Slow Highly Charged Ions as a New Tool for Surface Nanostructuring

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Highly charged ions (HCI) carry a large amount of potential energy. Upon interaction with solid surfaces the HCI deposit their potential energy within a very short time (a few fs) within a nanometer size volume close to the surface. It is therefore not astonishing that surface modifications with nanometer dimensions have been demonstrated for the impact of individual slow highly charged ions on various surfaces (see [1-3] and references therein), similar to the impact of individual swift heavy ions [4].

These nanostructures have been observed not only on insulator surfaces (CaF_2, KBr, LiF, Mica, PMMA) and oxides (TiO_2, SiO_2) but also on semiconductors (Si) and even conducting substrates (HOPG, Au). Depending on the type of material, the amount of (potential) energy pumped into the topmost layers of the surface and maybe other factors like the scanning probe method used (STM or AFM) these nanostructures appear either as hillocks, craters/pits or caldera like structures. In cases where this was investigated (HOPG, Mica, CaF_2, Si, KBr), the size (e.g. volume, diameter, height/depth) of the generated nanostructures is nearly independent of the kinetic energy of the impinging HCI but usually strongly depends on the potential energy deposited by the HCI into the surface. The onset of nanostructure formation is usually only found above a clear and well-defined threshold in potential energy [1-3]. The occurrence of such potential energy threshold(s) seems to be a general feature for HCI-induced surface-nanostructures.

Corresponding research currently attempts to control the production of material modifications on surfaces and thin films with well-defined size in the nanometer region by a variation of the HCI´s potential energy. For possible applications in nanofabrication this new method holds the promise of forming regular structures on surfaces without inducing defects in deeper lying crystal layers.

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[1] A.S. El-Said, et al., Phys. Rev. Lett. 100 (2008) 237601
[2] R. Heller, et al., Phys. Rev. Lett. 101 (2008) 096102
[3] F. Aumayr, et al., Nucl. Instrum. Meth. B 266 (2008) 2729
[4] E. Akcöltekin, et al., Nature - Nanotechnology 2 (2007) 290

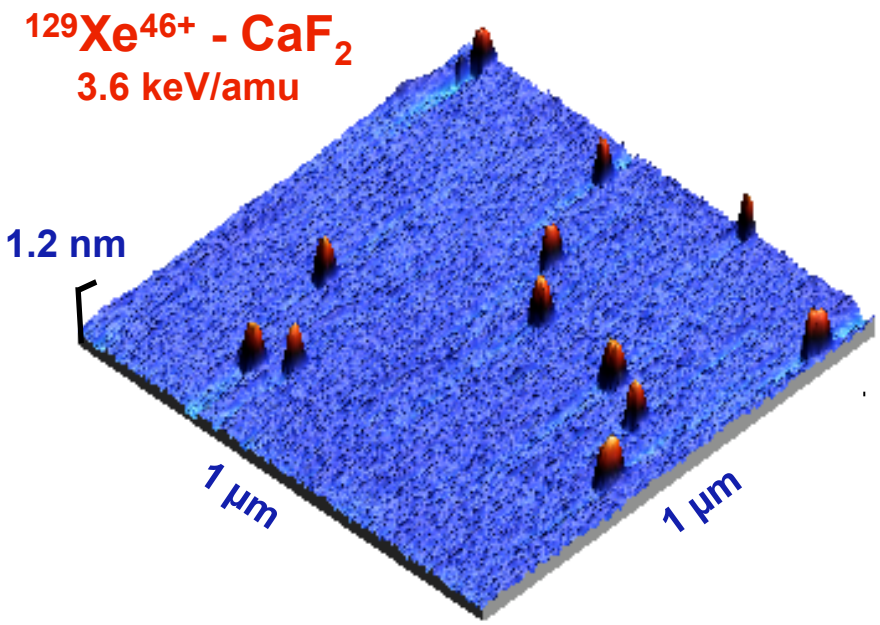

Fig 1: Irradiation of CaF_2 single crystal surfaces by individual slow (keV/amu) highly charged Xe ions leads to the formation of nano-hillocks protruding from the surface [1].