ICO XIX
Optics for the Quality of Life

19th Congress of the International Commission for Optics

Technical Digest

Part 2 of Two Parts

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Editors

SPIE Proceedings Volume 4829

The papers appearing in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and are published as presented and without change, in the interest of timely dissemination. Their inclusion in this publication does not necessarily constitute endorsement by the editors or by SPIE.

Please use the following format to cite material from this book:
Author(s), "Title of paper," in **ICO XIX: Optics for the Quality of Life**, A. Consortini and G.C. Righini, Editors, Proc. SPIE 4829, page numbers (2002).

SPIE ISBN: 0-8194-4569-7

This volume was published by

SPIE – The International Society for Optical Engineering
P.O. Box 10, Bellingham, Washington 98227-0010 USA
http://www.spie.org

in cooperation with
COST-01 - Comitato Italiano per la Promozione delle Scienze e Tecnologie Ottiche
http://www.fotonica.it
ICO - International Commission for Optics
http://www.ico-optics.org
with the financial support of
P.F. MADESS II - CNR Special Project on Materials and Devices for Solid State Electronics II
http://www.madess.cnr.it

Cover photo by G.C. Righini

A study of the holographic behaviour of thick dry layers of an acrylamide based photopolymer

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ABSTRACT

In this study we analyze the behaviour of thick dry layers of a PVA/acrylamide photopolymer when used as a holographic recording material. The thickness of the layers is greater than 150 μm and the holographic parameters studied are diffraction efficiency, sensitivity, stability and the possibility of overmodulation with high exposures.

1. INTRODUCTION

The interest of many laboratories is centred on the research and development of materials that fulfil the requirements necessary for them to be used in holographic applications. High energetic sensitivity, spectral bandwidth, high resolution and recording potential are some of the properties that holographic materials must have. Photopolymers can be considered holographic recording materials[1] because they have such holographic properties. Moreover, we could mention their ability to self-develop, dry processing, good stability and thick layers. Thick layers of photopolymer are necessary when working with holographic memories in information storage systems[2].
In this paper, we study the holographic behaviour (diffraction efficiency, sensitivity, stability and overmodulation) of photopolymers when they are deposited in layers of over 150μm in thickness. When thick layers of an acrylamide based photopolymer are used, the acrylamide crystallizes due to small variations in laboratory conditions (temperature and relative humidity). In order to prevent crystallization of the dry layer, experiments have been performed adding a liquid such as dimethylacrylamide (DMAA) to the photopolymer composition. This liquid does not crystallize and so it is possible to obtain thick layers of photopolymer with a certain degree of stability. The material must also give maximum diffraction efficiency from the holographic point of view. Once the plate is printed, it is necessary to eliminate the liquid completely so that the stored hologram does not lose its holographic properties with time.

2. EXPERIMENTAL SETUP

The recording material used is composed of a matrix of polyvinylalcohol (PVA), acrylamide (AA) as monomer, triethanolamine (TEA) as radical generator and yellowish eosin (EA) as sensitizer. The photopolymerizable solution was prepared by adding 1.3 ml of 8g/l yellowish eosin together with 8 ml of acrylamide and triethanolamine to 50 ml of PVA solution (6% w/v) and 1 ml of DMAA. The resulting solution was deposited on a 20 x40 cm^2 glass plate using an automatic depositor and adjusting the thickness of the film. The plate was dried for a period of 72h in the dark and normal laboratory conditions (T = 21-23°C, HR = 40-60%). Once dried it was cut into plates measuring 6.5 x 6.5 cm^2 to be used in our experimental setup. The concentration of each of the components can be seen in table 1.
The liquid added to the photopolymer composition is dimethylacrylamide (DMAA) because, on the one hand, we are using an acrylamide based photopolymer and, on the other, it is the only solvent for other dyes, such as pyrromethenes, that we are interested in studying.
To study the behavior of thick dry films of photopolymer as a holographic recording material we obtained diffraction gratings using a holographic setup in order to determine the diffraction efficiency of the material and its sensitivity. The

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holographic gratings were created with an Argon laser at a wavelength of 514 nm and the spatial frequency obtained was 1125 lines/mm. The diffracted intensity was monitored in real time with a He-Ne laser.

ACRYLAMIDE (AA)	0.44 M
TRIETHANOLAMINE (TEA)	0.20 M
YELLOWISH EOSIN (YE)	2.5×10^{-4} M
DIMETHYL ACRYLAMIDE (DMMA)	0.16 M
POLYVINYLALCOHOL (PVA)	4.98 % w/v

Table 1: components of photopolimerizable solution

3. RESULTS AND DISCUSSION

To analyze the behavior of the photopolymer employed as the holographic recording material we represented diffraction and transmission efficiency versus exposure in order to establish the influence of the DMAA, as can be seen in figure 1. The maximum diffraction efficiency attained was almost 90%, without correcting for Fresnel losses and absorption of the glass substrate, and the energetic sensitivity was 100 mJ/cm^2. As can be seen, the curve in figure 1 reaches the maximum diffraction efficiency and then declines with high exposures. Therefore, a study of the angular response enables us to know if overmodulation exists in the case of thicknesses of over 150 μm.

Since we used a liquid, DMAA, to obtain more stable thick dry layers, if we want the stored grating to remain stable over time, it is necessary to eliminate the DMAA completely, otherwise in a few hours the liquid would once again cover the whole area of the plate making the grating disappear. If we heat the printed plate in an oven at 80°C for 10 minutes, the DMAA may be eliminated completely with no loss of diffraction efficiency, as can be seen in figure 2 which shows the angular response of the photopolymer before and after heating the plate. The measurements were repeated several days later and no decrease was found in the values of diffraction efficiency

It may be concluded that it is possible to obtain layers of photopolymer over 150 μm thick with no crystallization problems. This makes it possible to obtain thicknesses of over 250μm and analyze the existence of overmodulation, which is suggested by the shape of the diffraction efficiency an its angular response[3] curve at high exposures.

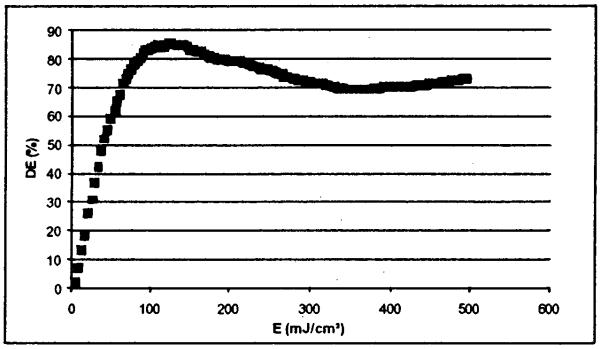

Figure 1: diffraction efficiency versus exposure

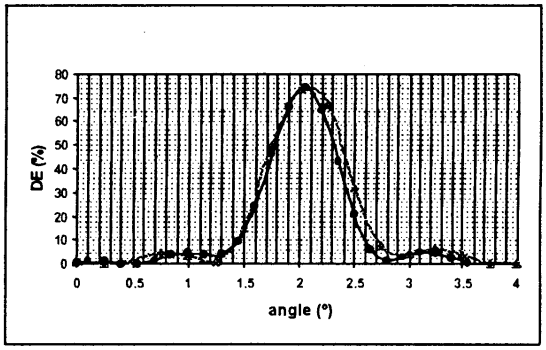

Figure 2: angular response. Before heating process (circle), after heating process (triangle)

ACKNOWLEDGMENTS

This work was supported by Ministerio de Ciencia y Tecnol., CICYT, Spain, under project MAT2000-1361-C04-04.

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