SEPARATION OF VAPOR FROM LIQUID IN ELECTRICALLY DRIVEN LIQUID FILM FLOW BOILING

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The enhancement of pool boiling, evaporation, and condensation heat transfer is of crucial importance to many industries, including the heating ventilating air conditioning (HVAC), power, process, electronics, and aerospace industries. A variety of enhancement techniques have been researched and implemented to a limited range of industrial applications. These techniques are commonly referred to as passive and active means of heat transfer enhancement.

Electrohydrodynamic (EHD) phenomenon involves the interaction between flow fields and electric fields in a dielectric fluid medium. EHD conduction pumping is primarily driven by the Coulomb force acting on free space charges which are redistributed to the vicinity of the energized electrodes. Free charges are formed due to the imbalance in the dissociation and recombination of neutral electrolytic species in the dielectric fluid. Proper asymmetric design of the electrodes generates net axial flow motion, pumping the fluid [1]. EHD conduction pumps can be used as the sole driving mechanism for small-scale heat transport systems and have a simple electrode design, which allows them to be fabricated in exceedingly compact form (down to micro-scale). EHD conduction is also an effective technique to pump a thin liquid film in the presence and absence of gravity.

Dielectrophoresis is a translational motion of neutral matter in a non-uniform electric field [2]. The non-uniform electric field results in field induced polarization of vapor bubbles or droplets in the medium. Unlike the Coulomb force (which acts on free charges), the DEP force acts on the polarized charges and can be used to influence vapor bubble motion during nucleate boiling or droplet motion during condensation.

This presentation will provide the experimental results of active augmentation of heat transfer with the application of external electrical fields in boiling. Specifically, EHD conduction pumping is combined with dielectrophoresis extraction force in liquid film flow boiling [3]. The results show remarkable enhancements exceeding 1000% in boiling heat transfer coefficient at a given superheat when both mechanisms are used simultaneously. The experimental data are important for applications in thermal management in terrestrial and space conditions. Select results in the absence of gravity will be presented as well.

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REFERENCES:

1. Atten, P. and Yagoobi, J. S., "Electrohydro-dynamically induced dielectric liquid flow through pure conduction in point/plane geometry", *Transactions on Dielectrics and Electrical Insulation*, 2003, Vol. 10, pp. 27-32.
2. Pohl, H. A., "Dielectrophoresis: The Behavior of Neutral Matter in Non-uniform Electric Fields", Cambridge University Press, Cambridge, UK, 1978.
3. Patel, V.K. and Yagoobi, J. S., "Combined Dielectrophoretic and Electrohydrodynamic Conduction Pumping for Enhancement of Liquid Film Flow Boiling", *ASME Journal of Heat Transfer,* June 2017, Vol. 139, pp. 061502-1 to 9.