

# Interfacial Phenomena in Nucleate Pool Boiling of Water: Their Role and Manipulation by Molecular Dynamics of Surface-Active Additives

Raj M. Manglik

Thermal-Fluids & Thermal Processing Laboratory

Department of Mechanical, Industrial and Nuclear Engineering

University of Cincinnati, Cincinnati, OH 45221-0072, USA

Phone: +1 (513) 556-5704; Fax: +1 (513) 556-3390; E-mail: [Raj.Manglik@uc.edu](mailto:Raj.Manglik@uc.edu)

## Abstract

Heat transport in ebullient phase-change is essentially governed by interfacial activity: the liquid-solid interface predicated wetting and nucleation of embryonic vapor bubbles, and the liquid-vapor interface affects dynamic surface tension, Marangoni convection, and the postnucleation ebullient dynamics. At the *micro-scale* in this process, the transient transport mechanisms at the solid-liquid-vapor interfaces during nucleation and the subsequent vaporbubble growth dynamics, which essentially characterize the *macro-scale* phase-change behavior (heat transport and ebullience or bubbling signature), can be altered by introducing small quantities of surface-active additives (reagents or polymers) in a pure liquid (water). In the case of surfactants in particular, the additive's ionic or non-ionic nature, molecular chain structure, level of ethoxylation, and molecular weight, among other factors, affect and control this process; in fact, surface wetting and surface tension can be decoupled. This keynote explores and delineates those aspects of micro-scale interfacial changes that are essentially caused at a *molecular-scale* by the relative adsorption-desorption of additives in a pure fluid at the liquidvapor interface, and their physisorption and electrokinetics at the liquid-solid interface. The consequent interface-control mechanisms, and in turn the ebullient phase-change processes are critical for developing novel micro-scale thermal-fluidic devices, space-based or low-gravity thermal systems, and effective management of very high heat fluxes and heat transfer rates in a broad spectrum of micro-scale devices (MEMS, Lab-on-Chip, sensors, etc.) to large-scale power and thermal-management systems, among others.