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Refractive Index Modification Due to the Uv-Photodecomposition of Polysilane and Its Application as Phase Mask

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The development of phase mask using the refractive index variation due to the UV-photodecomposition of the polysilane was examined. It was proven that the refractive index due to the UV-photodecomposition of the poly[methyl(phenyl)silane] changed from 1.70 to 1.56 by means of the ellipsometry measurements. Furthermore, it was confirmed that information of the phase difference could be recorded by providing the pattern of the UV photodecomposition of the polysilane.

Keywords: photorefractive polymer; optical correlator; phase mask; polysilane; UV-photodecomposition; refractive index

INTRODUCTION

Photorefractive (PR) polymers have many potential applications as coherent optical systems. [1] Utilizing the properties of real time recording of light fringe as refractive index grating in PR polymer, transient hologram recording and reproducing have been attempted. In our previous work, we tried to apply the modified PVK-based PR polymer with high performance[2] to the real-time optical correlation system.[3] In order to apply such optical correlation for the security system, however, it is indispensable to develop phase difference mask instead conventional pattern mask so that the information written-in could not be copied as a replica. To do this, polysilane seems to be the best suited because the UV-photodecomposition of the polymer

is known to reduce its refractive index.

Refractive index variation in polysilane film

Poly[methyl(phenyl)silane] (PMPS) was used in this study because of the good film-forming ability and the large absorption in the UV region suitable to UV-exposure from a Hg lamp. PMPS films were prepared on the silicon substrates with thickness of about 0.3 μm. The refractive index of PMPS film were measured using the ellipsometry with the He-Ne laser in light source.

The refractive index variation in the PMPS film by the UV-light irradiation is shown in Fig. 1. When the excimer lamp of the wavelength of 308 nm was used for irradiation light source, the refractive index lowered from 1.70 initial value to 1.63 with UV-light irradiation, and the saturation was shown. On the other hand, when the mercury-arc lamp was used, amount of change of refractive index was more increased, and it lowered to 1.58. From the examination of the wavelength dependence of UV-photodecomposition reaction of PMPS film, it was proven that large reduce of the refractive index with shorter wavelength light, such as mercury-arc lamp, derived from the elimination of the side-chain phenyl group. The details will be discussed in the different opportunity.

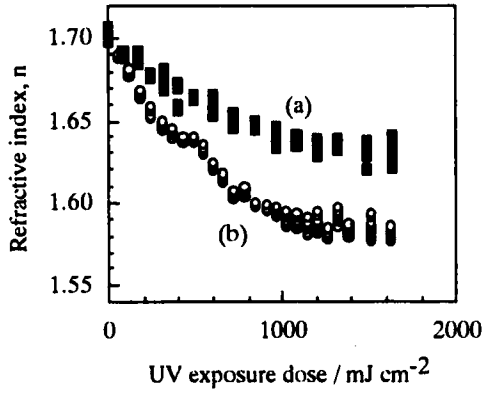

FIGURE 1 The refractive index variation in the PMPS film (thickness: 0.3 μm) by the UV-light irradiation using different light source, (a) excime lamp (308 nm), (b) mercury-arc lamp (185, 254, 303 nm).

Phase information recording in polysilane film

Whether it could make phase masks using the refractive index variation with UV-photodecomposition of PMPS actually was examined. Figures 2 shows the mapping data of the refractive index in a PMPS film, which was formed the round shape by UV-photodecomposition. While the about 1.70 refractive indexes is shown in the part in the circumference which does not irradiated with UV-light, the refractive index lowers to about 1.58 only in the part photodecomposed by UV-light in round shape at the center. It seems to be measurement error based on the surface shape change of a film by the UV-photodecomposition that the edge portion minute shows 1.90 and high refractive index. This result shows that the patterning of the refractive index variation to a PMPS film is possible.

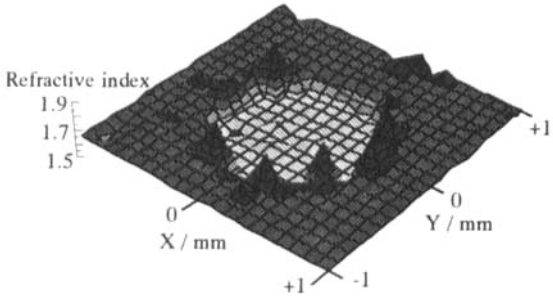

FIGURE 2 Three-dimensional plot of the refractive index mapping in a PMPS film formed the round shape by UV-photodecomposition.

Next, a PMPS thin film was formed on glass substrates, and the Mach-Zehnder interferometer was used, and the phase modulation with the UV photolysis was observed. The thickness of a PMPS film was made to be the about 3.1 μm in order to obtain the sufficient phase modulation considering the refractive index variation quantity estimated from above experiments. The photograph of interference fringe is shown in Fig. 3(a). In the central region of polysilane film photodecomposed by UV-light in round shape, it is clearly shown that interference fringe has deviated in comparison with the part in the circumference. This shows that the refractive index variation, which

originates from the UV-photodecomposition of the polysilane can record pattern information of phase change in a film. The phase modulation quantity calculated from the slippage of such fringes is dependent on the UV exposure dose and changes continuously as shown in Fig.3(b). The phase modulation quantity can be controlled as desired by changing the UV exposure dose.

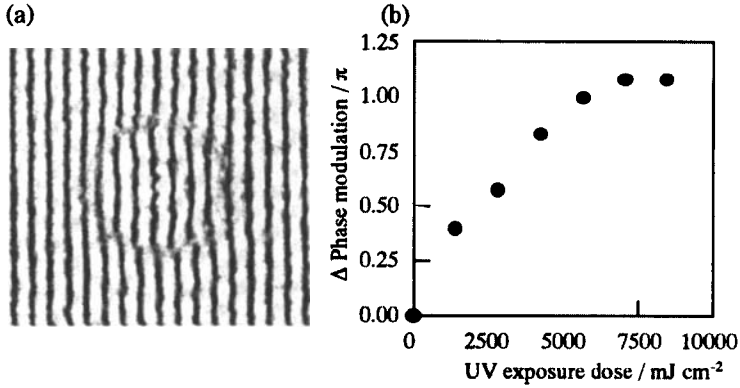

FIGURE 3 (a) The Photograph of interference fringe obtained from PMPS film with UV-photodecomposition in round shape, and (b) the variation of phase modulation calculated from the slippage of such fringes.

In summary, The refractive index of the polysilane lowered from 1.70 to 1.56 with UV-photodecomposition. By utilizing the refractive index variation with UV-photodecomposition of the polysilane, it was experimentally demonstrated that the possibility of using a polysilane film as the phase difference mask which recorded phase difference information. Furthermore, by utilizing such phase difference mask, PR based optical correlation system in which graphic information recognition was possible sould be developed to the security system.

References

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