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Analysis of holographic lenses in PVA/acrylamide photopolymer

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Summary

A method to obtain holographic lenses in photopolymer is presented. The imaging quality of these lenses is evaluated by means of the modulation transfer function (MTF). This function is obtained by using a CCD camera on the image focal plane. Lenses of different focal lengths have been recorded.

Introduction

Holographic optical elements (HOE) are frequently used in applications such as optics communications [1], information processing [2] and information storage [3]. Holographic lenses (HLs) are a typical example of HOE; they can combine several optical functions such as multiple focusing onto an image plane and beam splitting.

Before using a HL it is necessary to analyze their imaging quality.

In this work HLs with different focal length are recorded using photopolymers as holographic recording material and its imaging quality is analyzed. An evaluation of the imaging quality is done using the point spread function (PSF) and the modulation transfer function.

Experimental Setup

The experimental setup used to store holographic lenses is shown in figure 1. The HLs were recorded with a He-Ne laser tuned at 633 nm with an incident intensity $I = 4 \, \text{mW/cm}^2$. The laser beam was split into two secondary beams and then spatially filtered. Both object (convergent) and reference (collimated) beams were recombined at the recording medium at an angle of 20.7° to the normal with an appropriate set of mirrors.

To analyze the HL, it is illuminated only with the reference beam. The reconstructed wave front is captured by a CCD camera situated in the focal plane.

In order to evaluate the optical quality of these images, we used the intensity profile and the MTF.
The photopolymer employed to store the holographic lens was made up of acrylamide as monomer, polyvinylalcohol 4-98 supplied by Fluka as binder, triethanolamine as coinitiator, methylene blue as dye and N,N'-metilienbisacrilamide as crosslinker. This composition is the one that gives the best results in terms of diffraction efficiency and sensitivity, together with stability and solubility, when diffraction gratings are stored.

Discussion

In order to obtain HLs of different focal length biconvex refractive lenses (RL) of focal length: f = 150 mm, f = 200 mm and f = 300 mm have been used. HLs focal length f= 100 mm, f = 150 mm and f = 250 mm have been obtained. A computer program to obtain the MTFs has been developed. The cutoff frequencies for a MTF of 0.1 are shown in table 1.

<table>
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<th>$v_O$ (lines/mm)</th>
<th>$f_L$ H</th>
<th>$v_O$ (lines/mm)</th>
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<tr>
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Table 1. Cutoff frequencies for MTF of 0.1

As can be seen in Table 1 the cutoff frequency decreases when the focal length increases according to theory. HL cutoff frequency is greater than RL cutoff frequency used in its recording. This is because HL focal length is lower than RL focal length.

In conclusion, these results show that it is possible to obtain holographic lenses in photopolymers with high optical quality.

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References