PhD student:

Polarisation mapping in ferroelectric nanostructures by momentum-resolved Scanning Transmission Electron Microscopy

Advertising institute: Forschungszentrum Jülich (Research Centre Jülich), Peter Grünberg Institut, Ernst-Ruska-Centre-1 - Physics of Nanoscale Systems
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The **Ernst Ruska-Centre (ER-C) for Microscopy and Spectroscopy with Electrons** at **Forschungszentrum Jülich** is a national facility dedicated to research at the frontiers of electron microscopy and materials science. In cooperation with the **RWTH Aachen** it hosts up-to-date infrastructure including versatile aberration-corrected electron microscopes. The research team at ER-C is looking for a

PhD student

with a strong background in physics.

Start: **06/2018** (or as soon as possible thereafter).

Scientific background

Ferroelectric materials exhibit a spontaneous electric polarisation switchable under an external electric field. Contemporary research covers both fundamental science as to the atomistic origin of ferroelectricity, phase transitions or domain formation. Concerning applications for non-volatile random access memories (RAMs), research partly focuses on ferroelectric tunnel junctions (FTJs). They overcome the limited scalability and the destructive, capacitance-based read-out of ferroelectric RAMs (FRAMs). FTJ devices exploit the polarisation-dependent tunneling electroresistance (TER) effect in ultrathin ferroelectric layers. However, the practical implementation of FTJ is currently hampered because ultrathin ferroelectric layers are observed to be unswitchable which could be attributed to the formation of domains with different ferroelectric polarisations at scales of a few nm.
Progress in this field indispensably depends on the development of experimental techniques to map polarisations at the scale of crystal unit cells and to study them under an external electric field. The subatomic spatial resolution down to 50pm of aberration-corrected scanning transmission electron microscopy (STEM), combined with ultrafast diffraction cameras nowadays yields a wealth of information in a 4-dimensional data set. This combination of real- and momentum space information has initiated a new imaging mode, *momentum-resolved* STEM. Whereas atomic electric fields have been mapped recently, the mapping of ferroelectric polarisations remains a challenge to be addressed in this project.

Project description

A momentum-resolved STEM method is to be developed to directly measure ferroelectric polarisation fields in perovskite structures ($BaTiO_3$, $Pb(ZrTi)O_3$) provided by national and international university partners. In particular, the long-range variations of the rather weak ferroelectric polarisation must be disentangled from dynamical electron scattering and the much stronger atomic electric fields. Using the advanced electron microscopy infrastructure at the ER-C, the results are to be cross-checked by structural characterisations, involving the measurement of picometre-range atomic displacements. Besides the experimental work, this project involves accompanying simulation studies and the preparation of an in-depth theoretical understanding of ferroelectricity. Enabling polarisation mapping by momentum-resolved STEM does not only enhance electron microscopy methodology drastically, it especially provides new possibilities in contemporary materials science and nanotechnology. These include in-situ biasing experiments to observe polarisation switching and/or the mapping of polarisations in advanced ferroelectric nanostructures.

Your profile

The successful candidate should have a master degree in physics. A background and strong interest in solid-state theory, and/or experiences in electron microscopy are desirable, together with progrmming experience in, e.g., Matlab. Both your written and spoken English should be very good. Most importantly, you

explore uncharted territory with enthusiasm, develop and follow your own ideas and work autonomously in close interaction within a team.

Our profile

You will be part of the *more*STEM research group dedicated to the theory and practice of momentum-resolved STEM. We provide access to state-of-the-art computing facilities and aberration-corrected transmission electron microscopes equipped with ultrafast detectors of the latest generation. We welcome you as a member of a highly motivated team providing feedback and expertise in the multiple facets of electron microscopy and materials science. The position comes with a competitive salary and is limited to 3 years.

Forschungszentrum Jülich aims to employ more women in this area and therefore particularly welcomes applications from women. We also welcome applications from disabled persons.

Please address your electronic (PDF) application (in English or German) including curriculum vitae, a description of research background and interests, and a copy of relevant certificates to

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