An Innovative EBL Writing Strategy for High Speed and Precision Lithography of Large Circle Arrays for Microfiltration and Photonics in Solar Cells

Kevin E. Burcham, Jason E. Sanabia
RAITH USA, 2805 Veteran's Memorial Hwy., Ste. 23, Ronkonkoma, NY 11779
kb@raithusa.com

Michael Kahl, Axel Rudzinski,
RAITH GmbH, Konrad-Adenauer-Allee 8, Dortmund, 44263, Germany

Markus Fleger, Oliver Humbach
temicon GmbH, Konrad-Adenauer-Allee 11, Dortmund, 44263, Germany

With a growing world population, nanotechnology is one approach to address the rising demands for improving the quality of food and for green energy. Nano sieves for micro-filtration are proposed to serve a growing demand for filtration, *e.g.* for beer or milk production [1], not only increasing shelf life and preserving the sensory quality of the product, but saving energy costs and generating new products [2]. Many groups have already indicated that perforated membranes with sharply defined cylindrical pore diameters will have a broad range of applications, such as sterile filtration (particle and bacteria) and size exclusion-based separation [3-5]. In green energy, 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 [6-7]. Controlling the scattering of photons in the absorbing material by adding photonic crystal arrays or other periodic nanostructures can potentially enhance the efficiency of these devices. In both applications, the large circle arrays can cover significant areas (over several square inches), and writing times by patterning with conventional electron beam lithography (EBL), "stitching errors", and pitch control between adjacent "stitched" fields can be issues, especially for photonic crystal arrays.

To meet the needs of these applications, we present and discuss the differences between two EBL patterning modes, one being the conventional stitching EBL (Figure 1), and the other being a new and unique "stitch-error-free" EBL writing strategy called MBMS. MBMS is 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 laser interferometer stage results in stitch-free strips of periodic nanostructures as shown in Figure 2. We demonstrate that this technique can produce large circle arrays for nano sieves (Figure 3) and photonic crystals with uniform pore size distributions, fast EBL patterning times, and with virtually no stitching boundaries and high pitch accuracy.

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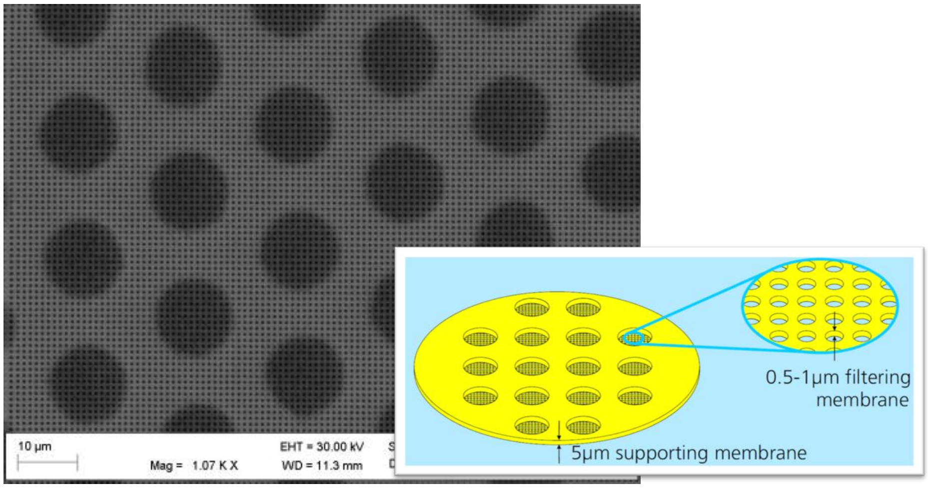

Figure 1. A micro filter featuring a 3mm x 3mm area circle array in a nickel membrane, written by conventional stitching electron beam lithography.

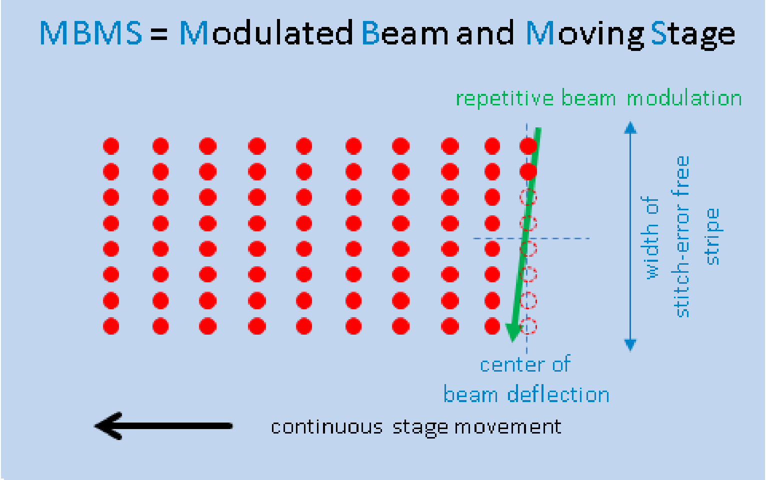

Figure 2. Exposure methodology of Modulated Beam and Moving Stage technology.

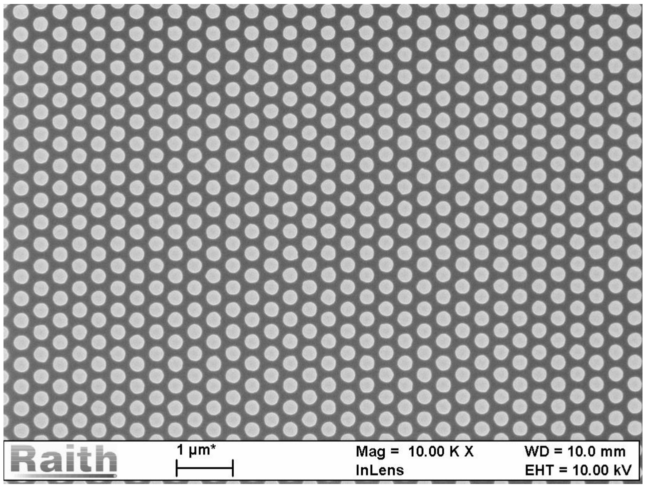

Figure 3. Hexagonal array of circles written with Modulated Beam and Moving Stage technology.