Nanoscale thermal transport and unconventional thermoelectric phenomena in 2D materials

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Resume : With 2D materials such as graphene (GR) and hexagonal boron nitride possessing highest known thermal conductivities, one-atom thick nature of these materials makes thermal transport in them drastically dependent on the local environment. Moreover, the equally extraordinary electronic properties of GR such as relativistic carrier dynamics combined with GR highly anisotropic thermal conductance may point to unusual thermoelectric properties. In order to study thermal and thermoelectric phenomena in these nanoscale materials, we applied scanning thermal microscopy (SThM) that uses a sharp tip in contact with the probed surface that can create a controlled local sample temperature rise in the few nm across spot, while measuring the resulting sample temperature and a heat flow. We used high vacuum environment that eliminates spurious heat dissipation channels to boost accuracy and sensitivity and to allow cryogenic measurements. We show that the thermal resistance of GR on SiO2 is increased by one order of magnitude by the addition of a top layer of MoS2, over the temperature range 150-300 K with DFT calculations attributing this increase to the phonon transport filtering in the weak vdW coupling and vibrational mismatch between dissimilar 2D materials. By measuring the heat generated in the nanoscale constrictions in monolayer GR devices, we have discovered unconventional thermoelectric Peltier effect due to geometrical shape of 2D material and not requiring a junction of dissimilar materials, with phenomenon confirmed by measuring the Seebeck thermovoltage map due to local heating by the SThM tip. The novel nonlinear thermoelectric phenomena due to “electron wind”, and effects of GR doping and layer number are also reported.

https://www.european-mrs.com/nanomaterial-thermal-transport-properties-and-nanothermodynamics-emrs

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