Physico-chemical nanomaterials science

Cassie-Baxter to Wenzel state transition during freezing of water droplet

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Icing of surfaces exposed to low temperatures and high humidity are an extremely important issue in industry and daily life, e.g. deicing of plane wings or windmills is very time- and cost consuming. Extensive investigations are carried out in order to obtain passive anti-icing surfaces. Most strategies rely on water repellency as a prerequisite for icephobicity. Extreme water repellency is provided by superhydrophobic surfaces (SHS), combining nano- and micrometric hierarchical topography with low surface free energy (SFE).

Several phenomena occur on SHS after exposure to icing conditions. These include a transition between two characteristic wetting states: from the non-wetted Cassie-Baxter state to the fully wetted Wenzel state. The transition is usually detrimental because in the Wenzel state the contact area between substrate surface and water is several times higher than in the Cassie-Baxter state, which results in a significantly higher ice adhesion. Better understanding of such processes will be very helpful for designing of anti-icing coatings

In the presented study surfaces with micrometric topography were obtained in SU-8, by a direct photolithographic process, or in epoxy resin, by replication of negative SU-8 photolithographic patterns. Nanometric roughness was introduced on the top of the microstructures, by means of RF air plasma etching. Low SFE was provided by chemical modification with perfluorododecyltrichlorosilane

To observe Cassie-Baxter – Wenzel transitions, transparent superhydrophobic materials are handy, which is the case for our SHS. Transparency allows to observe water droplet freezing from the bottom. We performed such experiments using a homemade apparatus based on an inverted microscope with long working distance objective lenses. These experiments allowed us to visualize Cassie-Baxter to Wenzel transitions during water droplet freezing and to investigate parameters determining such transitions.

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