Superstructured hybrid materials with unusual thermal transport behaviors

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主讲人：Wee-Liat Ong 浙江大学副教授

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举办单位：生命与环境科学学院

主讲人简介：

Wee-Liat graduated with a BEng in Mechanical Engineering from the National University of Singapore (NUS) and was the valedictorian of his class as well as the recipient of the IES gold medal and Lee Kuan Yew gold medal in 2002. He joined the Institute of Microelectronics, Singapore and worked in the fields of bioMEMS and microfluidics. In 2015 he received his PhD in Mechanical Engineering at Carnegie Mellon University under Prof. Jonathan Malen and Prof. Alan McGaughey, where he studied nanoscale heat transfer focusing on organic-inorganic nanostructured materials using both experimental and simulation techniques. Before coming to Zhejiang University, he is a joint post-doctoral fellow at Columbia University and Carnegie Mellon University working with chemists to characterize novel hybrid materials.

内容简介:

Superstructured hybrid materials self-assemble from solutions and are scalable replacements for single crystal semiconductors for many technologies. Although their electrical, electronics, and optoelectronics properties have been investigated, thermal properties of these materials remain relatively unchartered. This inhibits technological adoption where thermal management is requisite to prevent performance and lifetime degradation. In this talk, I will focus on thermal transport in two hybrid material systems – nanocrystal arrays (NCAs) and superatom crystals (SACs). NCAs are organized arrays of ligand-stabilized colloidal nanocrystals with size-tunable electronic and optical structure. SACs are periodic self-assemblies of superatoms which are clusters of atoms that behave as a unit with emergent properties distinct from their elemental atoms. In my presentation, I will explain the mechanisms of thermal transport in these three-dimensional organic-inorganic superstructured materials. I have used the frequency domain thermoreflectance technique to measure the thermal conductivity in NCA thin films and nanoliter-sized SAC single crystals. Complementing these experiments, I employed molecular dynamics simulations, lattice dynamics calculations, and density functional theory calculations to interpret the measurements and explore experimentally-inaccessible nanoscale phenomena. The thermal conductivity of the NCAs is controlled by the organic-inorganic interface. Room temperature thermal conductivity measurements of various SACs depict a dependence on their group velocities, indicating the importance of cooperative modes. Temperature dependent measurements elucidate the importance of dynamic disorder in SACs for thermal transport. The low thermal conductivity measured in the NCAs presents a challenge for thermal management but a boon for thermoelectric waste heat scavenging. The SACs exhibit a tunable amorphous to crystalline thermal conductivity behavior, suggesting the possibility of using them for applications in phononic and active thermal transport switching.

徐汇校区:上海市徐汇区桂林路100号 | 奉贤校区:上海市奉贤区海思路100号 联系电话：021-64322000
邮政编码：200234