14th November, 2013

Analysis of Convection in the Presence of Apparent Slip

Hodes Marc

Associate Professor

Department of Mechanical Engineering, Tufts University

Abstract: When liquid flows over a structured surface consisting of, e.g., an array of micron-scale longitudinal ridges, a lubricating air layer may be trapped between the liquid and the base of the structures. The effect of the lubricating air layer on drag reduction is somewhat well understood. However, only recently has heat transfer to a liquid in such a configuration been considered. At the microscale, scale analysis shows that heat transfer in the vicinity of the solid-liquid interface may be approximated as purely diffusive and this fact may be exploited to determine the so-called thermal slip length which manifests itself as a Neumann boundary condition on the thermal energy equation at the channel scale. In this seminar, I will show how to compute thermal slip lengths and corresponding Nusselt numbers for several types of surface topographies and flow configurations, respectively. Then, I will consider the secondary effects of thermocapillary stress, evaporation, and condensation on hydrodynamic and thermal slip lengths and macroscopic parameters, i.e., friction factor and Nusselt number. I will conclude by showing how structured surfaces may be exploited to reduce the thermal resistance of liquid metal cooling of microelectronics.

Marc Hodes received his MS in Mechanical Engineering from the University of Minnesota, where he performed research on dielectric liquid cooling of microelectronics. In 1998, he received his PhD in Mechanical Engineering from the Massachusetts Institute of Technology, where his research addressed salt deposition (fouling) in supercritical water oxidation reactors used for the destruction of hazardous organic wastes. After holding a succession of appointments from Postdoctoral Member of Technical Staff to Manager over a 10 year period at Bell Labs, he joined the Mechanical Engineering Department at Tufts University in the Fall of 2008 as an Associate Professor. His area of interest is heat and mass transfer. Currently, research is in three areas. First, experiments are being performed to measure the rate of conversion of alcogels to aerogels (for use as "super" thermal insulators) by supercritical CO_2-based extraction. Secondly, liquid metal (Galinstan®)-based heat sinks are being investigated.

Finally, analysis of convective heat transfer in the presence of apparent slip is underway.

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