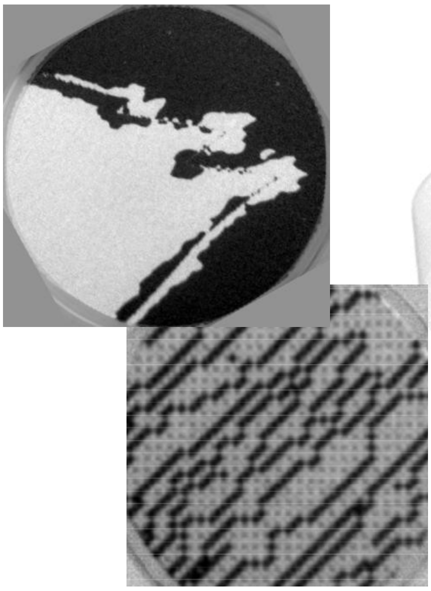

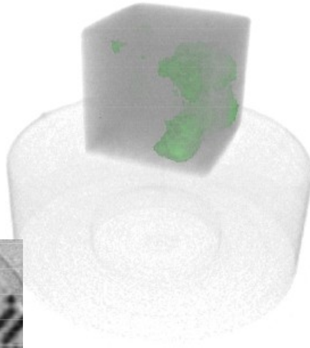

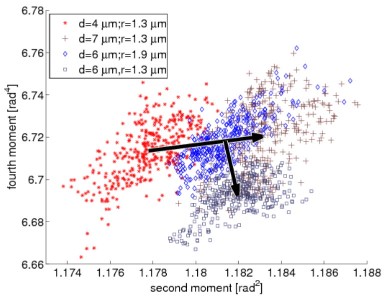

SLS Symposium on

Imaging

Tuesday, December 3, 2013

10:00 to 12:15, WBGB/019

10:00 Prospects of X-ray Photoemission Electron Microscopy at the first beamline of Polish synchrotron SOLARIS
M. Ślęzak, T. Giela, D. Wilgocka-Ślęzak, N. Spiridis, T. Ślęzak, M. Zając, M. Stankiewicz, N. Pilet, J. Raabe, C. Quitmann, and J. Korecki

10:30 Direct observation of thermal relaxation in artificial spin ice
A. Farhan, P. M. Derlet, A. Kleibert, A. Balan, R.V. Chopdekar, L. Anghinolfi, M.Wyss, J. Perron, A. Scholl, F. Nolting, and L.J. Heyderman

11:00 Coffee

11:15 (Energy-selective) neutron imaging bridging transmission and diffraction
S. Peetermans and E. H. Lehmann

11:45 Multiple scattering tomography
P. Modregger, M. Kagias, S. Peter, M. Abis, V. A. Guzenko, C. David, R. Bellotti, and M. Stampanoni

Prospects of X-ray Photoemission Electron Microscopy at the first beamline of Polish synchrotron SOLARIS

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The first Polish synchrotron radiation facility "Solaris" is currently being built in Krakow [1]. The first experimental beamline at "Solaris" will use bending magnet radiation and two exchangeable end-stations: a spectroscopic X-ray photoemission electron microscope (SPE-XPEEM) and a soft X-ray absorption spectroscopy (XAS) chamber. In this contribution we present the beamline specification and exemplary results obtained with our end-station microscope, which (in the status nascendi of "Solaris") has been operated at the NanoXAS beamline in Swiss Light Source (SLS). The end-stations should be available for broad users community at "Solaris" at the end of 2015.

The SPE-XPEEM instrument, equipped with the energy analyzer, can also work in the Low Energy Electron Microscopy (LEEM) mode, which expands its application field also to structural surface studies. A preparation chamber is attached to the microscope, which enables in situ MBE growth and characterization of metal and oxide surfaces, films and nanostructures. Most of the X-PEEM [2] capabilities including imaging with chemical and magnetic [3] sensitivity given by XAS, X-ray photoemission spectroscopy and magnetic dichroism (XMCD and XMLD) could be tested and verified. The full-field spectro-microscopy with the ultimate spatial resolution below 50 nm and micro-spectroscopy including broad range of elements and their chemical as well as magnetic states will be demonstrated for in situ and ex situ prepared surface nanostructures. An exemplary result is shown in Fig.1, where both chemical an magnetic sensitivity is exploited to image the magnetic domain structure in Fe/Au/Co trilayers grown in situ on W(110).

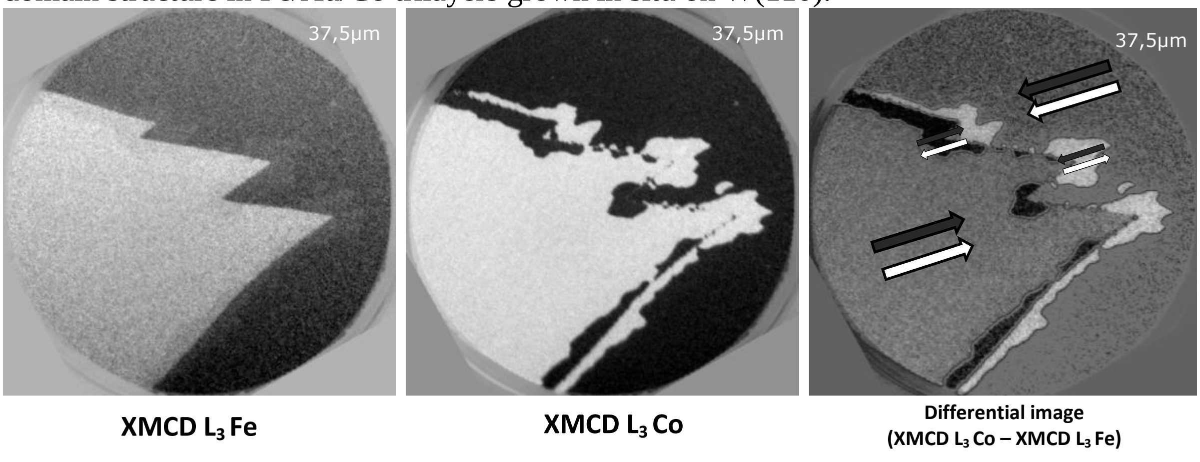

Fig.1. Magnetic domains structures in Fe/Au/Co trilayers grown on W(110) as seen by XMCD-PEEM. Arrows indicate relative magnetization alignment of Fe and Co layers.

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This work was supported by EU European Regional Development Fund and by the Scientific Exchange Programme NMS-CH (SCIEX) project.

Direct observation of thermal relaxation in artificial spin ice

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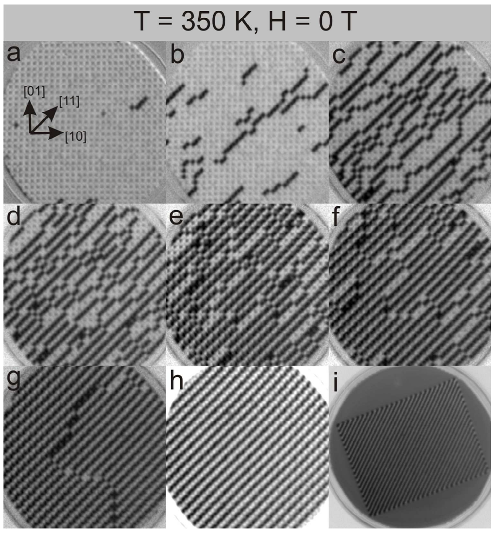
Artificial spin ice systems [1], comprised of elongated monodomain nanomagnets arranged in frustrated geometries are considered to be two-dimensional analogues to the bulk pyrochlore spin ice [2]. Investigations thus far focused mainly on field driven experiments [1, 3, 4], while access to the thermodynamics was not possible due to blocking temperatures of the nanomagnets that were far above room temperature. An exception was the observation of frozen-in ground state configurations as a result of thermal film growth [5], but a direct visualization of a transition to an ordered ground state has remained unobserved. Recently, we have demonstrated a way to achieve thermal fluctuations in finite-size structures of artificial kagome spin ice close to room temperature [6]. Using a similar approach, we present here a real-space and real-time observation of thermal relaxation in quasi-infinite arrays of artificial square ice [7], going from a well defined energetically excited state to one of the two degenerate ground states. Microscopically we show how the migration of thermal excitations governs the relaxation process. The experimental results and their temporal evolution are in good agreement with kinetic monte carlo simulations, if disorder is taken into account. The relaxation mechanism can be understood by considering the effective interaction energy associated with the separation and propagation of pairs of vertex excitations.



PEEM observation of thermal relaxation in a quasi-infinite array of artificial square ice. (a)-(d) show the system in the string regime. (e)-(g) show the system in the domain regime. (h)-(i) demonstrate a 100% ground state ordering of the observed system.

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(Energy-selective) neutron imaging bridging transmission and diffraction

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Common neutron imaging techniques study the attenuation of a neutron beam going through a sample of interest. The recorded radiograph shows a contrast depending on traversed material and its thickness. Tomography allows separating both and obtaining 3D spatial information. It is routinely performed at PSI´s neutron imaging facilities and has solved problems in numerous fields: ranging from water droplet formation in fuel cells to separating fossils from stone in paleontology.

Energy-selective neutron imaging extends the range of observable contrasts in neutron imaging by using a reduced wavelength bandwidth. Observed contrasts/image information can be understood in the context of the Bragg law $2d_{hkl}\sin(\theta_{hkl})=\lambda$.

For polycrystalline samples, it will lead to appearance of sharp Bragg edges in the cross section at $\lambda=2d_{hkl}$. Much like diffraction peaks, they contain information on e.g. crystal phase or integrated strain. In samples with few grains or even single crystals, one rather obtains contrast between those grains fulfilling the Bragg condition – scattering and decreasing the transmitted beam intensity – and those that do not [1].

But where do these scattered neutrons go to? A new set-up was developed to permit simultaneous transmission and diffractive neutron imaging. Technical details will be presented along with preliminary results showing a range of potential applications [2].

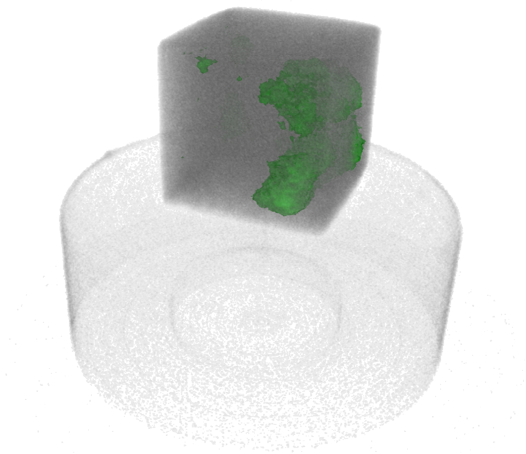

Fig. 1. Volume rendering of reconstructed attenuation coefficient (gray) and regions of increased local Bragg reflectivity (green) for an iron single crystal.

References

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Multiple scattering tomography

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Multiple scattering constitutes a challenge for a wide variety of modern tomographic imaging techniques such as low coherence interferometry, optical coherence tomography, electron scattering tomography, neutron or x-ray scattering methods and more. The effects of multiple scattering are disadvantageous in almost all instances ranging from increased noise levels to severe artefacts that render the results physically meaningless. Up top now, these detrimental effects occurred since an appropriate line integral was not available.

In the presentation we will derive a line integral that takes multiple scattering adequately into account [1]. The frame work is experimentally validated with grating interferometry, a modern phase-sensitive X-ray imaging technique that is especially suitable to investigate multiple scattering [2]. We find that the result of multiple scattering tomography are compatible with theoretical expectations (Kolmogorov-Smirnov test) while the established single scattering approach was rejected. As an example for the impact of the proposed line integral we demonstrate a new access to sub-pixel structural information with grating interferometry.

This work constitutes the first investigation of combining tomography with multiple scattering. The frame work is independent of the type of probe (X-rays, neutrons, photons, etc.) and only requires the availability of pixel-wise angular resolved scattering distributions. Thus, the multiple scattering tomography is directly applicable to grating interferometry, analyzer-based imaging and small-angle X-ray or neutron scattering. Therefore, we expect a wide spread application of the proposed line integral and a positive impact of its availability to all research areas affected by multiple scattering.

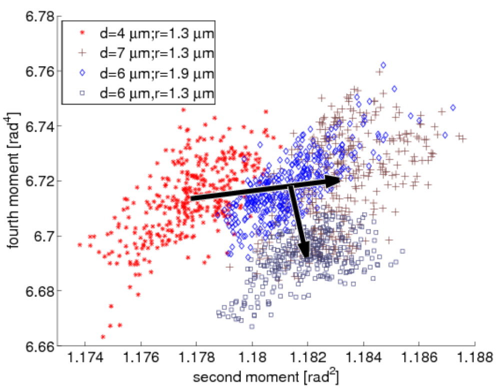

Fig. 1: Previously unobtainable structural information that is provided by using mutliple scattering tomography with grating interferometry. The scatter plot shows the effect of varying distance and varying radius of holes in a PMMA substrate on the second and fourth moment of the reconstructed scattering distributions.

References

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