Efficient volume production of periodic nanostructures using Raith EBPG Electron Beam Lithography System and Eulitha PHABLE Technology

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Gaussian-beam Electron Beam Lithography is capable of fabricating highly precise arrays of nanostructures down to the 10 nm range with nm accuracies. However, the efficient fabrication of periodic nanostructures ranging over large areas requires a different approach to compensate for the throughput limitations of serial EBL writing.

In this application note, a solution for volume production of periodic nanostructures over large areas is suggested that combines high resolution and high-precision EBL for mask fabrication with the throughput advantages of optical lithography using conventional masks. However, conventional mask aligners are known to be unable to deliver resolution and half pitch below 500nm.

EULITHA

PHABLE is a new photolithography technology introduced by the Swiss startup firm Eulitha for low-cost and high-throughput fabrication of periodic nanostructures[1]. Many applications in photonics, optoelectronics, displays, biosensors, and other fields where large areas need to be covered with such patterns stand to benefit from the introduction of this innovative technology.

PhableR 100 has already been installed at major research centers in Europe and Asia. The operating principle of PHABLE is similar to conventional contact or proximity lithography (as in a mask aligner), in the sense that a full-field photomask is needed in the exposure. The method, which was invented by the founders of Eulitha, is called “Displacement Talbot Lithography”.

Writing of high-resolution precise photomasks requires the use of state-of-the-art high-precision electron beam lithography. This should be deployed efficiently to minimize writing time over large areas, which is very important in successful industrial application. In addition, stitching errors have to be controlled tightly, as they may cause significant distortion in the exposure of periodic structures. Moreover, the photomask writing process has to be reliable and reproducible, which is critical for production of large-area masks at an acceptable cost.

Eulitha uses a Raith EBPG5000Plus* system installed at the Paul Scherrer Institute (PSI) in order to write the photomasks required in its own production

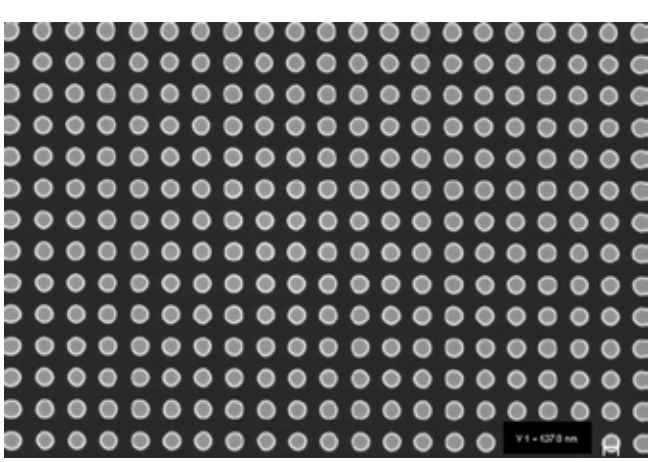

Figure 1: Precisely fabricated dot matrix using Displacement Talbot Lithography principle. Dot period and diameter are 300nm and 140nm respectively.

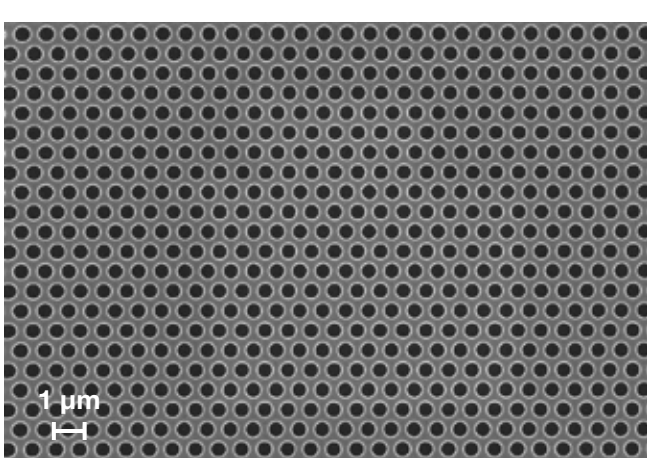

Figure 2: Array of holes on a hexagonal lattice printed on the PhableR 100 system. Hole period and diameter are 600nm and 300nm, respectively.

as well as fulfill customer requests. The patterns, with dimensions of about 100nm, are typically created on standard 5-inch Cr-coated fused silica plates. After electron beam writing, the patterns are dry-etched into the Cr film.

The Raith EBPG5000Plus system can also be used to fabricate phase-shifting masks, which are used to improve image contrast, obtain a particular image, or simply boost exposure efficiency. In this case the pattern is further etched into the fused silica substrate and the Cr is stripped to obtain clear phase-shifting masks.

The EBPG5000Plus system (former VISTEC) installed at the PSI

Using this method and in collaboration with researchers at the PSI, Eulitha has successfully been fabricating various types of photomasks with the required resolution, minimized writing time, and excellent uniformity.

In conclusion, the Raith EBPG5000Plus system has all the features required for writing photomasks for successful use of PHABLE technology, including the ability to write high-resolution features reproducibly at high throughput and with minimum stitching errors.

* The EBPG5000Plus is no longer available and replaced by the EBPG5200 and EBPG5150 series in 2015. Please contact Raith to learn more about EBPG or EULITHA to learn more about PhableR 100.

References

[1] H. H. Solak, C. Dais, F. Clube, Optics Express, Vol.19, No.11 (2011).

Figure 3: EBPG5200 Electron Beam Lithography System

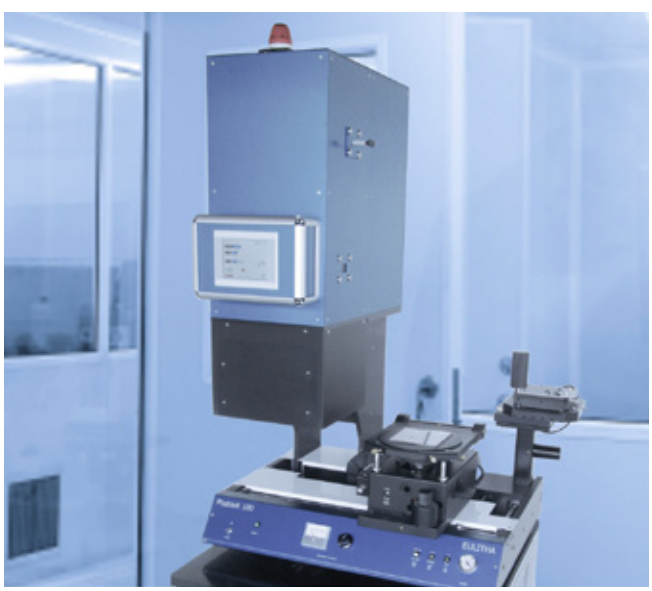

Figure 4: PhableR 100 Displacement Talbot Lithography System

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