nanoFin Effect (nFE)

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BIOGRAPHY: Prof. Banerjee was selected as a Fellow of ASME in 2016 and the Dean's Fellow of EnMED (School of Engineering Medicine) in 2019. He served as an Associate Editor (AE) of the ASME Transactions Journal of Heat Transfer and ASME Journal of Energy Resources Technology. In the recent past, he has served as an AE and multiple times as Guest Editor (Special Issue) for the ASME Journal of Nanotechnology in Engineering & Medicine. He received his Ph.D. in Mechanical Engineering (with minor in MEMS) from the University of California, Los Angeles (UCLA), and the Bachelor of Technology (Honors) in Mechanical Engineering from the Indian Institute of Technology (IIT-Kharagpur). He supervised research of 35 undergraduates (3 honors thesis) and 45 graduate students (20 PhD and 25 MS), yielding more than 200 archival publications. He received 17 US patents from his prior research work at Applied Biosystems Inc./ ABI (Life Technologies, CA), NanoInk Inc., Ciphergen Biosystems Inc., Coventor Inc., Tata (India) and TAMU. He was selected for "ASEE Summer Faculty Fellowship ('06, '07, '09)" at AFRL (Dayton, OH) and at Space & Naval Warfare Center/ SPAWAR-SSC (San Diego, CA).

ABSTRACT: We are leveraging bio/micro/nano-technologies for augmenting bio-sensing, cooling, energy storage and safety systems (involving both experimental and computational studies). The presentation will encompass these topics:

Nano-Coatings (Nano-Fins): *Nano-thermocouples* and *diode temperature nano-sensors* integrated with *nano-coatings* enhanced the non-linear coupling of thermal and hydrodynamic transport during phase change (boiling, condensation) which causes spatio-temporal fluctuations of temperature (boiling chaos and fractal structures) at the micro/ nano-scales. These are called "*cold- spots*" and transmit over 60-90% of the total heat flux. *Nano-coatings* enhanced heat flux by 100% in compact condensers.

Using *silicon nanofins* - cooling was enhanced by ~120%. Using *Carbon-Nanotube (CNT)* nano-coatings - cooling was enhanced by 60~300% by leveraging cold-spots and the *"**nano-fin effect (nFE)**"* (i.e., in excess of the enhanced surface area).

Nano-Fluids: *Specific heat capacity was enhanced* by ~120% for ***nanofluids***., which can be leveraged for Thermal Energy Storage (TES) in Small Modular Reactors (SMR) and Concentrated Solar Power (CSP) using molten salt nanofluids. Flow of nanofluids in a microchannel showed that the precipitated nanoparticles behaved as nanofins (***nFE***). ***nFE*** dominate heat transfer for micro/nanoscale flows while reducing corrosion by 2~4 times.

Phase-Change Materials (PCM) & Machine Learning (ML): *The reliability of PCM was demonstrated for 1000 cycles of repeated melting and solidification using additives (nucleation promoters).* Machine Learning (AI/ ML) techniques were deployed for improving reliability of TES platforms that leverage PCMs for mitigating Food-Energy-Water (FEW) nexus. We are extending this work for a solar-desalination platform using swirl-flow flash-evaporation and phase-separation platform. Effectiveness of 3-D Printed Heat Exchangers (TES) was enhanced using PCM and tested successfully for electronics cooling in self-driving electric-cars (students won 2018 SAE awards).

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