Heat flow, transport and fluctuations in etched semiconductor quantum wire structures

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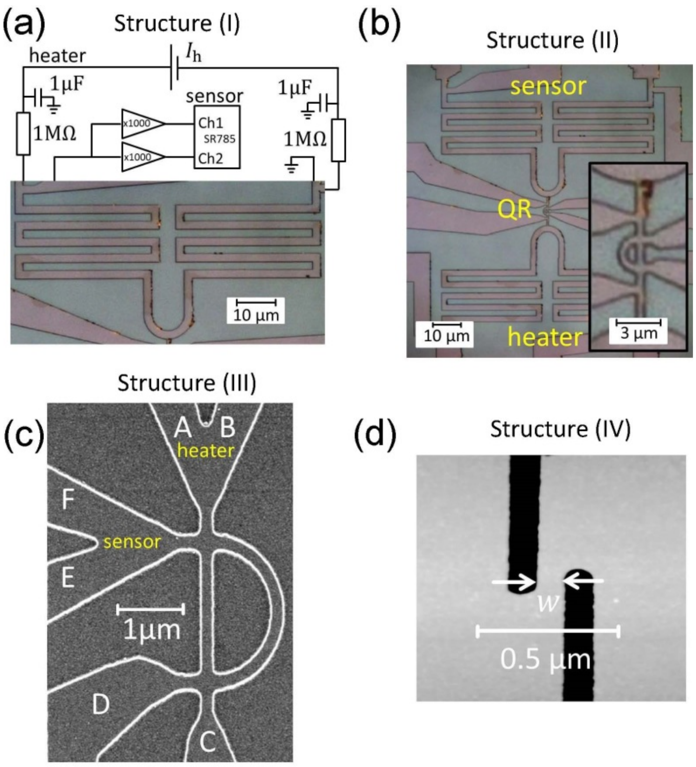
Phys. Status Solidi A **213**, 571-581 (2016).

Short Abstract

Low-dimensional transport in semiconductor meso- and nanostructures is a topical field of fundamental research with potential applications in quantum devices. However, thermal non-equilibrium may destroy phase coherence and is yet to be explored experimentally. Here, we present the effects of thermal non-equilibrium in various implementations of low-dimensional electron systems. These include narrow quasi-two-dimensional (2D) channels, quasi-one dimensional (1D) waveguide networks, and quantum rings (QRs). The electrical conductance and the voltage-noise are measured with respect to bath temperatures, heating currents, thermal gradients and electric fields. We determine and discuss heat transport processes, electron-energy loss rates and electron-phonon interaction, and our results are consistent with the Wiedemann-Franz relation.



Above. Micro- and nanostructures discussed in this work. (a) Optical micrograph of structure (I) with a narrow 2D meander-like channel and a schematic of the noise measurement and heating circuits. (b) Optical micrograph of structure (II): Two narrow 2D channels depicted as heater and sensor are connected by a quantum wire ring (QR). (c) Scanning electron micrograph of structure (III): Extended 1D waveguide network in the form of a QR, fabricated from the same heterostructure as structure (I) and (II), covered by a global Ti/Au top-gate (not shown). The letters A to F refer to 2D electron reservoirs connected by the 1D waveguide network. (d) Scanning electron micrograph of structure (IV): A typical etched quantum point contact (QPC) covered by a global Ti/Au top-gate (not shown).