Blocking the Phonon Thermal Transport at the Nanoscale

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The study of thermal conductance of nanowires at very low temperature is quite complex from an experimental as well as a theoretical point of view. Our approach consists in using the 3-omega method to measure the thermal conductance of free standing nanosystems. We report the measurement of thermal conductance of suspended silicon nanowires (200nm, 100nm and 10um) between 0.3K and 6K. It is revealed by the non-trivial temperature dependence of the thermal conductance signature; a mix between ballistic and diffusive transport governed by the competition between the mean value of the roughness and the dominant phonon wavelength. The thermalization of the phonon on the surfaces is strongly modified at the nanoscale by the specular reflection implying an increase of the phonon mean free path. To illustrate that point we measured also nanowires having a serpentine nanostructure evidencing that changes in geometrical shape can strongly affect heat flow. By engineering serpentine shaped nanowires, the phonon transmission is reduced by nearly 40% at temperatures below 5K [1] as compared to the straight nanowires. This amount of reduction is strikingly large demonstrating the blocking of the ballistic phonon transport. We have performed a detailed transmission function analysis going beyond a simple Ziman model. It yields a very satisfactory agreement with experimental measurements.

[1]J.-S. Heron, C. Bera, T. Fournier, N. Mingo, and O. Bourgeois, Phys. Rev. B. **82**, 155458 (2010).