2017 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

High Spatial Resolution Magnetic Characterization in the Transmission Electron Microscope

Helmholtz Centre and institute:

Forschungszentrum Jülich, Ernst Ruska-Centre for Microscopy and Spectroscopy of Electrons

Project leader:

Prof. Dr. Rafal E. Dunin-Borkowski, Director, Ernst Ruska-Centre for Microscopy and Spectroscopy of Electrons and Director, Institute for Microstructure Research

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Description of the project:

The development of novel magnetic materials, such as those based on epitaxial oxide heterostructures, is of great importance for spintronic applications for future energy-efficient information technology. However, it is highly challenging to characterise the magnetic properties of such materials experimentally with close-to-atomic spatial resolution. This information is essential to obtain a fundamental understanding of the cooperative interplay between charge, spin, orbital and lattice degrees of freedom, which is in turn a prerequisite to improve device functionality.

This project aims to develop the complementary techniques of electron magnetic circular dichroism (EMCD) and off-axis electron holography to provide close-to-atomic spatial resolution magnetic imaging in the transmission electron microscope (TEM). Leading expertise in the former technique is available in the National Center for Electron Microscopy in Beijing, while expertise in the latter technique and unique experimental capabilities are available in the Ernst Ruska-Centre for Microscopy and Spectroscopy of Electrons in Forschungszentrum Jülich.
Both techniques will be developed by making use of recent advances in chromatic aberration correction, which are available on the Titan PICO TEM in Jülich.
The technique of EMCD relies on the analysis of differences between momentum-resolved electron energy-loss spectra recorded with the aperture of an electron energy-loss

spectrometer placed at specific positions in the diffraction pattern of a crystalline sample. It is sensitive to out-of-plane magnetization and can be used to measure both the spin and the orbital magnetic moment of a sample with sub-nm spatial resolution.
In this project, out-of-plane magnetic information recorded using EMCD will be combined with measurements of in-plane magetization obtained from the same samples in Lorentz mode using chromatic aberration corrected off-axis electron holography, with local atomically-resolved information about strain and chemical composition recorded from the same samples using spherical aberation corrected TEM.
Samples that will be characterised using both techniques include magnetic skyrmions that exhibit topological stability and offer improved performance in spin-electronic devices when compared with traditional magnetic domains and epitaxial oxides that support antiferromagnetic spin configurations on the atomic scale.
The overall aim of the project will be to access site-specific crystallographic, electronic and magnetic information from skyrmions, antiferromagnetic oxides and other topical magnetic materials at the sub-nm (and even atomic) scale, both in projection and in three dimensions.

By contributing to a detailed understanding of the physical origins of the magnetic properties of materials at the highest spatial resolution, this project will improve basic scientific knowledge about nanoscale magnetic materials and lead to new designs for energy-efficient spintronic devices.

Description of existing or sought Chinese collaboration partner institute:

A collaboration already exists with the National Center for Electron Microscopy in Beijing, School of Materials Science and Engineering, Tsinghua University. This is a National Science and Technology Infrastructure - National Large Scientific Instrument Center in China. It introduced the first aberration-corrected Titan 80-300 transmission electron microscope in China and also houses a double-aberration-corrected Titan Themis G2 transmission electron microscope.
Recently, scientists from the National Center for Electron Microscopy in Beijing developed a protocol to quantitatively determining site-specific magnetic structure information in complex oxides using EMCD, opening the door to the atomic scale characterisation of the magnetic properties of materials in the TEM.
This existing collaboration is an example of best practice in joining forces between German and Chinese research institutes. We welcome collaborations with any Chinese institution that deals with the same subjects and shares our scientific interests.

Required qualification of the post-doc:

The candidate will perform EMCD and electron holography experiments in an aberration-corrected transmission electron microscope.

Requirements for the candidate are as follows:

- PhD in physics, materials science or an equivalent subject completed in the past 5 years;

- Hands-on experience with aberration-corrected (scanning) transmission electron microscopy, electron energy-loss spectroscopy and/or off-axis electron holography;
- Not older than 35 years at the time of application;
- Skills in electron energy-loss magnetic circular dichroism and dynamical diffraction simulations would be preferred.

PART B

Documents to be provided by the post-doc:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team