3차원 정보 저장 용 고분자 소재

Polymeric materials for 3D information storage

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Storing information throughout volume of a medium, rather than just on its surface, is an intriguing high-capacity recording method.[1-2] One such volumetric approach, holographic data storage, was conceived decades ago. Holographic data storage can in principle achieve a storage density of one bit per cubic wavelength, $1/\lambda^3$. However, the lack of suitable recording materials has long been an obstacle to the development of 3D data storage. WORM (write once read many) memory realized with, for example, a photopolymer.[3] The photopolymer can be designed to have large refractive index contrast and high photosensitivity, record permanent holograms, and be easily processed. However, their application to data storage is severely limited due to their limited thickness and high shrinkage during holographic exposure. Thus low shrinkage photopolymers, photorefractive polymers, and photochromic polymers have been actively studied to solve the problems. Although the ideal materials seem to be lacking, photopolymers and photochromic materials appear to be prosperous candidates because no electric field is required to write or read the information. Moreover, the recorded information can either be permanently stored or be erased for repeated recordings.[4] For example, due to their photochromic nature, the recording layers may first be recorded by coloration with UV radiation and then erased by bleaching with a visible light or by heat, or vice versa.

In this paper we report preparation and characterization of photopolymer and photochromic films for 3D recording.

Photopolymerizable solutions were prepared by dispersing a high refractive index aromatic methacrylic monomer in a sol-gel matrix or transparent polymer solution. In particular, the sol-gel matrix containing organically modified precursor (TSPEG) was crucial component affecting physical properties of the composite films, such as rigidity, environmental stability, low dimensional changes upon holographic exposure, and maximum achievable thickness.

Figure 1 shows diffraction efficiency determined by interfering two collimated plane wave beams of 532 nm. The diffraction efficiency (DE) was increased sharply within 10 sec and reached a maximum of

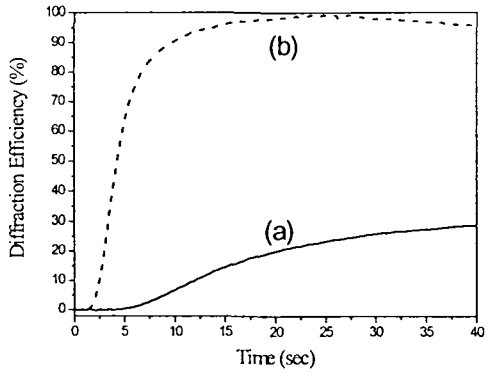

Fig. 1. DE (%) as a function of exposure time for 200 μm thick photopolymer film prepared (a) withou and (b) with TSPEG (0.25 mol).

98% with an exposure power of 5 mW. On the other hand, photopolymer film prepared without TSPEG showed low DE (Fig. 1(a)). High diffraction efficiency could be ascribed to fast diffusion and efficient polymerization of monomers during the holographic recording. Diffusion process was also controlled by modifying monomer composition in polymer matrix.

Rewritable holographic recording was attempted using photochromic polymer films. Fluoroacrylates polymer films containing photochromophore could be prepared by UV irradiation using a mixture of fluoroacrylate monomers and diarylethene in the presence of photoinitiator. The photo cured film was transparent red initially and turned to a transparent pale yellow when exposed to a room light. Such color change could be attributed to the photochromic conversion of diarylethene during the photo curing of fluoroacrylates under UV irradiation. The photochromic property of diarylethene is based on the reversible ring cyclization by UV and ring opening by visible light[5].

Before writing with a 532 nm laser, the photochromic film was initially exposed to a homogeneous and incoherent excitation beam from UV lamp at 365 nm, until maximal coloring occurred. Holographic recording was performed with a diode laser at 532 nm using the colored film. An interference pattern on the photochromic film was produced by two-wave mixing of 532 nm light. Alternative colored and transparent stripes were observed when magnified 50 times. Such interference pattern implied effective photochromic conversion of diarylethene in fluoroacrylate matrix by the two beam coupling method.

This photochromic film did not exhibit any apparent fatigue or shrinkage, even after 100 write/erase cycles. Such stability is attributed to the chemical stability of diarylethenes. Since the holographic recording is based on the photochromic conversion of diarylethene, volume change is much less than typical photopolymer media, in which crosslinking of photoactive monomers by writing beam results in significant volume change[6].

Since the reverse reaction (toward pale yellow state) could occur with 532 nm, the measurement for diffraction efficiency should be carried out under non-destructive condition with a monitoring light source having longer wavelength (> 700 nm). The result on diffraction efficiency and holographic image quality of the photochromic films will be presented. Further characterization is in progress and will hopefully explore non-destructive method of reading.

References

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