TT 9 Transport: Nanoelectronics III - Molecular Electronics

Time: Monday 14:00–17:45 Room: HSZ 304

TT 9.1 Mon 14:00 HSZ 304

Franck-Condon blockade beyond sequential tunneling — •Jens Koch[1], Felix von Oppen[1], and A. V. Andreev[2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Department of Physics, University of Washington, Box 351560, Seattle, WA 98195, U.S.A.

Recent studies of electronic transport through single-molecule devices have revealed that the coupling of electronic degrees of freedom to a well-defined mode of molecular vibrations may result in a significant current suppression (Franck-Condon blockade). This effect also has characteristic consequences for Fano factors and noise spectra. However, similar to the case of Coulomb blockade, higher-order processes beyond sequential tunneling may become relevant in the blockade regime. Here, we discuss the effects of such corrections on the current-voltage characteristics and noise properties of the system.

TT 9.2 Mon 14:15 HSZ 304

Electromechanical properties of a biphenyl transistor — •Andrea Donarini, Utpal Sarkar, Milena Grifoni, and Klaus Richter — Theoretische Physik, Universitätsstraße 31, D-93053 Regensburg

Electrical transport through gated single molecules (also called molecular transistors) has become since a few years an active research field both theoretically and experimentally [1]. We investigate the interplay between electrical and mechanical degrees of freedom in transport across a biphenyl molecule in the Coulomb blockade regime. In particular, we analyze the role played in the electrical transport by the twisting mode between the phenyl rings. At low biases we can restrict our analysis to the neutral and anionic (one extra electron) state of the molecule only. The neutral molecule has two stable configurations at finite dihedral angles ($\theta \approx \pm\pi/4$) while the anion state is planar. Charge transitions between the electrical states are thus modulated by Franck Condon amplitudes that account for the torsional degree of freedom yielding big phonon blockade effects [2]. We study the system using a generalized master equation for the reduced density matrix. We find that, due to the mechanically degenerate neutral state, the coherencies and not only the populations of the reduced density matrix determine the transport characteristics [3].

[1] A. Yacoby *et al.* Nature **436**, 677 (2005)
[2] J. Koch, F. von Oppen, Phys. Rev. Lett. **94**, 206804 (2005)
[3] A. Donarini, U. Sarkar, M. Grifoni and K. Richter in preparation

TT 9.3 Mon 14:30 HSZ 304

Controlled Nanogap Manufacturing for Single Molecule Contacts by Electromigration — •Veit Wagner, Arne Hoppe, and Jörg Seekamp — International University Bremen

Electrical measurements of single molecules require a pair of electrodes separated by a nanogap of only a few nanometers. Many preparation methods lack the possibility to form an additional gate electrode. We report on nanogap formation by electromigration using the substrate as additional gate electrode. A small metal wire of typically 100 nm width is broken by imposing a high current density at l-He temperature. At room temperature (RT) this approach usually leads to gaps much larger than molecular sizes. Recently Strachan et al. reported on successful nanogap production at RT by using an active control scheme for the applied voltage in dependence of the measured conductivity of the wire. Following this approach we present an alternative control scheme, which includes in addition the time derivative of the conductivity and the average noise level. Gold nanowires of 100 nm width and 20nm height with a Ti adhesion layer on a SiO2-surface were prepared by e-beam lithography. A current level of about 5 mA is usually sufficient to start the electromigration process at room temperature. We test different wire shapes, e.g. a long thin wire of constant thickness or a thick wire with a lithographically defined short narrowing. We find the long thin wire to be more demanding for our control loop than a wire with a short narrowing. The regulation behavior of our control loop for various regions of the process is discussed. With our approach we can reproducibly manufacture gaps at RT with gap sizes smaller than 10 nm.

TT 9.4 Mon 14:45 HSZ 304

Atomic-Scale Quantum Switches: An Approach towards Quantum Electronics at Room Temperature — •Thomas Schimmel[1,2], Fangqing Xie[1], and Christian Obermair[1] — [1]Institute of Applied Physics, University of Karlsruhe, D-76128 Karlsruhe, Germany — [2]Institute of Nanotechnology (INT), Forschungszentrum Karlsruhe, D-76021 Karlsruhe, Germany

Using a novel electrochemical approach, we demonstrate the fabrication of bistable atomic-scale metallic point contacts, which can be reproducibly opened and closed by means of a voltage applied to an independent third electrode used as a gate electrode [1]. In this way, an electrical circuit can be opened and closed by the controlled and reproducible reconfiguration of the contacting atoms. After the fabrication of the atomic-scale contact by electrochemical deposition of silver within a nanoscale gap, the bistable configuration of the contact is achieved by an electrochemical cycling process. When the contact is closed, is shows conductance quantization, the conductance being $G_0 = 2e^2/h$ or predefined multiples of this value, the on-state conductance being controlled by the cycling parameters. The device reproducibly operates at room temperature. It represents a first demonstration of an atomic relay or transistor, opening intriguing perspectives for the emerging fields of quantum electronics and logics on the atomic scale.

[1] F.-Q. Xie, L. Nittler, Ch. Obermair and Th. Schimmel, Phys. Rev. Lett. 93, 128303 (2004).

TT 9.5 Mon 15:00 HSZ 304

Spin-dependent transport through individual carbon nanotubes — •Emiliano Pallecchi[1], Dominik Preusche[1], Elsa Thune[1], Benoit Witkamp[2], Alberto Morpurgo[2], and Christoph Strunk[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [2]Kavli Institute of Nanoscience, TU Delft, Netherlands

We report on experiments on carbon nanotubes (CNTs) with ferromagnetic contacts made from $Pd_{0.6}Fe_{0.4}$ alloys. The nanotubes and the micromagnetic properties of the contacts have been characterized by high resolution TEM and Lorentz-microscopy. We have performed low temperature magnetoconductance measurements on individually contacted CNTs as a function of gate voltage and magnetic field. From the weak localization effect in multiwall CNTs we get a signature of the band structure. The low field magnetoconductance shows a hysteretic switching behavior that we attribute to the magnetization reversal of the contacts. The amplitude of the low-field magnetoconductance varies strongly with gate voltage.

TT 9.6 Mon 15:15 HSZ 304

Electron transport in bundles of metallic single-walled carbon nanotubes — •Christoph Wolfgang Marquardt[1], Frank Hennrich[1], Hilbert v. Löhneysen[2,3], and Ralph Krupke[1] — [1]Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021 Karlsruhe, Germany — [2]Universität Karlsruhe, Physikalisches Institut, 76128 Karlsruhe, Germany — [3]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, 76021 Karlsruhe, Germany

Concerning the electronic transport properties, an individual metallic single-walled carbon nanotube (SWNT) has been described as a Luttinger liquid system (LL). This regime can describe the power law behaviour found in the temperature dependent conductance, as well as in the voltage dependent differential conductance [1]. In heterogeneous bundles of SWNTs, that are composite bundles of metallic and semiconducting tubes, similar power law behaviour has been observed [2], which implies, that the metallic tubes in a heterogeneous bundle are well decoupled from each other by the semiconducting nanotube matrix. During the fabrication of carbon nanotubes both metallic and semiconducting ones are produced. Using dielectrophoresis as method to separate these types [3], we are able to prepare samples of bundles of exclusively metallic SWNTs, i.e. without the semiconducting nanotube matrix. Here we present measurements of the transport characteristics of such samples, that show obvious deviation from the LL behaviour.

[1] M. Bockrath et al., Nature 397 (1999) 598 [2] R. Krupke et al., Nano Lett. 3 (2003) 1019 [3] R. Krupke et al., Science 301 (2003) 344