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Development of nanostructured surfaces for ice protection applications[1]

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Ice accretion on surfaces of aircrafts, wind turbine blades, oil and gas rigs and heat exchangers, to name a few examples, presents long recognized problems with respect to efficiency and cost of operation. For instance, significant ice accretion on critical surfaces of an aircraft will cause problems during lift off (and will change the aerodynamics of the wings during flight. On the other hand, ice built up on wind turbine blades in cold climates ($T < -20\,^{\circ}C$) drastically reduces the efficiency of power generation. Despite considerable number of studies and significant progress toward development of icephobic coatings, development of *robust ice-resistance or anti-icing coatings* is still elusive. Several approaches towards development of anti-icing surfaces have recently postulated that the superhydrophobic properties of hierarchically textured coatings, with contact angles $> 150\,^{\circ}$, may lead to a significant reduction and perhaps elimination of snow and ice accretion. However, the exact mechanism of delayed icing on these surfaces is still under debate. Here we present a systematic study of early stages of ice formation upon water droplet impact on a range of hydrophobic, hydrophilic, textured and chemically patterned surfaces. We show that, in addition to a significant reduction in ice-adhesion strength on superhydrophobic surfaces, decreasing the water-substrate contact area plays a *dual* role in delaying ice nucleation: first by reducing heat-transfer and second by reducing the probability of heterogeneous nucleation at the water-substrate interface. The study presented here also offers a comprehensive perspective on the efficacy of textured surfaces for practical non-icing applications.

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