Mechanical & Aerospace Engineering

seminar

Manipulating Polarization for Thermoscience Applications: Solid-State Refrigeration to Finger-Actuated Digital Microfluidics

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abstract

In this talk, we will present an overview of research projects at the Multiscale Thermosciences Lab (MTSL) at UCLA with a focus on two areas, where we explore the use of polarizable dielectric materials 1) in powering digital microfluidic devices for portable lab-on-chip applications and 2) in realizing high-efficiency solid-state coolers to combat the global climate change.

Finger-Actuated Digital Microfluidics: We report finger-actuated digital microfluidics (F-DMF) based on the manipulation of discrete droplets. Instead of requiring an external power supply or high-voltage circuits, our F-DMF uses mechanical work by human fingers to manipulate polarizations in piezoelectric materials and generate electric voltage pulses for droplet actuation. Using this energy conversion scheme, we have successfully demonstrated basic modes of droplet operation based on the electrowetting on dielectric (EWOD) and electrophoretic phenomenon, such as droplet transport and merging. F-DMF offers intriguing paths for various portable and other microfluidic devices where access to high-voltage power sources is limited.

Electrocaloric (EC) Cooling: Solid-state coolers have received renewed interest lately to complement or potentially replace existing refrigerators and air conditioners based on vapor compression cycles. Refrigerants currently used in vapor compression cycles present significant global warming potential, orders of magnitudes larger than that of CO_2. We will present our studies of an alternative solid-state cooling concept based on the electrocaloric (EC) effect.

abstract cont'd The EC effect refers to changes in the temperature of a dielectric material when an external electric field is applied to, and removed from, the material to change its electric polarization. Since the EC effect is a reversible phenomenon, the efficiency of EC cooling can closely approach the Carnot limit, making it promising for distributed building HVAC and semiconductor device cooling applications.

biosketch

Professor Y. Sungtaek Ju received his PhD degree from Stanford University in 1999. He worked as a research staff member at IBM Research, leading the development of magnetic sensors, micro/nanoscale fabrication, and thermal management technologies, before joining UCLA in 2003. His research group is engaged in a wide variety of interdisciplinary research projects, focusing on micro/nanoscale transport and interfacial phenomena. These include the development of human-powered portable lab-on-chip devices and the development of novel materials/device architectures for energy harvesting and water conservation applications. Professor Ju has served as PI for interdisciplinary projects sponsored by DARPA, NSF, ARPA-E, AFOSR, and DOE.