

Centro Singular de Investigación en **Química Biolóxica** e **Materiais Moleculares**

Conferencia: Individual Molecules Investigated by Scanning Probe Microscopy with Atomically Functionalized Tips

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IBM Research – Zurich -Switzerland

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XUNTA DE GALICIA Consellería de Cultura, educación e ordenación universitaria Leo Gross Research Staff Member Zurich Research Laboratory, Zurich, Switzerland LGR @zurich.ibm.com +41-44-724-83-32

<u>Leo Gross</u>, a native of Berlin, Germany, has been a Research Staff Member at the IBM Research - Zurich Laboratory since 2009. He is working together with <u>Dr. G. Meyer</u> on <u>atomic/molecular manipulation</u> by scanning tunneling microscopy (STM) and atomic force microscopy (AFM), and on <u>nanostencil lithography</u>.

Leo Gross has been with the IBM Research - Zurich Laboratory since 2005. He originally joined IBM Research as a post-doc in the group of Dr. G. Meyer.

Leo Gross received his PhD in Physics in 2005 from the Free University of Berlin in the group of Prof. K.-H. Rieder.

Leo Gross received his Master's (*Diplom*) degree in Physics in 2001 from the University of Muenster, Germany, in the group of Prof. H. Fuchs. Before that Leo Gross studied one year at the Tulane University, New Orleans, and worked in the group of Prof. U. Diebold. As an undergraduate, he attended the Free University of Berlin.

Awards

- Feynman Prize for Nanotechnology, 2012 Awarded by the Foresight Institute. The Feynman Prize for experiment 2012 was awarded to the team of Gerhard Meyer, Leo Gross, and Jascha Repp for their work at IBM Research in Zurich. The award recognizes the experiments advancing the frontiers of scanning probe microscopy.
- Gerhard Ertl Young Investigator Award, 2010 Awarded by the Surface Science division of the German Physical Society for the paper entitled "Charge measurement of atoms and atomic resolution of molecules with noncontact AFM".
- **Tiburtius Preis, 2006** Awarded by the Berlin Universities for Leo Gross' dissertation entitled "LT-STM Investigation of Organic Molecules for Molecular Electronics: Lander and Hexabenzocoronene Derivatives on Copper Surfaces".

Individual Molecules Investigated by Scanning Probe Microscopy with Atomically Functionalized Tips

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Single organic molecules adsorbed on ultrathin insulating films were investigated using scanning tunnelling microscopy (STM), noncontact atomic force microscopy (NC-AFM), and Kelvin probe force microscopy (KPFM). With all of these techniques submolecular resolution was obtained due to tip functionalization by atomic manipulation. The techniques yield complementary information regarding the molecular structural and electronic properties.

Using NC-AFM with CO functionalized tips, atomic resolution on molecules was demonstrated [1]. Moreover, different bond orders of individual carbon-carbon bonds in polycyclic aromatic hydrocarbons and fullerenes were distinguished [2]. Using KPFM information about the distribution of charges within molecules was gained [3].

Recently, we investigated other tip functionalizations for AFM, i.e., Cl, Br, Xe, Kr, and NO [4]. The prospects to use high resolution AFM for molecular structure identification [5] or adsorption geometry determination will be discussed.

- [1] L. Gross, F. Mohn, N. Moll, P. Liljeroth, G. Meyer, Science 325, 1110 (2009)
- [2] L. Gross, F. Mohn, N. Moll, B. Schuler, A. Criado, E. Guitián, D. Peña, A. Gourdon, G. Meyer, *Science* 337, 1326 (2012)
- [3] F. Mohn, L. Gross, N. Moll, G. Meyer *Nature Nanotechnol.* 7, 227 (2012)
- [4] F. Mohn, B. Schuler, L. Gross, G. Meyer, Appl. Phys. Lett. in print (2013)
- [5] L. Gross, F. Mohn, N. Moll, G. Meyer, R. Ebel, W. M. Abdel-Mageed, M. Jaspars, *Nature Chem.* 2, 821 (2010)



Figure: Different scanning probe microscopy modes (STM, AFM and KPFM) using functionalized tips demonstrated with atomic resolution on a single naphthalocyanine molecule adsorbed on a double layer NaCl on Cu(111).