

(Sample : 要約と本文)

## Study on Optical Device Fabrication by Cold Ultra-Violet Stamping

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In this work, we present a new way of fabrication of optical device components. These components are passive and polymer based. As core material we used a formulation of three materials. As polyfunctional monomer we used pentaerythritol triacrylate, then we used N-methyldiethanolamine as a cosynergist and eosin Y as a dye. This formulation is a liquid negative-type photoresist material and in this dissertation thesis we are going to call it by the capitals of its principal components - PNME. In this work, we present the properties of this material, such as absorption spectrum, refractive indices together with the dispersion curve, light induced self-writing property, and a propagation loss as a function of waveguide length measured at  $\lambda = 1.3 \mu\text{m}$ . The measured absorption spectrum shows a peak at  $\lambda = 0.530 \mu\text{m}$ , otherwise the formulation is transparent up to  $\lambda = 1.7 \mu\text{m}$ . Transparency in the telecom region was also confirmed by subsequent measurement of the propagation loss in an optical waveguide by cut-back method. The measurement was carried out at  $\lambda = 1.3 \mu\text{m}$  and the measured propagation loss was 0.99dB/cm. Refractive indices of the formulation were measured to be  $n=1.512$ ,  $n=1.501$ , and  $n=1.499$  at  $\lambda = 0.633 \mu\text{m}$ ,  $\lambda = 1.3 \mu\text{m}$ , and  $\lambda$

=1.55  $\mu$  m, respectively. All of the refractive indices were measured with routine resolution of  $\pm 0.0005$ .

The method we used to fabricate the optical waveguides, gratings, and the optical waveguides with gratings is called “cold ultra violet stamping.” The method is based on polymerization of photo-sensitive formulation PNME inside a vessel of specific shape. For the fabrication of slab optical waveguide by cold UV stamping, the vessel was made by two glass plates separated by a spacer. One of the plates was treated with antisticking release layer. Therefore the liquid PNME after solidification adhered to the other glass plate. Coming out of this basic concept, elaborate optical components were fabricated. In order to confirm the suitability of cold UV stamping for fabrication of high precision optical components, a periodic grating structure was copied onto the slab waveguide. The vessel used in this experiment was again made of two glass plates separated by a spacer. This time, a thin film of electron-beam (EB) resist was spun on top of one of the glass plates. Then a grating with period  $\Lambda = 0.5 \mu$  m was prepared by EB lithography. This grating structure was then covered by protective and release layer and successfully copied onto PNME material. Thus we confirmed that cold UV stamping is a high resolution fabrication technique. Another step was a fabrication of a channel optical waveguide. In order to do so, the vessel, which was again made by two glass plates separated by a spacer, was only partially transparent. Instead we used a gold mask to block the ultra violet light. Therefore, not all the inside volume of the vessel filled with PNME solidified. The mask was made on one of the glass plates. This plate was also covered by a proper cladding material, which was called C2727 and was supplied by NTT-AT. The other plate supported

a spacer made by SU-8 photoresist made by Microchem Corp. The thickness of the spacer was controlled by controlling the spincoating conditions of SU-8.

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## 1. Introduction

In this work, we present a new way of fabrication of optical device components. These components are passive and polymer based. As core material we used a formulation of three materials. As polyfunctional monomer we used pentaerythritol triacrylate, then we used N-methyldiethanolamine as a cosynergist and eosin Y as a dye. This formulation is a liquid negative-type photoresist material and in this dissertation thesis we are going to call it by the capitals of its principal components - PNME. In this work, we present the properties of this material, such as absorption spectrum, refractive indices together with the dispersion curve, light induced self-writing property, and a propagation loss as a function of waveguide length measured at  $\lambda = 1.3 \mu\text{m}$ . The measured absorption spectrum shows a peak at  $\lambda = 0.530 \mu\text{m}$ , otherwise the formulation is transparent up to  $\lambda = 1.7 \mu\text{m}$ . Transparency in the telecom region was also confirmed by subsequent measurement of the propagation loss in an optical waveguide by cut-back method. The measurement was carried out at  $\lambda = 1.3 \mu\text{m}$  and the measured propagation loss was 0.99dB/cm. Refractive indices of the formulation were measured to be  $n=1.512$ ,  $n=1.501$ , and  $n=1.499$  at  $\lambda = 0.633 \mu\text{m}$ ,  $\lambda = 1.3 \mu\text{m}$ , and  $\lambda = 1.55 \mu\text{m}$ , respectively. All of the refractive indices were measured with routine resolution of  $\pm 0.0005$ .

## 2. Second Title

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