MAR14-2013-008952

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Nanophononics at low temperature: manipulating heat at the nanoscale[1]

OLIVIER BOURGEOIS, Institut Neel, CNRS

Nanophononics is an emerging field of condensed matter that deals with transport of thermal phonons at small length scales. When the section of a waveguide becomes smaller than the mean free path or the phonon wavelength, heat transfer are strongly affected. Here, I will present the results we obtained by ultra- sensitive measurements of thermal conductance of suspended nano-objects (nanowires and membranes) using the 3ω method. This experimental set-up allows the measurement of power as small as a fraction of femtoWatt (10^{-15} Watt). These experiments show that the concepts of mean free path and dominant wavelength are crucial to understand the phonon thermal transport below 10K. The phonon transport, at this temperature, is well described by the Casimir-Ziman model used here to treat the data. The contribution of the thermal contact between a nanowire and the heat bath has been estimated to be close to one, thanks to the fact that the nanowire are made out of monolithic single crystal. Strong reduction of thermal conductance has been obtained in serpentine nanowire where the transport of ballistic phonons is blocked. Moreover, in corrugated silicon nanowire, we showed that the corrugations induce significant backscattering of phonon that severely reduces the mean free path, beating in some cases, the Casimir limit. These experiments demonstrate the ability to manipulate ballistic phonons by adjusting the geometry of thermal conductors, and hence manipulate heat transfer. Finally, the use of these new concepts of engineering ballistic phonons at the nanoscale allows considering the development of new nanostructured materials for thermoelectrics at room temperature, opening exciting prospects for future applications in the energy recovery. J.-S. Heron, T. Fournier, N. Mingo and O. Bourgeois, Nano Letters 9, 1861 (2009). J-S. Heron, C. Bera, T. Fournier, N. Mingo, and O. Bourgeois, Phys. Rev. B 82, 155458 (2010). C. Blanc, A. Rajabpour, S. Volz, T. Fournier, and O. Bourgeois, Appl. Phys. Lett. 103, 043109 (2013).

[1]EU Merging Project grant Agreement No. 309150