Conductance quantization in magnetic and nonmagnetic metallic nanowires

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Room-temperature electronic transport properties of ferromagnetic quantum wires have not been yet fully understood, and the role of electronic structure of magnetic atoms in the conductance quantization is still under discussion. We present experimental results on the conductance quantization in point contacts between ferromagnetic (Co) or nonmagnetic (Au) wires and 20 nm Co/Si layers. A description of the quantization phenomena is presented in terms of the Landauer formalism. Using the Landauer formula [1], the conductance G can be expressed as

$$G = \frac{e^2}{h}\left(\sum_{i=1}^{N_\uparrow} T_{i\uparrow} + \sum_{i=1}^{N_\downarrow} T_{i\downarrow} \right),$$

where the sums run over all $N_\uparrow$ and $N_\downarrow$ occupied conductance channels (sub-bands) for up and down spin orientations, respectively, and $T_{i\uparrow}$ and $T_{i\downarrow}$ are the corresponding electron transmission probabilities.

Our data have been statistically analyzed by plotting histograms for more than thousand measured conductance values. We obtained typical features of the conductance measured in the units of $G_0=2e^2/h$ and the measurements clearly demonstrate that the room-temperature conductance of Co-Co break-junctions is quantized with the corresponding conductance plateaus at nG_0. Such behavior of the conductance is a consequence of the complex electronic structure of magnetic 3d transition-metal atoms. These results create new opportunities for a deeper understanding of the spin dependent electronic structure of the ferromagnetic quantum wires and may have important implications for the development of future spintronic devices based on magnetoresistance phenomena in ferromagnetic quantum wires and point contact.

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[1] R. Landauer, IBM J. Rev. Dev. **1** (1957) 223 and **44** (2000) 251.

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