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Conference Paper

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Scanning Field-Emission Microscopy with Polarization Analysis

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Scanning Field-Emission Microscopy (SFEM) is based on STM technology, but instead of imaging in a tunneling regime the tip is retracted by some tenths of nanometers away from the sample surface and imaged in a field emission regime. In order to generate a field emission current a negative voltage is applied to the tip, which is kept constant as well as the distance between tip apex and sample during the scanning of the surface. In contrast to the tunneling technique SFEM produces secondary electrons out of the sample, which can be analyzed by different detectors such as SED, energy analyzer or spin polarimeter. With this novel technique we have shown a secondary electron contrast of 30% between a clean W(011) surface and monoatomic Fe islands on top of it and that the lateral resolution can be as high as 1 nm [1]. An energy analysis of these secondary electrons has revealed that a large amount of them are "truly" secondary with respect to the elastic scattered electrons.

Recent spin analysis with a Mott polarimeter has shown that these secondary electrons are carrying the magnetic signature of the sample. Hysteresis loop measurements of eight monolayers Fe on top of W(011) measured with the SFEM method demonstrate a typical magnetic behavior for that model magnetic sample. These measurements are confirmed with an in situ scanning electron microscope (SEM) revealing the very same magnetic signature (Fig.1).

The method of SFEM with polarization analysis (SFEMPA) enables the mapping of magnetic samples with high lateral resolution in principle as high as 1 nm. First results will be presented and compared with the method of SEM with polarization analysis (SEMPA).

References:

[1] Zanin DA, De Pietro LG, Peter Q, Kostanyan A, Cabrera H, Vindigni A, Bähler Th, Pescia D, Ramsperger U. 2016 *Thirty per cent contrast in secondary-electron imaging by scanning field-emission microscopy*.
Proc. R. Soc. A472: 20160475

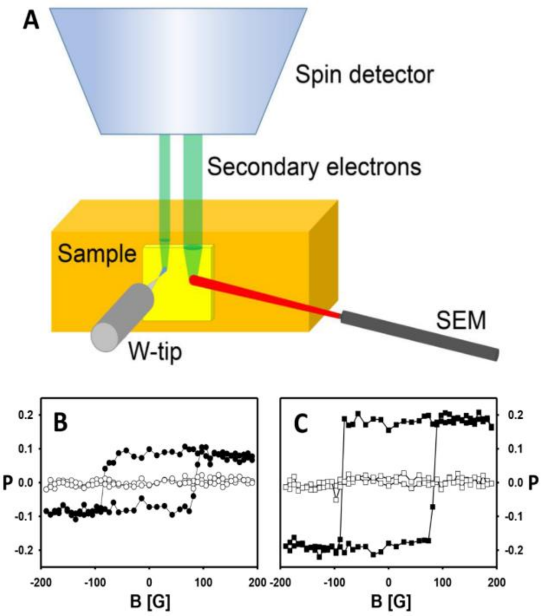

Figure 1. A) Schema of the SFEMPA and SEMPA setup. For SEMPA measurements the primary electron beam of the SEM (red) hits the sample (yellow) and produces secondary electrons (green), which are analyzed in the spin detector. For SFEMPA measurements, the primary electrons (blue) are extracted from the W-tip. These electrons generate secondary electrons (green) out of the sample, which are analyzed in the same spin detector. All measurements have been done under ultra high vacuum (UHV) conditions and at room temperature.

B) Hysteresis loops of 8 ML of Fe on top of W(011) measured with the technique of SFEMPA. The Fe film shows a 20% polarization (black circles) in the in-plane direction, whereas the out of plane polarization is 0% (white circles). The tip sample distance is 100 nm and the voltage applied to the tip V = -62 V.

C) Hysteresis loops of the same sample as B), but this time measured with the technique of SEMPA. The in plane polarization amounts to 40% (black squares), while the out of plane is 0% (white squares). In B) and C) the coercivity is the same.

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