Fabrication of holographic materials by photo-induced polymers

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ABSTRACT

A fabrication approach using PMMA [poly(methyl methacrylate)] and EGPEA (ethylene glycol phenyl ether acrylate) for holographic materials is presented. Diffraction efficiencies with various interference angles are studied. A 3D image reconstructed by this hologram is presented as well.

Keywords: hologram, optical storage materials, diffraction efficiency, holographic storage

1. INTRODUCTION

Photopolymerizable materials can be used for holographic recording due to their good light sensitivity, real-time image development, large dynamic range, and low cost [1-6]. It typically consists of a specific type of photo-initiated guest monomers and a photo-initiator; both are well dispersed in a host matrix. The light illumination makes the photo-initiators and monomers to produce polymer chains inside the host matrix. Refractive index of this material is therefore modulated by the light illumination. In general, the optical storage properties of these photo-polymeric recording medium rely crucially on the characteristic of the host and guest molecules; the host matrix should be highly porous such that the monomer and the initiator can infiltrate into its pores.

In this paper, an approach to fabricate photopolymerizable materials is presented. The EGPEA (ethylene glycol phenyl ether acrylate) is selected as the monomer, and the Irgacure 784 is employed as the photo-initiator. The porous substrate formed by PMMA [poly(methyl methacrylate)] is then subjected to the subsequent infiltration of the monomers EGPEA and the photo-initiator Irgacure 784. Once it is exposed to photo-illumination, the linear acrylate polymer chains are formed within the PMMA matrix, leading to a change of refractive index.

2. FABRICATION METHOD AND EXPERIMENT

Figure 1 illustrates the flow chart of the fabrication process. The PMMA uniformly distributed in ethanol is mixed with the monomers EGPEA and the photo-initiator Irgacure 784. The composite gel is then mechanically stirred in circulated condition at room temperature for 15 minutes. After validation for 24 hours, a photopolymerizable material is formed.

Figure 2(a) shows the optical configuration for holographic recording. A DPSS laser which generates light waves with 532nm wavelength was used as the light source. A beam splitter divided the laser beam into two beams. Directed by two mirrors, these two beams interfered with each other within the holographic medium. The constructive interference made the linear acrylate polymer chains formed within the PMMA matrix, while the destructive interference kept the monomers EGPEA uniformly distributed in the matrix. A phase grating was therefore generated in the matrix. The incident angles of the light waves were $\theta_1 = \theta_2 = 1.5^o$, resulting in a grating period of 10.16 μm in the holographic medium.

A He-Ne laser with wavelength of 633 nm was used to evaluate the diffraction efficiency. Figure 2(b) depicts the optical configuration. In our experiments, the thickness of the holographic material was 500μm. It was a volume hologram. Thus, the incident angle of the reading beam was approximately 1.8^o.

Photonic Fiber and Crystal Devices: Advances in Materials and Innovations in Device Applications X,
edited by Shizhuo Yin, Ruyan Guo, Proc. of SPIE Vol. 9958, 99581C · © 2016
SPIE · CCC code: 0277-786X/16/$18 · doi: 10.1117/12.2240070

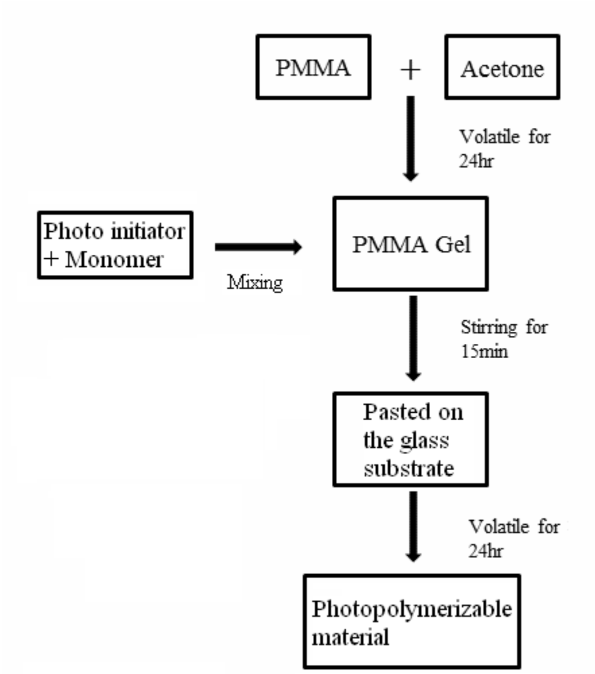
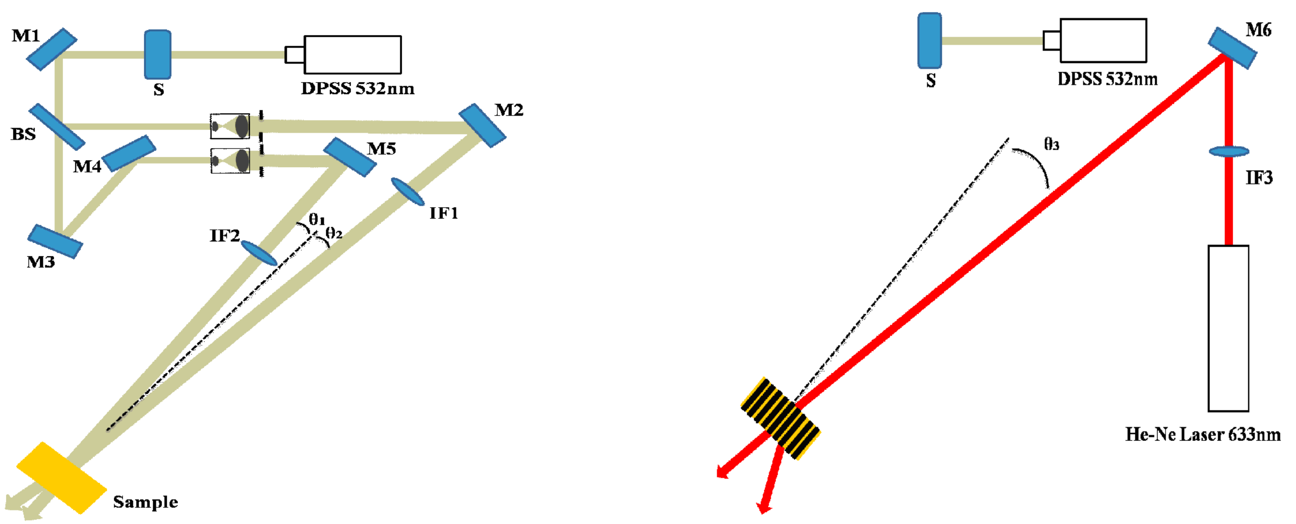


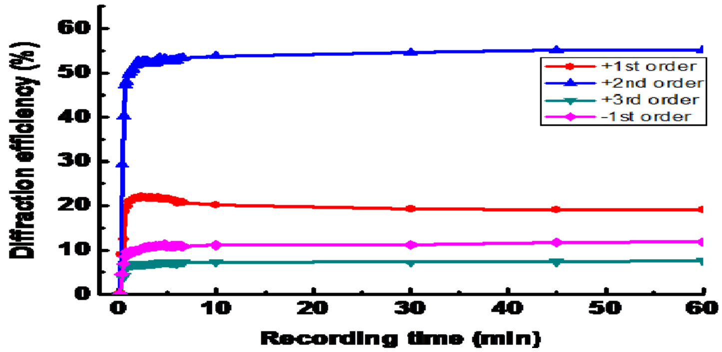
Figure 1. Flow chart of the fabrication process.



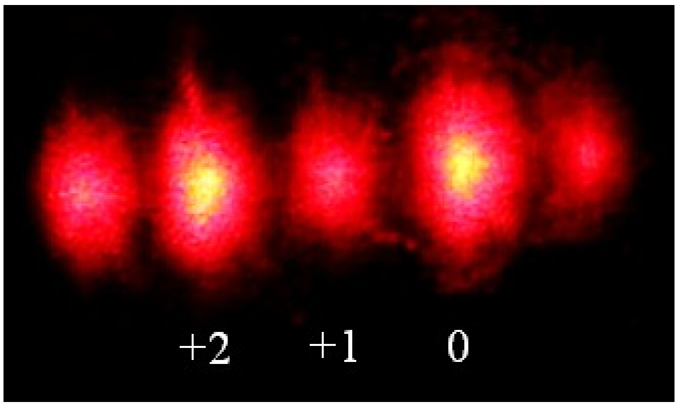
(a) (b)

Figure 2. (a) Holographic setup in the recording proceedure. (b) Optical configuration to measure the diffraction efficeincy.

A number of holographic materials with different molar ratios of PMMA/EGPEA composites were fabricated. Figure 3(a) shows the diffraction efficiencies with the recording time for various diffraction orders, in which the molar ratio of PMMA/EGPEA was 5/3. It is found that the diffraction efficiency of the 2nd order was more than 50%, which was higher than the 1st order. Appearance of the diffraction beams projected on the screen is shown in Fig. 3(b). The reason might come from that Bragg's mismatch appeared within this material. Another examples with the molar ratios of PMMA/EGPEA 5/4 and 5/2 are illustrated as Fig. 4(a) and Fig. 4(b), respectively.

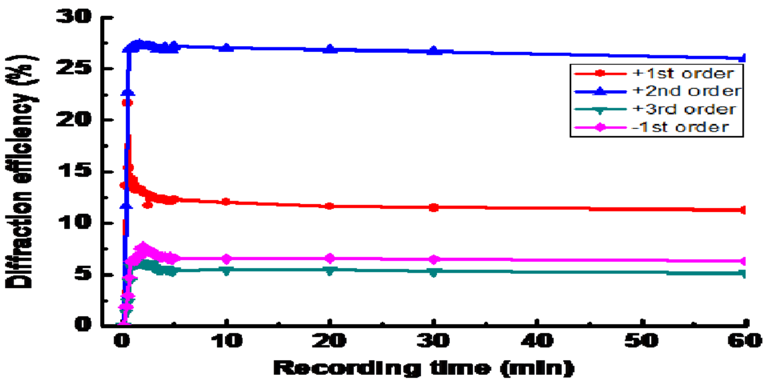


(a)

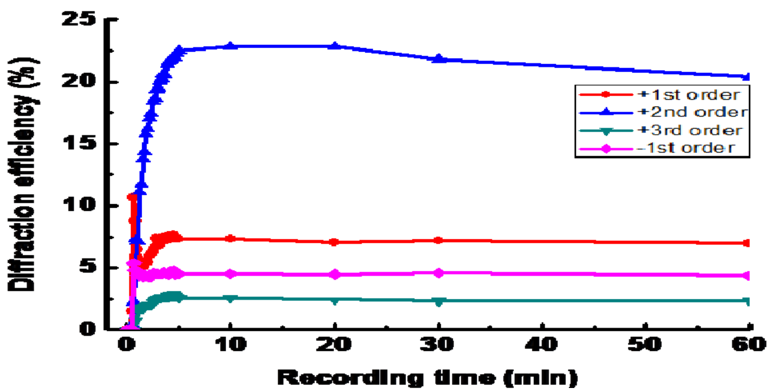


(b)

Figure 3. (a) Diffraction efficiencies with the recoding time for various diffraction orders. The molar ratio of PMMA/EGPEA was 5/3. (b) Appearance of the diffraction beams with different diffraction orders.



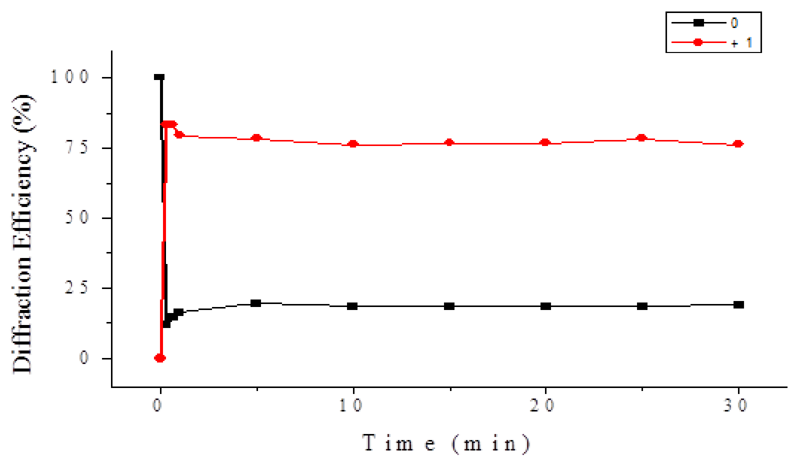
(a)



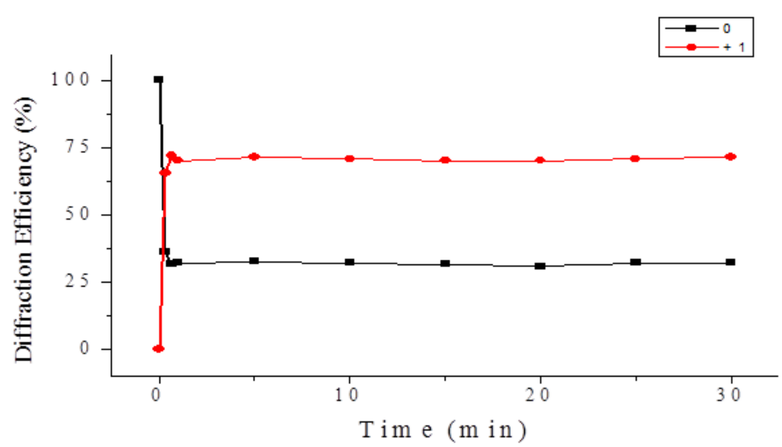
(b)

Figure 4. Diffraction efficiencies with the recoding time for various diffraction orders. The molar ratio of PMMA/EGPEA was (a) 5/4, and (b) 5/2.

A set of phase gratings with various grating periods by changing the incident angles θ_1 & θ_2 was performed. Diffraction efficiencies for different incident angles were illustrated as Fig. 5.



(a)



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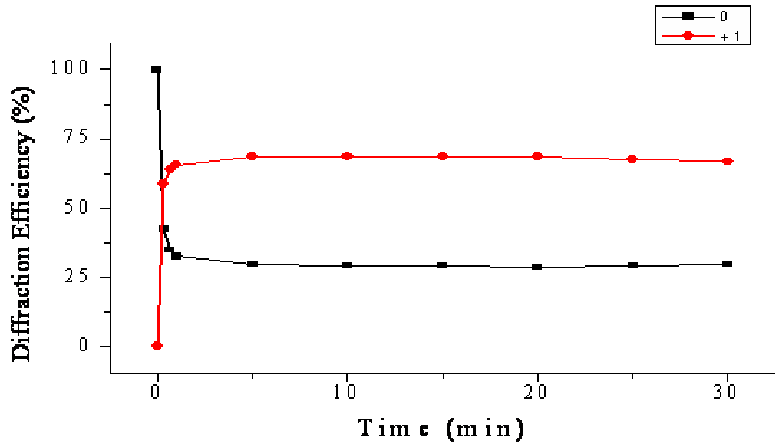
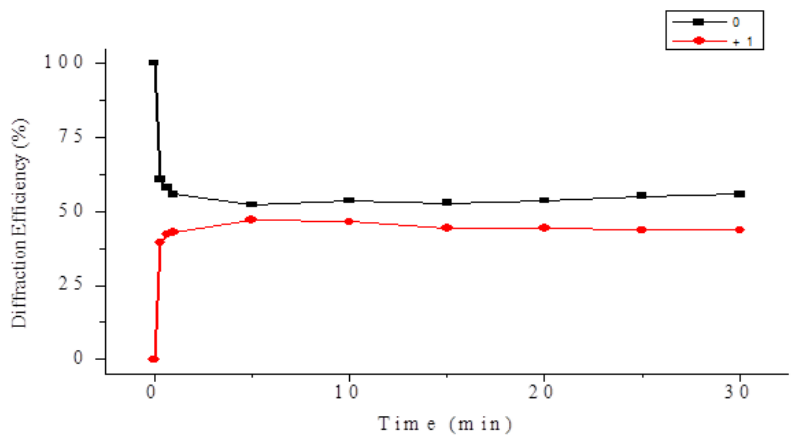


(c)



(d)

Figure 5. Diffraction efficiencies for different incident angles: (a) $\theta_1 = \theta_2 = 3°$, (b) $\theta_1 = \theta_2 = 15°$, (c) $\theta_1 = \theta_2 = 30°$, and (d) $\theta_1 = \theta_2 = 45°$.

3. CONCLUSION

We have described an approach using PMMA/EGPEA composites to fabricate holographic materials. A holographic configuration has been set up for optical recording and reading on the optical storage materials Diffraction efficiencies of various molar ratios of PMMA/EGPEA have been evaluated. A set of phase gratings with various grating periods by changing the incident angles θ_1 & θ_2 was performed as well. For interference angles $\theta_1 + \theta_2 < 85°$, diffraction efficiency more than 70% can be achieved.

4. REFERENCES

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