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Optical Correlation System by Use of Photorefractive Polymer

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Optical Correlation System by Use of Photorefractive Polymer

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A photorefractive polymer based on poly(N-vinylcarbazole) photoconductive polymer was improved by use of plasticizer mixture of N-ethylcrbazole and 1,3-biscarbazolylpropane. The modified photorefractive polymer was applied to the nonlinear materials for a matched-filter four-wave-mixing optical correlator. The operation of image correlation was demonstrated with the 10:1 of signal-to-noise ratio.

Keywords: photorefractive polymer; poly(N-vinylcarbazole); plasticizer doping; optical correlator; matched-filter; four-wave-mixing

INTRODUCTION

Photorefractive (PR) polymers have many potential applications as coherent optical systems including real-time holographic image processing, optical data storage, optical switching, light amplification, and phase conjugate mirror. To manifest photorefractivity, materials must simultaneously possess photoconductivity and electro-optic effect. Recently, many attempts have been made to apply organic PR polymers to various optical systems based on inorganic PR materials so far because of their advantages of wide material flexibility, easy processability and low cost.

In our previous work, the modification of the poly(N-vinylcarbazole) (PVK)-based PR polymer consisting of PVK/2,4,7,-trinitro-9-fluorenone (TNF) photoconducting polymer, NLO (Non-linear optic compound) and N-ethylcrbazole (EtCz) as a hole transportable plasticizer, first reported by Arizona University's group[1], has been made by replacing EtCz with 1,3-

biscarbazolylpropane (BisCzPro; dimer compound, Fig. 1) to ensure low Tg for "orientational enhancement" [2] with no crystallization. As a result, we succeeded in demonstrating the real-time holographic recording and reproduction with our modified PR polymers.[3]

In the present work, we have tried to further improve the PR polymer by use of plasticizer mixture and tried to apply this modified PR polymer to the real-time optical correlation system.

Modification of PR polymer

A PR polymer was used consisting of 4'-(N, N-diethylamino)benziliden-2-methyl-4-nitroaniline (DBMNA), PVK, EtCz, BisCzPro, TNF; 50, 25, 18, 6, 1 wt%. This composition was employed to ensure the stable and low Tg PR polymer with no crystallization. Chemical structures of these compounds were illustrated in Fig. 1 with their abbreviations. BisCzPro shows same characteristics of hole transport and plasticity as EtCz. Films were cast from tetrahydrofuran solution of above compounds onto glass substrates and dried at room temperature over 24 hours and continuously dried *in vacuo* for 2 hours. Samples were then prepared by sandwiching between two transparent indium-tin-oxide (ITO) -covered glass substrates at about 100°C and the sample thickness was controlled to be about 100 μm with the use of polyimide spacers.

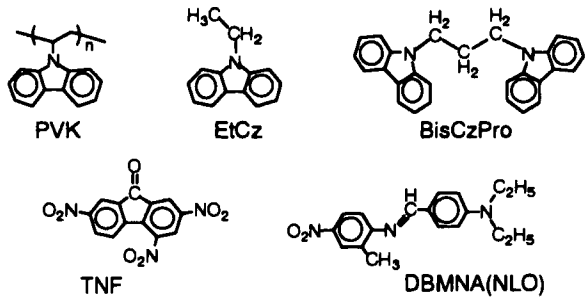

FIGURE 1 Compounds constructing the PR polymer used.

Using the mixture of plasticizers, EtCz and BisCzPro with the ratio of EtCz: BisCzPro = 3 : 1, the PR polymer exhibited lower Tg (= – 6.3 °C) than that only BisCzPro (Tg = 13.0 °C), and still maintained the high stability.

Image correlation

The optical correlation, in particular, the matched-filter architecture, can be achieved by means of four-wave mixing with spatially modulated beams.[4] Optical setup of image correlator is shown in Fig. 2. Holographic grating was written in a photorefractive polymer placed on the fourier plane of 4-f optics using two continuous He-Ne Laser beams of that from image plane P1 and the reference one. When the image on plane P2 was the same to that on P1, the reading beam through P2 was diffracted to the direction of reference beam (phase conjugated signal), resulting in appearing a strong correlation signal on CCD camera.

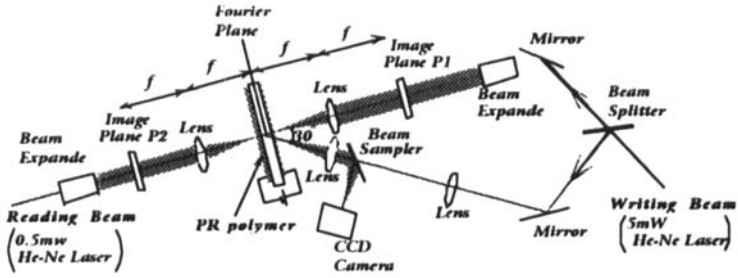

FIGURE 2 Experimental setup for optical image correlation.

The images of correlation signal on CCD camera were stored into the personal computer and were redrew by means of three-dimensional plot. At first, we confirmed the generation of strong correlation signal, when the same images were placed on both plane P1 and P2. When different images were placed, the signal of correlation was decreased. Furthermore, when the

photomask with three different images in shape was used on plane P2, the triangle, which was identical to reference image, generates the largest correlation signal (Fig. 3).

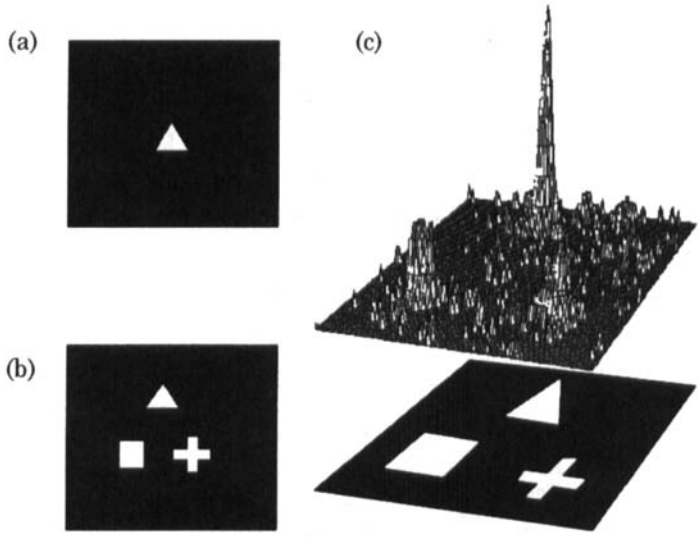

FIGURE 3 (a) Reference image, (b) database of images to be searched, (c) correlation of the images in (a) and (b).

In summary, we modified the PVK based PR polymer by using plasticizer mixture to obtain the low Tg film without crystallization. And we experimentally demonstrated the performance in pattern recognition using the four-wave-mixing based optical correlator with our modified PR polymer as matched-filter.

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