LSU DEPARTMENT OF MECHANICAL ENGINEERING

The Sidney E. Fuchs Seminar Series

3:30-4:20pm, Friday, September 6, 2013
Frank H. Walk Design Presentation Room

Rarefied Flows in Micro- and Nano-Systems: Fundamental Physics and Effects on Device Design

by **Michael J. Martin***

Assistant Professor, Mechanical and Industrial Engineering, LSU

As micro- and nano-structures are integrated into devices, scaling issues, including the breakdown of the continuum limit for gas flows, determine the performance of the device. Accurate simulation of these devices requires not only using gas flow and thermal models that include these effects, but integrating continuum breakdown model with simulations of conduction heat transfer within the device, and thermo-mechanical and thermo-electrical effects.

This talk begins by looking at nano-mechanical devices built around suspended nanowires. Free-molecular models for the gas flow and heat transfer are combined with structural, thermal, and electrical models to predict the performance of the devices. We then continue to cover momentum and heat transfer through arrays of carbon-nanotubes, where the variety of length scales encountered ranges from the continuum to the free-molecular.

A related set of issues is encountered in the thermal actuation of micro- and nano-bridges. We look at two cases- using a steady heat input for device positioning, and using a sinusoidal heat addition to create a vibration in the system. The devices obey a macro-scale non-dimensional scaling law. However, nano-scale effects such as a pressure-sensitive heat transfer coefficient, and thermal vibration of the molecules of the bridge, still play a large role in determining the performance of the system.

In the rarefied gas regime, flows are also affected by surface properties. At the free molecular limit, shear stress, pressure, and heat transfer depend on molecular collisions at the surface. The nature of the collision is captured using accommodation coefficients. However, these accommodation coefficients are not well characterized. An experimental method for measuring these coefficients, and preliminary results, will be presented.

* Michael James Martin is an Assistant Professor of Mechanical Engineering at Louisiana State University in Baton Rouge, LA. He completed his Bachelor's in Mechanical Engineering at the University of Florida, and an MS in Mechanical Engineering, an MA in East Asian Studies, and a PhD in Aerospace Engineering at the University of Michigan. While in graduate school, he was a visiting researcher at Hitachi's Mechanical Engineering Research Laboratory, and a Science and Technology Policy Fellow at the National Academies. He joined the LSU faculty in 2008, after post-doctoral work at the Naval Research Laboratory in Washington, DC. He has also spent two summers as a NASA-JPL Faculty Fellow in the Micro Devices Laboratory at the Jet Propulsion Laboratory in Pasadena, CA. His research interests include micro-scale heat transfer and fluid mechanics, rarefied gas dynamics, and space systems design.