New insights into nanomagnetism by spin-polarized scanning tunneling microscopy and spectroscopy

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Spin-polarized scanning tunneling microscopy (SP-STM) allows imaging and spectroscopic characterization of nanostructures with unsurpassed spatial resolution. Its working principle exploits the dependence of the tunnel current on the relative magnetization orientation of a sample and the magnetic STM tip. We present results by SP-STM, where we investigate the correlation between structural, electronic, and magnetic properties of individual nm small Co islands with several hundred to thousands of atoms. We use external magnetic fields of up to 4 T to tune the magnetic state of both tip and sample, and we extract the corresponding change of the differential conductance of the tunnel junction.

A recent example is our measurement of magnetic hysteresis loops of individual nm small Co islands on Cu(111) at 8 K by SP-STM in external magnetic fields. We find switching fields of up to 2.5 T for islands with roughly 8,000 atoms. The quantitative analysis of these results provides novel insights into the magnetization reversal on the nanoscale, and deviations from the venerable Stoner-Wohlfarth model are discussed.

We also exploit the high spatial resolution of SP-STM in magnetic fields to measure maps of the differential conductance within a single nm-small Co island for different magnetization states. In connection with density functional theory calculations we demonstrate that the spin polarization is not homogeneous but spatially modulated within the Co island, as indicated in Fig. 1. We ascribe the spatial modulation of the spin polarization to spin-dependent electron confinement within the Co island [1].

References

[1] Oka, Ignatiev, Wedekind, Rodary, Niebergall, Stepanyuk, Sander, Kirschner, Science **327**(2010) 347.

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Figures

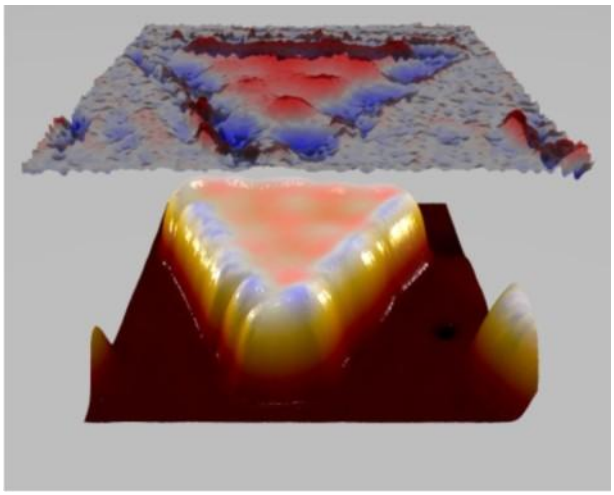

Fig. 1. Superposition of a 3D-topographic representation of a bilayer high Co island with a base length of 12 nm from STM topography (bottom) with a map of the asymmetry of the differential conductance measured at the Fermi energy (top). Blue: negative; red: positive, gray: zero asymmetry. The top map reflects a spatial modulation of the spin-polarization, induced by spin-dependent electron confinement within the Co island [1].