Water Droplets on Superhydrophobic Surfaces: Tunable Optical Microcavities

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Surface hydrophobicity is enhanced by roughness. While the static contact angle of a water droplet can be maximum ~120^o on a smooth hydrophobic surface, it can be increased above 150^o by surface roughness. Applications of superhydrophobic surfaces require control of the surface roughness from micrometer to nanometer length scales. Nano-rough surfaces are transparent to visible light and have potential to be used in optical applications.

In the first part of the talk, the control of the surface hydrophobicity of polymer-nanoparticle nanocomposites will be discussed. The addition of hydrophobically coated nanoparticles in a polymer increases the contact angle θ of a water drop with respect to that on polymer surface due to change of surface composition and/or surface roughness. When the nanoparticles disperse well in the polymer, Cosθ decreases linearly with increasing amount of nanoparticles indicating a composite surface consisting of smooth polystyrene regions and rough nanoparticle regions. In case of formation of nanoparticle aggregates in the polymer, Cosθ decreases sharply at a critical concentration of nanoparticles. The observed behaviour was modeled in terms of a transition from Wenzel regime to Cassie-Baxter regime at a critical roughness length scale below which the Laplace pressure prevented the penetration of the water drop into the surface undulations. We argue that multiple length scales are needed below the critical roughness length scale to increase the contact angle further by decreasing the fraction of surface area of solid material (increasing the fraction of surface area of air) underlying the water drop.

The second part of the talk will be on the use of water microdroplets on nano-rough superhydrophobic surfaces as tunable optical microcavities. Water microdroplets act as optical microsphere microcavities due to their nearly spherical shapes. Transparency of the surfaces to visible light allows the optical characterization of the microcavities. In a humidity chamber, we have demonstrated the tunability of these microcavities over large spectral ranges by controlled evaporation and condensation. The importance of optical resonances for the characterization of the superhydrophobic surfaces will be discussed.