Production of noble gas ion beams in a FIB machine *using* an electron beam ion trap

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Nowadays focused ion beam (FIB) is a very popular and adequate patterning technique for relatively small operations on individual chips on a wafer as a direct write "resistless" patterning. Traditionally FIB patterning is based on material removal by ion sputtering down to the nanoscale. Generally a focused gallium ion beam having an energy typically around 30 keV is scanned over the sample surface to create a pattern through topographical modification, deposition or sputtering. In such cases for most materials, the material removal rate for a 30 keV gallium ion is around 1-10 atoms per incident ion, corresponding to a machining rate of around 0.1-1 μm^3 per nC of incident ions.

The aim of this paper is to report on our preliminary investigations in evaluating a new kind of FIB instrument realized by coupling an advanced FIB “nanowriter” [**1**] with a compact electron beam ion trap using highly charged ions (HCIs) as projectiles.
Apart from the interest of using noble gas ions instead of gallium, the availability of a new class of projectiles, such as slow HCIs is a very promising method. Indeed the creation of nanometer-scale structures in the surface without causing implantation-like damages in deeper layers of the solid would help to solve a fundamental issue in ion beam patterning: the damage creation. Compared to kinetic sputtering (i.e., sputtering of target atoms due to momentum transfer through multiple collision cascades), which unavoidably generate damage in deeper layers, sputtering induced by the potential energy of slow highly charged ions (termed potential sputtering) holds great promise as a tool for more gentle nano-structuring [**2**].

We will present our first results of target imaging and patterning using a focused beam of noble gas ions (helium, argon, krypton and xenon). The achieved resolution in the sub-micrometer range and the probe current of some pA have allowed us to test some patterning schemes based on local ion beam mixing on thin magnetic layers. These results and the instrument architecture will be detailed and analyzed in the presentation.

[**1**] J. Gierak, E. Bourhis, A. Madouri, M. Strassner, I. Sagnes, S. Bouchoule, M.N. Mérat Combes, D. Mailly, P. Hawkes, R. Jede, L. Bardotti, B. Prével, A. Hannour, P. Mélinon and A. Perez, J. Ferré, J.-P. Jamet, A. Mougin, C. Chappert and V. Mathet, *Exploration of the ultimate patterning potential of focused ion beams*
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[**2**] U. Kentsch, S. Landgraf, M. Schmidt, H. Tyrroff, G. Zschornack, F. Grossmann, V.P. Ovsyannikov, F. Ullmann, *Slow highly charged ions for nanoscale surface modifications*, Nucl. Instr. and Meth. in Phys. Res. B 216, 196 (2004)