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EBIS-Based HCI Micro-Beams

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We describe the development of an ion beam irradiation system with focused beams of highly charged ions (HCI), whereby the use of HCI of noble gas creates unique features leading to applications which can complement the existing equipment market. The developed, built and commissioned facility consists of an electron beam ion source (EBIS), a downstream Wien filter for the ion mass and charge state separation, an ion-optical column for the fine-focussed ion beam formation, a specimen chamber with a simple sample transfer system, a sample table with sub-micrometer positioning precision and a TOF-SIMS spectrometer for surface analysis.

Compared to known classical focussed ion beam systems and commercially available solutions, the system differs significantly in the following items:

- nearly all elements of the PSE will be available in a broad ion charge spectrum for applications,
- fine-focussed noble gas ion beams can be used as non-toxic projectiles for materials analysis and surface modifications,
- different kinetic energies are available even without changing the acceleration potential by selecting a different charge state of the used element, allowing e.g. different implantation depths in solids,
- two-dimensional and three-dimensional “chemical maps” of different samples can be created by combining the HCI-FIB’s SEM imaging capability with the TOF-SIMS technique,
- optimized projectile-energy combinations provide optimal conditions for the analysis of biological or other soft-matter samples.

The first experiments yielded argon and helium ion beams with currents of approx. 2 nA at d = 1 mm, 50 pA at d = 50 µm and 5 pA at d = 20 µm. (d - ion beam diameter)

Potential applications of the described technique are fields such as photolithography-free structuring for nanoelectronics (ion-beam-induced etching, nanomasks, nano-column epitaxy), intensive local sputtering of micro-regions, or delivering selected ion species and ion charges to selected places for structuring via single ion implantation (vacancy centers, doping) and materials analysis.

Authors: Mr SCHMIDT, Mike (Dreebit GmbH, Großröhrsdorf); Mr LAUX, Paul-Friedmar (Dreebit GmbH, Großröhrsdorf); Dr GIERAK, Jacques (C2N –Site de Marcoussis, Marcoussis); Dr ZSCHORNACK, Günter (Dreebit GmbH, Großröhrsdorf, Dresden University of Technology, Department of Physics, Dresden)

Presenter: Mr LAUX, Paul-Friedmar (Dreebit GmbH, Großröhrsdorf)

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