Unidirectional wetting of anisotropic textured GaSb surfaces

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1. Introduction

Texturizing represents a huge interest to improve or modify surface properties like wetting, tribology or adhesion. In particular, anisotropic surfaces can be optimized for unidirectional surface properties.
Textured surfaces have been prepared by self-etching ionic abrasion of monocristalline GaSb wafers. The resulting surfaces are covered with nanometric disordered cones that can be tilted with an angle β normal to the surface. This angle, between 15° and 60°, gives a specific orientation to the structures that results in anisotropic topology of the surface. The wetting properties have been studied in relation with this anisotropy and we show that tilt angle gives unidirectional advancing to the liquid droplet. Moreover a chemical treatment of the surfaces is used to fabricate surfaces presenting a rose-petal effect. Thus, only with chemical modification of this specific topology, we are able to have either a Wenzel state, sensitive to the cones tilt, or a Cassie state, much less sensitive to this orientation.

2. Characterization and results

Textured surfaces were covered of nanocones tilted normally to the surface thanks to a self-etching ionic abrasion[1]. SEM-FEG was used to analyze surface morphology. Dynamic wetting was studied with the help of a DSA100 apparatus (Krüss).

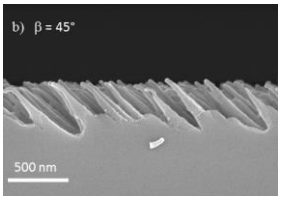

Fig. 1 SEM image of GaSb cones with 45° tilt angle

The smooth GaSb is at the interface hydrophobic/philic with a static contact angle of 89°±5° and an advancing contact angle of 87°. The addition of texturation emphasizes the hydrophobic behavior of the surface and liquid evaporation experiment showed that water droplets are impaled on the surface that is in a Wenzel state. Interestingly on surfaces with tilted cones, the water contact line moves preferentially "against" the cones. The advancing angle is also strongly dependent on the tilt angle whereas no receding angle can be detected whatever the inclination.

We present some simple geometric argument to interpret this unidirectional behavior.

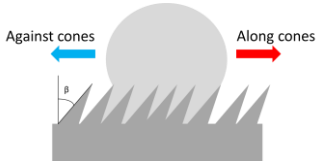

Fig. 2 Direction of motion on textured GaSb

Chemical treatment with silane adsorbed on the surface reduces surface tension and surfaces become superhydrophobic. In that case, the dependence to the tilt angle decreases. The reason is that the water droplet is in Cassie state and is not sensitive to the asperities geometry or inclination. Nevertheless, no receding is measured neither for these surfaces which have a high contact angle hysteresis (CAH). High CAH of superhydrophobic surfaces are typical of surfaces presenting a "rose-petal effect". This effect is the contrary of the well-known lotus effect for which water droplet rolls on the surface.
By modifying surface topology, we are thus capable to control unidirectional advancing of water droplet. Moreover, modifying the chemistry of textured anisotropic surface is efficient to modify the wetting sensitivity to the cones tilt.

3. Perspectives

Textured surfaces covered of high aspect ratio asperities generally present impalement and pinning of the liquid droplet[2]. To overcome this effect, the addition of a perturbation through mechanical vibrations can help to emphasize contact line motion[3,4]. A commercial wetting apparatus (DSA30, Krüss) has been adapted to add vibrations to surfaces. Preliminary results with this equipment are presented and analyzed in relation with results on surfaces presenting anisotropic texturizing.

4. References

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