Multi-probe scanning tunneling spectroscopy for in-plane electronic transport: theory and experiment

P. Brandimarte[1]
M. Kolmer[2,3], J. Lis[2], R. Zuzak[2], S. Godlewski[2], H. Kawai[4], A. Garcia-Lekue[1,5], N. Lorente[6], T. Frederiksen[1,5], C. Joachim[7], D. Sánchez-Portal[1,6] and M. Szymonski[2]

[1] Donostia International Physics Center, Spain
[2] NANOSAM – Jagiellonian University, Poland
[3] CNMS – Oak Ridge National Laboratory, USA
[4] IMRE – National University of Singapore, Singapore
[5] IKERBASQUE, Basque Foundation for Science, Spain
[6] Centro de Física de Materiales CSIC-UPV/EHU, Spain
[7] CEMES-CNRS, France

brandimarte@pm.me

In a typical experiment using a Scanning Tunneling Microscope (STM) for spectroscopy one measures the electronic transport from the STM tip to the bulk substrate, having an adsorbed molecule or the substrate surface itself as an intermediary which is intended to be characterized. However, the determination of intrinsic transport properties from low dimensional systems (1-D or 2-D) requires at least two in-plane contacts, whose fabrication at nanoscale with high precision can be very challenging. Another possibility is the use of multi-probe STM where more than one tip approach simultaneously the system under analysis with atomic precision.

We introduce a methodology for the characterization of the in-plane electronic transport in atomic-scale circuits engineered on surface with a two-probe STM/spectroscopy.[1] In this joint theoretical and experimental work, we take as a proof of concept the anisotropic Germanium (001) surface and demonstrate a quasi-one-dimensional coherent transport of hot electrons through the Germanium dimers in the surface. Realistic first-principles calculations using Density Functional Theory together with Non-Equilibrium Green's Function formalism [2, 3] of a four-terminal setup involving up to 5000 atoms were carried out to simulate the two-tip experiment on the semiconductor surface. Comparison of both experimental and theoretical results confirm a quasi-ballistic coherent electronic transport through unoccupied states of Germanium dimer wires on the surface.

References

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