The multi-scale pattern magnifies the oleophobic ability of the fluoride. Shells appear on the side face of pillars at 3min. The gaps between the shells and pillars induce PAO easier to penetrate the multi-scale pattern. With the increase of the etching time, most shells disappear at 6min etching, so the surface has the property of low adhesion again. But the dimensions of the pillars decrease too much because of the etching, the CA of PAO on the surface with 6min etching is less than the surface with 1min etching.

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