NANO-OPTICAL PHASE MASKS USING HOLOGRAPHIC LITHOGRAPHY

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Novel fiber lasers in visible wavelength range attract many research interests recently. The technical challenge is to develop new fiber Bragg grating (FBGs) at short wavelengths for fiber laser resonators. The FBGs are inscripted in the photosensitive fiber core by interference fringes obtained either from intersection of two laser beams, or from a prefabricated phase mask illuminated by a UV laser beam. Holographic phase masks have advantages for higher optical quality and lower noise level over the e-beam phase masks in this application.

Conventional phase masks have the minimum grating period limited to 550-600nm, which can be used to fabricate the FBGs at the IR wavelengths of 800-870 nm. Objective of our project is to generate in the holographic phase masks finer structures in nanometer scales, which cannot be achieved by the conventional holographic lithography, in order to fabricate the FBGs for visible wavelengths. The fine structures in the phase masks are optimized for producing high efficiency in the high diffraction orders. We are trying to obtain the phase masks, which emphasize the ±2 and ±3 orders, so that the diffracted orders have large interference incident angles after the phase mask to form the interference fringes, which corresponds to those obtained from the phase masks of 440 - 300 nm periods. Such nano-scale structured phase masks can be used to fabricate the new FBGs operating at 660 - 390 nm, respectively.

The simulation of the nano-scale structured phase masks is implemented using the Rigorous Coupled Wave analysis (RCWA) [1]. Figure 1 shows an atomic force microscopy image of a one-dimensional grating with the exposed developed photoresist. Reactive Ion Etching, (RIE) is then applied to transfer the surface relief pattern into the fused silica substrate.

References:

[1] M.G. Mohamram, D. A. Pommet and E. B. Grann, "Stable implementation of rigorous coupled-wave analysis for surface-relief grating: enhanced transmittance matrix approach" J. Opt. Soc. Am., A Vol.12, No.5, May 1995, pp1077-1086.

Figures:

Figure 1: AFM Image of a phase mask fabricated by holographic lithography (before etching)