ZERNIKE INSTITUTE COLLOQUIUM

Thursday, October 3rd, 2013

16:00h, Lecture Hall: 5111.0080 **Coffee and cakes from 15:30h**

Atomic force microscopy using the qPlus sensor: resolving charge distributions within atoms, exchange interactions and atomic resolution in ambient conditions

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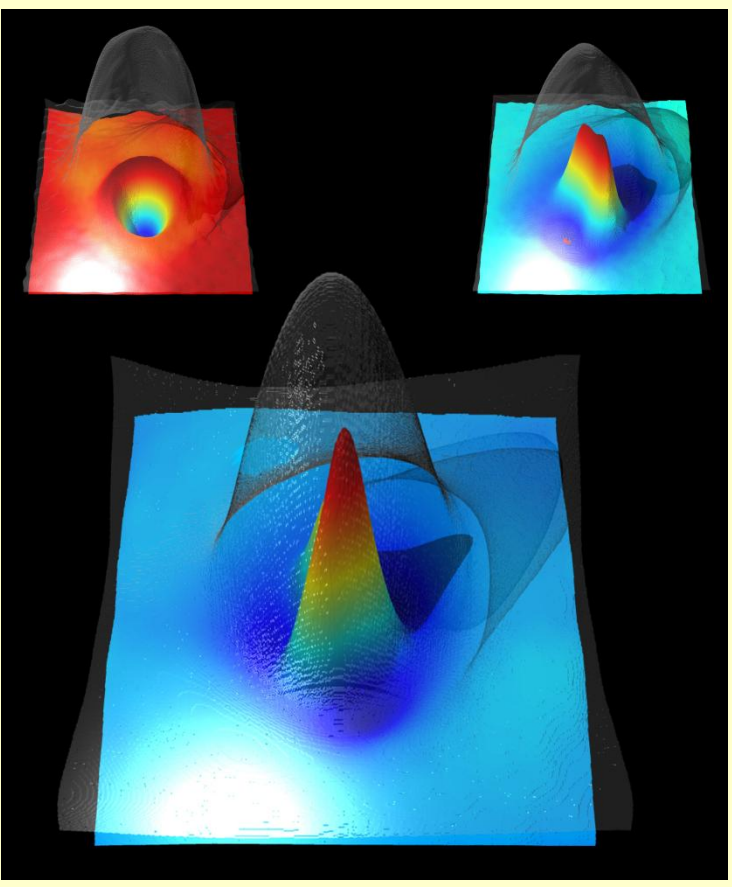
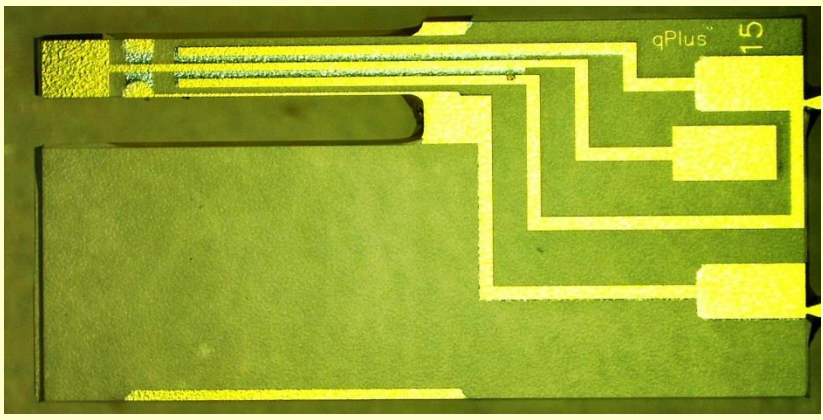
Frequency-modulation atomic force microscopy (AFM) can be combined with scanning tunneling microscopy (STM), yielding a simultaneous data set for current and average force gradient. The qPlus force sensor [1] allows to perform simultaneous STM and AFM with sub-Angstrom oscillation amplitudes.



Ternes et al. [2] have shown that for some metallic contacts, force and current are proportional within a certain distance range such that AFM and STM images should be similar. The figure below [3] shows an example, where combined AFM/STM reveals two strongly distinct aspects of the atomic structure of matter. The gray veil depicts the inverted tunneling current between a CO molecule adsorbed on Cu(111) and a tungsten tip, while the colored surface shows the corresponding force profiles, where the left image corresponds to a W tip oriented in a <100> direction, the right to a <110> direction and the bottom to a <111> direction [3]. Such strong angular dependencies of chemical bonding forces have been observed before for Si tips interacting with Si surfaces [4], W tips interacting with graphite [5] and similarities exist between metal tips interacting with CO molecules on Cu and Si adatoms [6]. In the latter two cases, light atoms such as carbon or oxygen interacted with much heavier and much larger metal atoms.

Recently, Gross et al. found that CO is an excellent probe for organic molecules. For example, pentacene can be imaged at excellent resolution with CO terminated tips [7]. Tips made of permanent magnets such as CoSm allow to resolve the spin order as well as the distance dependence of the exchange interaction in the antiferromagnetic insulator nickel oxide [8]. The stiff cantilever/ small amplitude technique used here also allows true atomic resolution in ambient conditions [9].



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[2] M. Ternes et al., *Phys. Rev. Lett*. **106**, 016802 (2011).
[3] J. Welker, F. J. Giessibl, *Science* **336**, 444 (2012).
[4] F. J. Giessibl, S. Hembacher, H. Bielefeldt, J. Mannhart, *Science* **289**, 422 (2000).
[5] S. Hembacher, F. J. Giessibl, J. Mannhart, *Science* **305**, 380, (2004).
[6] J. Welker, J. Weymouth, F. J. Giessibl, *ACS Nano*, DOI: 10.1021/nn403106v (2013).
[7] L. Gross et al. *Science* **325**, 1110 (2009).
[8] F. Pielmeier, F. J. Giessibl, *Phys. Rev. Lett*. **110,** 266101 (2013).
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