MONASH University
Centre for Electron Microscopy

SEMINAR

Beyond the limits of imaging: Advances and applications of model-based transmission electron microscopy

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Science Lecture Theatre S1, Building 25
16 Rainforest Walk, Monash University

Abstract and Bio

New developments in the field of nanoscience and nanotechnology drive the need for advanced quantitative materials characterisation techniques that can be applied to complex nanostructures. The physical properties of these nanostructures are obviously controlled by composition and chemical bonding, but also by the positions of the atoms. Indeed, changing the interatomic distances by picometers can turn an insulator into a conductor. Because of the presence of defects, interfaces and surfaces, the locations of atoms deviate from their equilibrium bulk positions giving rise to strain. In order to study nanostructures, transmission electron microscopy (TEM) is an excellent technique because of the strong interaction of electrons with small volumes of matter providing local information on the material under study. Over the past few years, remarkable high-technology developments in the lens design greatly improved the image resolution. Nowadays, a resolution of the order of 50 pm can be achieved. For most atom types, this exceeds the point where the electrostatic potential of the atoms is the limiting factor. Furthermore, new data collection geometries are emerging that allow one to optimise the experimental settings. In addition, detectors behave more and more as ideal quantum detectors. In this manner, the microscope itself becomes less restricting and the quality of the experimental images is mainly set by the unavoidable presence of electron counting noise and environmental disturbances. In order to measure the atom positions and atom types as accurately and precisely as possible from atomic resolution TEM images, quantitative methods are required. To reach this goal, the use of statistical parameter estimation theory is of great help. This methodology allows one to measure 2D atomic column positions with sub-picometer precision, to measure compositional changes at interfaces, to count atoms with single atom sensitivity, and to reconstruct 3D atomic structures. Using current state-of-the-art experimental examples, it will be shown how statistical parameter estimation techniques can be used to overcome the traditional limits set by modern TEM. The precision that can be achieved in this quantitative manner far exceeds the resolution performance of the instrument. This opens up a whole new range of possibilities to understand and characterise nanostructures at the atomic level and to help developing innovative materials with revolutionary interesting properties.

Sandra Van Aert received her Ph.D. at the Delft University of Technology (The Netherlands) in 2003. Thereafter, she joined the Electron Microscopy for Materials Research (EMAT) group of the University of Antwerp (Belgium) where she became a Senior Lecturer in 2009. Her research focuses on new developments in the field of model-based electron microscopy aiming at quantitative measurements of atomic positions, atomic types, and chemical concentrations with the highest possible precision.

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