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Helium Ion Imaging and Milling at the Nanometer Dimensions

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The helium ion microscope (HeIM) is a new, powerful instrument for nano-metrology and nanotechnology. As an emerging imaging and measurement tool it offers several advantages over the traditional scanning electron microscope (SEM) currently in use in research and manufacturing facilities across the world. First, resolution 2 to 4 times better than that from comparable SEMs is theoretically possible, due to the very high source brightness and the short wavelength of the helium ions. Ion images with unprecedented resolution have been routinely collected on a wide range of samples with sub-nanometer features. More importantly, the interaction volume of the helium ion beam in the sample is substantially different in its size and shape from that of the electron beam in an SEM. As a consequence, the signals generated, especially secondary electrons, reveal more surface details. Imaging by the HeIM can further benefit from the superb depth of field and the fact that He ion imaging is less susceptible to sample charging. In addition, it is possible to compensate for charging by the use of an electron flood gun. Scattered He ions produced as a result of Rutherford scattering of the incident ions on the target nuclei can provide material contrast information that can be used for quantitative compositional analysis. Beyond imaging, the HeIM is a potent tool for milling and modifying surface structures at the nanometer scale, due to the relatively low mass of the helium ion, the narrow ion beam, and especially the low beam currents. It is possible to drill close to 10 nm diameter holes and mill other nanoscale structures that cannot be fabricated with any other method. It is expected that, as with the electron beam, it is feasible to expose resist and deposit various materials with He ion beam irradiation. The work is at its exploratory stage, and likely soon will yield more exciting results. This presentation will report on some of the newest research work on the NIST helium ion microscope. * Contribution of the National Institute of Standards and Technology; not subject to copyright