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Caught between Ions and Electrons - the Best of Helium Ion Microscopy

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The Helium ion microscope (HeIM) is now commercially two years old and very much a unique instrument for imaging and characterization of materials and composites [1]. As we evaluate this still very new technology we now have a better understanding of what how this microscope fits into the microscopy world. The helium ion source has proven to be very stable and offers high brightness, low virtual size and low energy spread as compared to a conventional FEG type SEM. Remarkable depth of field, a unique compositional analysis ability via the Rutherford backscattering imaging system, a method to limit charging effects and excellent surface information on low Z materials, as well imaging of doped semiconductor materials has also been attempted [2]. Besides microscopy, the ability of He ions to etch and modify low Z materials has attracted a lot of attention from groups doing graphene research [3], and development of helium ion lithography using standard resists has also shown promise [4]. Subsurface feature imaging has also been demonstrated using Rutherford backscattered ion imaging (RBI), to allow imaging of the underlying details of fabricated devices.

Some of our research from the past year has been surprising and may provide a foundation for a change in analysis techniques of many different materials. The imaging and contrast mechanisms are different in comparison to standard SEM imaging and provide further details of materials such as nano-composities (Fig. 1) and magnetic materials that have been previously unobtainable or at the least difficult to acquire. The nature of the Helium ion beam interactions with the sample shows enhanced edge contrast which is especially useful for critical dimension measurements; one particularly interesting development is the imaging of magnetic materials as used for high density storage devices, showing a contrast due to three apparent mechanisms simultaneously - atomic number, channeling contrast and a possible domain orientation or edge contrast (Fig. 2). Helium ion microscopy is still in its infancy (while the conventional SEM has been available for decades), there are still many more discoveries waiting.

References

[1] D.C. Bell "Contrast Mechanisms and Image Formation in Helium Ion Microscopy", Microscopy and Microanalysis, 15 (2009), pp. 147-153
[2] M.A.E. Jepson, B.J. Inkson, C. Rodenburg and D.C. Bell, "Dopant Contrast in the Helium Ion Microscope", *Europhysics Letters*, 85 (2009) 46001
[3] D.C. Bell, M.C. Lemme, L.A. Stern, J.R. Williams, C.M. Marcus, "Precision cutting and patterning of graphene with helium ions", *Nanotechnology* 20 (2009) 455301
[4] D. Winston, B.M. Cord, B. Ming, D.C. Bell, W. DiNatale and L.A. Stern, A.E. Vladar, M.T. Postek, M.K. Mondol, J.K.W. Yang, K.K. Berggren "Scanning-helium-ion-beam lithography with hydrogen silsesquioxane resist", J. Vac. Sci. Technol. B 27 2702 (2009)

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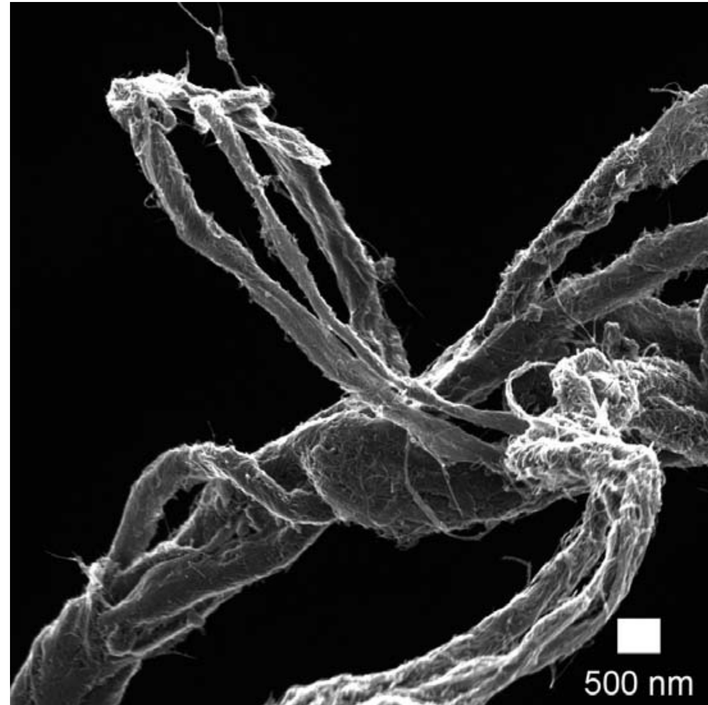

Figure 1. What helium ion microscopy is really good at, imaging of carbon fibre nano-composites, showing very clearly the carbon nanotube components

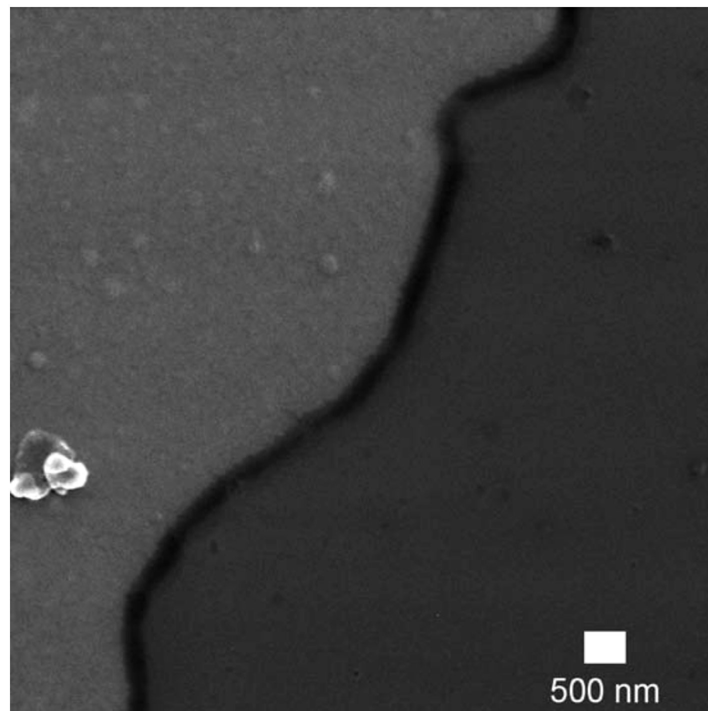

Figure 2. An interesting result: Imaging magnetic films. The darker contrast on the right is due to a cobalt coating; the contrast on the left is due to a cobalt-lead intermixed coating, the dark line does not appear in SEM images, a direct artifact of imaging with helium ion microscopy.

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