NEW HORIZONS IN NANOMAGNETISM BY ATOMIC-SCALE MAGNETIC SPM PROBING

Roland Wiesendanger

University of Hamburg, Inst. of Applied Physics, Jungiusstr. 11, D-20355 Hamburg, Germany, www.nanoscience.de, Email: wiesendanger@physnet.uni-hamburg.de

Spin-polarized Scanning Tunneling Microscopy (SP-STM) [1] and Spectroscopy (SP-STS) [2] allow the visualization of atomic-scale spin structures [3,4] and the investigation of the spin-dependent local density of states spatially resolved [5]. Spin-dependent scattering at single atomic impurities was visualized in real-space reflecting the orbital nature of the electronic states involved as well as their spin character [6]. For ferrimagnetic samples [3] the different magnitude of magnetic moments could directly be made visible at the atomic level while for antiferromagnetic samples, the different orientation of magnetic moments showed up in atomically resolved SP-STM data [4].

More recently, we have proven the existence of a novel antiferromagnetic ground state of a single atomic layer of Fe on a W(001) substrate by SP-STM [7] while a single atomic layer of Fe on a W(110) substrate was proven to be in a ferromagnetic ground state [8]. We have even succeeded for the first time to resolve the atomic spin structure of domain walls in antiferromagnetic systems [9]. For a single atomic layer of Fe on Ir(111) we discovered a novel nanomagnetic state with 15 Fe atoms per unit cell by SP-STM [10]. Interestingly, 7 Fe atoms have magnetic moments pointing in one and 8 Fe atoms have magnetic moments pointing in the opposite direction. Therefore, the system exhibits ferromagnetic characteristics locally and antiferromagnetic characteristics macroscopically. To extend the possibility of atomic-scale spin mapping to insulating material systems we have recently succeeded in establishing magnetic exchange force microscopy (MExFM) as a reliable and reproducible technique [11]. We demonstrate for the first time clear atomic-scale spin contrast by MExFM on NiO(001) surfaces and discuss further applications of this novel exciting scanning probe method in the field of nanomagnetism.

References:

[1] R. Wiesendanger et al., Phys. Rev. Lett. 65, 247 (1990).
[2] M. Bode, M. Getzlaff, R. Wiesendanger, Phys. Rev. Lett. 81, 4256 (1998).
[3] R. Wiesendanger et al., Science 255, 583 (1992).
[4] S. Heinze et al., Science 288, 1805 (2000).
[5] O. Pietzsch et al., Phys. Rev. Lett. 92, 057202 (2004).
[6] K. von Bergmann et al., Phys. Rev. Lett. 92, 046801 (2004).
[7] A. Kubetzka et al., Phys. Rev. Lett. 94, 087204 (2005).
[8] O. Pietzsch et al., Phys. Rev. Lett. 84, 5212 (2000).
[9] M. Bode et al., Nature Materials 5, 477 (2006).
[10] K. von Bergmann et al., Phys. Rev. Lett. 96, 167203 (2006).
[11] U. Kaiser, A. Schwarz, and R. Wiesendanger, submitted.