Ultra-High Resolution Imaging in ORION® PLUS

Product Information

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Application

Deep sub-nanometer imaging resolution for accurate measurement of nanometer sized features.

ORION® PLUS Capabilities

Small probe size, system stability that provide the world's highest secondary electron image resolution.

Background

There is an ever greater need in nanotechnology imaging to achieve the highest possible image resolution. It is not sufficient, for example, to image 2-3 nanometer sized objects with a 1 nanometer probe. The probe size of the microscope is thus the key factor that limits a tool's ability to view and measure structures accurately. The smaller this probe size the better the resolution of the tool can be.

Challenge

The brightness of the source in a charged particle optical system defines the fundamental envelope of performance. There is very little that can be done to change this limiter to image resolution. The optics of the tool must also deliver the beam into the focused probe without broadening it too much due to optical aberrations. In SEM, for example, the energy spread of the source leads to a chromatic blur which is a limiter to probe size reduction. The diffraction spot also imposes a limit, and the two of these factors are balanced to define the final probe. Finally, the tool itself must be of sufficient stability to place and hold the beam at the addressed locations of the intended image field.

ORION® PLUS Solution

The helium ion source has both a very small source size (an atomic diameter or less) and also a very small energy spread. In addition, diffraction effects are negligible since the mass of the helium ion is so much greater than that of an electron. Thus with modest column demagnification – and with no use of complicated correction optics, a deep sub-nanometer probe size is achievable. Optics calculation indeed predict a minimum spot size of approximately 0.25 nanometers. With the microscope placed into a stable environment (similar in specification to what is required for a high resolution SEM), tuned to minimize vibrations, and maintained in a sufficiently clean state, image resolution at this level can be realized. This has been accomplished on an engineering development ORION® PLUS tool. The first image below is of asbestos (specifically, crocidolite) taken at a 200 nm field of view with the ORION® PLUS. For a material such as this with

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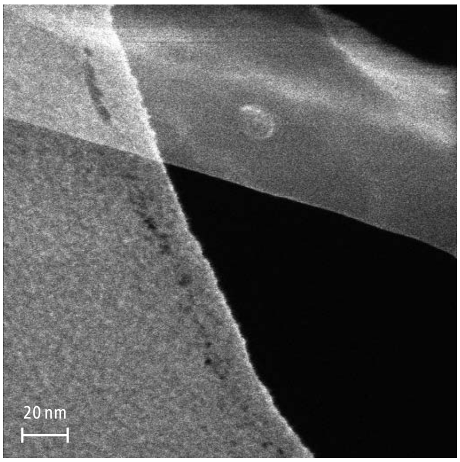
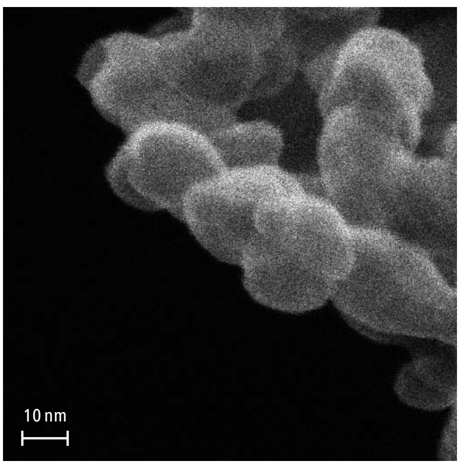
very sharp edges, the limitation in viewing the true sample structure is the microscope's probe size and system stability. An ultimate resolution (signal rise on an edge) of 0.21 ± 0.06 nm is measured from this image. This achievement was even more challenging to obtain due to the fact that the pixel resolution was very high (2048 x 2048 image size), requiring about 160 seconds to acquire the image. We have repeatedly obtained 0.25 nm resolution in secondary electron imaging, a first-ever accomplishment for a charged particle microscope. The second image below is of graphitized carbon, taken at a field of view of only 100 nm (1.14 MX, Polaroid reference). This demonstrates the system stability that can be achieved at extreme magnification. An edge resolution of 0.29 ± 0.08 nm is measured for this image. The imaging resolution demonstrated here will be available as an upgrade option to ORION® PLUS microscope owners.



ORION® PLUS image of the edge of a crocidolite fiber at 571 kX.



ORION® PLUS image of graphitized carbon at 1.14 MX.

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