Influence of polarization on absorbance modulated sub-wavelength grating structures

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Polarization has been shown to affect the optical fields generated beneath sub-wavelength metallic[1] and dielectric gratings[2] for near-field lithographic systems. Absorbance modulation optical lithography (AMOL)[3] uses a layer of photochromic material and illumination from far-field sources to create a dynamic absorbance pattern which is then used as a near-field lithography mask. We report here on the use of a finite-element simulator (COMSOL) to examine polarisation effects on transmission through absorbance gratings, showing differences from the metallic and dielectric gratings studied to date.

We first compare 200nm thick sub-wavelength metal, dielectric and absorbance gratings having 150nm period and 50% duty cycle. The gratings are suspended in air with a normal incident field of either transverse electric (TE) or transverse magnetic (TM) polarization at a wavelength of 400nm. The comparison (Fig.1) shows large differences between polarizations when observed at the exit plane of the grating. There is low transmission of TE light but clear enhancement at the edges of the gratings under TM illumination providing improved contrast below the grating. This is most pronounced for the metal grating but is observed for each grating type.

The effects of polarisation on the absorbance grating were further investigated through the interchange of the rectangular profile for a graduated absorbance pattern similar to one that may be produced in AMOL (Fig. 2). Simulation results (Fig. 3) demonstrate the large differences between the TM and TE cases and show the TM light producing higher contrast beneath the grating for sub-wavelength periods. It is further noted that the TE light has reproduced the pattern out of phase in the sub-wavelength domain. The results here increase the understanding of the absorbance modulation layer and how they can be can be used in applications such as sub-wavelength optical lithography.

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[1] S. J. McNab and R. J. Blaikie, Applied Optics **39**, 20 (2000).
[2] U. Bockelmann, Europhysics Letters **16**, 601 (1991).
[3] R. Menon and H. I. Smith, Journal of the Optical Society of America A **23**, 2290 (2006).

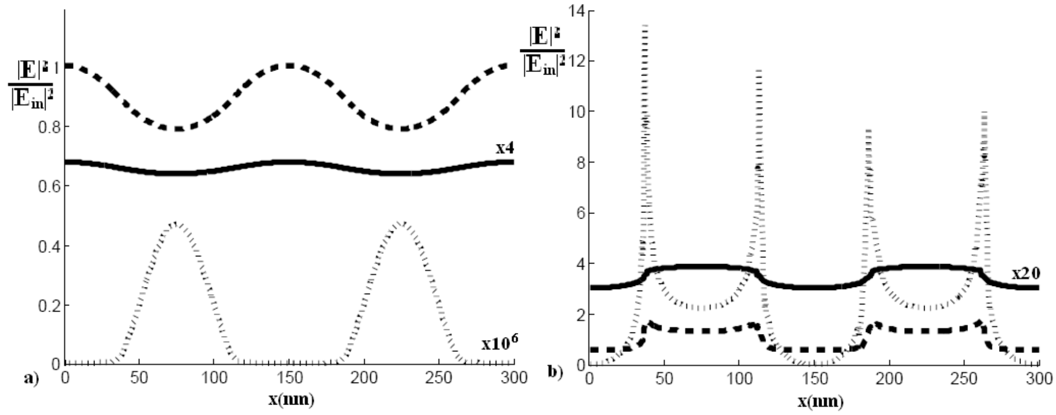

Figure 1: Comparison of a) TE and b) TM polarised light transmission through relative metal (dotted), dielectric (dashed) and absorbance (solid) gratings showing the intensity against input intensity (scale factors indicated on graphs).

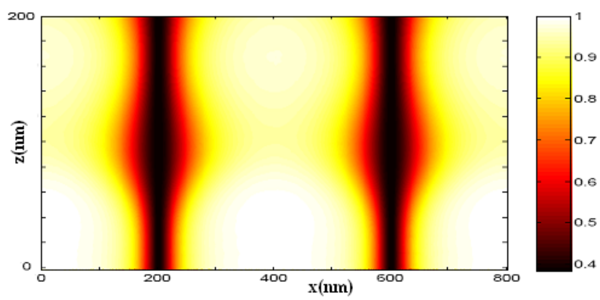

Figure 2: Example of a relative absorbance pattern as used in the simulation. The scale represents the absorbance relative to the maximum level.

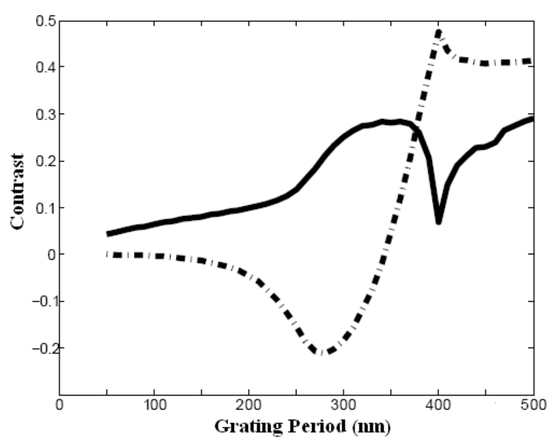

Figure 3: Contrast achieved beneath the grating for TE (dotted) and TM (solid) transmission through an absorbance gradient with changing period.