Advanced FIB-Patterning Strategies for seamless Photonic Devices

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Focused ion beam (FIB) systems are valuable tools for nanofabrication and rapid prototyping in R&D by providing direct and resistless patterning [1, 2]. Although FIB milling is typically slower than a resist process, the simplification of the nanofabrication approach can help to achieve faster results.
However, FIB milling of large nano or micro devices is always a trade-off between resolution (low ion beam current for small beam size) and short process time (high beam current for large volume removal). Furthermore, patterning with conventional FIB-SEM tools is usually limited to a single field of view.
The system used here (Raith VELION) overcomes nanofabrication specific limitations of analytical FIB instruments by a dedicated lithography architecture.
Here we present FIB patterning of extended photonic crystals and mm-long waveguides. To overcome FIB milling related patterning, artifacts like edge effects at stitch field boundaries, caused by higher sputter rates during milling of elements at an existing edge, advanced strategies have been developed. In case of hexagonal photonic crystals (Figure 1) dividing single circle elements at stitch field boarders can be simply avoided by overlapping write fields and stage movement steps with the size of a base cell of the photonic crystal. For the fabrication of waveguides, which do not fit into a single field, more complex strategies like a combination of repetitive stage movements and field boundary shifts need to be applied to completely remove edge effect artifacts (Figure 2). Thus, mm-long waveguides can be accurately fabricated during an unattended automatic over-night process (Figure 3).

References

[1] L. Bruchhaus et al., Appl. Phys. Rev. 4, 011302 (2017); doi: 10.1063/1.4972262.
[2] A. Joshi-Imre and S. Bauerdick, J. Nanotechnol. 2014, 170415 (2014)

Figures

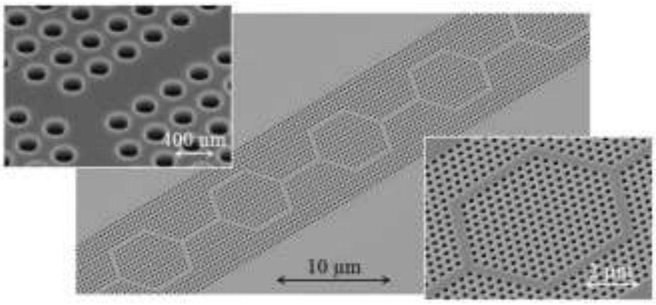

Figure 1: SEM micrograph of a 2 mm long photonic crystal device employing field stitching with overlapping write fields

Figure 2: Etch effect milling artifacts at stitch field boundaries: a) if no further strategies are

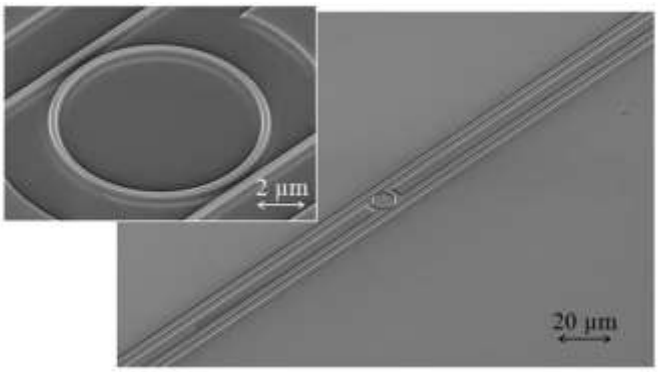

Figure 3: Extract of 3 mm long waveguide device including ring resonator (45° sample tilt).