Does the SEM have a future in Metrology ?

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The scanning electron microscope (SEM) has now been available as an imaging tool for more than 50 years and for most of that time it has been the instrument of choice for device metrology. SEM technology is now fully mature, but the size of the device structures to which it is applied continues to steadily decrease. It is therefore appropriate to ask whether the SEM, in its present form or in some enhanced version, can continue to be of use. Optimizing the performance of the SEM involves a balance between many operational parameters. For the past two decades the consensus has been to use the lowest possible beam energy because this reduces or eliminates charging, minimizes sample penetration by the beam so enhancing contrast, and maximizes the secondary electron yield. While this mode has found favor it sets fundamental limits on the imaging performance because diffraction and chromatic aberration effects dominate the probe size and the gun brightness is reduced. As a result further improvements in the performance of this type of instrument are, at best, incremental. Three possible strategies to extend the utility of the SEM to smaller device nodes are available:

(1) Keep the instrument in its current form but provide aberration correction[1]. This approach has only recently become feasible and simultaneously provides enhanced resolution and more beam current. These advantages are achieved at the expense of imaging depth of field, and incur considerable additional cost and complexity associated with the corrector system.
(2) Operate the SEM at higher energies (i.e. the 20 to200keV range) [2]. This permits a major reduction in probe size and enhances the gun brightness ensuring more beam current. The high penetration of the beam makes possible top-down overlay metrology with the beam for multiple metal levels, and the technology is already available in a highly developed form. There are, however, questions about the collateral damage generated by high energy electrons which require resolution.
(3) Replace the electron beam with an ion beam. The high performance helium ion scanning microscope from ALIS-Carl Zeiss [3] has the advantages of a bright source and probe forming optics limited only by spherical aberration. At 20-30keV each helium ion generates 10 to 50x more secondary electrons than an electron while still producing a surface specific image containing both topographic and chemical information. However this technology is not yet fully optimized and aspects of the ion interaction processes are not well documented.

1. K. Honda and S. Takashima, *JEOL News* **38**, 36 (2003)
2. M. Bishop and D C Joy, *Characterization and Metrology for ULSI Technology 2005*, ed D G Seiler et al. (AIP:NY), 407, (2005)
3. ALIS-a Carl Zeiss SMT Company, Peabody MA 01960 (www.aliscorporation.com)