Angular spectrum 분해 기법에 근거한 광섬유격자 제작용 위상마스크의 회절패턴 해석

Diffraction pattern analysis of phase mask for fiber grating fabrication based on angular spectrum decomposition method

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1. Introduction

Fiber Bragg grating has found many important applications in recent years [1], most notably in the field of WDM optical communication. The most reliable method of fabricating fiber Bragg grating to date makes use of a phase mask, which diffracts most of the incident UV beam energy into the ± 1 spatial harmonic components. Interference of these components in turn produces a periodic index perturbation in a photosensitive fiber sample. It has been noted that an utmost precision is required in the design and fabrication of these phase masks in order that the efficiency of converting the incident UV energy into these components is maximized [2].

Because the typical distance between the phase mask and the fiber sample is on the order of a μm to tens of μms - too close to be considered as being in the so-called farfield (Fraunhofer) regime - the usual scalar diffraction theory coupled with Fourier optics is not adequate for the analysis on hand. Accordingly, we present in this paper some preliminary calculation results on the diffraction pattern at such intermediate distances by modeling the mask as a thin phase screen and by employing angular spectrum decomposition method [3].

2. Analysis and results

In accordance with our thin phase screen assumption, the UV beam emerging from the phase mask is modeled as possessing a periodic phase profile, with the amplitude distribution unchanged. By expressing the emerging field distribution in terms of its angular spectral components, i.e., 2-D plane wave components propagating in various directions, and propagating each component through distance z, we can obtain the diffracted field distribution at distance z away from the phase mask.

Figs. 1 and 2 represent a portion of the computed intensity distributions resulting from a periodic rectangular phase profile, a "binary" phase mask with a duty cycle of 50 %. UV wavelength of 244 nm and the phase mask period of 1.063 μm were assumed for the calculations. Both sets of figures contain a prominent sinusoidal component as a result of the interference between the large ± 1 diffraction components and the complete or nearly-complete suppression of the zeroth-order (field) component in accordance with the design. Nevertheless, Fig. 1 displays the rather noticeable variations in the shape of the intensity profile at different distances from the phase mask location due to the interference among the propagating ± 1 and ± 3 components. Also, Fig. 2 - computed at the distance of 10 μm - shows the effect on the intensity profile produced by a modest level of perturbation in the value of the phase retardation difference parameter corresponding to 7 and 10 % of the "optimal" value of (π), respectively.

3. Conclusion

We have presented analytical results for diffraction pattern of phase masks based on angular spectrum decomposition method. While the method enables a quick approximation to phase mask design, for a more accurate result, improvements in modeling of the electromagnetic interaction within the phase mask are still required as well as resolution of issues such as the polarization dependence and the influence of the fiber sample itself.

References

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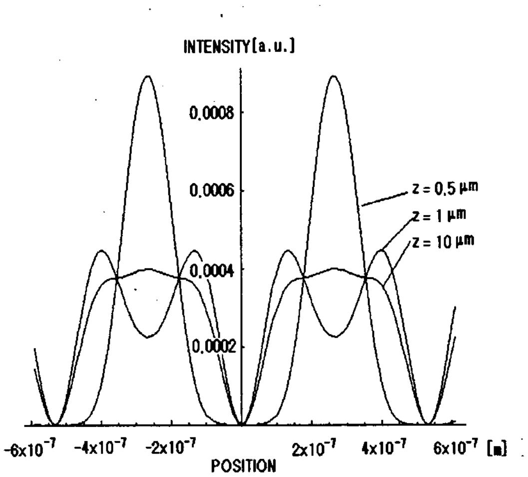

Fig. 1. Diffraction pattern at various distances from the phase mask.

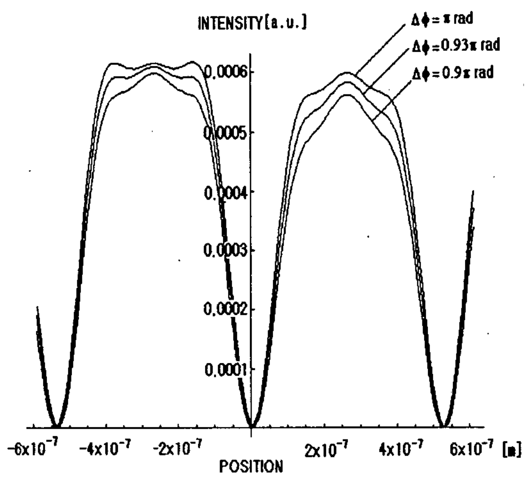

Fig 2. Diffraction pattern for various phase retardation difference values.