Helium Ion Microscopy versus Scanning Electron Microscopy

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The helium ion microscope is a new type of microscope that uses helium ions for surface imaging and analysis. Its functionality is similar to a scanning electron microscope, but it uses a focused beam of helium ions instead of electrons. Since helium ions can be focused into a smaller probe size and provide a much smaller interaction volume at the sample surface compared to electrons, the HIM generates higher resolution images with better material contrast and improved depth of focus. The high resolution arises from the use of a finely sharpened needle and a process that strips individual atoms away from the source until an atomic pyramid is created with just three atoms at the very end of the source tip. The HIM achieves a resolution of less than 0.3nm at energy of 25-30kV and can deliver beam currents between 1fA and 25pA. Analysis of material composition can also be performed using Rutherford backscattering spectrometry.

Being able to see to the atomic level is critical. Scanning Electron Microscopes typically have excellent resolution, but not particularly good material contrast. Without good material contrast, it can be difficult to determine where the edge of a critical feature is. The helium ion microscope offers some advantages over traditional SEM technology. SEM's typically produce one secondary electron for each incoming electron. The helium ion beam, by contrast, produces from 3-9 secondary electrons, depending on the substrate material, for each incoming helium ion. This creates a better signal with higher contrast between different materials. In the field of defect review the standard for material identification today is energy dispersive X-ray analysis. This technique suffers from a lack of resolution, as the volume being analyzed can often be much larger than the defect itself. The helium ion microscope can collect energy spectra of backscattered helium ions and identify elements in the sample with submicron resolution. We will show examples of biological, bio-geo materials and energy materials showing differences in imaging with HIM vs. SEM along with some EDS and RBS data.

PNNL has become the first US national lab to acquire a ZEISS ORION PLUS helium-ion microscope. One of the Department of Energy's (DOE's) ten national laboratories, managed by DOE's Office of Science, PNNL offers an open, collaborative environment for scientific discovery to researchers around the world. EMSL, the Environmental Molecular Sciences Laboratory, is a national scientific user facility sponsored by the Department of Energy's Office of Science, Biological and Environmental Research program that is located at Pacific Northwest National Laboratory.

References

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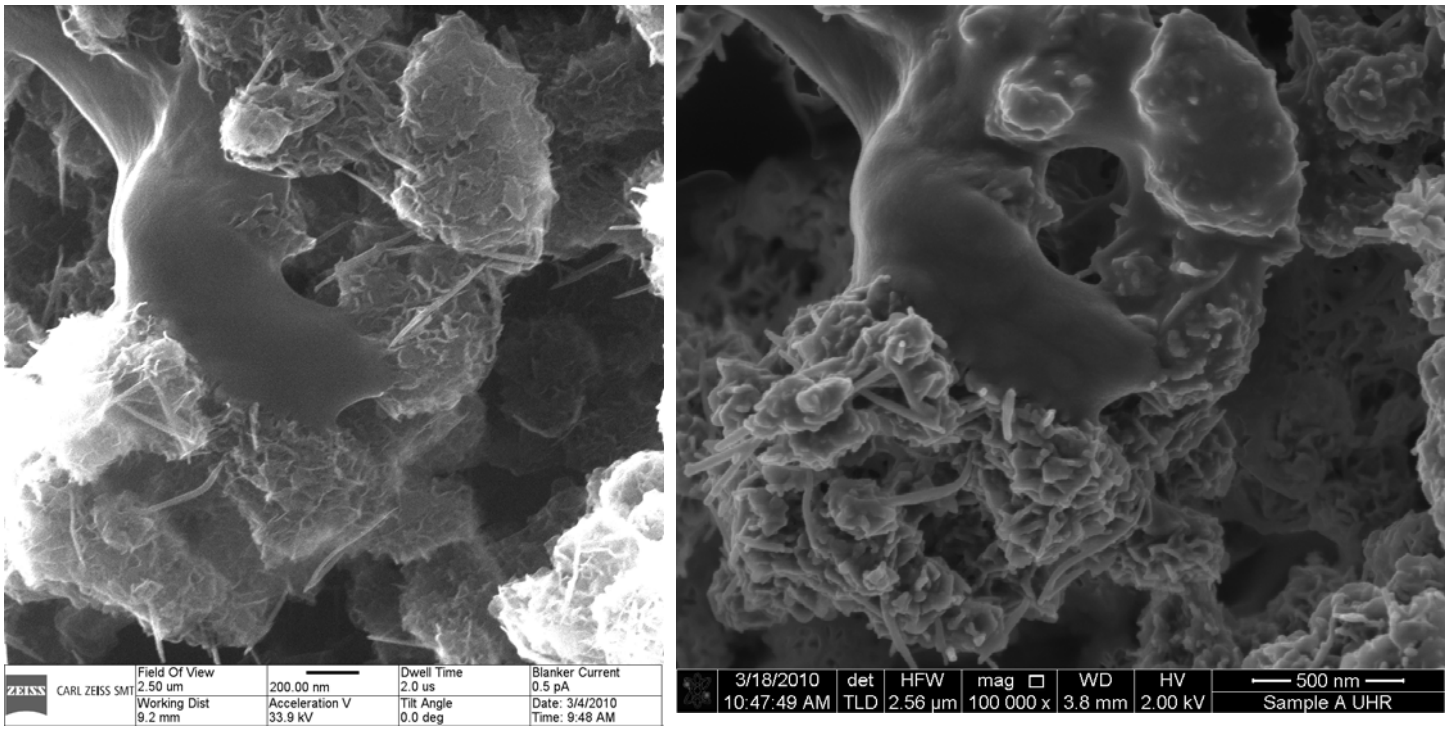

Fig.1.(A) Helium Ion image (B)SEM image.