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Holographic lenses in non-plane substrates using photopolymers.

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ABSTRACT

We propose the use of the photopolymers that have been optimized in our Laboratory to obtain holographic lenses in non-plane substrates. Because photopolymers are self-developing, it is possible to introduce them between two spherical plates of glass which are concentric so that by using the adequate spacers, we generate a uniform layer of photopolymer on the spheric substrates.

2.- INTRODUCTION.

Using spherical instead of planar substrates has been suggested as a method to reduce both nonchromatic¹⁻⁴ and chromatic aberrations⁵. All of the papers cited are theoretical ones. The purpose of this paper is to present the possibilities of making Holographic Optical Elements on substrates that are spherical in shape.

Among the different materials that can be used, dichromated gelatins and photoresins are the ones that are most well-known in terms of application to planar substrates. However, using them requires advanced technology and application conditions that are very difficult to obtain and to repeat with non-planar substrates. Both kinds of materials also require subsequent developing, and dichromated gelatins a cementing procedure. All of these problems make it difficult to experimentally analyze holographic optical elements in spheric substrates.

One possibility is to use photopolymers as a recording material. Photopolymers have been shown to have high sensitivity and excellent signal-noise (SNR) ratio. Additionally, they are usually used between two plates of glass and because they are liquid, they conform to any kind of substrate they are deposited on. This leads us to believe that they can be used to manufacture these holographic systems.

3.-PHOTOPOLYMER SYSTEM

Holographic photopolymer systems are usually mixtures of acrylic monomers with a photoinitiator. The system selected in this work, based on the one previously described by Sugawara et al.⁶, is formed by mixing two aqueous solutions: Solution A: the polymerizable system, with acrylamide 7M, zinc acrylate 1M and N,N'-methylenebis-acrylamide 0.7M, (the polymerization of which gives rise to a tridimensional crosslinked polymer), and solution B: the photoinitiator system, with Methylene Blue 3.6×10^{-4} M, Rose Bengal 6.0×10^{-4} M and p-toluensulphinic acid 1.7×10^{-2} M. Both dyes act as photoinitiators because they have high absorption at 633 and 546 nm, respectively, and generate free radicals upon irradiation, whilst p-toluenesulphinic acid is a coinitiator. The to-be-irradiated solution, is formed by mixing four volumes of solution A with one volume of solution B.

4.- EXPERIMENTAL CONSIDERATION.

The solution is placed between two glass plates with a curvature radius of 120 mm (R) (as we can see in Figure 1), separated by a spacer of constant thickness of $45 \pm 5 \mu\text{m}$, and irradiated in a typical holographic set-up for Holographic Optical Elements recording.

Figure 1

A set of films with the two dyes was submitted to preexposure and subsequent irradiation with 633nm. The intensity and the time of preexposure to the beam was changed in order to study the influences on energetic sensibility and on the layer's rigidity. The influences of the preexposure has been demonstrate in a previous paper⁷, and it is possible to increase the energetic sensitivity and at the same time have a panchromatic system. When exposure is completed, this system is self-developing so, unlike systems using dichromated gelatins or photoresins, no developer is needed.

The diffraction efficiency achieved with this system was 60% with a sensitivity of 3 mJ/cm^2 at 633 nm.

This system has been used to make holographic lenses by means of interference of a spheric wave with a plane wave. The diameter of the usable holographic lenses was 6 cm and the focal length 30 cm. In future studies, image quality and uniformity in diffraction efficiency throughout the system's exit pupil will be analyzed.

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