# Bit-array patterns with density over 1 Terabit/in$^2$ fabricated by Extreme Ultraviolet Interference Lithography

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Patterned media is currently investigated intensely by the hard disc industry as a way to further increase the data storage density on magnetic storage media [1]. Lithographic fabrication of patterned media places extreme requirements on the fabrication method which includes high-throughput and resolution below 40 nm in terms of pattern period. Extreme Ultraviolet Interference Lithography (EUV-IL) has the potential to address these challenges. We fabricated hole-arrays in photoresist with period down to 25 nm using four-beam EUV-IL (Fig. 1). The corresponding aerial density of the array is 1032 Gbit/in$^2$. By using a different phase relation between the beams we obtained dot-array patterns with a period of 35.3 nm (Fig. 2).

The EUV-IL method is based on diffraction gratings to form interfering beams. The gratings are illuminated with EUV light at a wavelength of ~13 nm from a synchrotron source. The pattern formed by the interfering beams has a period that is smaller than the period of the gratings by a factor of 1.4 – 2 depending on the design [2]. This demagnification factor simplifies the production of the masks. By using grating based interference it is possible to form one- and two-dimensional patterns as well as patterns that have circular symmetry, such as bits on circular tracks [3].

The EUV-IL technique has a number of important advantages. The interference method provides patterns with precisely positioned bits, i.e. low jitter – an essential requirement for the data-storage application. The proximity effect caused by photoelectrons generated in the resist and the substrate is practically absent at the used beam energy of 92.5 eV. The aerial image is strictly related to the grating pattern on the mask which greatly helps with the reproducibility of the lithographic process. The ultimate limit of resolution in EUV-IL in terms of the pattern period is $\lambda/2$ which corresponds to about 7 nm. This resolution potential combined with the high-throughput of this parallel printing method makes EUV-IL a candidate for the production of dense patterns for patterned data storage applications.

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2. H. H. Solak, C. David, J. Gobrecht, L. Wang, and F. Cerrina J. Vac. Sci. Technol. B 20, 2844 (2002).

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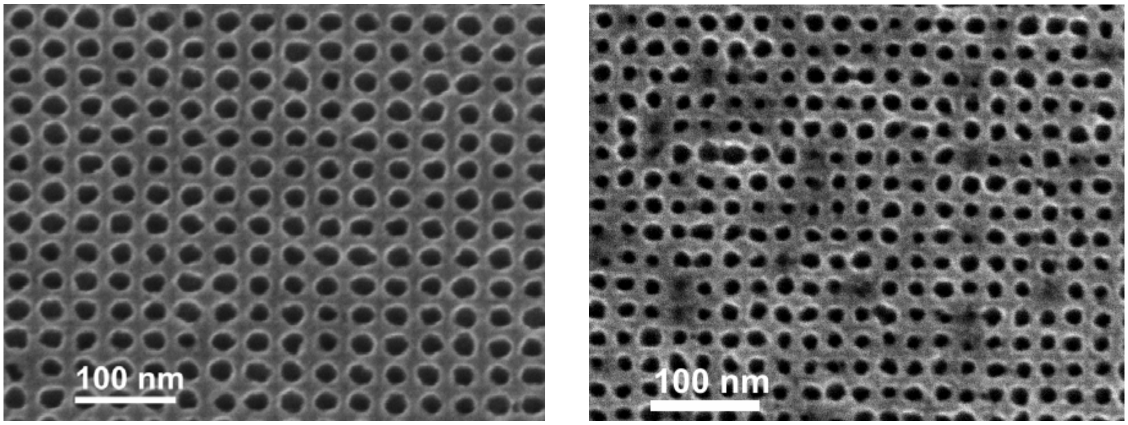

(a) (b)

**Fig. 1.** SEM image of hole arrays in calixarene resist. (a) rectangular lattice with periods 30 nm in the vertical and 35 nm in the horizontal directions; density 614 Gbit/in$^2$ (b) Square lattice with period 25 nm; density 1032 Gbit/in$^2$.

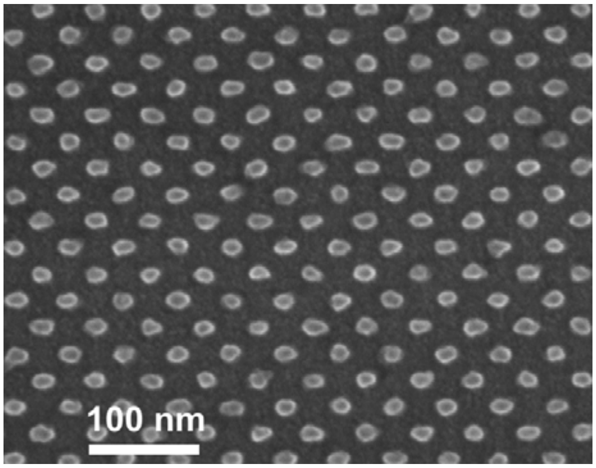

**Fig. 2.** SEM image of 35.3 nm period dot-array in calixarene resist. The corresponding density is 516 Gbit/in$^2$.