

Imaging, Modification, and Analysis of Nanostructures with the Helium Ion Microscope

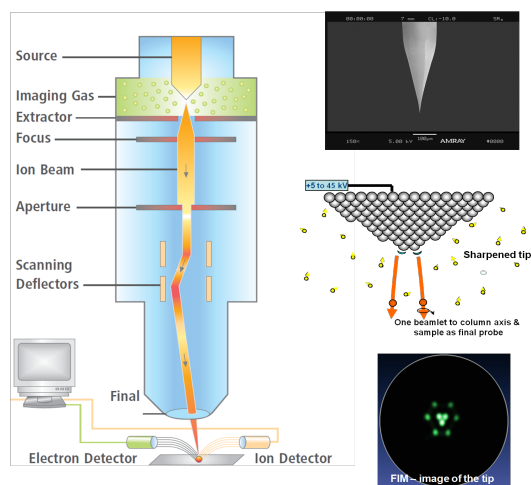
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The Helium Ion Microscope (HIM) utilizes a focused beam of He^+ ions to image and modify materials with high spatial resolution and chemical sensitivity [1]. A HIM operates similar to a Scanning Electron Microscope (SEM). However, its helium ion beam can be focused into a smaller region than an electron beam, and a HIM is thus capable to resolve features down to 0.25 nm. Helium ions are also more surface sensitive than electrons and they interact more strongly with matter. HIM images thus show much stronger chemical and topographical contrasts than SEM images. The HIM is further capable to image not only conductive, but also insulating samples without special treatment. This allows the investigation of unstained biomaterials and cell surfaces. When applying higher ion currents, the HIM can be also used for the modification and the milling of materials.

The presentation will review principles of Helium Ion Microscopy and will contain examples of HIM imaging and lithography with a particular focus on 2D materials. 1 nm thick carbon nanomembranes (CNMs) with a controlled thickness, elasticity, conductivity and porosity [2] are investigated. HIM images provide valuable information to understand the structure of CNMs and their formation process [3]. The capability of the HIM for nanolithography of 2D materials will be shown by examples of milling 2D materials (CNMs and graphene), where nanopores with diameters down to 1.3 nm were fabricated [4]. HIM imaging of different carbon materials from soot particles in flames [5] to biological cells [6] will be presented and discussed.

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Schematic of a Helium Ion Microscope (HIM): The He^+ ion source, realized by a metal tip sharpened in a field ion microscope to form an atomic trimer at the tip apex (Fig. from Carl Zeiss).