Multi-species FIB for high resolution and large area nanofabrication applications

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Focused ion beam (FIB) for nanofabrication and rapid prototyping can be very effective method for various scientific and engineering development works. Although FIB nanofabrication process could be slower than some resist-accelerated process, such as electron beam lithography, the relatively straight forward FIB approach, especially for the direct processing of novel materials, can effectively shorten the sample fabrication time. Besides using FIB alone for completing a nanofabrication task, FIB can also mix and match with other lithography techniques, such as EBL and laser lithography, providing complementary strengths like direct, resistless and three-dimensional patterning over large area. We report on our development of advance FIB technology along with an instrumentation platform dedicated to high resolution and possibly large area nanofabrication.

The FIB nanofabrication has essential requirements in terms of stability, resolution and processing techniques. For advance nanofabrication applications, we have improved gallium-based liquid metal ion source (LMIS) with a stable gun emission design enabling low drifts in probe current and beam position. Sub-10nm resolution FIB milling using Ga ions is demonstrated in Fig. 1. Combining this FIB technology with an engineering nanolithography platform optimized for nanometer scale patterning over large areas and extended period of time, we can demonstrate using FIB to fabricate functional samples for applications such as X-ray zone plates [1] (Fig. 2), large area gratings [2], plasmonic arrays, photonic crystals (Fig. 3), and wafer-scale nanopore devices, etc.

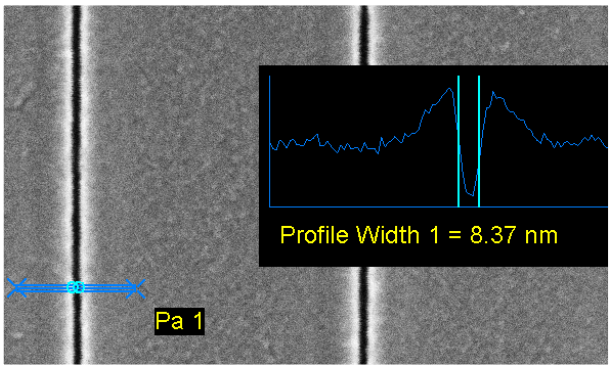

Fig. 1. Sub-10nm Ga ion FIB milling.

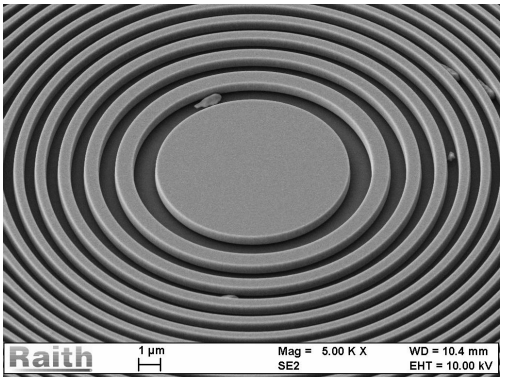

Fig. 2. FIB fabricated zone plate.

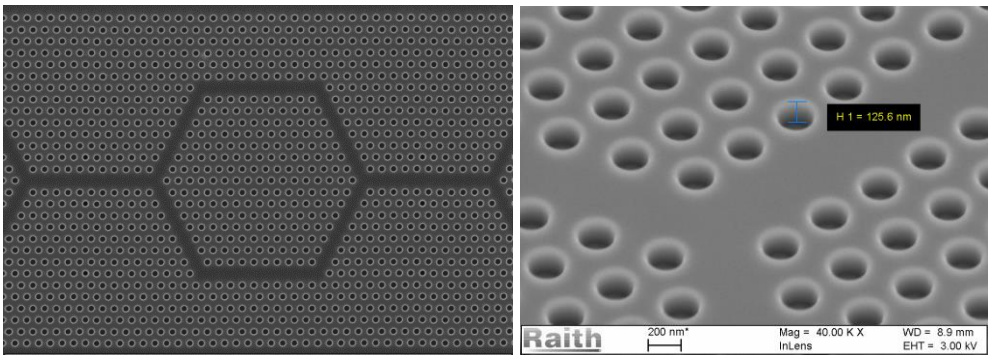

Fig. 3. Photonic crystals fabricated using FIB. Plan-view (left) and higher magnification (right) images.

References

[1] A. Nadzeyka et al, Microelectr. Engineering 98 (2012), 198-201.
[2] S. Tripathi et al., J. Micromech. Microeng. 22 (2012) 055005.
[3] S. Bauerdick et al., JVST B 31 (2013) 06F404.