Nanostructured Thermal Interface for Advanced Thermal Management

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Thermal resistance of interfaces has been widely identified as the critical technical bottleneck in cooling electronic devices and systems. The “ideal” thermal interface materials must simultaneously possess high thermal conductivity for minimizing thermal resistance, and high flexibility and compliance for adapting to soft and curved surfaces and accommodating the thermal stress derived from the mismatch of thermal expansion between two jointed materials. However, conventional thermal interface materials, such as solders, greases, gels and epoxies, cannot satisfy the demanding technical criteria, making the development of high-performance thermal interfaces extremely imperative. Solders display high thermal conductivity but feature poor mechanical compliance. Thermal greases, epoxies and other polymer-based composites have high compliance but struggle with low thermal conductivity. Here we demonstrate new types of nanostructured thermal interface materials that can thermally bridges 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 demonstrate a thermal resistance as small as about 0.5 mm²K/W and polymer-like compliance. They exhibit exceptional long-term reliability with >1,000 thermal cycles over a wide temperature range. With the significantly enhanced heat transfer and compliance, these nanostructured thermal interface materials can greatly benefit flexible electronics and microelectronics by allowing the systems to reliably operate at lower temperatures or at the same temperature but with higher performance and higher power.

BIOGRAPHY

![Sheng Shen](image)
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.