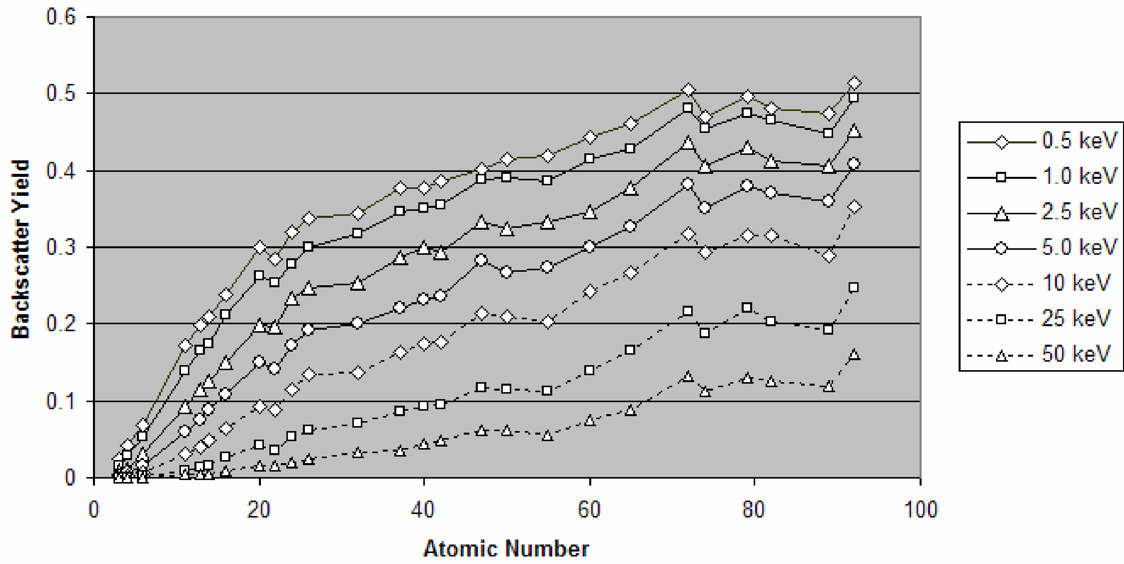
Elemental Analysis with the Helium Ion Microscope

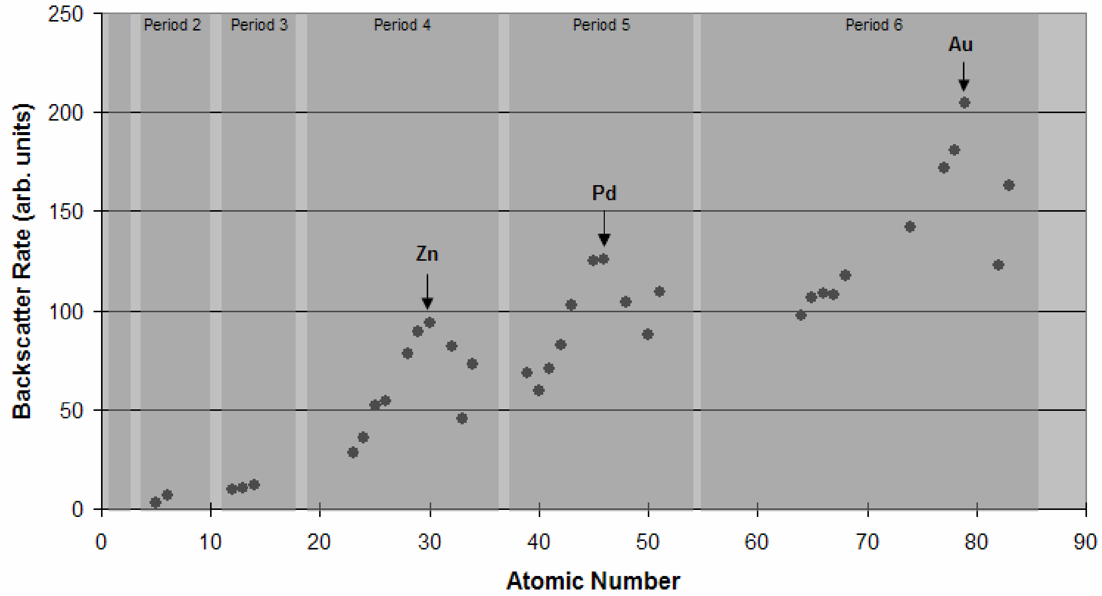
John A. Notte, Sybren Sijbrandij, Nicholas P. Economou, Bill Ward
ALIS Business Unit, Carl Zeiss SMT, One Corporation Way, Peabody, MA 01960

New experiments have shown that the ORION™ helium ion microscope can be used for elemental identification. Heretofore, the helium ion microscope has been chiefly employed for high resolution imaging. The nature of the ion source, and the advantageous properties of helium ions, allow a helium ion beam to be focused to a probe size as small as 0.25 nm. Upon striking the sample, the helium ion beam produces many generated particles such as photons, secondary electrons, and backscattered helium atoms (both neutral and ionized). As with a SEM or traditional FIB the images are produced on a pixel by pixel basis by some characteristic of these generated particles (such as their abundance, energy, angle, etc.). Such images also provide contrast mechanisms and surface sensitivity which is distinctly different from a SEM or a gallium FIB.

Aside from image formation, there are several techniques whereby the helium beam can be used to ascertain the elemental composition of the sample. One of the more promising techniques involves the analysis of the helium atoms which are backscattered from the sample. Typically, 0.1% to 10% of the helium ions that enter the sample will be backscattered out of the sample (as ions or neutrals). The larger scattering probability is seen with lower beam energies, and with larger target atomic numbers, Z. According to SRIM simulations[1], the backscatter yield should be a nearly monotonic function of Z (Fig 1). However, repeated experiments indicate a distinctly different dependence on Z (Fig 2) which includes substantial oscillations which repeat across periods 4 through 6 of the periodic table. At present this discrepancy is not understood.

Recently a detector has been developed which permits the energy measurement of the backscattered helium atoms. Based upon the simple two-body scattering physics[2], the backscatter energy (together with the scattering angle) can be used to determine the mass of the target atom. Some corrections are necessary to account for (a) inelastic losses as the helium ion traverses the sample, (b) multiple scattering effects, and (c) detector inefficiencies. The performance of this detector has been characterized with several elemental samples and the results are consistent with expectations. Preliminary results will be presented.





[1] J. F. Ziegler, J. P. Biersack and U. Littmark, Pergamon Press, New York, 1985
[2] J. Wayne Rabalais, "Principles and Applications of Ion Scattering Spectrometry", Wiley Interscience, Hoboken, NJ, 2003