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Dynamic Holographic Gratings Recorded in Photochromic Organic Material

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DYNAMIC HOLOGRAPHIC GRATINGS RECORDED IN PHOTOCHROMIC ORGANIC MATERIAL.

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Abstract We investigate the volume holographic properties of a polymer sensitised with a photochromic spiropyrane. The experiments report the behaviour of the material during the recording and the reconstruction steps; the holographic grating is characterised by the diffraction efficiency and the temporal evolution of the diffracted beam.

INTRODUCTION

Usually, dynamic holograms are recorded on ferroelectric crystals (BSO, BGO,...) because they allow high diffraction efficiencies and fast response time. However, their effective size is limited (few cm^2), their thickness is important (1mm to 1 cm) and present optical activity. In several applications, these drawbacks can modify the diffraction properties of the hologram and are of prime importance [1].

Photochromic organic materials undergo reversible changes in colour when illuminated at an appropriate wavelength and therefore appear to be an attractive alternative for information storage application in which a "write - read - erase" process is desired. Even if their sensitivity is low and their diffraction efficiency is also low, the material is easy to prepare and the thickness can be easily adjusted (10 µm to 100 µm). We present in the following the results obtained with a spiropyrane used as the photochromic agent to record real-time holograms.

EXPERIMENTAL SET-UP.

The experimental set up is shown in figure 1.

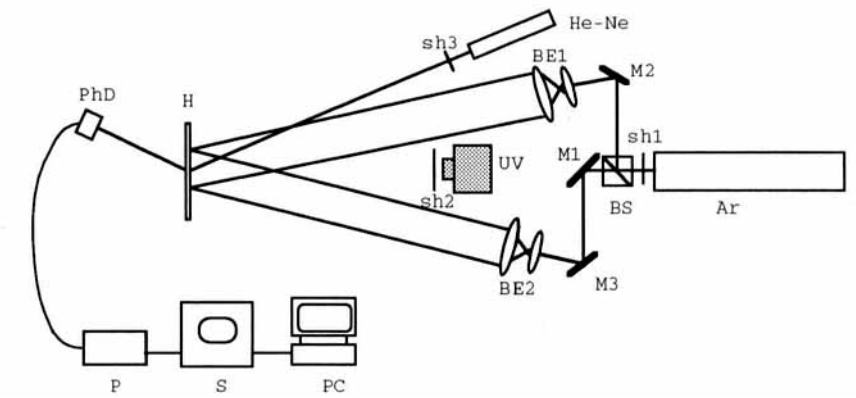

FIGURE 1. Experimental set up. H: Hologram; PhD: Photodiode, P: Powermeter, S: scope, sh1,2,3: Shutters.

The holographic plate H consist of a glass support on which we poured a film of photochromic synthesised spiropyrane (3,3'-dimethyl-1'isopropylspiro-8-methoxybenzopyran-2,2'-indoline) dissolved in toluene, mixed with a styrene - butadiene copolymer (Pliolite 5S-E). After drying, the thickness of the layer is 95 μm and the bulk refractive index is 1.5925. The plate is firstly exposed to UV light of a mercury lamp (sh2 open) to "switch" the emulsion in its merocyanine form and the absorption becomes maximum in the visible light. The mean wavelength λ_{UV} is 380 nm and the intensity on the plate is 0.35 mW/cm^2. The plate is then illuminated with two expanded and collimated Argon laser beam (sh1 open) of equal intensity and making an angle of 7° with the normal of the plate. The wavelength λ_A is 514 nm and the total intensity is 15 mW/cm^2. The spatial frequency of the thick amplitude grating generated is about 500 lines/mm. To control the evolution of the grating, an He-Ne laser beam of 1mW/cm^2 is incident on the hologram at Bragg angle and the intensity of the diffracted beam is measured by a photodiode connected to a powermeter, a scope and a computer. The figure 2 shows the variations of the diffraction efficiency $^2\eta$ in function of the illumination time t. The intensity of the diffracted beam reaches a maximum of approximately 1% after an exposure of 1.8 J/cm^2 an slowly decrease if the Ar illumination persists, indicating a degradation in the structure of the holographic fringes.

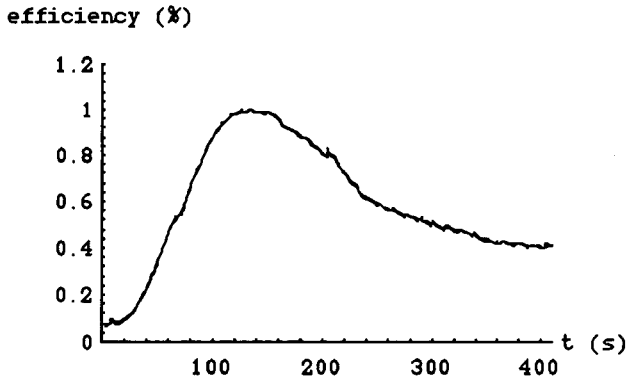

FIGURE 2. Evolution of η during holographic recording.

When the maximum is reached and the Ar illumination is stopped, the grating can be erased by uniform exposure to UV (curve B) or He-Ne (curve A), the photochromic material being respectively in the merocyanine and the thermally stable form (Figure 3).

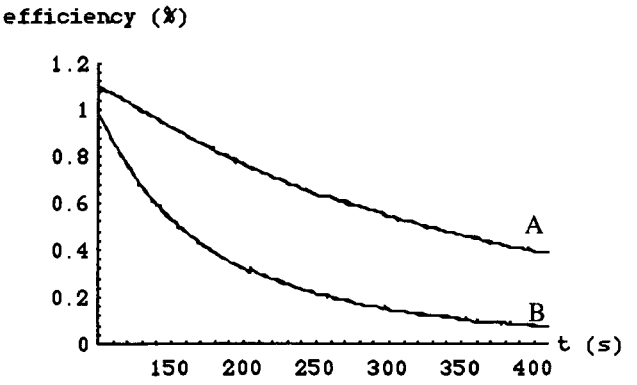

FIGURE 3. Erasure of holographic grating due to uniform exposure to UV (B) or visible light (A).

When the intensity of the Ar beams is carefully adjusted relatively to the UV and He-Ne intensities (6.5 mW/cm^2), the diffraction efficiency is somewhat lower (0.6%) but can be stabilised for hours indicating that the grating is continuously destroyed by

the uniform exposure to UV and He-Ne, and at the same time reconstructed by the interference created by the Ar beams (figure 4).

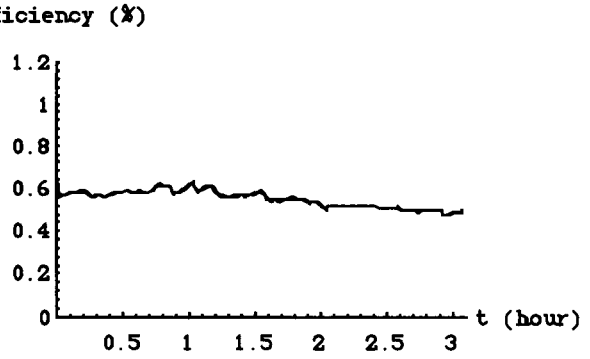

FIGURE 4. Stabilisation of the diffracted intensity during real-time hologram recording and reconstruction.

CONCLUSION.

We have analysed the behaviour of an organic photochromic polymer based on spiropyrane during dynamic recording of holograms; in particular, we have measured the diffraction efficiency during the formation and the erasure of the holographic grating and we have shown that, in an appropriate recording configuration, the amplitude grating can be stabilised for long periods.

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