# Innovative Patterning Strategies and Process Control using Multi-Application Nanolithography Tools for Microfiltration, Solar Cells and Bragg Gratings

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With a growing world population, nanotechnology can be one approach to address the rising demands for improving quality of food, green energy, communication and security.
For e.g. milk production [1], nanosieves are proposed to serve a growing need for microfiltration in order to increase shelf life and preserve the sensory quality of the product [2-4].
Solar cells are seen as a promising method for energy generation, but their cost and efficiencies would need to be drastically improved in order for them to become a viable option. E.g. adding photonic crystal arrays can potentially enhance the efficiency of these devices [5-6].
High quality Bragg gratings are indispensable ingredients of modern communication and optical variable devices, and are used for filters and multiplexers or security labels respectively. Sub-nm pitch control and perfect periodicity of such gratings over large areas is still a challenge.
The corresponding nm-sized patterns of above applications consist of large circle or line arrays, which can cover several cm$^2$. Writing times with conventional electron beam lithography (EBL), stitching errors, and pitch control are crucial issues, which can significantly affect device performances.
We present the differences between two EBL patterning modes, one being the conventional stitching EBL, and the other a new and unique "stitch-error-free" EBL writing strategy called MBMS - a Modulated Beam and Moving Stage lithography module that comprises the design, control, and patterning of periodic nanostructures over large areas. In the MBMS exposure mode, the beam movement is defined such that the combination of repetitive beam patterning and synchronized continuous movement of the laserinterferometer stage results in stitch-free strips of periodic nanostructures. We demonstrate that this technique can produce large circle arrays for nanosieves, photonic crystals with uniform pore size distributions and highest quality Bragg gratings - with fast patterning times, high pitch accuracy and virtually no stitching boundaries.

[1] http://www.microfiltration.nl/index.php
[2] Rijn, C. J. M.; Elwenspoek, M. IEEE Conf. MEMS'95, 1995; pp 83-87.
[3] Mulder, M., Basic Principles of Membrane Technology; Kluwer, Academic Publishers: Norwell, MA, 1998.
[4] Freitas, R. A. Stud. Health Techn. Infor. 2002, 80, 45-59.
[5] Munday, Jeremy, N., Journal of Applied Physics, **112**, 6, (2012).
[6] Jeong, S., Wang, S., Cui, Y., J. Vac. Sci. Technol., **A30(6),** (Nov/Dec 2012).

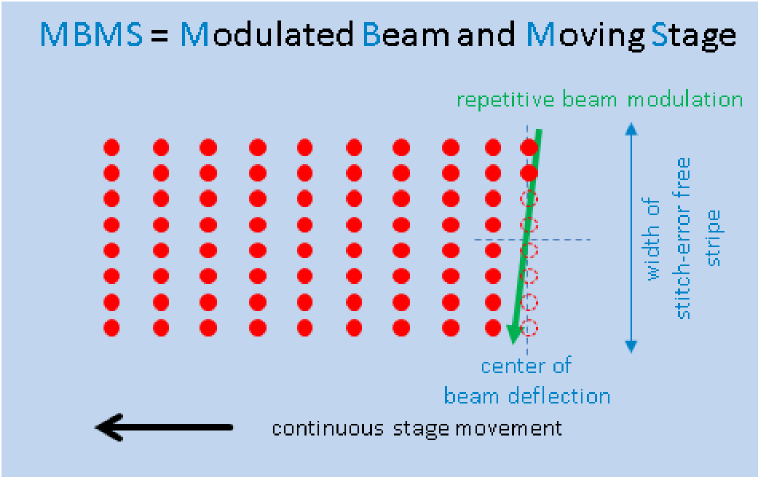


Figure 1. Exposure methodology of Modulated Beam and Moving Stage technology.

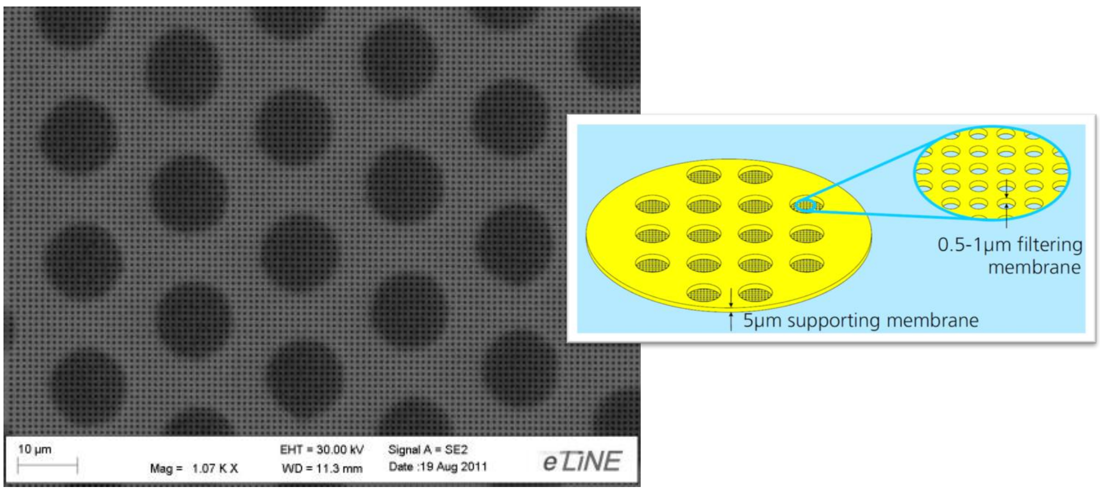


Figure 2. A micro filter featuring a 3mm x 3mm area circle array in a nickel membrane.

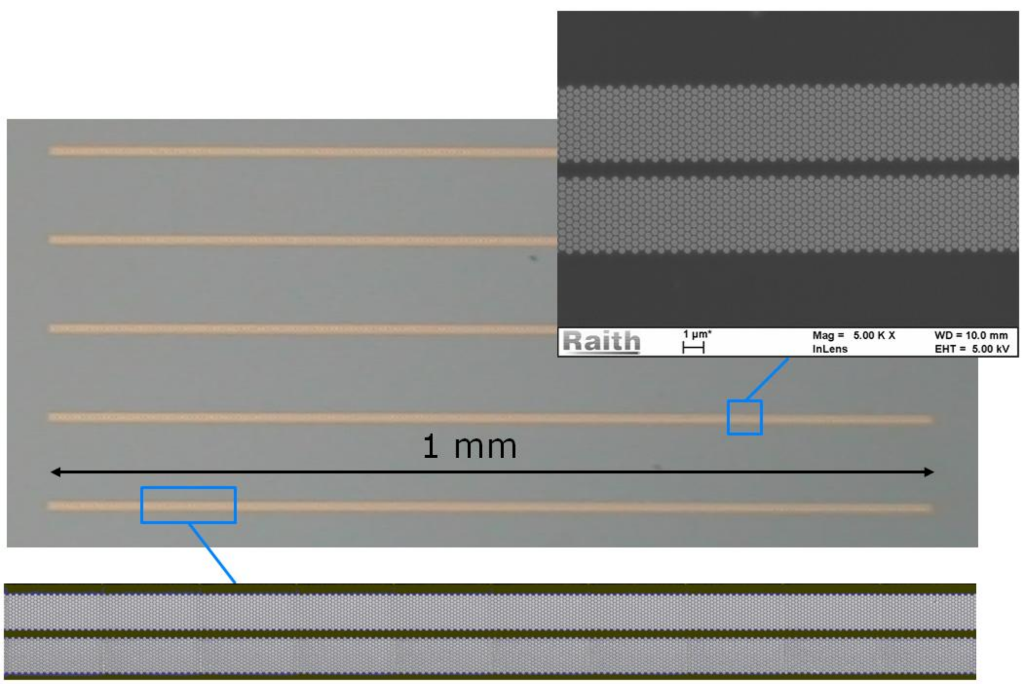


Figure 3. Hexagonal array of a 1mm-long, stiching error free photonic crystal waveguide written with MBMS stage technology.