MAKING CONTACTS TO NANOSTRUCTURES BY SPM

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In this talk I will present three different areas of research pursued in my group. The common link is that we are investigating various systems wit potential in nanoelectronics by the technique of scanning probe microscopy (SPM).

Atomically defined contacts to molecules are crucial if the electrical transport properties of molecules are to be understood. We used a combined ultra-high vacuum scanning tunnelling and atomic force microscope (UHV STM/AFM) to study W tip- Au(111) sample interactions in the regimes from weak coupling to strong interaction and simultaneously measure current changes from pA to μA. Close correlation between conductance and interaction forces in a STM configuration was observed. In particular, the electrical and mechanical points of contact are determined based on the observed barrier collapse and adhesive bond formation, respectively. These points of contacts as defined by force and current measurements coincide within measurement error. Ab initio calculations of the current as a function of distance in the tunneling regime is in quantitative agreement with experimental results, as shown in fig.1. The obtained results are discussed in the context of dissipation in non-contact AFM as well as electrical contact formation in molecular electronics.

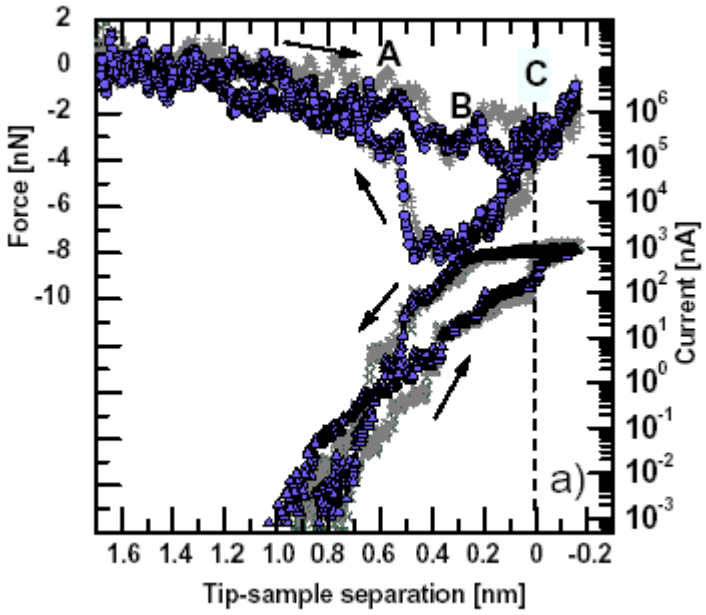

Fig. 1: Simultaneously accquired force-distance F(z) and current-distance I(z) curves covering a large tip-sample separation up to elastic contact. W tip, Au(111) sample, bias 50 mV; UHV.

The properties of self-assembled quantum dots can be measured by cryogenic electrostatic force microcopy. The addition of an extra electron manifests itself as a readily measurable increase of the electrostatic interaction between tip and sample. We will present initial results the change in resonance frequency of the AFM tip as function of tip-sample bias voltage, or electrostatic force spectroscopy, of bare InP and a InAs/InP quantum dot. In the case of bare InP an asymmetric frequency-voltage dependence was observed that enabled us to determine the charge sign of the carrier and to deduce the work function potential of the material. Fig. 2 shows a typical frequency shift and dissipation spectra acquired over a quantum at at 4.5 K.

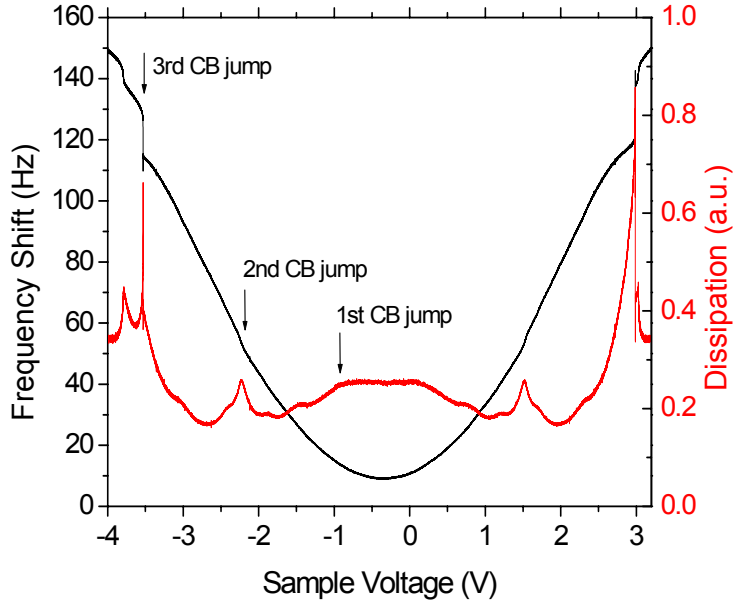

Fig. 2: Electrostatic force spectroscopy at 4.5 K over an InP quantum dot.