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Multiplexing storage using angular variation in a transmission holographic polymer dispersed liquid crystal

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ABSTRACT

Simultaneous angular multiplexing of transmission gratings in a holographic polymer dispersed liquid crystal (HPDLC) film as a function of resin and film compositions, irradiation intensity, and cell thickness has been studied by exposing the material to three coherent laser beams. It was found that the diffraction efficiency monotonically increases with irradiation intensity and cell gap, whereas a maximum of 43% is obtained at specific compositions of trimethylolpropane triacrylate (TMPTA)/*N*-vinylpyrrolidone (NVP) = 8/1 and polymer/LC = 65/35. The multiplexed gratings have been captured using SEM imaging and the reconstructed images using a charge-coupled device camera, showing successful reconstructed images of gratings.

1. Introduction

Holographic polymer dispersed liquid crystal (HPDLC) is divided into the transmission HPDLC and reflective HPDLC. Generally, the transmission HPDLC is applied to the hologram and information storage, while the reflective HPDLC is used to the display. Until now, HPDLC has been researched for the inclement in the electro-optic properties such as the low driving voltage, high contrast ratio, and fast response time and so on. Recently, much attention has been focused on holographic processes and the development of novel materials for high-performance holograms. This is largely due to the need for expanding the information storage technology presently available. Holographic storage has long promised large digital storage capacity because the information packing densities can be considerably increased by employing three-dimensional storage techniques in the form of interference patterns [1]. Holographic storage also enables fast data transfer because it permits simultaneous reading and writing of data. Multiple holograms may be stored in volume-holographic means through angular [2,3], phase-encoded, amplitude-encoded, wavelength, or spatial multiplexing, or by more than one of these techniques in combination [4–6].

The storage system has conventionally been formed using a photorefractive crystal, photopolymer, and photosensitive glasses. Banyal and Prasad [7] used Fe–Ce–Ti-doped $LiNbO_3$ crystals to improve the recording sensitivity. Li et al. [8] fabricated high-density holographic data storage on azobenzene photopolymer film, which can undergo a reversible geometrical photoisomerization (trans–cis). Huang et al. [9] reported holographic recording parameters of a novel two-dyes-sensitized photopolymer under different exposure wavelengths. However, the photopolymerization process is generally irreversible, and the recorded gratings are permanent and not erasable. In contrast, HPDLC is switched between light transmission and light refraction when an electric field is applied to the HPDLC. In addition, HPDLC devices have clear readouts as well as high data capacity to be used in wavelength division multiplexing (WDM) and information storage materials. However, to our knowledge, little has been reported about HPDLC as a simultaneously angular multiplexing material, the exception being the study by Crawford et al. [10], who noted a maximum diffraction efficiency of about 18% in HPDLC with urethane oligomer. B. K. Kim. et. al were published the paper about the image storage in 2011 [11]. Theoretically, transflective HPDLC prepared using three coherent beams should have three gratings (two horizontal and one perpendicular gratings) for diffraction and reflective efficiencies. However, reflective grating was not detected in spite of complex of reflective HPDLC and transmission HPDLC, and only diffraction efficiency was measured. It is because the variable reflective grating (horizontal grating) is fabricated under the exquisite interference of two beams. This phenomenon has a significantly effect on the image storage, resulting in the reconstruction of distorted and cloudy images.

In the present work, the multiplex transmission HPDLC was prepared using the angular variation technique to overcome this drawback. Two transmission gratings using three coherent laser beams directly on reactive diluents, and the effects of diluent type, polymer–liquid crystal (LC) composition, cell gap, and irradiation intensity on the diffraction efficiency and reading image were investigated. In addition, the

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Table 1
Formulations and diffraction efficiencies of the films prepared at various conditions.

Prepolymer (wt%)	LC content (wt%)	Rose bengal (wt%)	NPG (wt%)	Cell gap (μm)	Laser intensity (mW/cm^2)	Diffraction efficiency (%)		Run number	Prepolymer (wt%)	Diffraction efficiency (%)		Run number
						DE$_1$	DE$_2$			DE$_1$	DE$_2$	
TMPTA/ NVP = 8/1	25	14	1.8	14	50	24	0.33	1	**DPHPA/ NVP = 5/1**	**15**	**0.25**	**13**
	30					32	0.47	2		**20**	**0.27**	**14**
	35			4.2	50	26	0.20	3		–	–	–
				7.9		27	0.21	4				
				9.8		28	0.22	5				
				11		31	0.45	6				
				30	37	0.25	7	25		**0.20**	**15**	
				50	43	0.52	8	30		**0.30**	**16**	
				70	50	0.87	9	45		**0.52**	**17**	
				90	60	1.20	10	48		**0.72**	**18**	
	40			14	50	25	0.27	11		**35**	**0.36**	**19**
	45					24	0.20	12		**23**	**0.19**	**20**

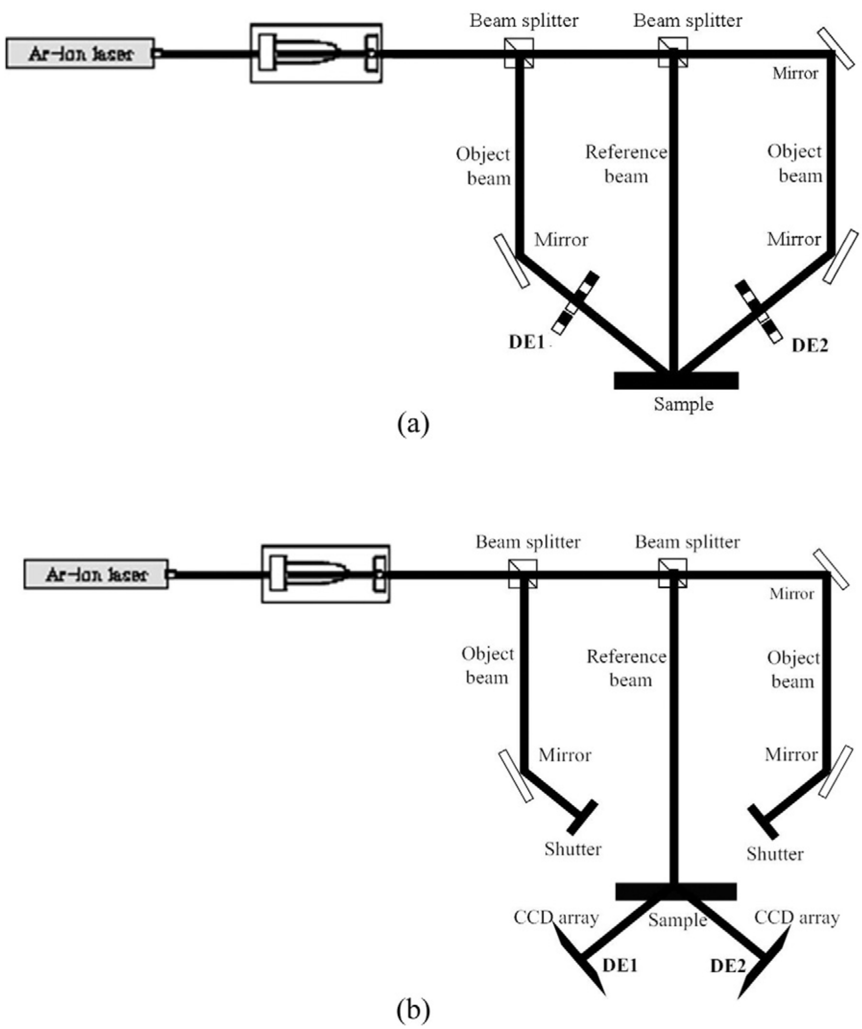

Fig. 1. Experimental setup for the multiplexing transmission grating of HPDLC: (a) recording and (b) reconstruction arrangement.