He Ion Microscopes: Potential and pitfalls

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The He Ion Microscope (HIM) produces a sub-nanometer spot size with a beam energy between 20-35 KeV. The tool brings the ion beam community to the real nanoscale regime in a commercially available tool.

The main uses of the apparatus are: 1) imaging via secondary electron emission, 2) ion beam lithography and 3) ion beam machining on the nanoscale. In addition various groups are developing element identification tools operable at the nanoscale, nanoscale writing via radiation enhanced CVD, and unique transmission geometries to look for thin crystal channeling. A variety of successful examples of HIM use will be given in the following talks. Some examples from the Rutgers laboratory include:

1) Collaborative projects in the biological and biomedical fields.
2) Development a Time-of-Flight system capable of element identification.
3) He beam induced single atom defects in MoS_2 and their effects on the host lattice.
4) Machining of SiC for structured graphene growth and stress regulation in graphene.
5) Selective defect production in 2D material such as MoS_2.

Successful operation depends on a thorough knowledge of the particle-solid interaction familiar to those in the field. The advantages of the HIM for imaging are directly connected to the decrease of multiple scattering at the surface as compared to electron beams. HIM imaging makes use of the secondary electron emission, but is limited by ion beam induced damage. Ion beam machining makes use of macroscopic and microscopic defect production associated with the ion beam-solid interaction but now at the nanometer level.

While a number of successes currently exist (see the following talks) more precise knowledge of ion beam solid physics is required to bring the tool to the desired level of quantitative use. These include issues such as a quantitative basis of electron emission, the so called non-charging effects, electron emission associated with large angle scattering events, the formation of sub-surface “blisters” and the blister dependence on material type, ion beam sputtering and electron emission dependence on doping in semiconductors. In addition to these factors the challenges associated with element analysis will be discussed.

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