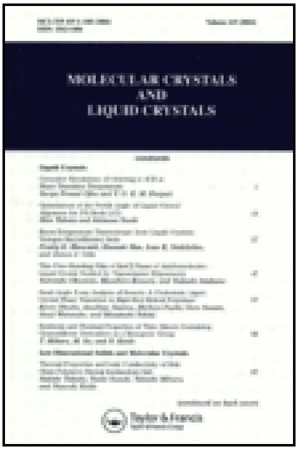

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Optical Correlation System Based on Photorefractive Polymer and Polysilane Phase Mask

Tetsuo Sato [a], Norio Nagayama [a] & Masaaki Yokoyama [a]

[a] Material and Life Science, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka, 565-0871, Japan

Version of record first published: 24 Sep 2006

To cite this article: Tetsuo Sato, Norio Nagayama & Masaaki Yokoyama (2001): Optical Correlation System Based on Photorefractive Polymer and Polysilane Phase Mask, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 370:1, 115-118

To link to this article: http://dx.doi.org/10.1080/10587250108030050

Mol. Cryst. and Liq. Cryst., 2001, Vol. 370, pp. 115-118

Optical Correlation System Based on Photorefractive Polymer and Polysilane Phase Mask

TETSUO SATO, NORIO NAGAYAMA and MASAAKI YOKOYAMA

Material and Life Science, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan

Modification of the refractive index of polysilanes due to the UV-photodecomposition and its application to phase mask were investigated. From the wavelength dependence of UV-photodecomposition in the poly[methyl(phenyl) silane] (PMPS) film, the refractive index was found to be effectively lowered by eliminating phenyl side-group with shorter wavelength UV light. It was also confirmed that the phase difference information could be recordable by utilizing such refractive index changes in PMPS films. Utilizing the 4-*f* matched-filter architecture based on the four-wave mixing with photorefractive polymers as the optical correlator, the occurrence of large correlation signal was successfully observed only when the image written in the PMPS phase mask was coincident with the phase difference pattern on the PMPS film as a reference. This result indicates that the polysilane films with UV-photodecomposition pattern can be useful for the phase difference mask in the optical correlation system.

Keywords: polysilane; UV-photodecomposition; refractive index modification; optical correlation; photorefractive; phase mask

INTRODUCTION

Organic photorefractive (PR) polymers have considerable potential application in the coherent optical data processing such as real-time hologram, light amplification, correction of distorted image, pattern recognition and so on taking the advantages of their easy processability and large-area film formating [1]. In our previous work [2, 3], we reported the possible application of the modified PVK-based PR polymer to the real-time optical correlation system. In order to apply such optical correlation to security system, however, it is essential to develop well-defined phase mask with smooth surface instead of conventional pattern mask so as not to be copied as a replica for the orginal data written-in. In a previous paper, we proposed that the refractive index change of polysilane accompanied by UV irradiation could be applicable to fabricate such a phase mask with level surface [4]. Here, we report the phase pattern recognition using polysilane phase masks in optical correlation system based on the PVK-based PR polymer.

RESULTS AND DISCUSSION

Refractive index changes of polysilanes

The refractive index change due to UV-photodecomposition of polysilanes was evaluated by ellipsometry for spin-coated thin films on a Si substrate. The refractive index of the poly[methyl (phenyl)silane] (PMPS) film was clearly reduced from 1.70 to 1.57 continuously with the amount of UV exposure dose as shown in Figure 1. When polysilane films were exposed with shorter wavelength UV-light (< 280 nm), the refractive index was reduced more effectively. From UV absorption spectra and IR spectra, it was revealed that such large refractive index change was induced by eliminating of phenyl side-groups followed by the cleavage of Si backbone. The details will be reported elsewhere.

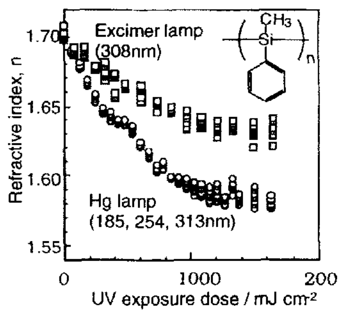

FIGURE 1 The refractive index variation in the PMPS film.

Polysilane phase mask

To make phase masks, PMPS thin films were prepared on glass substrates. The phase modulation due to the UV photolysis of PMPS films was confirmed by using a Mach-Zehnder interferometer. The thickness of the

PMPS film was chosen to be about 3 μm so as to obtain sufficient phase difference taking refractive index difference between UV-irradiated and unirradiated portions into account. The photograph of interference fringe is shown in Figure 2. In the central part of the PMPS film photodecomposed in a circle shape, it was clearly shown that interference fringes have been shifted from those of the surrounding. This result strongly indicates that the pattern entry of phase difference can be possible using refractive index changes due to the UV-photodecomposition of the PMPS film. The control of phase modulation quantity can be also possible by changing the UV exposure dose and complete photodecomposition of 3 μm-thick PMPS gave the phase difference of $\pi/2$.

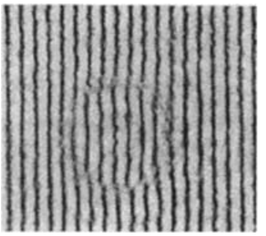

FIGURE 2 The photograph of interference fringe.

Optical correlation using polysilane phase mask

As mentioned above, it was shown that the phase difference image was successfully recorded on the PMPS film due to the refractive index changes in the PMPS film. Then, PMPS films, on which such a phase difference image was written-in, were used as input information, and the correlation operation was carried out using optical correlation system incorporating the PR polymer as holographic plate.

For a phase mask, a PMPS film on a glass substrate was UV-photodecomposed in the stripe line pattern. The Fourier transformed (FT) image of the PMPS phase mask was almost equal to the FT image of the photo-mask with perpendicular line pattern as shown in Figure 3. This means that the photo-mask pattern was

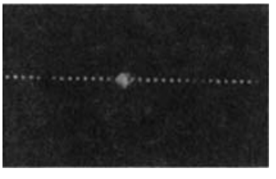

FIGURE 3 The FT image of PMPS phase mask.

recorded in a PMPS film as phase difference information.

Using such a polysilane phase mask, the correlation operation was performed in a 4-f matched filter correlator with the PR polymer as a real-time holographic plate as described in our previous work [4]. Three-dimensional plot of the output intensity of correlation signals using the polysilane phase masks as both input and reference information is shown in Figure 4. In the position of input phase image identical to the reference image, a large correlation signal was observed. This result indicates that the polysilane phase mask using the refractive index changes due to UV-photodecomposition is applicable as an information-recording medium for the optical correlation system.

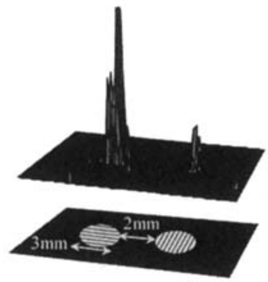

FIGURE 4 Three-dimensional plot of the correlation signal using PMPS phase mask.

CONCLUSION

In this work, we constructed the optical correlation system using the PVK-based PR polymer as hologram plate and polysilane phase mask. By utilizing the refractive index modification accompanied with UV-photodecompositon of the polysilane, the possibility of polysilane films as the phase mask was clearly shown. Furthermore, the successful recognition of the phase difference pattern in the optical correlation system utilizing polysilane phase mask and PR polymer will open the door to the security system.

References

[1] B. L. Volodin, B. Kippelen, K. Meerholz, B. Javidi, N. Peyghambarian, *Nature*, **383**, 58(1996).

[2] M. Yokoyama, *Proceedings of Korea-Japan Joint Forum '97*, 11(1997).

[3] N. Nagayama, M. Yokoyama, *Mol. Cryst. and Liq. Cryst.*, **327**, 19-22(1999).

[4] N. Nagayama, M. Shimono, T. Sato, M. Yokoyama, *Proceedings of Korea-Japan Joint Forum '99*, 67(1999).