

Projection Mask-Less Patterning (PMLP) for Nanotechnology Applications

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There are existing and emerging scientific and industrial needs of the reliable and cost-effective fabrication of complex patterns for a large variety of promising nanotechnology applications: (i) nano-imprint templates, (ii) functionalized materials as well as 2D and 3D surface structures for nano - electronic / magnetic / photonic / biotechnology devices.

To fulfill these needs the technique of Projection Mask-Less Patterning (PMLP) is developed by IMS Nanofabrication together with 18 partners within the European project CHARPAN.¹ The PMLP technology is based on charged particle projection optics with 200x reduction providing thousands of electron or ion beams (H^+ , He^+ , Ar^+ , C_{60}^- ...) working in parallel on the substrate (Figure 1a).

As part of the CHARPAN project a PMLP Proof-of-Concept Tool has been realized (Figure 1b). Using resolution templates, fine features have been fabricated in a variety of materials with 10 keV Argon ion beam resist exposure and resistless sputtering of material surfaces (Figure 2). Inserting a programmable aperture plate system providing 4008 beams, first HSQ resist exposure and resistless patterning results have been accomplished, implementing grayscale exposure techniques.²

In 2008 the PMLP tool is upgraded with a programmable aperture plate system providing ca. 40,000 beams. In addition, a precursor gas injection system for in-situ ion multi-beam induced etching and deposition is developed and will be inserted. Finally the tool platform will be upgraded with a laser-interferometer controlled vacuum stage to realize a PMLP Engineering Tool.

Nanotechnology applications of ion multi-beam PMLP techniques will be discussed.

¹ CHARPAN (Charged Particle Nanotech) is an integrated project of the 6th European framework program (FP6): www.charpan.com

² Elmar Platzgummer, Hans Loeschner and Gerhard Gross, "Projection Mask-Less Patterning (PMLP) for the fabrication of leading-edge complex masks and nano-imprint templates", Proc. of SPIE Vol. 6730, pp. 673033-1 – 673033-9 (2007).

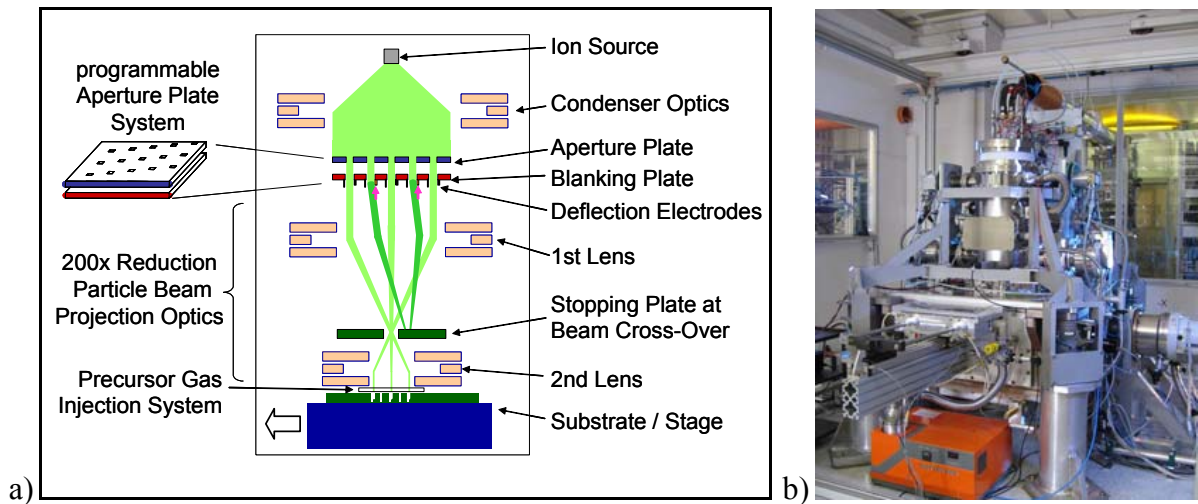


Figure 1: Principles of Projection Mask-Less Patterning and PMLP Proof-of-Concept Tool

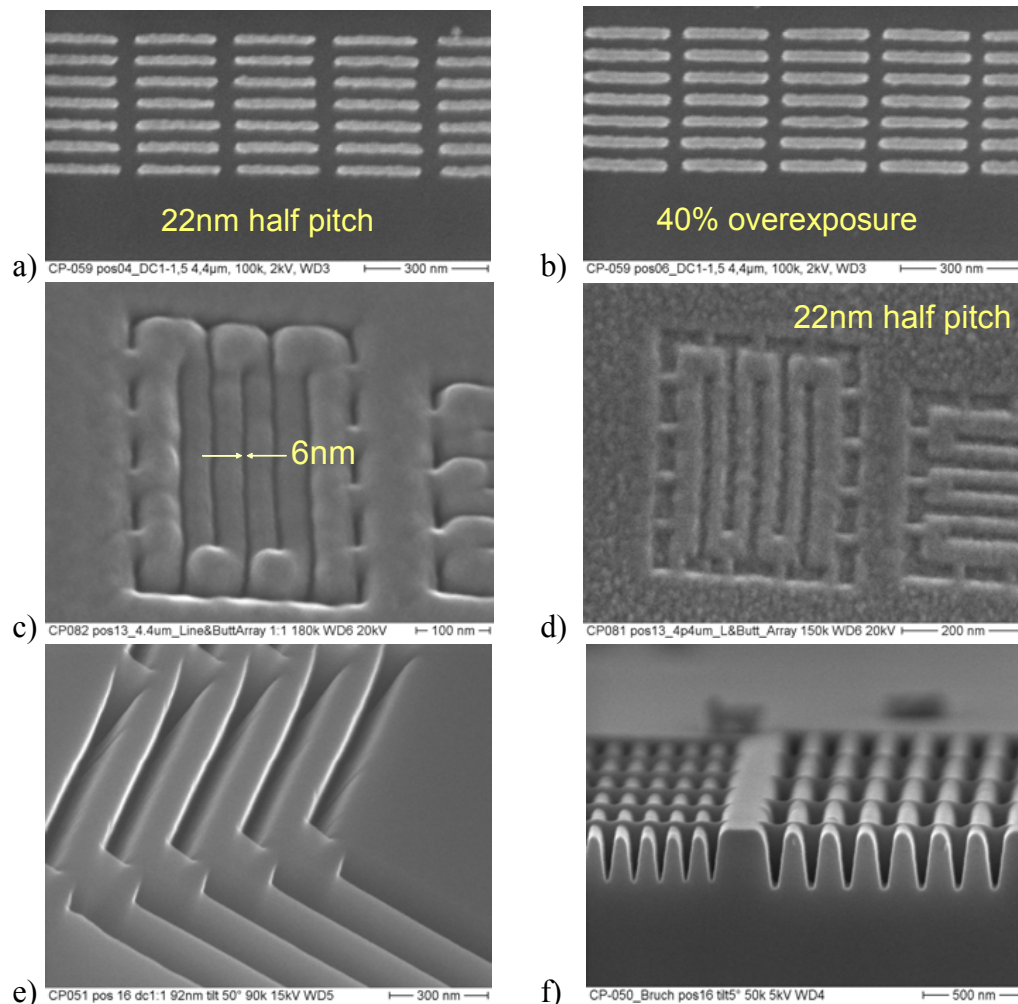


Figure 2: PMLP PoC Tool results using resolution templates and 10 keV Ar^+ multi-beams:
 (i) 22nm half pitch exposure of 20nm HSQ resist: a) dose: $5.66 \mu\text{C}/\text{cm}^2$, b) $8.00 \mu\text{C}/\text{cm}^2$;
 (ii) resistless 22nm half pitch patterning: c) of 70nm Cr on quartz with $39 \text{ mC}/\text{cm}^2$,
 d) of 25nm MoSi on Cr with $9.34 \text{ mC}/\text{cm}^2$;
 (iii) resistless patterning of Si wafer surface with a dose of $100 \text{ mC}/\text{cm}^2$: e) and f).