Stevens Institute of Technology

Nanotechnology Graduate Program

Multiscale Engineering of solid-liquid interfaces

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In this talk, we describe chemical and micromanufacturing techniques to micro- and nano-engineer solid-liquid interfaces, with applications in coating technologies and heat transport. The first part of the talk is focused on the formation of deposits during the drying of nanoliter drops containing colloidal particles. The system studied involves aqueous drops containing Titania nanoparticles evaporating on a glass substrate. An in-house numerical modeling of the drop drying process is presented. Deposit shapes from spotted drops at different pH values are measured using a laser profilometer. Our results show that the pH of the solution influences the dried deposit pattern, which can be ring-like or more uniform. The transition between these patterns is explained by considering how DLVO interactions such as the electrostatic and van der Waals forces modify the particle deposition process. Also, a phase diagram is proposed to describe how the shape of a colloidal deposit results from the competition among three flow patterns: a radial flow driven by evaporation at the wetting line, a Marangoni recirculating flow driven by surface tension gradients, and the transport of particles toward the substrate driven by DLVO interactions. This phase diagram explains three types of deposits commonly observed experimentally, such as a peripheral ring, a small central bump, or a uniform layer. In the second part of the talk, we demonstrate that smooth and flat surfaces combining hydrophilic and hydrophobic patterns significantly improve pool boiling performance. Compared to a plain hydrophilic surface, the measured critical heat flux and heat transfer coefficients of the enhanced surfaces are up to respectively 65 and 100% higher. Different networks combining hydrophilic and hydrophobic regions are characterized. While all tested networks enhance the heat transfer coefficient, large enhancements of critical heat flux are typically found for hydrophilic networks featuring hydrophobic islands. These networks indeed are shown to prevent the formation of an insulating vapor layer.

Professor Daniel Attinger conducts numerical and experimental research focused on multiphase microfluidics, i.e. the dynamical behavior of several fluids or phases constrained by a micro-geometry. Daniel Attinger is the recipient of the ETH Zurich medal for outstanding Ph.D. thesis (2001), and is currently Assistant Professor at Columbia University. He has produced 25 journal articles, 40 conference papers, 2 book chapters, and 2 edited books. He has given five keynote lectures at international heat transfer and microfluidic conferences, and about 30 invited talks in Harvard, Berkeley, MIT, Princeton, RPI, IIT Chennai, ETH Zurich and the Hong Kong University of Science and Technology. Since 2004, the US National Science Foundation has awarded him five grants as a PI, including the NSF CAREER award for young investigators. Since February 2010, he has received awards for more than one million $US as a primary investigator, from NSF and the US Department of Justice. Attinger is a member of the American Society of Mechanical Engineers and of the American Physical Society.

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