

The EMAT electron microscopy research group at the University of Antwerp, Belgium, announces an open

Ph.D. position
on the theme

**Quantitative electron microscopy :
from experimental measurements to precise numbers**

Project

In materials science and in nanoscience in particular, there is an evolution from describing towards understanding and designing. Physics-based models are continuously improving and ab-initio methods to compute the properties of nanostructures are nowadays available. However, these models require structure parameters which have to be determined with sufficiently high precision from experiments. For illustration: for many materials, the properties change if atoms are moved over a distance of the order of 1 pm. Therefore, the precision with which atom positions have to be measured, should be of the order of 1 pm. Electron microscopy is most suitable to perform this task and is able to provide a number of relevant structure parameters such as atom positions, concentrations of atoms, atom types and energy levels of inelastic excitations. During the last decades, electron microscopy has been characterized by breakthrough technology developments in microscope design, especially, in lens design, stability of electronics and detectors. Thanks to the improved stability, experiments are better reproducible now. Spatial resolutions up to 50 pm can be obtained. For most atom types, this exceeds the point where the electrostatic potential of the atoms is the limiting factor. Detectors behave more and more as ideal quantum detectors and energy resolutions up to 100 meV provide spectral information exceeding the limit of the natural lifetime broadening for most inelastic excitations. For these reasons, the microscope itself is less restricting and the experimental measurements are predominantly determined by the physical interaction of the fast electrons with the sample. Therefore, the electron microscope can be considered as an ideal measurement instrument that allows one to explore the physical limits. However, electron microscopy measurements mostly provide images or spectra which cannot directly be interpreted in terms of structure parameters. In this project, a method will be proposed to extract these structure parameters from the available measurements. The aim of this research project is to determine unknown structure parameters such as atom positions, concentrations of atoms, atom types, and energy levels of inelastic excitations, in a quantitative way from experimental measurements obtained by means of electron microscopy. Therefore, use will be made of statistical parameter estimation theory which is expected to provide a considerable improvement in accuracy, precision and reproducibility in comparison to conventional ad-hoc methods which are currently used to extract parameters from experimental measurements. In this project, we will focus on a number of important applications: estimating the dielectric function, determining atom positions of unknown nanostructures with a precision of 1 pm, reconstructing the complex exit wave from an interference pattern, quantifying the atomic number Z , detecting individual atoms, and quantitatively measuring lens aberrations.

Tasks

The PhD candidate will be expected to

- acquire knowledge in the field of statistical parameter estimation theory and physical electron-object interactions in electron microscopy
- apply this theory to measure unknown structure parameters from experimental data

- implement this theory (preferably in Matlab) in order to numerically estimate unknown parameters
- discuss the results in terms of the expected performance of the technique and fundamental physical limitations

Your profile

Candidates for this challenging project should have a Master's degree and a background in e.g., physics, mathematics, statistics or systems and control. The candidate must be enthusiastic and greatly interested in applied statistics, scientific programming and fundamental theoretical research. A background in electron microscopy will be considered as a plus, but is not necessary. In addition to this, a good command of the English language is required.

Project term

Enrolment will start as soon as possible. The Ph.D. student will be appointed for a period of four years; after the first year an evaluation will take place. You will form part of a world-class research environment with state-of-the-art instrumentation (see also <http://www.emat.ua.ac.be>).

Information and application

Additional information about the vacancy can be obtained from: Dr. S. Van Aert, tel. +32 3 265 3252, Sandra.VanAert@ua.ac.be or Dr. J. Verbeeck, tel. +32 3 265 3249, Jo.Verbeeck@ua.ac.be, University of Antwerp, EMAT, Groenenborgerlaan 171, B-2020 Antwerp, Belgium, <http://www.emat.ua.ac.be>

Interested applicants should send their Curriculum Vitae, the names of two professional referees, a summary of their M.Sc. thesis and a cover letter stating their motivation to Dr. S. Van Aert and Dr. J. Verbeeck.

Antwerp, September 2009