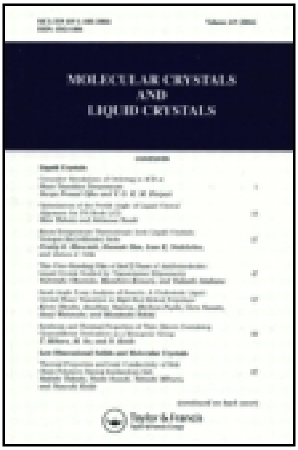

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Formation of Nonlinear Waveguide Components Based-on Nanoimprint Technology

Yanlong Che [a], Okihiro Sugihara [a], Shinya Shibata [a], Hisashi Fujimura [a], Naomichi Okamoto [a] & Chikara Egami [a]

[a] Satellite Venture Business Laboratory, Shizuoka University Faculty of Engineering, Shizuoka University, 3-5-1 Johoku, Hamamatsu, 432-8561, Japan

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YANLONG CHE*, OKIHIRO SUGIHARA, SHINYA SHIBATA, HISASHI FUJIMURA, NAOMICHI OKAMOTO, CHIKARA EGAMI

**Satellite Venture Business Laboratory, Shizuoka University Faculty of Engineering, Shizuoka University, 3-5-1 Johoku, Hamamatsu 432-8561, Japan*

Nonlinear waveguide components are fabricated based on simultaneous embossing and poling method. Thermal and mechanical stability of a master is investigated. Simultaneous formation of a grating with $\chi^{(2)}$ and a ridge-type channel waveguide is performed.

Keywords: nanoimprint; nonlinear grating; ridge-type channel waveguide; guest-host polymer

INTRODUCTION

The necessity and the demand for broad bandwidth communication networks such as "Fiber To The Home" (FTTH), "The Last One Mile" and optical interconnection have attracted much interesting. As for a strong candidate, organic nonlinear optical materials have attracted much attention due to its good characteristics for example: large nonlinearity, ease of process ability, low cost etc. Recently, there have been many reports on the applications of practical devices, such as highly efficient frequency conversion devices and/or wide bandwidth electro-optic (EO) modulators[1]. Therefore, the fabrication of the waveguide components such as $\chi^{(2)}$ gratings or channel waveguides are important.[2] Several fabrication methods have been reported, for example, periodical poling, UV-photobleaching, laser-assisted poling, serial grafting combined with reactive ion etching, etc. However, all these methods have different disadvantages. Simple fabrication technique of waveguide components in active polymer thin films by simultaneous process of embossing and poling at elevated temperatures was proposed and demonstrated in recent years[3]. This technique is suitable for mass-production of high-resolution active polymer devices. In order to obtain the mass-productivity, stability of grating masters for nanoimprint technology should be investigated. In this study, fabrication of master gratings and their characteristics are described. Moreover, simultaneous formation of the grating with $\chi^{(2)}$ and the ridge-type channel waveguide is performed.

RESULTS AND DISCUSSIONS

Fig. 1 shows the schematic of simultaneous embossing and poling. The master consists of a nickel plate (as an electrode as well as a base plate) and a dielectric material (as a grating die). A series of fluorinated polyimide films as the dielectric were selected because of their fine proprieties such as low cost, high glass transmission temperature (Tg)

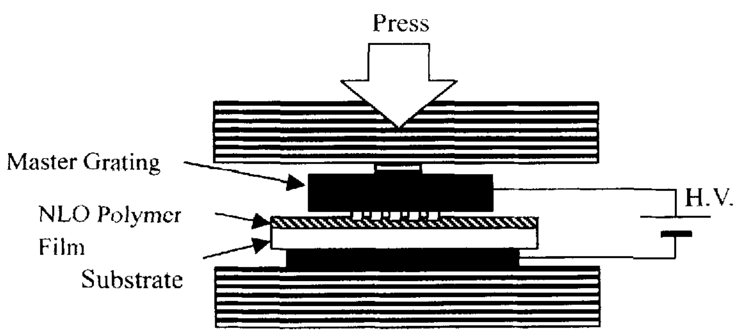

FIGURE 1 Schematic of simultaneous embossing and poling

(around 420 °C) and high mechanical strength. The relief grating was fabricated by single-pulse UV laser-interferometric method, where the laser source was a THG of Nd:YAG laser at 355 nm with pulse duration of 5 ns. In this study, a guest-host type nonlinear polymer DR1/PMMA was used.

The characteristics of the fabricated master grating were investigated. The diffraction efficiency of the master grating versus heat-treatment time at 200 °C and 300 °C was measured by inserting a He-Ne laser on the grating. The result shows that the diffraction efficiency kept stable even for 300-hour heating at 300 °C. Moreover, mechanical stability against embossing times was also investigated. Obvious change was not found on the master grating after 35-time-embossing and poling process. The results show that the master gratings are thermally and mechanically stable for sufficient mass-production of nonlinear replicas.

Moreover, we tried to perform simultaneous formation of the grating with $\chi^{(2)}$ and the ridge-type channel waveguide. The fabrication process of master is shown in Fig. 2. In the first step, Al film was evaporated onto the polyimide film, then, photoresist was spin-coated on the Al film, and the Al channel waveguide part was etched (a). In the second step, polyimide film of channel waveguide part was etched by RIE method (b). In the third step, the grating was fabricated at the bottom of the polyimide channel waveguide part by single-pulse UV laser ablation, before the Al film was cleaned by etching solvent, then the master was obtained (c).

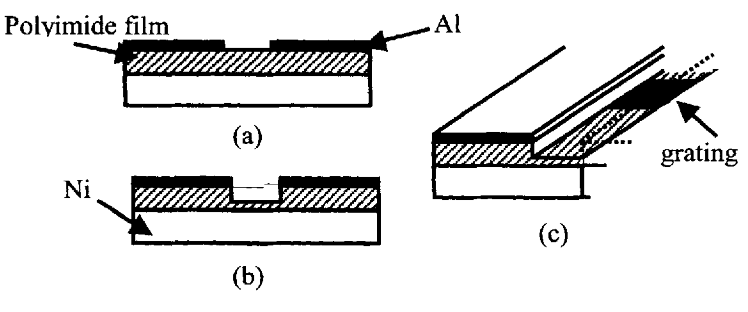

FIGURE 2 Fabrication process of master of forming channel waveguide with grating.

The master was set on the DR1/PMMA film as shown in Fig. 1. After keeping it in an oven for 10 minutes at mold temperature of 120 °C, the replica was obtained. Fig. 3 shows the microscope (×2500) photograph (a) and the surface trace (b) of the fabricated replica --- ridge-type channel waveguide, which was taken at the part with the grating. The thickness of waveguide is about 0.9 μm and the width is about 21 μm, which meets with the master's depth of 1.0 μm and width of 20 μm. The result confirmed that we successfully carried out the simultaneous formation of grating with $\chi^{(2)}$ and ridge-type channel waveguide.

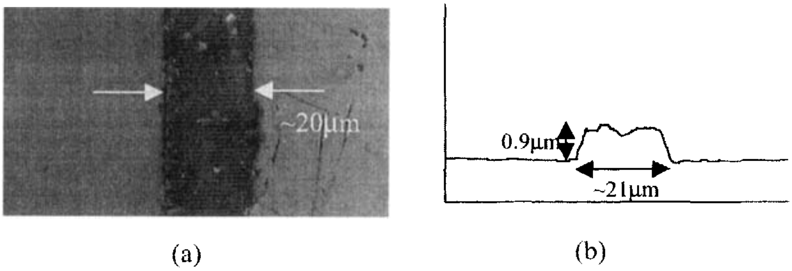

FIGURE 3 Microscopic photograph(a) and surface trace (b) of channel waveguide with grating.

CONCLUSION

The simultaneous embossing and poling method for fabrication waveguide components were proposed and demonstrated. The fabrication of master gratings and their characteristics were described. Moreover, simultaneous formation of the grating with $\chi^{(2)}$ and the ridge-type channel waveguide was successfully carried out.

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