nanoFin Effect (nFE)

Debjyoti Banerjee, Ph.D.
Professor, *J. Mike Walker '66 Department of Mechanical Engineering* [MEEN],
Professor (Joint Courtesy Appointment), *H. Vance Department of Petroleum Engineering* [PETE],
James J. Cain '51 Faculty Fellow I, College of Engineering [COE], TAMU
Texas A&M University [TAMU]

Dean's Fellow, Inter-Collegiate School of Engineering-Medicine (EnMed)
Adjunct Faculty (Courtesy), *Department of Medical Education*, College of Medicine [COM]

Address: Mail Stop 3123 TAMU, College Station, TX 77843-3123. Web: http://db.tamu.edu
Tel: (979) 845-4500, Fax: (979) 845-3081 Email: drdebban@yahoo.com, dbanerjee@tamu.edu

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).* 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).