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Emerging technologies at the nexus of multiphase thermofluidics and interfacial nanoengineering

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Abstract

Multiphase thermofluidics and interfacial nanoengineering impact basic industries such as energy, water, electronics cooling, transportation, textiles, etc. Driven by cost, consumption, and safety concerns, there has been an inexorable trend towards achieving higher performance in these areas, e.g., efficiency enhancement. However, in many cases further improvements are fundamentally limited by momentum/heat/mass transport occurring at interfaces. In particular, one major problem in multiphase thermofluidics is the uncontrolled accumulation of liquids and ice on surfaces—acting as a resistance to heat transfer in condensation, creating unsafe conditions when its surface icing—and recent research by us has been on developing rational strategies to mitigate it. In this talk, I will show how nanoengineered surfaces can be designed to alter momentum/heat/mass transport at interfaces to benefit droplet impact, freezing/icing, condensation, and related thermofluidic processes, setting a pathway towards transformational performance enhancements. To achieve the above, we first study the wetting (both static and dynamic) and phase change behavior of liquid droplets on surfaces with specific micro/nanotexture and chemical composition using high-temporal and/or high-spatial resolution optical and infrared imaging under a range of environmental conditions (low–to-high pressures/temperatures). Using this approach, I will present the development and application of our recent findings on interesting wetting and de-wetting mechanisms of droplets and ice on rationally engineered hydrophilic, superhydrophobic, and icephobic surfaces. In general, this work goes towards findings that add to our understanding of how droplet–surface interactions can control the accumulation of liquids or solids on surfaces—addressing needs in surface icing and phase change heat transfer—and how these materials and surfaces can be realized in real-world applications. Connected to all of this is the development and understanding of robust materials with advanced functionalities, and I will give a brief outlook on this.

Bio Sketch

Dr. Thomas Schutzius is a group leader (Micro- and Nanoscale Interfacial Transport Phenomena and Thermodynamics) in the Laboratory of Thermodynamics in Emerging Technologies at ETH-Zurich. He received his B.S. and Ph.D. degrees from the Department of Mechanical Engineering at the University of Illinois at Chicago (UIC) in 2008 and 2013, respectively. During his graduate studies, he was the recipient of the Dean’s Scholar Award and the UIC Outstanding Thesis Award. Afterwards, he received the ETH fellowship, which provided full funding for his postdoctoral research at ETH-Zurich. His major research interests include interfacial transport phenomena and processes, energy, materials science, thermodynamics and surface science, surface micro/nanoengineering, liquid repellency, and multiphase heat and mass transfer, focusing on producing performance and efficiency enhancements in the areas of energy, water, electronics cooling, and infrastructure.