A single-quantum-dot device is a heat valve violating the Wiedemann-Franz law

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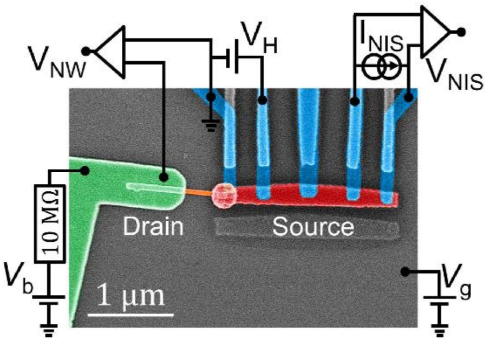
Single-quantum-dot (QD) junctions, which involve electron transport through a single quantum level, are a key element for studying dissipation mechanisms of energetic or 'hot' electrons in quantum electronics. We have studied the thermoelectric and thermal transport properties of such devices. Electron temperature maps taken in the immediate vicinity of the junction, as a function of the gate potential and bias voltage applied to the device, reveal a well-defined Coulomb diamonds pattern. Moreover, the thermal conductance of the device can be tuned with a gate potential: it thus constitutes a heat-valve, in quantitative agreement with the numerical calculations. Eventually, the heat carried by electrons across the quantum dot at resonance is shown to be significantly below the prediction from the Wiedemann-Franz (WF) law. Intuitively, the deviation from WF at resonance can be understood as stemming from the energy selectivity of the device transmission T(E), which is a delta-shaped transport distribution. Therefore, only electrons bound at the Fermi level within an energy window of width of QD's tunnel coupling can effectively tunnel, thereby suppressing contributions of the particles from the high-energy tails of the Fermi distribution. Our observations are well captured by a non-interacting scattering theory.



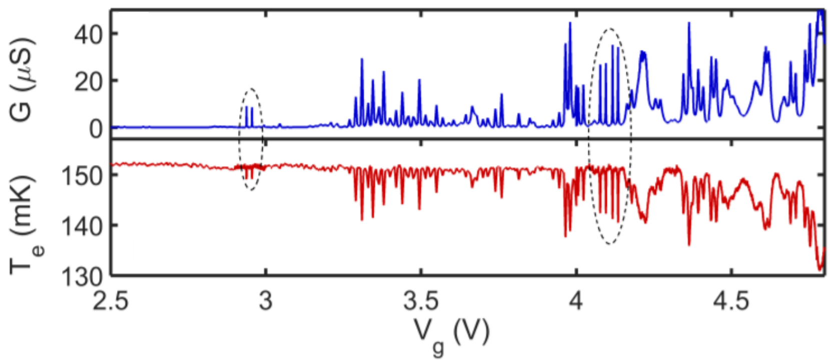


Figure 1. (Left) False-colored scanning electron micrograph of the device. (Top-right) Simultaneous electrical conductance at thermal equilibrium and (Bottom-right) temperature response T_e of the source island with heating power of Q_H = 16 fW as a function of the back gate potential V_g.