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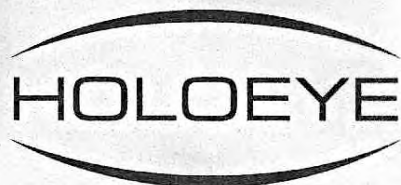
Coherence for Europe®

EOS Topical Meeting on Diffractive Optics 2007

20 – 23 November 2007

University of Barcelona, Faculty of Physics, Spain

Sponsors



ISBN 978-3-00-020989-5

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Application of a liquid crystal display to generate diffractive optical elements onto a photopolymer

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Summary

Liquid crystal displays (LCDs) have found widespread use in many areas in optics where spatial light modulation is necessary. In this paper we explore a novel application, where the LCD is used as the master to generate diffractive optical elements onto a photopolymer.

Introduction

Liquid crystal displays (LCDs) are widely used as spatial light modulators (SLMs) in many applications (optical signal processing, holographic data storage, diffractive optics...). In diffractive optics, LCDs are used to display programmable DOEs [1]. Programmable DOEs are needed in applications where it is interesting an active control through a computer of the function displayed onto the LCD. However, in many cases, passive DOEs are actually needed and a number of microoptics fabrication technologies [2], such as lithography, diamond turning, direct laser writing, are available to produce high quality passive DOEs. Low cost schemes have also been proposed and analyzed in the literature, such as production of computer-generated phase holograms using graphic devices and contact copying techniques [3]. This technique involves the manufacture of binary absorption masters by high resolution graphic devices. In order to increase the light efficiency, a contact print of these masters was made on a phase material [3]. In this sense, it is possible to use a LCD to display the DOE to be recorded onto the phase material, so as to enhance the flexibility of the recording architecture. In this microoptics application the goal is to use the LCD as an amplitude dynamic transparency. By means of an optical system we image the function addressed to the LCD onto the recording material. The element to be recorded onto the photopolymer can be easily changed simply by changing the function addressed to the LCD.

Among the recording materials, photopolymers [4] provide very attractive capabilities. They present a great flexibility in their composition, the recording layer can be manufactured in a wide range of possible thicknesses, and they are inexpensive. These properties make it an interesting material to generate the phase DOEs. Both the composition and the thickness need to be optimized for the application to DOEs.

In this work we explore the additional capabilities offered by the introduction of a LCD to produce DOEs onto a photosensitive material. In particular we consider polyvinyl alcohol (PVA) based photopolymers as the photosensitive material. First results dealing with the calibration of the recording setup including the LCD and the recording material are the main focus in this work.

Discussion and conclusions

In Fig. 1 we show the basic scheme for the experimental setup that we propose to generate the DOEs onto the recording material using the LCD as a master. We note that we use stop 2 to spatially filter the diffraction orders due to the pixelation of the LCD. This passive DOEs fabrication architecture imposes very demanding requirements since we have to combine an optimum control of the modulation regime of the LCD and of the modulation exhibited by the recording material as a function of exposure. A very significant property of this application is that the spatial frequencies of the DOEs generated are very low (below 50 lines/mm) in comparison with the application in holography (over 1000 lines/mm). This fact must be taken into account since holographic recording materials behave differently when used in the very low frequency region [5].

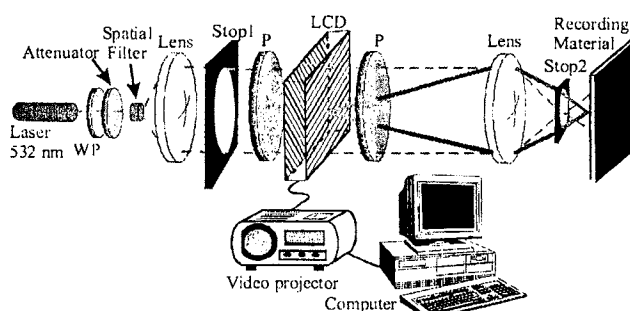


Fig. 1. Set-up. The recording material is exposed with $\lambda=532$ nm. WP is wave plate, P is polarizer.

Experimental results obtained for the calibration of the amplitude and phase shift modulations of the LCD as a function of gray level, and for the calibration of the phase-shift modulation of the photopolymer as a function of exposure, have been obtained. These two calibrations are combined to assign the appropriate gray levels onto the LCD to obtain the required phase-shift values onto the photopolymer. We have found that the maximum phase-shift modulation depth offered by the photopolymer exceeds 360° , which is the dynamic range needed for phase DOEs.

Acknowledgments

We acknowledge financial support from the Spanish Ministerio de Ciencia y Tecnología (grants FIS2005-05881-C02-01 and FIS2005-05881-C02-02), and from Generalitat Valenciana (project GV06/007).

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