

## Highly charged ions for nanotechnology applications and materials analysis

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Beams of Highly Charged Ions (HCI) are of principal interest for applications in surface structuring in nanometer dimensions and materials analysis. The most distinctive feature of these ions is their high amount of stored potential energy due to the ionization process. As a result, in interactions with solid state surfaces, a high amount of energy is deposited onto a small nanometer-scaled reaction zone leading to a power deposition onto the surface in the order of  $10^{12}$  to  $10^{14}$  W/cm<sup>2</sup>. This process is accompanied by exceptional high secondary ion and electron yields, a property complementing and improving different material analysis techniques (TOF-SIMS etc.). Furthermore, the spectrum of different charge states provides a broad usable kinetic energy range for adjusting ion range as well as sputter yield. The intense ion-surface interaction allows creating surface nanostructures by single ion hits altering the structure dimensions in dependence on the ion charge and energy from a few to some tens of nm modifying the morphology, electrical and optical properties.

In the first part of the talk we will introduce a sophisticated MicroFIB table-top platform based on an Electron Beam Ion Source (EBIS), capable of producing focused beams of HCI. Such probes having sub-micrometer diameters allows exploring the potential of single ion implantation technologies. In comparison to classical FIB there arise new possibilities due to:

- all elements can be used for source operation,
- free choice of the charge state (low charged up to highly charged ions),
- selection of the kinetic and potential energy of the projectiles by the ion charge state,
- variable sputter yield by variable kinetic and potential energy can be applied,
- variable ion range by variable kinetic energy for implantation processes,
- variable feature size by variable potential energy.

The listed advantages are an outstanding basis for applications in quantum technologies (quantum dots, quantum cryptography), lithography, nanoengineering, microphotonics, biomedicine etc. and are demonstrated with selected examples.

HCI in combination with special analytic tools such as TOF-SIMS or compact AMS open the door to extremely sensitive surface analysis as well as for a very sensitive analysis of liquid probes. The efficiency of the method is demonstrated with examples of measurements of metal content in liquids in the pbb-range, the analysis of isotope composition of copper clusters as well as the indication of the increasing efficiency of the secondary ions production by ions with increasing ion charge state. Possible future applications will be discussed.

### Biography:

Assoc. Prof. Dr. Guenter Zschornack has taught for more than 40 years at the Dresden University of Technology in the fields of atomic physics, ion beam physics as well as ion source physics. He is author and coauthor of more than 300 scientific papers, of about 400 conference contributions and of 3 books. Beside a lot of international cooperation he also worked at the Division of New Acceleration Methods of the Joint Institute for Nuclear Research Dubna /Russia for 8 years. Together with Dr. F.Grossmann he founded the Dreebit GmbH in 2006, a plasma, electron and ion beam technology company active in high-technology areas such as nanostructuring with highly charged ions and in the field of medical particle therapy.