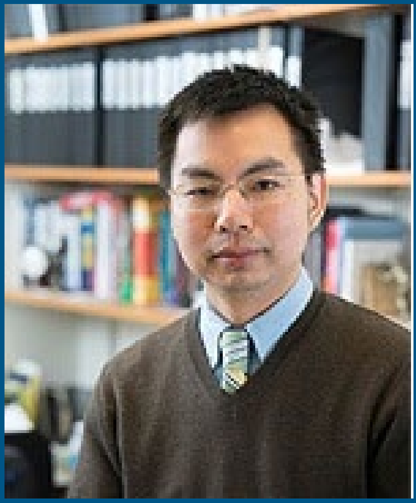
UCLA Samueli School of Engineering

Mechanical & Aerospace Engineering Departmental Seminar



Thursday, June 8, 2023, 3 PM – 4 PM
Engineering IV: 37-124

Pushing the Limits of Thermal Transport to Address Electronic, Energy, and Climate Challenges

Xiulin Ruan
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ABSTRACT: This talk will overview our recent effort in pushing the limits of thermal transport to address challenges in electronics thermal management, high temperature applications, sustainable energy, and climate crisis. The first part of the talk will cover our development of the general formulation and computational method of four-phonon scattering, and prediction of the unexpected significance of four-phonon scattering in thermal conductivity, thermal radiative properties, and Raman spectra. Our predictions have been confirmed by a wide range of experiments, including high and low thermal conductivity materials. For complex crystals at high temperature, the conventional phonon mean free path concept is insufficient, and we propose a dual-phonon transport theory to better describe their thermal transport. The second part will cover the invention of ultrawhite paints that can cool below the ambient temperature under direct sunlight without consuming power. We have fabricated $CaCO_3$-acrylic, $BaSO_4$-acrylic, and hBN-acrylic paints that reflect 95.5%, 98.1%, and 97.9% of sunlight respectively. The sky window emissivity is high. Therefore, these paints can emit more infrared heat than the absorbed solar irradiation, cooling the surfaces up to 4.5 °C below the ambient temperature and achieving a cooling power up to 117 W/m^2. Our predictions show that such high performance is due to pushing a few factors to the extreme simultaneously: moderately high electronic band gaps that eliminate solar absorption while yielding reasonably high refractive index, abundant vibrational modes in acrylic and $BaSO_4$, strong four-phonon scattering in $BaSO_4$, particle size in the neighborhood of solar photon wavelength, a broad particle size distribution, and high particle concentration. Radiative cooling paints can have broad implications from saving energy to mitigating climate crisis. The talk will close by exploring future opportunities.

BIO: Dr. Xiulin Ruan is a professor in the School of Mechanical Engineering and Birck Nanotechnology Center at Purdue University. He received his B.S. and M.S. in Engineering Thermophysics at Tsinghua University, in 2000 and 2002 respectively. He then received an M.S. in electrical engineering in 2006 and Ph.D. in mechanical engineering in 2007 from the University of Michigan at Ann Arbor. Subsequently he joined Purdue faculty. His research and teaching interests are in predictive simulations, scalable manufacturing, and multiscale characterizations of thermal transport materials and systems. Dr. Ruan received several awards, including NSF CAREER Award in 2012, Air Force Summer Faculty Fellowship in 2010, 2011, and 2013, ASME Heat Transfer Division Best Paper Award in 2015, Purdue University School of Mechanical Engineering Outstanding Engineering Graduate Student Mentor Award in 2016 and 2022, University Faculty Scholar Award in 2017, College of Engineering Research Excellence Award in 2022, Guinness World Record in 2022, South by Southwest (SXSW) Innovation Award for Sustainability in 2023, Brillouin Medal from the International Phononics Society in 2023, and was elected an ASME Fellow in 2020. He currently serves as an associate editor for the ASME Journal of Heat and Mass Transfer.

Light refreshments will be served

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