Low Dose And Highly Selective Patterning With Focused Ion Beams

J. Gierak, E. Bourhis, A.L. Biance, D. Mailly
LPN-CNRS, Route de Nozay, 91460 Marcoussis, France
Contact: jacques.gierak@lpn.cnrs.fr
R. Jede, L. Bruchhaus, S. Bauerdick, F. Nouvertné
Raith GmbH, Hauert 18, Technologiepark, 44227 Dortmund, Germany

The development of effective nanofabrication tools and processes are keys to the advancement of miniaturization into the nanometric regimes, thus enabling novel breakthroughs in important technologies, such as electronics or magnetic memories. In this context, reproducible patterning with lateral dimensions down to the nanometre scale (< 10 nm) remains a challenging, but attractive concept for many application purposes. Here is a clear demand for direct, i.e. resistless patterning techniques that would combine high-resolution, high-throughput capabilities together with reasonable costs and complexity.

Historically the main applications of FIB technology have mostly been focused on local ion sputtering - i.e. the removal of material, or on local deposition processes [1]. These require local ion doses of 10^{20} m^{-2} or even higher, usually of gallium ions (with energies of tens of keV). The essential premise of our research effort was considering that for nano-devices patterning, much smaller ion doses suffice leading to strongly improved spatial resolution in patterning – down to a level of sub 5 nm.

We will present our work aiming to explore the nano-structuring potential of a highly focussed pencil of ions. We will show that Focused Ion Beam technology (FIB) is capable of overcoming some basic limitations of current nano-fabrication techniques and to allow innovative patterning schemes. In this work, we will first detail the very high resolution FIB instrument we have developed specifically to meet nano-fabrication requirements. Then we will introduce and illustrate some new patterning schemes we propose for next generation FIB processing [2]. These patterning schemes are (**i**) Nano-engraving of membranes as a template for nano-pores and nano-masks fabrication. (**ii**) Local defect injection for magnetic thin film direct patterning. (**iii**) Functionalisation of graphite substrates to prepare 2D-organized arrays of clusters. (**iv**) Selective epitaxy of III-V semiconductors on FIB patterned surfaces. Finally we will show that FIB patterning is fully compatible with “bottom-up” or “organisation” processes.

We will conclude this presentation by detailing our last achievement in direct FIB patterning of thin membranes down to the sub 5 nm regime.

[1] *High-resolution focused ion beams*, Jon Orloff, Rev. Sci. Instrum. 64, 1105 (1993)
[2] *Exploration of the ultimate patterning potential of focused ion beams*, J. Gierak et al. J. Microlith., Microfab., Microsyst. 5, 011011 (2006)