Ultra compact interferometric lithography system realized with a desk-top extreme ultraviolet laser

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We present a compact nanopatterning tool based on an amplitude division interferometer and a desk top extreme ultraviolet laser. The system is based on inteferometric lithography (IL). This is a mask-less photo-lithographic technique that can be implemented with coherent light sources and it is very well suited for a EUV laser sources.

The nano-patterning tool is based on an amplitude division interferometer and a desk-top λ= 46.9 nm capillary discharge laser [1]. This compact set up enabled printing of lines with periods around 100 nm over areas of few millimeters square. The source is a compact λ= 46.9 nm Ne-like Ar capillary discharge laser configured to emit pulses with energy of 0.01mJ and 1 ns FWHM duration. The EUV laser can operate at repetition rates up to 12 Hz producing pulses with high degree of spatial and temporal coherence. The laser coherence length is approximately 470 µm determined by its line width $\Delta\lambda/\lambda<1\times10^{-4}$.

The IL set up was implemented using an amplitude division interferometer (ADI). This scheme utilized transmission diffraction gratings as beam splitters. Figure 1 shows a diagram of the interferometer used in this nanopatterning tool and a photograph of the device. The beam splitter was fabricated in a thin Si membrane, approximately 100 nm thick and 2×0.6 mm^2. On top of the Si membrane a thick photoresist layer approximately 350 nm was deposited by spin coating. The diffraction grating, consisting of a 2 microns period, 50% duty cycle was defined by electron beam lithography.

Figure 2 shows an atomic force microscope scan of the prints obtained with this set up consisting of regular lines with a period 145 nm. The grating was obtained by exposing a Si wafer coated by standard spin coating with hydrogen silsesquioxane (HSQ) photoresist. The exposure time was 20 minutes and the printed area corresponded to the grating area, in this experiment 2×0.6 mm^2.

The table top interferometric lithography set up has unique characteristics. The system is extremely robust and simple to align, and allowed to print large areas (several mm^2) gratings with periods around 100 nm. The main characteristic of this set up is its extreme compactness. The laser source has a footprint 0.4×0.7 m$^{2.}$ The nanopatterning tool consisting of the compact desk top EUV laser and the exposure chamber fits comfortably in an area 1.5×0.7 m^2. Figure 3 shows the whole system consisting of the desk-top EUV laser and the vacuum chamber that hosts the ADI. This compact system brings to the laboratory environment capabilities that so far were restricted to the use of large synchrotron facilities, and represents an interesting valuable alternative for nanofabrication.

1. Heinbuch, S., M. Grisham, D. Martz, and J.J. Rocca. Optics Express. **13,** 4050, (2005).

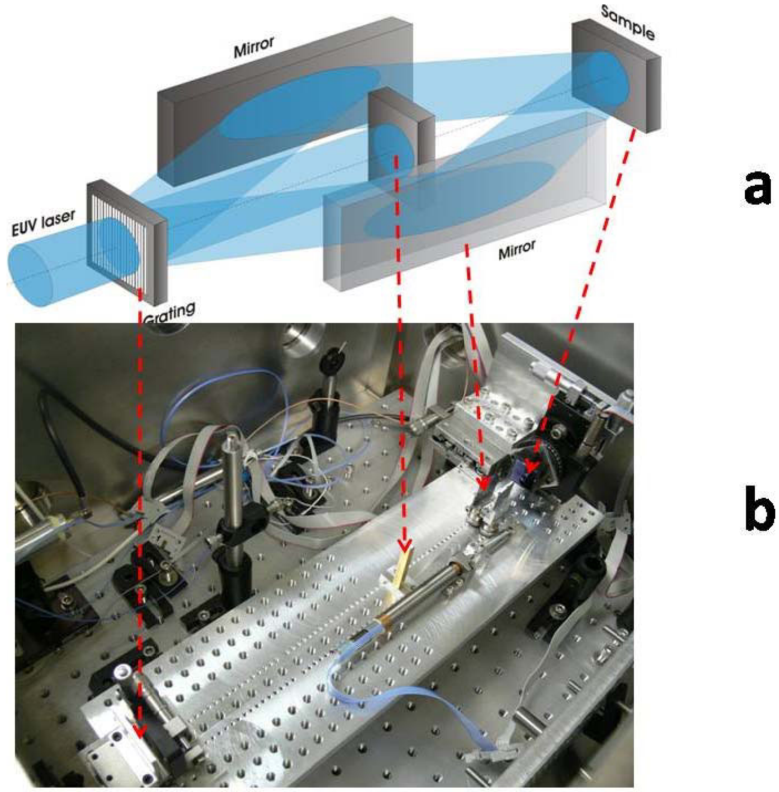

Figure 1: a) Scheme of the amplitude division interferometer used as an interferoemtric lithography tool. b) Amplitude Division Interferometer set up. The dashed arrows indicate the location of the diffraction grating, the two folding mirrors and the sample

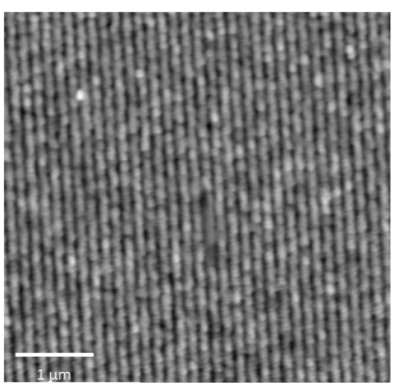

Figure 2: Atomic force microscope scan of a 140 nm period grating printed HSQ

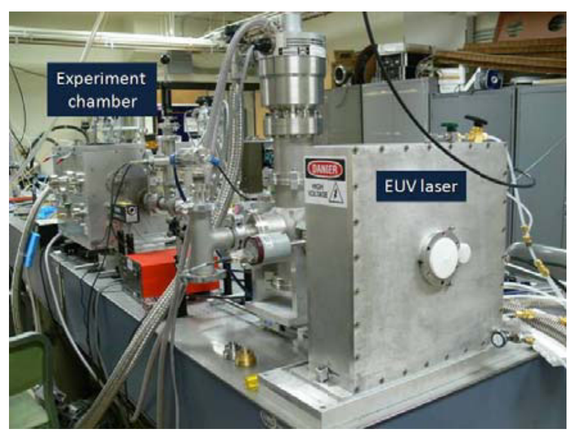

Figure 3: Table top nanopatterning tool. In front the desk top EUV laser unit connected though a vacuum manifold to the experiment chamber. The system occupies a surface only $0.7 \times 1.5\ m^2$