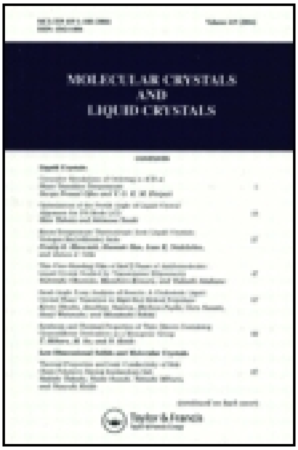

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Single Pulse Formation of Wide-Range Period Nonlinear Grating in Urethane-Urea Copolymer Films Using Ultraviolet Laser-Interferometric Method

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Wide-range period grating formation in urethane-urea copolymer film by use of single-pulse UV laser interferometric method is demonstrated. Two types of fabrication setups are introduced. Minimum grating period of 0.4 μm and maximum of 1.5mm are obtained.

Keywords: nonlinear grating; laser-interferometric method; urethane-urea copolymer

INTRODUCTION

During the past several years, second-harmonic generation (SHG) in optical waveguides with surface relief grating (SRG) (i.e. $\chi^{(2)}$ grating) has attracted much interest[1]. It is expected that similar devices will perform many useful functions[2] in light modulation, optical signal processing, SHG, optical logic and etc. There are several methods to fabricate the periodically poled structure ($\chi^{(2)}$ grating) using several techniques such as periodical poling, UV-photobleaching, laser-assisted poling, electron-beam direct writing, laser-beam direct writing, and serial grafting combined with reactive ion etching. Recently, there were some reports about formation of diffraction gratings on various kinds of films based on two-beam laser-interferometric method.[3] Generally, a visible Ar^+ laser at 488 nm or an ultraviolet (UV) laser at 355 nm or an excimer laser were chosen as light sources. However, as far as we know, there has been few reports on the formation of the nonlinear grating for frequency conversion and linear EO applications using polymeric nonlinear optical (NLO) materials by using UV laser-interferometric method. In this report, we proposed and demonstrated the fabrication of wide-range period nonlinear gratings by using single pulse UV laser-interferometric method. Two types of fabrication setups are introduced. Nonlinear gratings with period from submicron to millimeter are successfully fabricated.

RESULTS AND DISCUSSION

We have studied the formation of wide-range period nonlinear grating using single pulse UV laser-interferometric method. The polymer we investigated is a kind of azobenzene-contained copolymer named urethane-urea copolymer, whose chemical structure and the details of synthesis were described in reference [4]. The glass transmission temperature (Tg) is 141 °C. The copolymer films were obtained by spin-coating method, with a thickness of about 1.0 μm. To induce the second-order nonlinearity, the corona-poling was carried out. The electric field was set as 10 kV and the poling time was 10 min at temperature of 150 °C higher than its Tg. In order to form a periodical structure in the optical polymer waveguide, two types of optical configuration of two-beam interference[5] were arranged and single pulse UV laser is exposed directly onto the poled films.

We prove that these setups can easily fabricate the grating with period between submicron to several millimeters. Setup (a) is suitable to form the period from submicron to tens of microns. Moreover, using setup (b), we can fabricate much larger grating period than tens of microns till several millimeters. A single pulse of third-harmonic wave of Nd:YAG laser at 355 nm with pulse duration of 5 ns was used as the laser source. A vibration isolation table is not necessary for this system because mechanical vibration whose rate is of the order of microseconds is negligible within the single-pulse duration of the laser. Fig. 1 shows an atomic force microscope photograph of the fabricated grating with period of 0.4 μm by using setup (a). The exposure energy density of UV laser was set at 255mJ/cm^2.

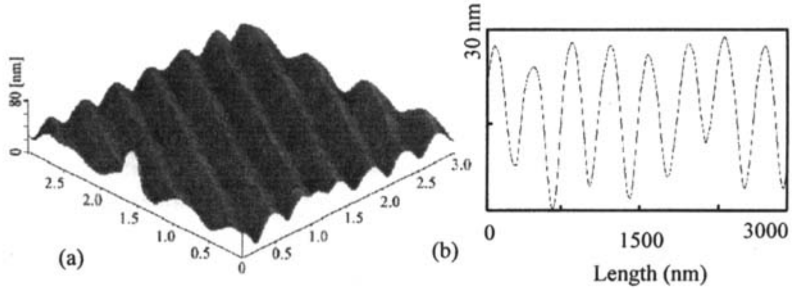
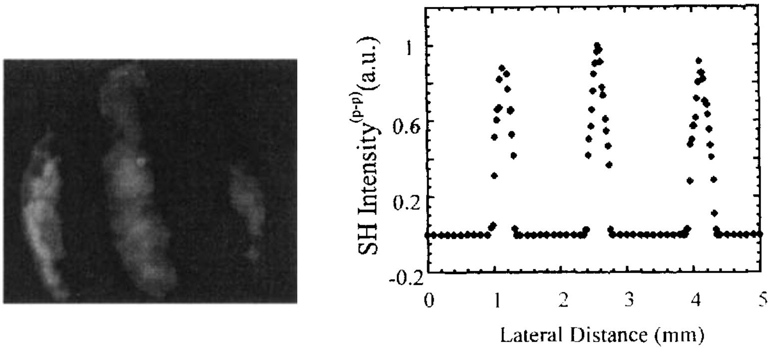


FIGURE 1 AFM photograph of 0.4-μm period SRG with $\chi^{(2)}$, (a) three-dimensional view, (b) surface trace.

Moreover, we successfully fabricated the nonlinear grating with larger period by use of setup (b). Fig. 2(a) is a photograph of the actually fabricated $\chi^{(2)}$ grating with 1.5-mm period in urethane-urea copolymer film, with total one pulse energy density of 580 mJ/cm^2. The second-order nonlinearity distribution of the fabricated grating was investigated by inserting a fundamental wave at 1064 nm of Nd:YAG laser on the grating region. With scanning the fundamental, the fringe pattern of the second-harmonic intensity was obtained and is shown in Fig. 2(b).



(a) (b)

FIGURE 2 (a) Photograph and (b) fringe pattern of second-harmonic intensity of fabricated $\chi^{(2)}$ grating with 1.5-mm period.

CONCLUSION

Wide-range nonlinear gratings from 0.4 μm to 1.5 mm period have been successfully fabricated by single pulse UV laser-interferometric method in urethane-urea copolymer films. The fabricated gratings are expected to be used for EO modulation and frequency conversion.

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