Surface-relief polarization gratings for visible light

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Polarization gratings are space-variant subwavelength structured photonic devices that modulate the state of polarization. Using electron beam lithography and reactive ion etching, we have fabricated such devices in the form of dielectric and metallic surface-relief profiles for operation in the visible wavelength region, where structural features with dimensions on the order of 100 nm are required. We provide experimental demonstrations of a triplicator with diffraction efficiency exceeding value that could be achieved by diffractive elements operating in the framework of scalar optics. In addition, we demonstrate the use of the metallic polarization grating structure as polarimeter.

We assume a linearly rotating subwavelength polarizarion grating geometry described by Gori[1] and Tervo[2]. Following the analysis of Gori and Tervo, there are only three nonzero diffraction orders, with efficiencies that can be tailored by proper choice of the incident field and grating parameters. In this paper we discuss the fabrication of the dielectric triplicator with uniform efficiencies and a metallic polarimeter consisting of rotating wire grid polarizers[3]. The grating parameters are optimized by using rigorous grating analysis by means of Fourier Modal Method (FMM). The material of the dielectric triplicator is Si_3N_4 grown by plasma enhanced chemical vapor deposition (PECVD). In the polarimeter, we use high vacuum deposited aluminum. The electron beam lithography is carried out by using Vistec EBPG 5000+ ES HR, and the patterns are transferred to the final grating materials by reactive ion etching with Oxford plasmalab 80+ and 100. The detailed process flow is described in Figure 1.

Figure 2 shows the SEM-images of the fabricated structures. The optimized and fabricated periods of the subwavelength fringes are 220 nm and 150 nm, for the triplicator and polarimeter, respectively. The rotation of the fringes is quantized so that the exposure can be split to segments with invariant fringe orientation. The effect of the segmentation is negligible as the number of the segments is large. Next we show the characterization results of these two types of polarization gratings. For the characterization we used a linearly polarized laser @532 nm and a CCD row detector. Figure 3 shows the CCD line detector image of the intensities of the three central diffraction orders behind the triplicator and polarimeter.

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[1]F. Gori, Opt. Lett. **24**, 584 (1999).
[2] J. Tervo and J. Turunen, Opt. Lett. **25**, 785 (2000).
[3]I. Vartiainen, J. Tervo and J. Turunen, Opt. Lett. **18**, 22850 (2010).

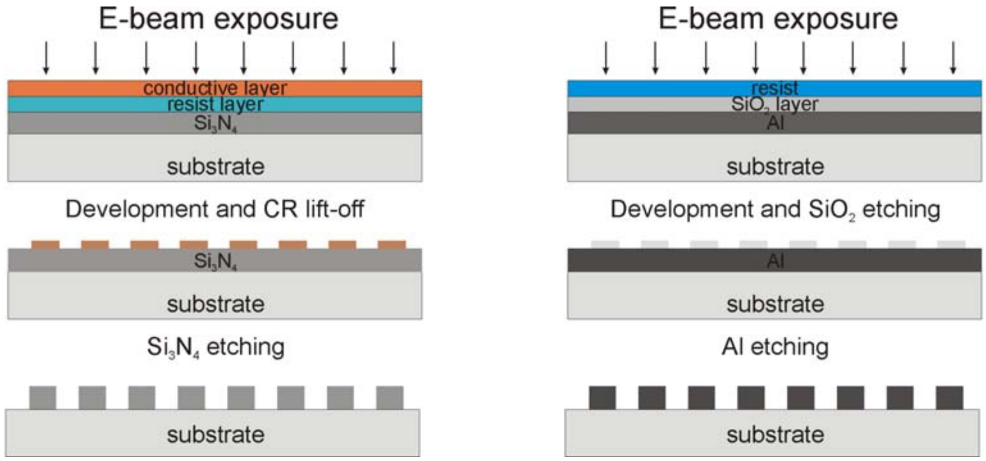

Figure 1: Process flow for Si3N4 (left) and Aluminum (right) grating.

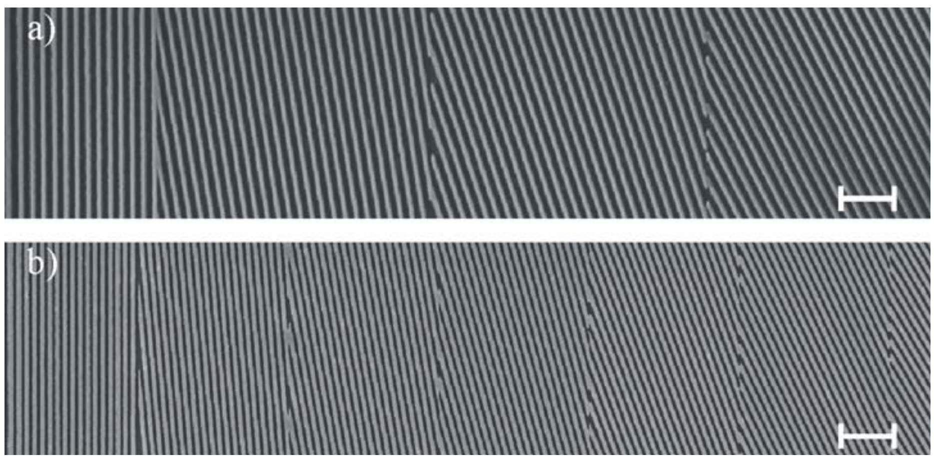

Figure 2: SEM images of the triplicator (a) and polarimeter (b). The length of the scale bar is 1 um.

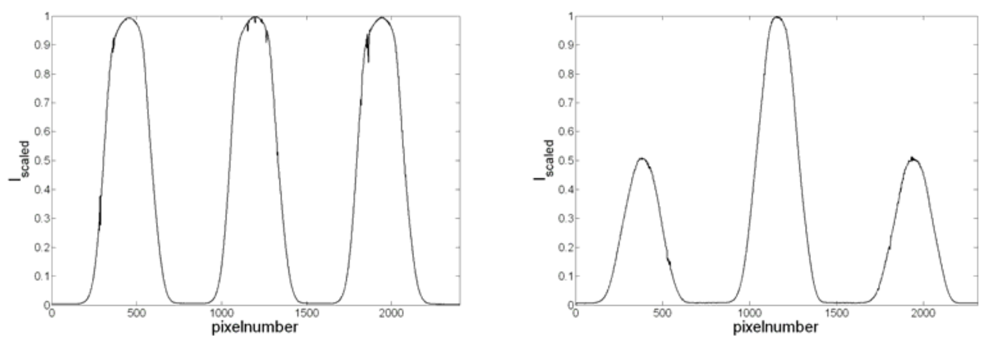

Figure 3: CCD line detector image of the three central diffraction orders behind the triplicator (left) and polarimeter (right).