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Fabrication of bionic surfaces with mixed superhydrophobic and superhydrophilic properties using fs-lasers

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Abstract

The exciting functionalities of natural superhydrophobic and superhydrophilic surfaces, e.g. the extreme water repellency of the lotus flower, served as inspiration for a variety of bionic designs. In contrast, little attention has been paid to combine superhydrophobic and superhydrophilic wetting properties to micropatterns. However, as the example of the Namib desert beetle shows, such micropatterns improve e.g. the water collection efficiency from fog. With this in mind, the patent-pending ClearSurface™ process by Spectra-Physics® was developed, which enables the functionalization of nearly all kind of substrates with mixed wetting properties of arbitrary shape. In this way, superhydrophilic micropatterns (contact angle < 5°) can be fabricated fast and flexible on a superhydrophobic background (contact angle > 150°). This process enables the design of novel devices for biomedical and microfluidic applications.

Keywords: ultrafast, laser, patterning, superhydrophobic, superhydrophilic, surfaces;

1. Introduction

The exciting functionalities of natural superhydrophobic and superhydrophilic surfaces, e.g. the extreme water repellency of the lotus flower, served as inspiration for a variety of bionic designs. In recent years, it

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was successfully demonstrated that either superhydrophobic or superhydrophilic surfaces could be fabricated by laser micromachining, as e.g. shown by Kietzig et al. (2009), Vorobyev and Guo (2015), and Baldacchini et al. (2006). In contrast, little attention has been paid to combine both extreme wetting states to micro patterns. However, as Garrod et al. (2007) showed, superhydrophobic/ superhydrophilic micro patterns, as on the elytra of the fog-collecting Namib Desert beetle, increase the water collection efficiency from fog. The aim of this study was to use laser micromachining to fabricate similar superhydrophobic/superhydrophilic micro patterns on glass.

2. Material & Methods

Superhydrophobic/superhydrophilic surfaces were fabricated using the patent-pending ClearSurface™ process by Spectra-Physics®. This process enables the functionalization of nearly all kind of substrates with mixed wetting properties of arbitrary shape in only three processing steps. In the first step (Fig. 1a)), an industrial fs-laser Spirit™ from Spectra-Physics® is used to generate a hierarchical micro/nano pattern on the surface, which adds superhydrophilic properties. In the second step (Fig. 1b)), a Teflon-like polymer $(CF2)_n$ is deposited by a plasma process that makes the patterned surface superhydrophobic. In the last step (Fig. 1c)), the Teflon-like coating is selectively removed by fs-laser ablation. In this way, superhydrophilic micropatterns (contact angle < 5°) can be fabricated fast and flexible on a superhydrophobic background (contact angle > 150°).

3. Results & Discussion

Following the example of the fog-collecting elytra of the Namib Desert beetle, superhydrophilic spots on a superhydrophobic background were generated on Pyrex wafers. The fog-collection behavior of the patterned sample was investigated in an artificial nebulizer setup. Fig 1d) shows that droplets formed on the superhydrophilic spots, accumulated to large bulbous drops due to the strong water repellency of the surrounding superhydrophobic areas, and detached from the surface due to gravity. The experiments also revealed that the surface micro patterns enhanced the collection efficiency compared to non-structured surfaces.

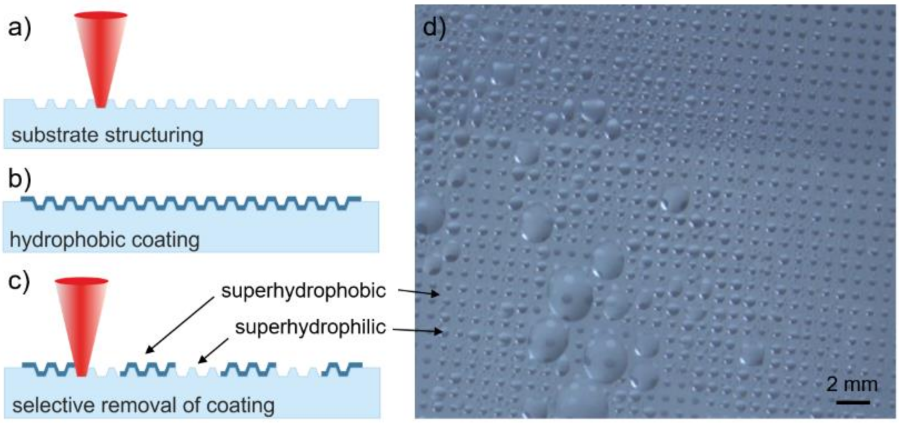

Fig 1. a) to c) Fabrications steps of the patent-pending ClearSurface™ process. d) Droplets collected from a nebulizer on the Superhydrophobic/Superhydrophilic micropattern.

4. Conclusion

The aim of this study was to fabricate superhydrophobic/superhydrophilic micropatterns e.g. in order to mimic the Namib Desert beetles elytra on a glass substrate. This was achieved using the patent-pending ClearSurface™ process from Spectra-Physics®, which is based on fs-laser surface structuring, coating, and selective coating ablation. This process enables the functionalization of nearly all kind of substrates with mixed wetting properties of arbitrary shape. ClearSurface™ enables the design of novel devices for biomedical and microfluidic applications.

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