O 35: Symposium: Atomic Wires at Surfaces II (Invited Speakers: Erio Tosatti, Serge Lemay, Shuji Hasegawa)

Time: Tuesday 14:00–16:45 Location: HE 101

Invited Talk O 35.1 Tue 14:00 HE 101

Magnetic phenomena, spin orbit effects, and electron transport in*nanowire contacts, particularly in Platinum — •Erio Tosatti[1,2], Alexander Smogunov[2,1], Andrea Dal Corso[1], Anna Delin[3], and Ruben Weht[4] — [1]SISSA and Democritos, Trieste, Italy — [2]ICTP, Trieste, Italy — [3]KTH Stockholm, Sweden — [4]CNEA San Martin, Argentina

Nanocontacts between metal tips take in some instances the shape of ultra-thin suspended nanowires. Ballistic electron conductance through nanowire contacts is calculated based on plane wave/ultrasoft pseudopotential code developed to handle magnetism and spin orbit. As an application, the effect of magnetism on conductance will be demonstrated for monatomic contacts of 3d metals such as Ni and Co [1] with results in good agreement with break junction data.[2] Next, I will describe a new form of nanomagnetism, consisting of the spontaneous appearance of local magnetism at the nanocontact even in transition metals that are nonmagnetic in bulk such as Pt or Pd. The presence of nanomagnetism should in principle affect the conductance, as is demonstrated by direct calculation. Due to strong spin orbit, magnetism in a monatomic Pt nanowire or nanocontact should provide a novel case of "colossal magnetic anisotropy".[3] [1] A. Smogunov et al., Phys.Rev.B 70, 045417 (2004); Phys. Rev. B 74, 045429 (2006). [2] C. Untiedt, et al., Phys. Rev. B 69, 081401 (2004). [3] A. Delin and E. Tosatti, Phys. Rev. B 68, 144434 (2003); A. Delin, et al., Phys. Rev. Lett. 92, 057201 (2004); A. Smogunov, A Dal Corso, A. Delin, R. Weht and E. Tosatti, to be published.

O 35.2 Tue 14:30 HE 101

One-dimensional low energy plasmons in Au atom chains — •Tadaaki Nagao — World Premier International(WPI) Research Center, International Center for Materials Nanoarchitectonics(MANA), National Institute for Materials Science (NIMS), 1-1 Namiki, Tsukuba 305-0044 JAPAN

Sound-wave-like collective excitation in dense one-dimensional (1D) electron systems confined to Au atom chains on the Si(557) surface is investigated [1]. Electron energy loss spectroscopy using a highly collimated slow electron beam has detected a characteristic low-energy 1D plasmon (wire plasmon) that Tomonaga has mentioned in his theory [2]. This plasmon freely propagates along the Au atom chain and appears as that of 1D free electron gas. However, theoretical analysis adopting a quantum-mechanical scheme beyond the free-electron model indicates a significant dynamic exchange-correlation effect due to strong 1D confinement. By cooling to below 100 K, we detected for the first time a significant change in the plasmon dispersion in the tiny momentum and energy region, which definitely reflects a tiny gap opening due to a metal-to-insulator transition of the atom chains. We also detected similar 1D charge excitations on different silicon surfaces.

\noindent [1] T. Nagao, S. Yaginuma, T. Inaoka, T. Sakurai, Phys. Rev. Lett. 97, 116802 (2006).

\noindent [2] S. Tomonaga, Prog. Theor. Phys. 5, 544(1950).

O 35.3 Tue 14:45 HE 101

Atomic structure and electronic properties of rare earth-silicide nanowires on Si(001) — •Martina Wanke[1], Christian Preinesberger[1], Gerd Pruskil[1], Denis Vyalikh[2], Sergeij Molodtsov[2], Steffen Danzenbächer[2], Clemens Laubschat[2], Petar Stojanov[3], Eric Huwald[3], John Riley[3], and Mario Dähne[1] — [1]Institute of Solid State Physics, Technical University Berlin, D-10623 Berlin, Germany — [2]Institute of Solid State Physics, Technical University Dresden, D-01219 Dresden, Germany — [3]School of Physics, La Trobe University, Bundoora, VIC 3086, Australia

Scanning tunneling microscopy (STM) and angle-resolved photoemission (ARPES) are used to investigate the self-assembly and electronic structure of rare earth silicide nanowires on Si(001) surfaces. Two types of self-assembled nanowires can be formed depending in particular on annealing temperature and material exposure. In high resolution STM images we found closed-packed thin nanowires and free-standing, broad nanowires with similar properties on planar and vicinal Si(001) surfaces. Using ARPES at BESSY II for electronic characterization we discovered three strongly dispersing bands crossing the Fermi energy along the nanowire direction for the free-standing nanowires. A beginning weak dispersion of electronic states is also found for the thin nanowire type. In perpendicular direction both types only show a periodic intensity variation at the Fermi energy, but negligible dispersion. The Fermi surface shows one-dimensional electronic features. This project was supported by DFG, project number Da 408/11.

O 35.4 Tue 15:00 HE 101

ELS-LEED investigations of Dy-silicide nanostructures on Silicon — •Svend Vagt[1], Eddy Patrick Rugeramigabo[1], Tadaaki Nagao[2], and Herbert Pfnür[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, Germany — [2]National Institute for Materials Science, Tsukuba, Japan

Dysprosium silicide nanostructures have been grown by depositing up to 1ML of Dy on Si(111) and on vicinal Si(001) substrates. Ultra-high vacuum conditions ($p \leq 1\times10^{-10}$ mbar during Dy deposition) are prerequisite to avoid Dy oxidation. The atomic and electronic properties have been investigated using ELS-LEED, which allows the simultaneous study of geometric and electronic properties at the same point in k-space with both high momentum and energy resolution.

Deposition of 1ML of Dy on Si(111) at RT followed by annealing at 500°C results in a flat monolayer with $DySi_2$ stoichiometry. The diffraction pattern revealed the typical 1×1 structure. A 2D-Plasmon dispersion is reported for the first time with a $\sqrt{q_{||}}$ behavior up to $q_{||}$=0.08 Å^{-1} in k-space. High quality arrays of parallel nanowires have been grown on 4°-vicinal Si(001) at 500°C for a Dy coverage around 0.4ML. A $n\times2$ periodicity has been found, with n shifting from 10 to 7 for increasing coverage up to 0.75ML. The energy loss disperses only in the direction along the nanowires, whereas in the perpendicular direction the plasmon can not be excited. The plasmon dispersion turned out to be a quasi-1D-plasmon. It has been accurately simulated by explicitely taking into account the finite width of the $DySi_2$ nanowire structures. Interactions between adjacent nanowires play a minor role.

15 min. break

Invited Talk O 35.5 Tue 15:30 HE 101

Simultaneous electrical transport and scanning tunneling spectroscopy of carbon nanotubes — Brian J. LeRoy, Iddo Heller, Vijay K. Pahilwani, Jing Kong, Cees Dekker, and •Serge G. Lemay — Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands

Using scanning tunneling spectroscopy, we demonstrate that current directly injected into a freely suspended individual single-wall carbon nanotube can be used to excite, detect and control a specific vibrational mode of the molecule. Electrons tunneling inelastically into the nanotube cause a non-equilibrium occupation of the radial breathing mode, leading to both stimulated emission and absorption of phonons by successive electron tunneling events. We exploit this effect to estimate a quality factor of well over 10,000 for this nanomechanical oscillator. We further employ the suspended geometry to perform scanning tunneling spectroscopy measurements on single-walled carbon nanotubes with independently addressable source and drain electrodes in the Coulomb blockade regime. This three-terminal configuration allows the coupling to the source and drain electrodes to be quantitatively measured, which we exploit to demonstrate that electrons were added to spin-degenerate states of the carbon nanotube. Unexpectedly, the Coulomb peaks also show a strong spatial dependence. By performing simultaneous scanning tunneling spectroscopy and electrical transport measurements we show that the probed states are extended between the source and drain electrodes and that the observed spatial dependence thus reflects a tip-induced modulation of the contact resistance.

Invited Talk O 35.6 Tue 16:00 HE 101

Transport at Atomic Wires on Silicon Surfaces — •Shuji Hasegawa — University of Tokyo, Tokyo, Japan

Owing to new techniques of microscopic four-point probes with four-tip scanning tunneling microscope (4T-STM) and monolithic four-point probes, electronic transport through single-atomic layers as well as atomic chains and nanowires on semiconductor crystals can be now measured directly. Interesting transport properties of such atomic-scale structures have been revealed; the instability and atomic-scale defects intrinsic to atomic wires play decisive roles in transport. I will introduce and summarize several topics in the talk such as metal-insulator transition, hoping conduction due to defects, inter-chain transport and so on. Recent advancements with metal-coated carbon-nanotube tips in 4T-STM are also introduced.

O 35.7 Tue 16:30 HE 101

Structural influence towards transport: Pb wires on Si(557)

— •Marcin Czubanowski, Annemarie Schuster, Christoph Tegenkamp, and Herbert Pfnür — Institut of Solid State Physics, Surface Science Department, Hannover, Germany

The adsorption of 1.3 ML of Pb on Si(557) substrates followed by annealing at 640K leads to the formation of an anisotropic metallic structures as revealed by conductivity, STM and ARPES measurements. Those structures below 78K show metallic conductance along the Pb-chains, whereas in the direction perpendicular to the chain-structure an insulating behavior has been found. Additionally, ARPES measurements have shown that below T_c, those structures undergo complete Fermi nesting in the direction normal to the structure. In our recent LEED experiments, the chain structure has been systematically investigated as a function of temperature by means of SPA-LEED analysis. The adsorption of Pb transforms (locally) the surface into a regularly stepped (223) facet below T_c. This structure undergoes reversibly a comensurable-incomensurable phase transition at $T_c = 78$K as judged from changes in position of step diffraction spots in the $[\overline{1}\overline{1}\ 2]$ direction and also the periodicity of domain wall reflexes in the $[1\overline{1}\ 0]$ direction. Furthermore, the transition depends crucially on the Pb coverage. If the steps are decorated by excess Pb, e.g. 1.5ML, the transition is strongly suppressed.