The experimental investigation of thermal conductivity and the Wiedemann-Franz law for single metallic nanowires

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A new method for the measurement of thermal conductivity of electrically conducting single nanowires is presented. First experimental investigations are focused on the thermal conductivity of metallic Pt nanowires with a diameter of (typically) 100 nm and a length of 10 μm. Thermal conductivity data are compared with measurements of electrical conductivity in order to test the Wiedemann–Franz law for metallic nanowires. Compared to the bulk values at room temperature, electrical and thermal conductivities of the nanowire are decreased by a factor of 2.5 and 3.4, respectively. Consequently, the Lorenz number $L = \lambda/\sigma\, T = 1.82 \times 10^{-8}\ \mathrm{V^2\ K^{-2}}$ of the nanowire is smaller than the bulk Lorenz number $L_{\mathrm{bulk}} = (\pi^2/3)(k/e)^2 = 2.44 \times 10^{-8}\ \mathrm{V^2\ K^{-2}}$ of metals. Furthermore, the temperature coefficient β of electrical resistivity is also reduced compared to the bulk value. These decreases of λ, σ and β can be attributed to size effects, mainly caused by grain boundary scattering of electrons.