Fabrication of Large-area Nanopatterns by All-fiber Interference Lithography (AFIL) System

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Laser Interference Lithography (LIL) is a widely adopted method to generate periodic nanopatterns over a large area [1]. LIL has demonstrated promising applications in fabricating display panels, CCD sensors, solar cells and magnetic storage devices [2]. Particularly, LIL has been used to fabricate master molds for nanoimprint lithography. Conventional LIL uses free space components, including mirrors, splitters, objectives, pinholes, etc., to pass and direct light. However, it's difficult to change the periodicity of interference patterns in a free-space LIL setup due to the inconvenience in realigning and readjusting the free-space optical components. Moreover, free-space setup is subject to air disturbance and environmental vibration, making long-time exposure of fine pitch gratings very challenging.

In this work, we demonstrate an all-fiber interference lithography system which does not only use fibers to deliver coherent light but also use fiber optical components to split the laser beam. In addition, the single-mode fiber output functions as a pinhole to obtain a Gaussian profile on the substrate, which was also shown in previous work [3]. Fig. 1a shows the schematic of the AFIL system. A single-frequency 405 nm laser module is coupled to a single-mode polarization-maintaining fiber through collimating optics and further split into two equal beams using a fused fiber splitter. At the two outputs of the fused fiber splitter, the two beams are expanded in free space with a Gaussian profile and overlapped on the substrate coated with a layer of photoresist. Flexibility and stability of fibers and fiber-based components make it easy to adjust the incident angle and beam spot size. Moreover, this AFIL system has an improved performance against environmental disturbance and can potentially provide a higher contrast on the interference pattern. Fig. 2 shows the images of AFIL-exposed photoresist gratings with three different periods from high-quality one to finest one. Fig. 2a shows the atomic force microscopy (AFM) image of 510 nm gratings with an inset of 3D profile. Fig. 2b is the Scanning Electron Microscopy image with a period of 420 nm. Fig. 2c is the AFM image of 238 nm gratings with an inset SEM image

This all-fiber interference lithography system is promising to provide a low-cost, high-performance and easy-to-operate approach for patterning periodic structures over large-areas in many emerging applications.

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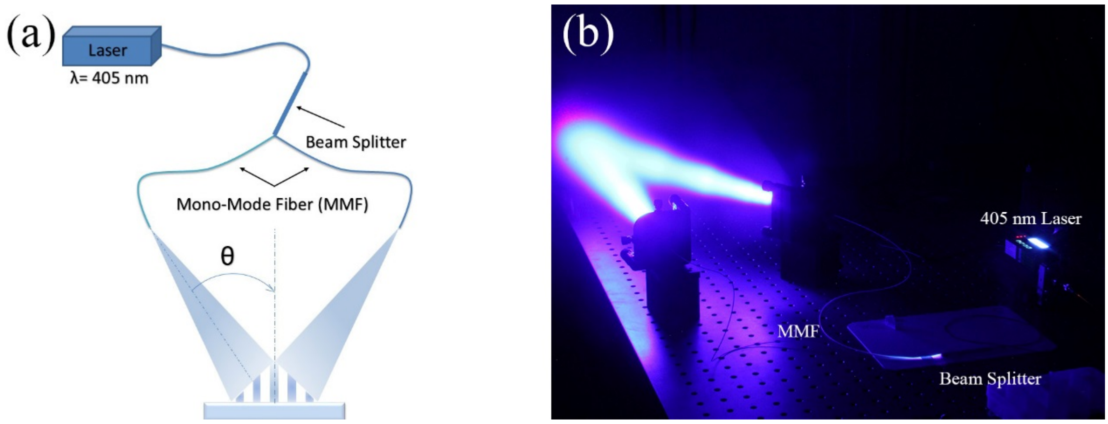

Fig.1 (a) Schematic of AFIL; (b) a photo of the actual working AFIL setup.

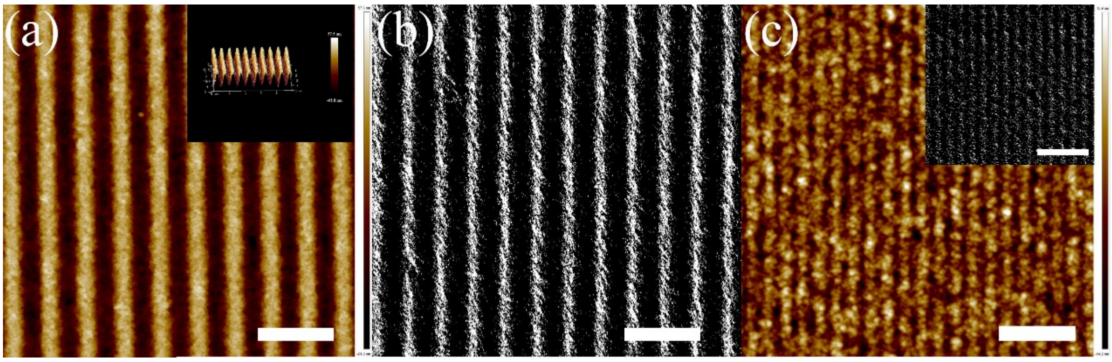

Fig.2 Images of the photoresist gratings exposed by 405 nm AFIL. (a) AFM image of 510 nm gratings with an inset of 3D profile, (b) 420 nm SEM image, (c) 238 nm gratings with an inset of SEM image. All the scale bar is 1 μm.