Highly Charged Ions
Tools for Nanometer Scale Surface Modifications

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1. Introduction

The implementation of low-charged ions in processes of modification and structuring of solid surfaces is a well developed field of research. The availability of a new class of projectiles, slow highly charged ions (HCIs), enables the creation of nanometer-scale structures in the surface without causing implantation-like damages in deeper layers of the solid.

New nanotechnical applications are the result of the unique properties of the HCIs. These are:

The high potential energy stored in an ion that can be released in the ion-surface interaction process. Since the potential energy depends on the atomic number and increases with increasing degree of ionization, the introduced potential energy can be controlled.

The deposition of high power density. Since the interaction area of ion-surface interactions is in the order of 100 nm^2 the power density deposited in the surface is $10^{12}...10^{14}$ W/cm^2. The affected area is orders of magnitude smaller than from laser-surface interactions.

The strong electric field. HCIs are surrounded by electric fields of up to 10^{16} V/cm.

The small dimensions. Compared to neutral atoms or low-charged ions the volume expansion of HCIs is very small. For example, the ratio of the volume expansion of a hydrogen atom and a hydrogen-like nickel ion is the same as the ratio of the size of the sun and the planet neptune.

The high charge state. Due to its charge HCIs can be accelerated more effective than low-charged ions. The specific energy gain ΔE increases with increasing ion charge state q according to $\Delta E \sim q$ in the case of linear accelerators and $\Delta E \sim q^2$ for cyclical accelerators, respectively.