Fabrication of Holographic Apodized Grating in Photopolymer using Spatial Light Modulator

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Apodized grating recorded in photopolymer are well-known as a key for reducing the crosstalk in optical demultiplexer for DWDM[1], or as a beam shaper, which reshapes the laser beam into another form such as a flattop distribution[2,3]. In those fields, the fabrication of the apodized grating intensively depends on the requirement of the optical system, i.e. when the size or apodizing profile is subject to be changed, all the recording system is set up again. In addition, the properties of holographic material is various and non linear generally. In our proposal, a Spatial Light Modulator SLM is used as an intensity controlling device that provides the desired intensity distribution profiles.

Generally, the transmittance response and the optical quality of a LCD are not linear and outstanding. In addition, fringes due to interference between interfaces inside may be one of the obstacles for the LCD being applied in broad coherent applications. Therefore, it is necessary to make a compensation for the LCD to create a desired intensity profile. This is done by the use of the (Charge Coupled Device) CCD camera capturing the brightness of the light transmitted through the LCD when different uniform gray levels are put into the LCD in sequence. The captures images are processed and used as the input data of a compensating program. The pictures of the Gaussian profile captured by CCD camera before and after using the compensating program are shown in Fig. 1. It is obvious that the fringes are much suppressed in the latter case.

Firstly, to fabricate the apodized grating, the characteristics of the photopolymer must be known. A number of transmission holograms in HRF-150-38 photopolymer are exposed and monitored in the experimental setup that shown in Fig. 2. The laser beam from a continuous wave (CW) Nd:YAG source (wavelength λ_w =532 nm) is filtered by a spatial filter, collimated by a lens, and passed centrally by an aperture to ensure that its intensity has the uniform distribution. The recording beams are symmetrically interfering, each incident with an angle θ_w to the holographic plate normal of 15° in air. The shutter controlled by a computer blocks a beam for every 10s. The detectors collect the intensity data of the diffracted and transmitted beams at the blocking time. The diffraction efficiency is calculated by the ratio of the intensity of the diffracted beam to the total output intensity. The recording intensity of one beam is set in a range from 0.1 to 0.8 mW/cm^2 with the increasing step of 0.1 mW/cm^2. The result that presents the growth of the diffraction efficiency versus the exposure time is shown in Fig. 3.

Figure 4 shows the scheme of the recording system. The LCD with 640x480 resolution is illuminated by the uniform laser light of 532 nm wavelength, which is emitted from a Nd:YAG laser source and collimated by lenses. The light intensity changed by the LCD gray level. The data pattern is modified in such a way that compensates the fringe as mentioned above. A beam splitter divides such beam into two beams with the ratio of 1:1. A couple of filters, which consist of 4-f systems, are used in two arms of recording beams to filter the high diffraction orders created by the LCD. The recording material is placed in the interference region of these two beams in around 300 s, each of which has the intensity in the center of 0.3 mW/cm^2. Then, the grating is fixed by UV exposure and measured by the 633 nm He-Ne laser beam. The grating is horizontally shifted over the probe beam by a linear stage as depicted in Fig. 5. A computer automatically collected the intensity value of the diffracted light, which is measured by the detector. Figure 6 shows the results of a Gaussian apodized grating of 14-mm width created and measured by the above fabricating process. A Gaussian function used to fit to the measured data has the standard deviation is 1.7 mm. From the figure, it is clear that the fringes due to the LCD are not completely compensated. To avoid this problem, other spatial light modulator that has good optical quality such as Digital Micromirror Device (DMD) should be used.

By the use ofthe LCD and the understanding of the characteristic of the holographic material, it is possible to create gratings in various sizes and profiles without changing recording setup. This is very useful to make holographic elements for applications such as laser diode beam shaping and low cross-talk filtering.


a) b)

Fig. 1. The Gaussian pattern of LCD a) before and b) after the fringe compensation

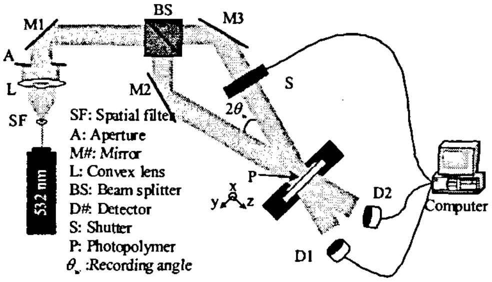


Fig. 2. Experimental setup to investigate characteristic of the photopolymer

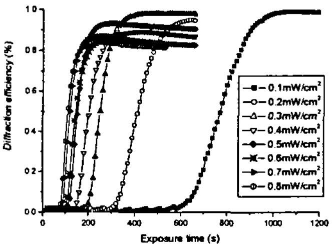
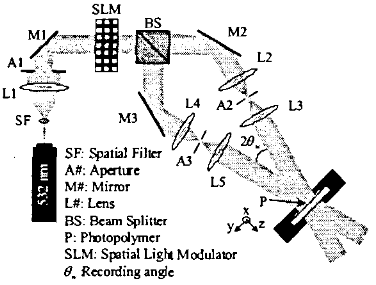
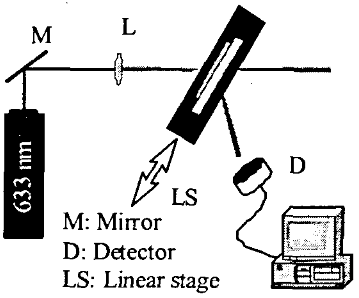


Fig. 3. Diffraction efficiency of the photopolymer depends on the exposure time





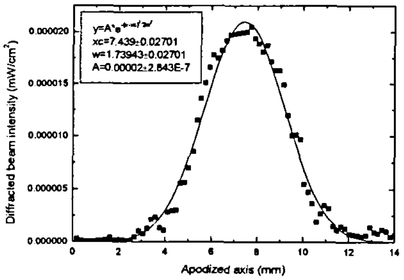


Fig. 4. Experimental setup to record apodized grating

Fig. 5. Experimental setup to measure grating profile

Fig. 6. Gaussian apodized grating profile

References

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