Amgen Seminar Series in Chemical Engineering

in

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Graphene and Copper Coatings for Phase Change Heat Transfer

By

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Phase change heat transfer is crucial to various engineering applications. Some prominent examples include distillation reboiler, nuclear reactor, high-powered electronic systems, and refrigeration. Boiling is a heat transfer process accompanied by phase change from liquid to vapor, subsequently, pool boiling involves the boiling of a stagnant liquid over a heated surface. This talk aims to examine the physical mechanisms of boiling heat transfer that are of prime importance to quantify the efficacy of the process. For various manifestations, the pool boiling performance of a surface is dictated by higher critical heat fluxes and heat transfer coefficients. This talk examines various strategies to create multiscale surface-active engineered surfaces with tunable properties essentially roughness, porosity, hydrophilicity, wickability and wicking rates and their influence on the heat transfer properties. First, several surface engineering methods and the resultant physical properties that can effectively modify the vapor bubble dynamics will be discussed using multiscale graphene coatings as an example. The second part of the talk will focus on electrodeposited graphene nanoplatelet (GNP) enriched copper composite coatings formed systematically by increasing the GNP concentration to yield hierarchal porous structures. These superhydrophilic with very high wicking rates resulted in high critical heat flux (CHF) and heat transfer coefficient (HTC). The copper/2 wt% GNP (weight/volume) composites exceeded the highest pool boiling performance reported in literature with a CHF of 286 W/cm^2 and HTC of 204 kW/m^2-°C, representing an improvement of 130% in CHF and 290% in HTC over a polished copper surface. High thermal conductivity along with improved hydrophilicity and wickability of the copper/GNP coatings are attributed for the enhanced CHF. High-speed images revealed reduced bubble departure diameters and micro-size pores on the electrodeposited surface serving as nucleation sites. The increase in the bubble frequency and delayed formation of vapor blanket resulted in enhanced heat transfer properties.

Bio: Anju Gupta graduated from University of Rhode Island with her doctorate in Chemical Engineering from Geoff Bothun's laboratory in May 2012. Her Intefacial Thermal and Transport lab studies phase change heat transfer on novel substrates, and transport mechanisms across the cell membrane. Dr Gupta has received funding from NSF, ACS PRF and Ward Ford Foundation and hold two patents. Dr. Gupta is an active member of AIChE , ACS, North American Thermal Analysis Society and ASEE and has published her work in a variety of scientific and education journals.

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