Tm이 첨가된 stoichiometric $LiNbO_3$의 이색 홀로그램 저장
Two-color holographic recording in Tm-doped $LiNbO_3$

Van-Thai Pham, SunKyun Lee, Minh-Tuan Trinh, Ki-Soo Lim*, K. Polgar**
*Department of Physics, Chungbuk National University
**Hungarian Academy of Sciences, Budapest, Hungary

e-mail: kslim@trut.chungbuk.ac.kr

Abstract We have observed nonvolatile hologram in a as-grown 500 ppm thulium doped stoichiometric $LiNbO_3$ crystal by use of a Ar^+ laser at 514 nm for recording and a third harmonic Nd-YAG laser pulse at 355 nm for gating. The gating light increased the recording efficiency by six times and produced 0.03% nonvolatile diffraction efficiency. The dynamic range and sensitivity of the recording process was studied with various gating intensities and recording intensities to find the optimum condition for nonvolatile storage.

Recently, doped stoichiometric $LiNbO_3$ crystals have been intensively investigated for their high photorefractive sensitivity and nonvolatile holographic storage. The longer lifetime of electrons in shallow trap due to less defect makes the crystal more sensitive. Doping with rare-earth ion such as Tb or Pr ions has been reported to show the enhanced sensitivity [1]. Among rare-earth dopants, Tm ions have not been doped in $LiNbO_3$ for holographic recording so far. In this work, we present light-induced absorption and two-color holographic recording in a 500 ppm Tm doped stoichiometric $LiNbO_3$ crystal.

The material was grown by the high temperature top seeded solution method in a diameter controlled growth apparatus from K_2O-Li_2O-Nb_2O fluxes. It was cut and polished into 4.35 x 4.75 x 6 mm (a x b x c). The bandgap energy of the crystal was evaluated from absorption data to be 4 eV [3], which is larger than congruent one, thus indicate that the crystal is highly stoichiometric.

Figure 1 shows dynamic behavior of the induced absorption at 633 nm under 325 nm (curve (a)) and 442 nm (curve (b)) illumination. The crystal exhibited faster response than Tb doped near-stoichiometric samples [1] and a pronounced induced absorption. The rise time and magnitude of UV (325 nm)-induced absorption at 633 nm were 1.3 s and 0.1 cm-1 for pump intensity of 280 mW/cm^2, and those of blue (442 nm) induced absorption at the same wavelength are 8 s and 0.22 cm-1 for pump of 1200 mW/cm^2. The faster response of UV-induced absorption is likely due to the stronger absorption of the sample for this light. The lifetime of electron in shallow trap was determined from effective decay time of the induced absorption to be 4s which is similar to that of SLN: Tb [1]. Two-color holographic recording was demonstrated by use of 514 nm for recording and a Nd-YAG laser pulse at 355 nm for gating. A recording-read-erase curve is shown in Fig. 2. The diffraction efficiency and sensitivity was improved by factors of 6 and 4 with gating light. The diffraction efficiency shows a substantial decrease at initial stage of readout process and remains nonvolatile at 0.03 %, which is three times larger than that of a reduced congruent LiNbO3: Er [4]. The hologram recorded by 514 nm and gated by 355 nm at different gating intensities shows optimum condition for high diffraction efficiency at the intensity of 1.5 mW/cm2corresponding to a gating-to-recording intensity ratio IG/IR of 0.002 (Fig. 3). For the gating intensities above the optimum one, the increase in gate intensity leads to a decrease of diffraction efficiency and sensitivity because the strong gating lights also erase grating and depopulate electron in shallow center during recording.

In conclusion, we have demonstrated nonvolatile readout in $LiNbO_3$: Tm and found the optimum ratio IG/IR for hologram formation. The photochromic effect observed in light induced absorption makes the material an attractive candidate for two-center nonvolatile holographic storage.

T
C

Reference

1. Myeongkyu Lee, et all *J. Appl. Phys.*,vol 88, no.8, pp. 4476, (2000)
2. Yasuo Tomita, et. al., *Jpn. J. Appl. Phys.* Vol 40, pp. L1035 ~L1037, 2001.

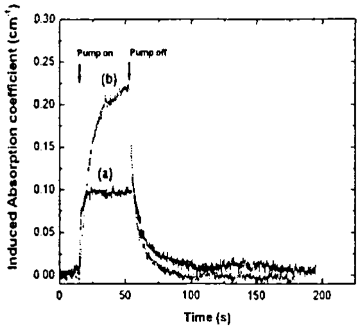

Figure 1: Time evolution of the light induced absorption measured by weak beam at 633 nm. The pump intensities are 280 mW/cm^2 and 1200 mW/cm^2 for 325 nm (a) and 442 nm (b) respectively.

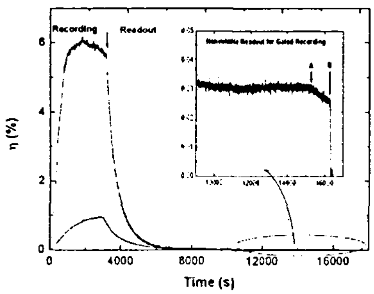

Figure 2: Time evolution of diffraction efficiency during recording, readout and erasing. The hologram was recorded with the 514 nm recording beam at a total intensity of 140 mW/cm^2 and the 355 nm gating beam with 2.5mW/cm^2. The inset illustrates a readout process with one of recording beam (without gating beam) and two stage of erasing process with one of recording beam and gating beam. The first erasing UV intensity was 2.5 mW/cm^2 (A) and the second one was 80 mW/cm^2 (B). The incident crossing angle was 40 degree.

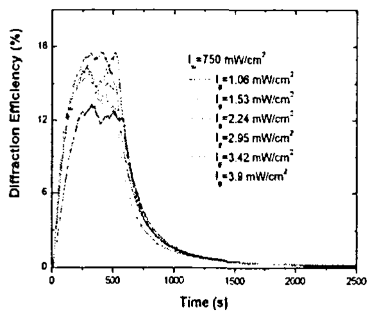

Figure 3: Time evolution of holographic recording at different gating intensities. The hologram was recorded by 514 nm and gated by 355 nm at an incident angle of 40 deg gating intensity varied within the range of 1 to 4 mW/cm^2.