High-Resolution Lithography

Serial writing and parallel printing of nanostructures

Introduction

A large number of lithographic techniques have been developed for the lateral structuring of surfaces on the micro- and nanometer scale.

For industrial mass production, photolithography is usually applied, due to its very high throughput and resolution capability below the 100 nm range. However, low volume production, or applications in R&D, often require a higher degree of flexibility or even better resolution.

PSI operates a state-of-the art electron-beam lithography (EBL) tool for the flexible writing of micro- and nanostructures with dimensions down to the 10 nm range. In addition, the fast parallel printing of periodic nanostructures with similar resolution is provided by interference lithography using extreme ultra-violet radiation (EUV-IL).

Figure 1: **High-resolution Vistec EBPG5000Plus direct-write electron-beam lithography tool in a dedicated, class 100 clean room.**

Nanolithography services

PSI's Laboratory for Micro- and Nanotechnology and its spin-off company Eulitha AG at Villigen offer expertise in both techniques for external customers, including:

- Consulting regarding nanofabrication
- Sample and data preparation
- Exposures, including pre- and post-processing steps

The range of applications for e-beam lithography is extremely wide. PSI offers broad experience in employing e-beam lithography, in particular for:

- Stamp origination for nano-imprint lithography
- the fabrication of diffractive optical elements (DOE)
- High-aspect ratio moulds for electroforming

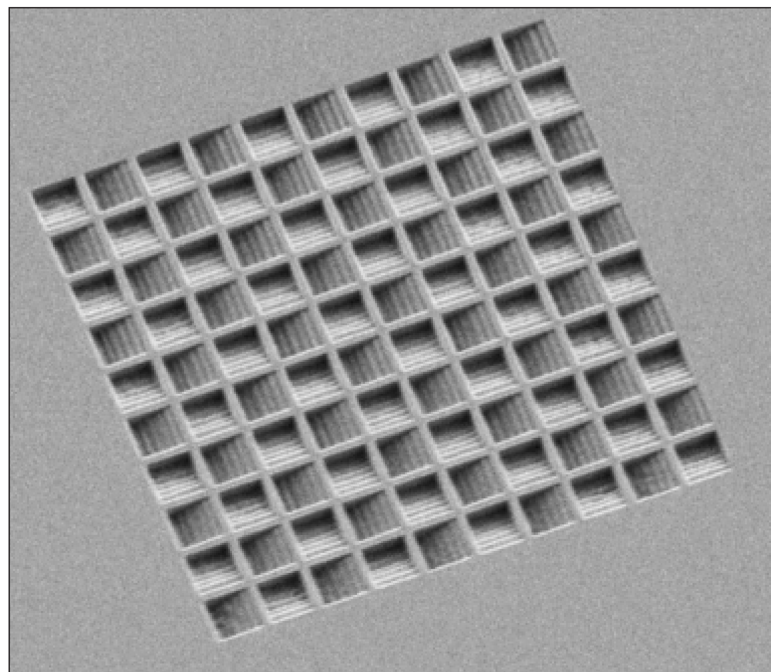


Figure 2: **3D lithography in PMMA for nano-imprint stamp origination.**

- The production of photomask manufacture
- The low-volume production of semiconductor components for many other R&D projects.

The E-beam writing tool at PSI

The Vistec EBPG 5000Plus direct-write tool has been in operation since March 2009. It is among the best Gaussian-shaped e-beam tools world-wide.

The key features of this tool are:
- Electron energy of 100keV enabling exposure of high aspect-ratio structures
- Rapid exposures provided by an intelligent pattern generator
- Substrate size up to 150 mm width
- Excellent resolution, stitching and overlay accuracy
- Continuously variable writing grid for accurate exposure of periodic structures

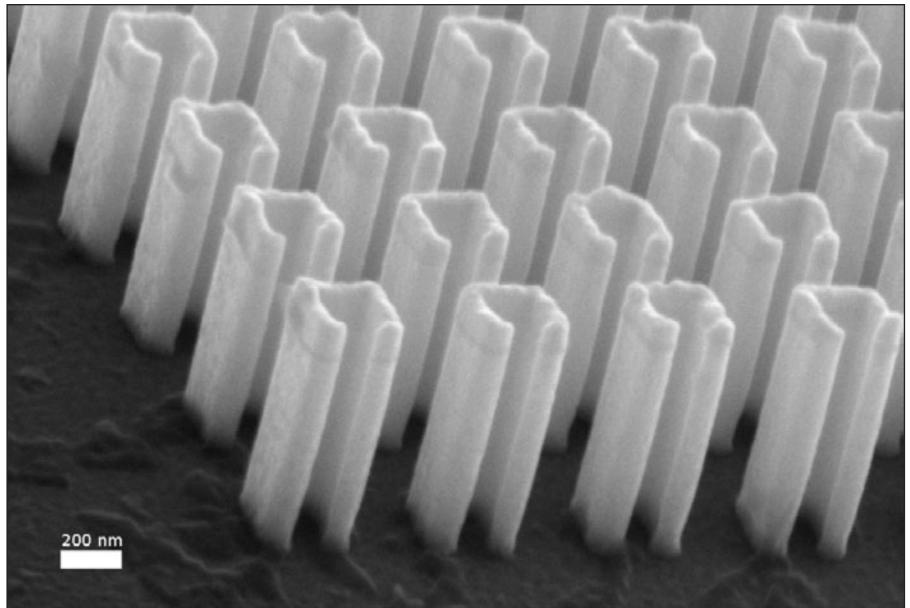


Figure 3: **High aspect-ratio split-ring resonators for plasmonic biosensing applications, made of electroplated gold.**

EUV interference lithography

Extreme Ultraviolet Interference Lithography (EUV-IL) is a revolutionary technology for the high-throughput fabrication of periodic nano-patterns developed at PSI. Eulitha – a spin-off company of PSI – provides nano-structured products based on this new technology.

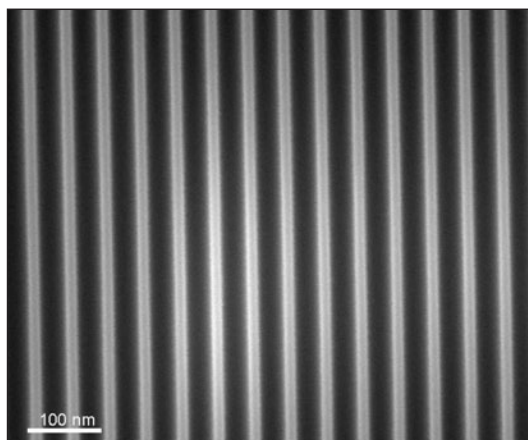
In EUV-IL, a coherent EUV beam obtained from the Swiss Light Source is used to create an interference fringe pattern. A photoresist-coated substrate is exposed to this beam and processed, resulting in resist nanostructures. Thanks to the short wavelength (ca. 13 nm) of the EUV light, the structures produced have extremely high resolution, below the 20 nm scale. While the same resolution can be achieved with state-of-the-art EBL machines, the higher throughput of EUV-IL means that it can be employed to cover large areas with nanostructures that would be unaffordable with EBL.

Applications of Eulitha's products include:
- Nano-imprint process development
- Patterned magnetic media
- Microscopy calibration samples
- Templates for self-assembly
- Nanophotonics
- Templates for assisted self assembly

Contact
Dr. Vitaliy Guzenko
e-beam lithography
Tel. +41 (0)56 310 54 36
vitaliy.guzenko@psi.ch

Dr. Harun Solak
Eulitha
Tel. +41 (0)56 310 42 79
www.eulitha.com

Paul Scherrer Institut
5232 Villigen PSI, Switzerland
Tel. +41 (0)56 310 21 11
www.psi.ch



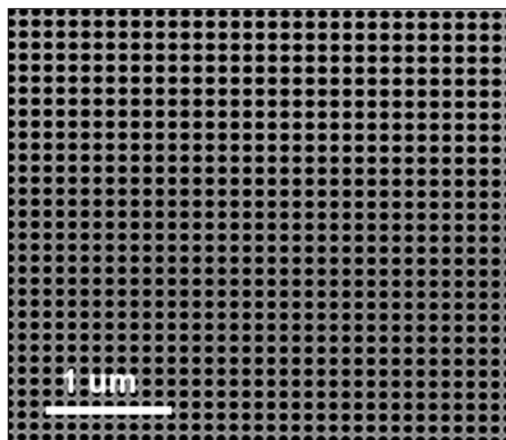


Figure 4: **Periodic nanostructures fabricated by EUV-IL: 25 nm half-pitch grating etched in Si (top) and 45 nm half-pitch hole array (below).**

SYN-F19-D-10, 10. 2010