Diffractive and interferometric methods to characterize photopolymers with crystal liquid molecules as holographic recording material

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Summary

We present two methods, interferometry at the zero spatial frequency limit and analysis of diffracted orders for very low spatial frequency gratings, to characterize photopolymers with dispersed nematic liquid crystals. These methods provide us information in real time about the transformations taking place inside the material during recording.

Introduction

Usually the characterization of holographic recording materials is based on the recording of holographic gratings [1-2]. The main advantage of this method is that characterization and optimization of the material, and of the processes to store recorded holographic gratings, are performed simultaneously. For example, it is possible to multiplex many gratings in the material, trying to achieve high values of diffraction efficiency, and to measure the signal-to-noise ratio. Nevertheless there are materials with many parameters involved in the hologram formation, and it is difficult to decouple the importance of each parameter to fit them separately. In particular in photopolymeric materials the interplay between polymerization and diffusion inside the material makes this task specially challenging and unambiguous.

We propose interferometric and diffractive methods to characterize certain properties of photopolymers as holographic recording materials, allowing to decouple the main parameters that govern the diffractive image formation. The first one is the interferometric analysis at zero spatial frequency limit. And the second one is the recording of very low spatial frequency gratings, where the measurement the intensity of the different diffracted orders permits us to fit the exact grating shape recorded and track the molecules diffusion in real time.

Discussion

The first method (Fig. 1) is based on an interferometer that has been successfully applied in the phase-shift versus applied voltage characterization of liquid-crystal displays (LCDs) [4]. It shows good precision, and, due to its quasi-common-path architecture, is a robust setup, less sensitive to changing environmental conditions and simpler to construct than Mach–Zehnder type

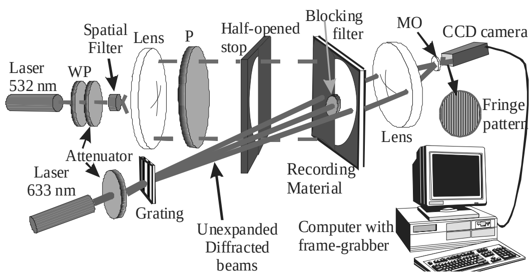

Fig. 1 Experimental setup for zero spatial frequency analysis. P is polarizer, WP is wave plate, MO is microscope objective.

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interferometers. We use a grating with a spatial frequency of 4 lines/mm to generate a series of diffracted orders; we block all the orders except +1 and -1. One of the two orders impinges on the exposed zone (illuminated by the Nd-YVO4 laser) and the other one impinges on the nonexposed zone. The distance between the two orders is approximately 1 cm, so as to eliminate the influence of the monomer diffusion in the polymerization process. Afterwards the orders are brought to interfere and from the interference pattern we may obtain the evolution in the material due to polymerization (diffusion is not present).

For very low spatial frequency analysis the diffractive-based experimental setup s presented in [5], where the periodic pattern is introduced using a LCD as the master which is copied onto the photopolymer.

Theses methods were employed to analyze the behavior of photopolymers with liquid crystal molecules. In particular, we have analyzed the importance of the liquid crystal presence in the polymerization processes. From Fig. 2.a it can be measured how the liquid crystal reduces the phase shift: it may inhibit the whole monomer polymerization. In Fig.2.b the recording of a grating with a spatial period of 168μm during 20 s and the post-recording evolution, which is due to diffusion, is presented.

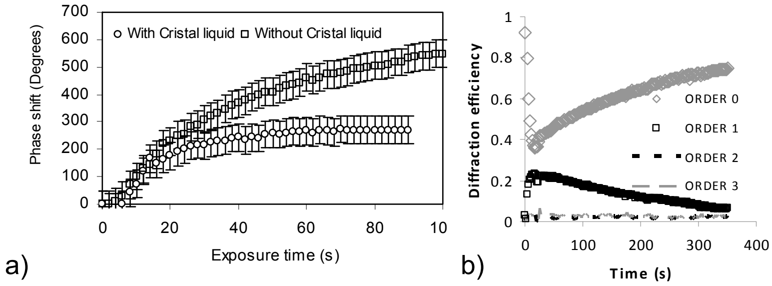

Fig. 2. a) Phase shift as a function of exposure. b) Main diffracted orders as a function of time.

Conclusions

Using interferometric and diffractive analysis we have shown the characterization of photopolymer with and without liquid crystal molecules. Combining the two methods we achieve the decoupling of the polymerization and diffusion analysis and we are able to discuss the influence of the liquid crystal molecules in the grating formation.

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