Atomic Force Microscopy combined with Field Ion Microscopy: structure-function determination for nanoelectronics

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It is experimentally well established that AFM can image the structure of surfaces with very high spatial resolution. Determination of structural information from this data needs theoretical modeling to compare to experimentally observed contrast. This is challenging, in particular if other properties such as electrical conductivity should be determined simultaneously, thus enabling powerful, quantitative structure-function relationships to be extracted from AFM experiments. On a fundamental level the major reason why this is challenging is because theoretical models need to make assumptions and experiments typically don't know enough atomic scale details of the AFM tip, leaving substantial room for approximations. I will discuss our experimental work using a combined STM/AFM-field ion microscopy (FIM) UHV system that allows the creation and investigation of atomically defined electrical and mechanical contacts [1]. Both contact electrodes can be characterized on an atomic scale, which in combination with state-of-the art transport and MD theory allows deep insights into the conductance of nanoscale metallic contacts. Based on detailed, atomic scale experimental characterization of the clean W tip – Au(111) sample system immediately before contact we demonstrate that the observed electronic transport has conductance values factors below that expected from simple ballistic transport models [2]. Furthermore, these experiments allow detailed insights into the energetics of mechanical contact formation and the initiation of plastic deformation [3]. Finally, I will discuss some of the experimental limitations in addition to the theoretical challenges.

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