SYSA 1: Synergistic Imaging Techniques: From Spins and Atoms to Ferroic Domains

Time: Monday 15:00–17:45 Location: H 0105

Invited Talk SYSA 1.1 Mon 15:00 H 0105

Imaging with coherent soft X-rays — •Bastian Pfau — Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin

Soft-X-ray microscopy is a well-established method to image emergent magnetic texture in thin films, uniquely providing access to the magnetic moments on a nanometer scale with spectroscopic sensitivity. In addition, X-ray imaging allows for time-resolved measurements on ultrafast timescales and convenient implementations of sample environments and excitations. I will present advances in coherent imaging based on X-ray holography, which has recently seen notable breakthroughs. Firstly, we developed coherent correlation imaging, a method for faster serial imaging of fluctuation dynamics. Secondly, we established imaging on a 5-nm level in routine operation. As research examples, I will particularly focus on studies on the dynamics of skyrmions in anisotropy-engineered ferromagnetic films. As an outlook, I will present imaging results of ferroelectric texture—a field where soft-X-ray methods may open new perspectives to study functionality.

Invited Talk SYSA 1.2 Mon 15:30 H 0105

Exploring ferroelectric domains and domain wall dynamics with quantitative STEM — •Marta D. Rossell — Empa, Swiss Federal Laboratories for Materials Science and Technology, Dübendorf, Switzerland

With increasing miniaturization, ferroelectric devices face a loss of their properties and major reliability issues hinder their commercialization. Overcoming these problems requires a deeper understanding of the microscopic mechanisms of domain wall motion, nucleation and the role of various types of defects, such as oxygen vacancies. A major challenge is thus the investigation of ferroelectric materials at the nanometer and atomic scale and under operando conditions. This has recently become feasible thanks to advances in aberration-corrected (scanning) transmission electron microscopy (S/TEM) and microelectromechanical (MEMS) technology for miniaturized TEM sample holders for in-situ heating and electrical biasing experiments. In this talk, I will show some recent results on how crystalline defects in various ferroelectric thin films can induce, for example, local polarization reversal, alter domain kinetics or even modify phase transition temperatures.

Invited Talk SYSA 1.3 Mon 16:00 H 0105

Scanning Oscillator Piezoresponse Microscopy: new tools to explore domain wall dynamics — •Neus Domingo[1], Shiva Raghuraman[1], Ralph Bulanadi[2], Patrycja Paruch[2], and Stephen Jesse[1] — [1]Oak Ridge National Laboratory, Oak Ridge, USA — [2]University of Geneva, Geneva, Switzerland

Dynamics of ferroelectric domain walls associated to domain wall switching are known to depend on bulk structure, being very sensitive to defects, chemical and structural pinning sites, as well as environmental conditions, modifying the electronic boundary conditions associated with screening dynamics. However, domain walls also show a sub-coercive field dynamics as a reversible motion, with vibrational states that strongly coupled to local structure and composition of the domain wall. In this presentation, we will show a novel microscopy mode based on a multifrequency approach which allows us to quantify domain wall oscillations under applied sub-coercive electric field, while simultaneously disentangle electrostatic from nanoelectromechanical signals, which can introduce severe distortions on the net piezoelectric response around neutral domain walls. This technique allows quick visualization of domain wall displacement, their velocities and dependence on pre-existing domain configurations and defects. When applied to lead titanate, this technique shows significant oscillations of the 180° domain walls between the antiparallel c+/c domains. Further, the displacement and velocities distinctly depend on existing a-c domain structures and relative orientations of domains. We will finally discuss about applications of this technique, including a wide range of stimuli such as light, heat, force and bias, to study dynamic phenomena in the second to sub-milisecond range.

15 min. break

Invited Talk SYSA 1.4 Mon 16:45 H 0105

Imaging probe nuclei environments using perturbed angular correlation spectroscopy: Examples from multiferroic $BiFeO_3$ — •Doru C. Lupascu[1], Thien Thanh Dang[1,2], Georg Marschick[3], Marianela Escobar[1], Astita Dubey[1], Ian Yap Chang Jie[1,2], and Juliana Heiniger-Schell[1,2] — [1]Institute for Materials Science and CENIDE, University of Duisburg-Essen — [2]CERN, Geneva, Switzerland — [3]X-Ray Center, Vienna University of Technology, Austria

Bismuth ferrite is our Drosophila system for multiferroicity at room temperature. In this presentation it is shown that decoupling of the magnetic and electric orders happens fundamentally at the unit cell level. Antiferromagnetism and cycloidal ordering of the Dzyaloshinskii-Moriya interaction generated magnetic moments are not necessary to be considered for explaining the low coupling. Our data from a nuclear solid state technique show that the magneto-electric coupling in the magnetic sub-lattice is actually enormous. The oxygen octahedral around the iron site experience a large tilt due to the onset of magnetic ordering. The Bi-containing complementary sub-lattice nevertheless is practically unaffected by this large structural change in its direct vicinity. Relation to classical magnetoelectric coupling schemes are drawn. The second part of the presentation will then deal with applications of this knowledge to the tuning of magnetic, electric and photon interaction properties in custom designed nanoparticles. Photocatalytic applications, hyperthermia treatment and net magnetization studies will be shown for nanoparticles differently doped on the two sub-lattices tuning strain and magnetic coupling. Surface effects will be considered.

Invited Talk SYSA 1.5 Mon 17:15 H 0105

Exploring antiferromagnetic order at the nanoscale with a single spin microscope — •Vincent Jacques and Aurore Finco — Laboratoire Charles Coulomb, CNRS and Uni. Montpellier, France

Antiferromagnetic materials are promising platforms for next-generation spintronics owing to their fast dynamics and high robustness against parasitic magnetic fields. However, nanoscale imaging of the magnetic order in such materials with vanishing net magnetization remains a notoriously difficult task. To address this issue, quantum sensors based on nitrogen-vacancy (NV) defect in diamond have become a widespread technical solution. In this talk, I will show how scanning-NV magnetometry can be used to image chiral spin textures in antiferromagnets.