# Analyzing Matter Atom-by-Atom with the Scanning Transmission Electron Microscope

Pacific Northwest NATIONAL LABORATORY

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Frontiers in Chemical Imaging
Seminar Series

**Presented by**


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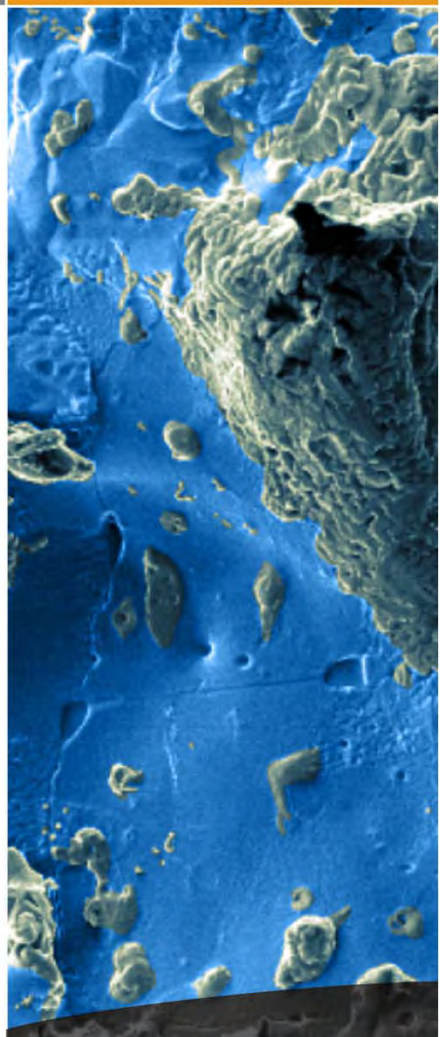
**President, Nion Co.**

**Wednesday**

**May 30, 2012**

**9:00 am**

**EMSL 1077**


### Abstract

Analyzing matter atom-by-atom with an Å-sized yet intense beam of electrons in a scanning transmission electron microscope (STEM) is now possible, principally because of 5 developments, several of which have been pioneered by Nion.

Correction of electron-optical aberrations has resulted in electron beams that are smaller than the typical atom, which means that the beam can be focused on one atom at a time. Aberration correction has allowed this performance to be maintained at low beam energies (30-80 keV), which do not cause knock-on radiation damage in materials such as graphene. As a result, very large electron doses can be used, leading to relatively noise-free images and spectra from individual atoms.

Improved cold field emission guns (CFEGs) are allowing electron currents of the order of 0.2 - 1 nA to be packed into the Å-sized probe. Ultra-high vacuum (UHV, pressure < $1x10^{-9}$ torr) has become available in the sample chamber, allowing samples to be examined without contamination and without contamination-caused beam-assisted chemical etching. Samples such as graphene and monolayer BN have become readily available, allowing atoms to be imaged in non-overlapping configurations, rather than imaging whole columns of atoms, as was the case with thicker samples.

These advances will be reviewed and illustrated by practical examples, such as annular dark field (ADF) imaging that identifies all individual atoms in a sample, and electron energy loss spectroscopy (EELS) and energy-dispersive X-ray spectroscopy (EDXS) that record spectra from individual foreign atoms in and on graphene. The EEL spectra will be shown to contain fine structures that provide information about the local environment of individual atoms.

Our progress on a new instrumentation project – reaching 30 meV and smaller energy EELS resolution with a nm-sized electron probe – will also be described.


### Bio

Ondrej Krivanek is a co-founder of Nion. Ondrej has worked as the director of Research at Gatan Inc., as professor at Arizona State University and as researcher at the Lawrence Berkeley Laboratory. He has been developing electron-optical instruments since his post-doctorate: serial-detection EELS in the early 1980's, parallel-detection EELS in the mid-1980's, CCD cameras and image analysis software for electron microscopy in the late 1980's, and imaging filters in the early 1990's. Since 1995, he has focused on aberration correction, whole microscope design and managing Nion. He has a Ph.D. in Physics from Cambridge University in the UK.

**More Info:** http://www.nion.com/about.html

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