"Enhanced Condensation Heat Transfer for Water and Beyond"

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Refreshments at 3:30, 116 Upson Hall

ABSTRACT
Vapor condensation is routinely used as an effective means of transferring heat or separating fluids for applications ranging from personal electronic device thermal management to natural gas processing and electrical power generation. Filmwise condensation, where the condensed fluid forms a liquid film, is prevalent in typical industrial-scale systems. Conversely, dropwise condensation, where the condensate forms discrete liquid droplets, results in an improvement in heat transfer performance of up to an order of magnitude compared to filmwise condensation, but it is not commonly used due to durability concerns with the required coatings. In the first part of my talk, I discuss the use of graphene, which is hydrophobic in nature, to achieve robust dropwise water condensation. We experimentally demonstrated a 400% improvement in water condensation heat transfer compared to filmwise condensation with robustness superior to state-of-the-art monolayer hydrophobic coatings. Meanwhile, low surface tension condensates pose a unique challenge since they often form a film, even on hydrophobic coatings. In the second part of my talk, I discuss lubricant infused surfaces (LIS), where a lubricant immiscible with the condensate is infused into a rough structure on the condenser surface to repel low surface tension fluids. I will present a detailed surface-energy-based model to provide design guidelines for any arbitrary solid-lubricant-condensate system. Heat transfer coefficients during dropwise condensation of low surface tension fluids on LIS were also characterized in a controlled environmental chamber for the first time. The improved heat transfer coefficients realized by this design present opportunities for significant energy savings in thermal management, heating and cooling, and power generation.

BIOGRAPHICAL SKETCH
Daniel Preston is a postdoctoral fellow in the Whitesides Research Group at Harvard University; prior to this appointment, he obtained his Ph.D. in Mechanical Engineering at MIT. Dan investigates phase change heat transfer for enhanced efficiency in electrical power generation and improved electronic device cooling. He has approached this goal from many angles, including “jumping droplets” on superhydrophobic surfaces, electrowetting-on-dielectric droplet manipulation, application of graphene and rare earth oxide coatings, and highly-porous wicking materials. During Dan’s six years of experience researching micro/nanoscale engineering, fluid mechanics, and heat transfer, he has directly supervised nineteen undergraduate students and produced twenty journal papers. Dan is a recipient of the NSF Graduate Research Fellowship, the Tau Beta Pi Fellowship, and the Wunsch Foundation Silent Hoist and Crane Award for Outstanding Graduate Research.