STEVENS
INSTITUTE OF TECHNOLOGY
1870

Ph.D. DISSERTATION DEFENSE

Candidate: Yingtao Wang
Degree: Doctor of Philosophy
School/Department: Charles V. Schaefer, Jr. School of Engineering and Science / Mechanical Engineering Department
Date: Monday, August 18, 2025
Time/Location: 9:00 a.m. / Carnegie 207
Title: Manufacturing and Thermal Transport Properties of Flexible Two-Dimensional Materials

Chairperson: Dr. Annie Zhang, Department of Mechanical Engineering, School of Engineering and Science

Committee Members: Dr. Eui-Hyeok Yang, Department of Mechanical Engineering, School Of Engineering and Science
Dr. Chang-Hwan Choi, Department of Mechanical Engineering, School of Engineering and Science
Dr. Stefan Strauf, Department of Physics, School of Engineering and Science

ABSTRACT

This dissertation presents a comprehensive investigation into the thermal transport properties of two-dimensional (2D) materials, with a focus on how strain engineering can modulate phonon and electron transport. A combination of experimental fabrication, advanced characterization, and first-principles simulations was employed to uncover the underlying mechanisms governing heat and charge conduction in low-dimensional systems.

The synthesis and transfer of high-quality monolayer and bilayer samples of various 2D materials, including graphene, MoS_2, Fe-MoS_2, were achieved by mechanical exfoliation, chemical vapor deposition, and wet transfer. In addition, a laser-based method was proposed to fabricate nanoscale structures with controlled morphology, offering new opportunities for energy-related and emerging quantum technologies.

The influence of tensile strain on thermal conductivity was systematically explored. Strain was found to alter both lattice geometry and defect distributions, leading to enhanced phonon scattering and reduced thermal transport. Bilayer structures, serpentine structure, elemental doping, and heterostructure formation were shown to be effective in mitigating strain-induced degradation, providing useful design principles for stabilizing heat conduction under mechanical deformation.

This work contributes to the fundamental understanding of thermal transport in 2D materials. It demonstrates that mechanical, chemical, and structural modifications can be strategically employed to tailor transport properties, offering practical guidelines for the design of next-generation materials in nanoelectronics, thermal management, and energy conversion applications.