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Surprises in Heat Transport in Sub-100 nm thin films and nanostructures: From Breaking the "Law to Putting a New Spin on Metals[1]

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Nanoscale engineering of materials for heat management or energy harvesting brings both tremendous promise and serious fundamental measurement challenges. For materials ranging from graphene to carbon nanotube hybrids to nanomagnetic systems or films, samples with one or more dimensions on the sub-100 nm scale are always difficult to thermally characterize. Our approach to these measurements uses micro- and nanomachined thermal isolation platforms that allow exceptional control over thermal gradients and unambiguous alignment of this gradient in the plane of a thin film or nanoscale sample. Micromachined electrical leads enable thermal conductivity, electrical conductivity, and Seebeck effect measurements all on the exact same sample. This allows a particularly powerful probe of the fundamental physics of thermal and thermoelectric transport, which has often revealed surprising behavior. In this talk I will overview several recent results including investigations of increased thermoelectric potential in semiconducting carbon nanotube systems, reduced thermal conductivity in thin gold films where a violation of the Wiedmann-Franz Law occurs, and the first indication of spin waves contributing to heat flow in a metallic ferromagnet.

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