Step-and-repeat Nanopatterning Using Compact Two-beam Fibre-optic Interference Lithography

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Interference lithography (IL) is the most adopted method to fabricate periodic structures such as gratings and pillar arrays. Lloyd's mirror and two-beam interference lithography in free space are two conventional configurations, but the former is limited to small exposed area while the latter is challenging in readjustment and realignment when the angle between the two beams is changed[1]. In this research we have developed a two-beam fibre-optic interference lithography (2-FOIL) setup to overcome these limitations[2, 3]. In our 2-FOIL setup, complex optical components are replaced by single-mode polarization-maintaining fibre-optic components, which can be achieved to guide, split, expand and control the laser beams. Both Lloyd's mirror and two-beam IL in free space need large-area optical table to install multiple optical components and experienced researchers to align and adjust optical path. However, the whole setup of our 2-FOIL system can be compacted in 1m by 1m by 1m space on an optical table and fibre-optic components are flexible enough to control the laser beams. Due to the beam expanding capacity of fibre-optic component, the exposed area can be as large as 3 inch in diameter. Combined with rotated sample stage, two-dimensional nanostructure of different geometries can be fabricated. Furthermore, assisted by multi-axis motion platform, step-and-repeat exposure configuration can also be achieved on substrate of larger area with different periodicity of the nanostructure.

Figure 1 shows the illustration of part of the design of our 2-FOIL setup with step-and-repeat exposure capability. The two slides driven by motors can guide the fibre-optic components to move along the semicircle track so that the desire periodicity of interference pattern can be configurable conveniently. The sample stage is attached onto a 3-axis motion platform to fabricate 2-D and distributed-area nanostructure. With the step-and repeat exposure capability, we demonstrate a 3-inch wafer exposed with 9 independent patterning fields of two-dimensional pillar arrays of hexagonal lattice with various periods of 500 nm, 900 nm, and 700 nm, and different exposure times, respectively, as shown in **Figure 2**[3]. Details of the system design and capability, particularly on the modeling and optimization of the pattern contrast through active phase locking, will be discussed.

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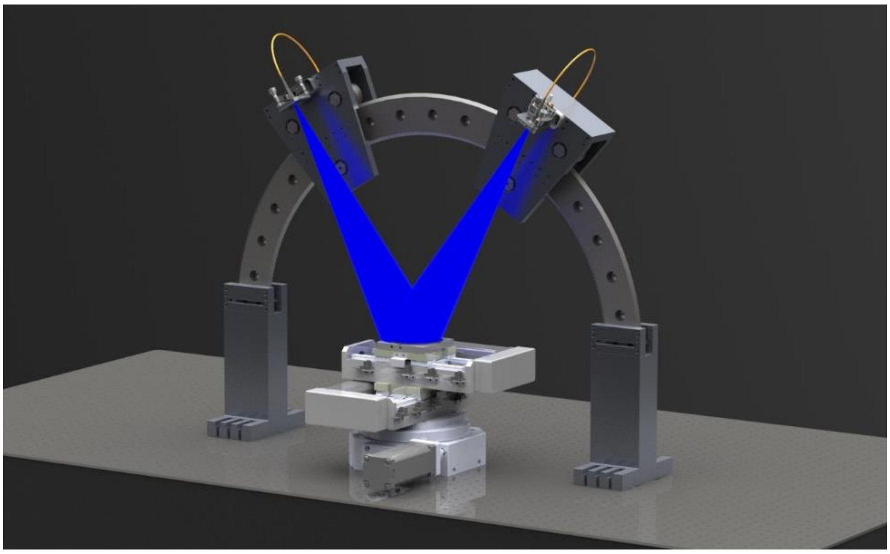

Figure 1. Schematic part of the detailed design of two-beam fibre-optic interference lithography setup.

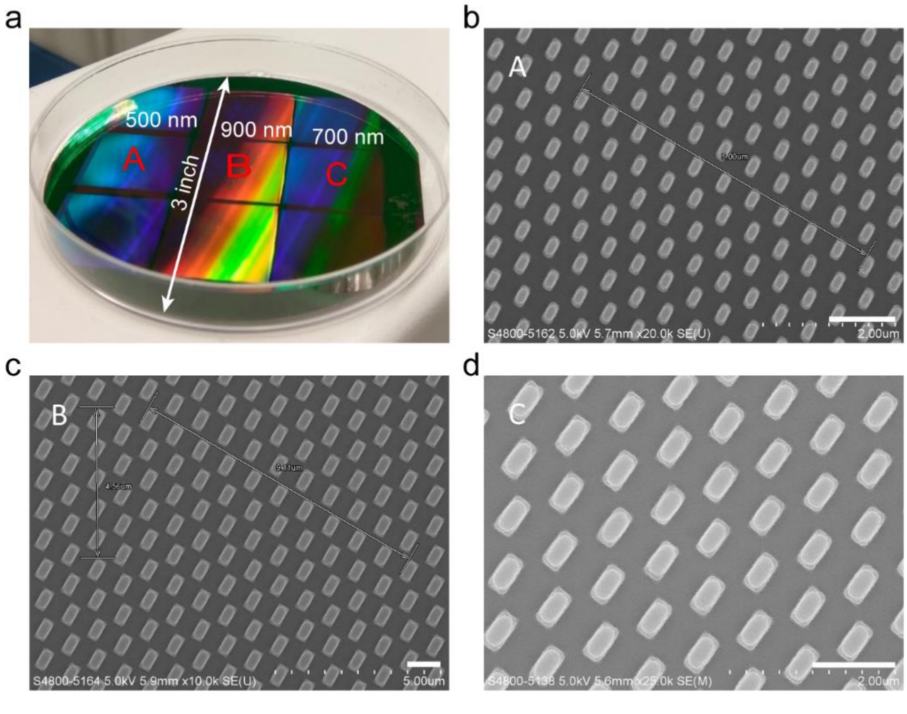

Figure 2. Photograph of a 3-inch silicon wafer with pillar arrays of hexagonal lattice (Period: left column: 500 nm, middle column: 900 nm, right column: 700 nm) patterned by the step-and-repeat exposure configuration. (b)(c)(d) The SEM images from a top view of position A, B, and C. The scale bars are 1 µm.