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Engineered Nanostructured Materials for Advanced Thermal Management, Rectification, and Encryption

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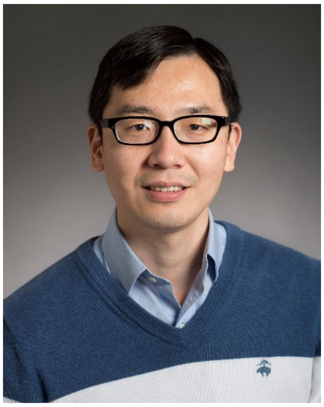
Date： Monday, July 22, 2024 10:30-11:30
Venue：Faculty of Engineering Bldg. 2, Room 31A



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Abstract: In this talk, I will give three examples about utilizing specially engineered nanostructured materials to develop advanced thermal components. First, I will introduce new types of nanostructured thermal interface materials that can thermally bridge the interfaces with ultra-low thermal resistance and mechanical compliance. Compared with the state-of-the-art thermal interface materials, the nanostructured thermal interface materials exhibit a thermal resistance as small as about 0.5 mm^2K/W, polymer-like compliance, and exceptional long-term reliability with >1,000 thermal cycles over a wide temperature range. With the significantly enhanced heat transfer and reliability, these nanostructured thermal interface materials hold great promise for enhancing the thermal management of energy-dense devices and systems, contributing to future energy efficiency and sustainability. Second, I will report an ultra-high-contrast and reversible nanoscale thermal switch based on the structural phase transition in crystalline polyethylene nanofibers, which enables a ~ 10X thermal switching ratio between the on-state (high) and the off-state (low) thermal conductance values. The observed high switching ratio exceeds by far any reported experimental values for solid-solid phase transition, solid-liquid phase transition and desiccation-hydration of materials. By fabricating a heterogeneous “irradiated-crystalline nanofiber junction” using an electron beam, we also demonstrate a high-performance solid-state nanoscale thermal diode with a rectification factor as high as ~ 54 %. Finally, I will present the design and fabrication of bio-inspired brochosome structures with and without through-holes, which appear visually similar under visible light but have their thermal emission profiles significantly distinct from each other. Such a property allows us to encode physical information with brochosome arrays that can only be decoded under infrared signals, which is potentially useful in the areas of thermal encryption, infrared holograph, and data storage.

Biography: Sheng Shen is a Professor at the Mechanical Engineering Department of Carnegie Mellon University (CMU). He also holds courtesy appointments in both the Electrical and Computer Engineering and the Materials Science and Engineering Departments at CMU. He received his PhD degree from the Mechanical Engineering Department, MIT, in 2010. Prior to joining CMU in 2011, he conducted his postdoctoral research at UC-Berkeley. His research interests include nanoscale heat transfer and energy conversion, nanophotonics, and their applications in energy conversion, thermal management, sensing, and multifunctional materials. Professor Shen is a recipient of NSF CAREER Award, DARPA Director's Fellowship, DARPA Young Faculty Award, and Elsevier/JQSRT Raymond Viskanta Award for Spectroscopy and Radiative Transfer. He also received the CMU Dean's Early Career Fellowship, the Philomathia Foundation Research Fellowship in Alternative Energy Research from UC-Berkeley, a Hewlett-Packard Best Paper Award from ASME Heat Transfer Division, and a Best Paper Award in Julius Springer Forum on Applied Physics.

主催： 東京大学大学院工学系研究科専攻間横断型教育プログラム 機械システム・イノベーション（GMSI）
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