Electric Field Driven Instabilities on Superhydrophobic Surfaces

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We study possible mechanisms of the transition from the Cassie state to the Wenzel state on superhydrophobic surfaces under the influence of electric fields. It is shown that the equilibrium shape of the composite interface between superhydrophobic surfaces and drops in the superhydrophobic Cassie state under electrowetting is determined by the balance of the Maxwell stress and the Laplace pressure. A simple analytical model for axisymmetric cavities and small deflections of the liquid menisci within the cavities reveals the existence of a novel electric field driven instability of the liquid surface. Fully self-consistent calculations of both electric field distribution and surface profiles show that this instability evolves from a global one towards a local Taylor cone-like instability for increasing aspect ratio of the cavities. A two-dimensional map is derived indicating the prevalence of the interfacial instability as compared to the depinning scenario of the three-phase contact line, which is well-known from ordinary superhydrophobic surfaces.