Role of surface engineering on liquid/surface interactions

Abstract

Wetting of liquids on solid surfaces are ubiquitous in nature and technology. In some applications, wetting of liquids on solid or more complex (porous) surfaces are undesirable, as for example, water accumulation on wind shields, clothes, condensers are name a few. Additionally, recent studies show that surface icing can be suppressed by minimizing the interaction of supercooled metastable water droplets to solid surfaces. Although interactions of liquids to solid surfaces are undesirable in above applications, there are cases where wetting of liquids on solid surfaces are preferred, such as, in painting, lubrication, dye application on solid surfaces etc. Importantly, most of heat transfer applications, where heat dissipation is very important for smooth operation of electronic devices, wetting of liquids (coolants) on heated solid surfaces is desirable to dissipate heat. Surface roughness (at micro- and nano- scale) and chemistry play a vital role to control the wetting of liquids on surfaces. My works aim to understand the role of surface engineering and chemistry on the interaction between water and solids in context of surface icing and heat dissipation.

Superhydrophobic surfaces with micro- and nano-scale roughness have shown excellent water repellency and low adhesion to water, and could possibly be a good choice to control surface icing. High droplet mobility of micro/nano-textured superydrophobic surfaces leads to spectacular rebound events. It is not clear however, if and under what conditions this rebound behavior is maintained, when such surfaces are severely undercooled possibly leading to the formation of frost and icing. Therefore, I investigated on the dynamic interaction of water droplets on engineered surfaces at severely low temperature conditions. The experimental results have been utilized to propose a rational design of nanoengineered superhydrophobic surfaces to suppress icing.

Next part of my talk focuses on the thermal management issue in electronic devices where heat dissipation is very important. Cooling technologies based on the single phase cooling with water and air being used as coolants, is limited to heat fluxes below 450 W/cm^2 and therefore cannot be used in high heat flux requirements. Cooling based on liquid to vapor phase change offers a solution, due to the large heat of vaporization, and has widely been applied in pool boiling, flow boiling, jet and spray cooling and heat pipes etc. In this work, two phase heat transfer is studied on copper based hierarchical bi-porous engineered surfaces. This work aims to investigate the effect of micro- and nano- scale roughness on two phase heat transfer performance. The last part of my talk focuses on the synthesis of phase change materials, which can be used to store thermal energy in electronic devices such as mobile phones, laptop etc. In this research, phase change materials based on paraffin and conductive nano particles are synthesized from a pickering emulsion of paraffin-carbon nanotubes/water. A thermal cycle is applied to nanocomposite based phase change materials to evaluate its performance.

Bio

Tanmoy Maitra received his B.S from University of Calcutta, and M.S from Indian Institute of Technology, Kanpur, India. In his master thesis, he investigated the catalytic activity of carbon nanotubes on the graphitic content to enhance the electrical conductivity of CNT-polymer derived carbon composite suspended fibers. Thereafter, he earned his PhD from Department of Mechanical and Process Engineering at Swiss Federal Institute of Technology (ETH), Zurich under the direction of Prof. Dimos Poulikakos. The aim of his PhD thesis was to understand the physics of textured-surface/droplet interaction at conditions conducive to icing to address the surface icing issue. He currently holds a Swiss National Science Foundation (SNSF) fellowship, working as a postdoctoral research scholar with Prof. Ken Goodson. In his current research, he is investigating the role of heterogeneous wettability of porous matrices at micro and nano-scale on two-phase electronics cooling.