EUV Bessel beam lithography

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Extreme ultraviolet interference lithography (EUV-IL) has recently been attracting growing interest as a fabrication tool for high-resolution periodic nanostructures due to its various fundamental features, e.g. high throughput, large depth of focus etc. Consequently, the technique has been successfully applied to a variety of nanofabrication problems. The most common experimental scheme in EUV-IL involves the illumination of a mask containing several diffraction gratings with a spatially coherent beam in order to overlap first-order or higher order diffracted beams at a certain distance from the mask and record the resulting interference pattern in a suitable photoresist. This way, the fabrication of one- and two-dimensional periodic nanostructures with high resolution becomes possible.

In addition to the most common scheme of IL in using two diffraction gratings, in this paper we introduce a maskless lithography scheme that employs the Bessel beam which generated by inference of infinite beams from a concentric ring shaped plate (equal to infinite diffraction gratings) to expose patterns of arbitrary geometry on a resist-coated substrate. It is illustrated schematically in Figure 1. The exposure/development simulation was implanted using Matlab^{TM} code. As shown in Figure 2(b), arrays of 10 dots were simulated and the experimental result fits well (see Figure 2(a)). To demonstrate the arbitrary written ability of such technique, an arbitrary pattern, in this case ‘PSI’ logo was written into HSQ with resolved lines down to 20 nm in width, as shown in Figure 3.

In this paper we show the application of non-diffracting beams for high-resolution lithography. These results prove the capability of EUV Bessel beam lithography could serve as a powerful tool alternative to electron beam lithography (EBL) for providing arbitrary patterns. This technique also holds advantages such as, no depth of focus, no proximity effect, massively parallel writing and no need of complex electron focusing lenses and columns.

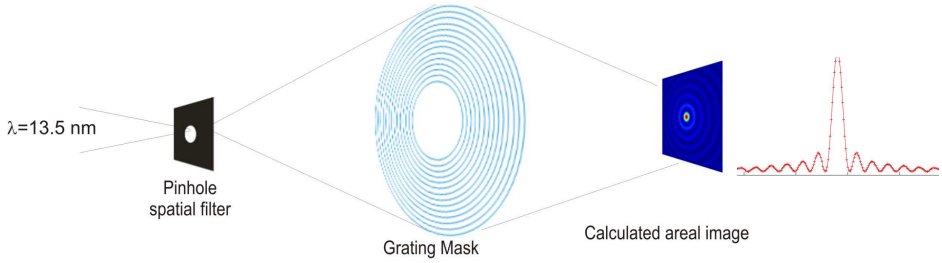

Figure 1: Schematic of EUV Bessel beam lithography. The arbitrary patterns can be written by the central beam with ultra-strong intensity (red spot) in the calculated areal image plane, which is non-diffraction. The red spectrum indicates the intensity cross-section of the calculated areal image.

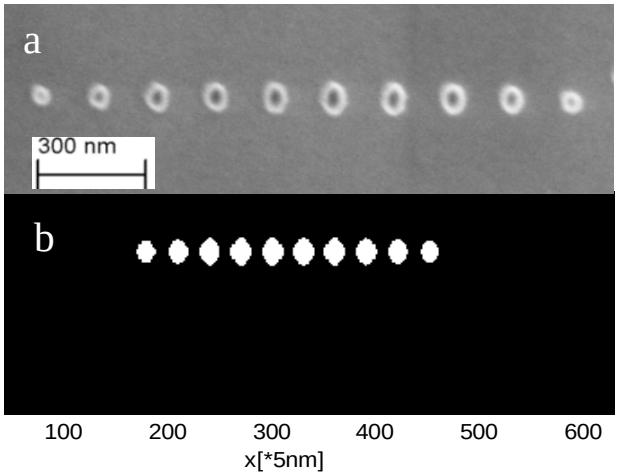

Figure 2: (a) SEM images of HSQ dots with period of 150 nm patterned by using EUV Bessel beam lithography. (b) Numerical simulated image pattern with a threshold fit very well with the experimental result in (a).

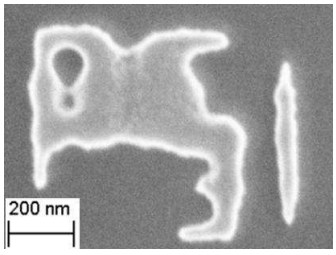

Figure 3: SEM image of an arbitrary HSQ pattern (PSI Logo) written by EUV Bessel beam lithography.