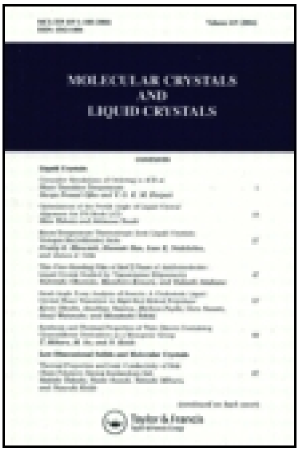

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Side Chain Liquid Crystal Polymer Films for Optical Recording System

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SIDE CHAIN LIQUID CRYSTAL POLYMER FILMS FOR OPTICAL RECORDING SYSTEM

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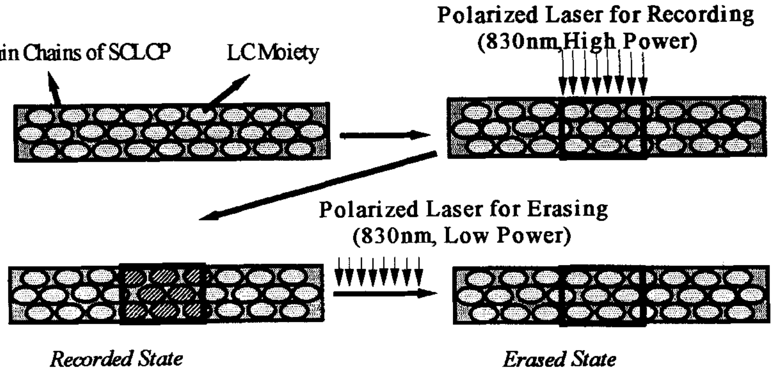
Abstract We developed novel recording/erasing system using only one laser source and polymeric liquid crystal material. To do this, LCP-105(Merck) was adapted for recording material and investigated the possibility of repeated optical recording and thermal erasing. After optical recording(7mW, 830nm) on SCLCP disk, recorded signal represented 32dB and this signal was completely diminished by heat treatment of recorded disk(85°C, 30sec). These results illustrate the possibility of recording/erasing system by laser irradiation of same laser source(same wavelength).

INTRODUCTION

Recently, we have reported on optical recording media of dye-containing polymeric materials which use laser radiation for phase transition or shape change of the matrix material.[1, 2] The difference of reflectance between irradiated and unirradiated regions of the matrix was used as the recording signal.

In general optical recording system of SCLCP(side chain liquid crystal polymer), two laser sources of different wavelengths[3] or conjugated system of light source and electric field[4] were adapted for writing and erasing procedures. But in this study, we developed novel recording/erasing system on SCLCP layer using only one laser source. SCLCP has a glass transition temperature(Tg) and also phase transition temperatures ($T_{N\text{-}I}$, $T_{S\text{-}I}$), so it shows both polymeric and liquid crystalline characteristics according to the temperature change. Dye-containing SCLCP is in amorphous isotropic state after heating above Ti by high powered laser-on, and early quenched by laser-off, therefore SCLCP is kept amorphous state(recorded state). By re-heating above Tg by low powered laser, the phase change of SCLCP from isotropic to liquid crystalline phase may result in the erasing of recorded signal(Scheme 1).

In this paper, we chose an SCLCP having a relatively high Tg and also investigated its thermo-optic properties for reverse optical recording/erasing.



SCHEME 1 Optical recording mechanism of SCLCP coated disk.

MATERIALS AND METHODS

LCP-105(Mw; 11680, Mn; 6470, Tg; 38°C, $T_{N\text{-}I}$; 127°C) as SCLCP was purchased from Merck Industrial Chemicals(Poole, England) and IR-820 as dye for laser absorption was obtained from Nihon Kankoh Shikiso(Okayama, Japan). Tetrafluoropropanol(TFP) for solvent was purchased from Wako Pure Chem. Ind.(Osaka, Japan). Thermo-optic properties of SCLCP was estimated by optical microscopy BH-2(Olympus, Tokyo, Japan) connected with a hot plate PF82HT(Mettler, Greffensee, Swiss) for the sample stage, the photo detector and analog recorder. SCLCP was melted on a cover glass and another cover glass was coupled on it, and the sample was cooled gradually to obtain micro domain liquid crystal structure. Then the sample was heated with rate of 25°C/min from 25°C to 150°C, and the time dependent transmittance change was measured. After drastic transmittance-change from dark to bright, it followed a cooling stage. The process was repeated.

Optical recording and reading of recorded signal was done with DDU-1000 (Pulstec, Hamamatsu, Japan), connected with spectrum analyzer Tektronix 2712(Wilsonville, Oregon, USA). Integrated Technology P-6204(Acushnet, MA, USA) was used for spin coating of SCLCP solution. Pregrooved polycarbonate disk was used for optical recording/erasing substrate of SCLCP. The TFP solution containing different contents of dye and SCLCP was filtered, spin coated(2000, 4000rpm) in clean room and fully dried *in vacuo*. Gold was sputtered for reflecting layer on SCLCP recording layer, then optical signal was recorded under conditions of varying recording power, speed and time. Erasing of the recorded signal was practiced thermally(85°C, 30 sec) and checked by measuring the remaining CNR. Recorded and unrecorded region were optically investigated with polarized microscope Optiphoto 2-POL(Nikon, Tokyo, Japan).

RESULTS AND DISCUSSION

Thermo-Optic Properties

Figure 1 shows the thermo-optic effects of the SCLCP film. The transmittance of SCLCP film nearly increased with continuous heating until 120°C and drastic increase was observed around 125°C, then transmittance was kept plateau above this temperature. Quenching this film , transparent state was kept. But cooling this film slowly below 120°C without quenching, transmittance was decreased and returned to its initial state. Such phenomena were also occurred reversibly by repeated heat treatment.

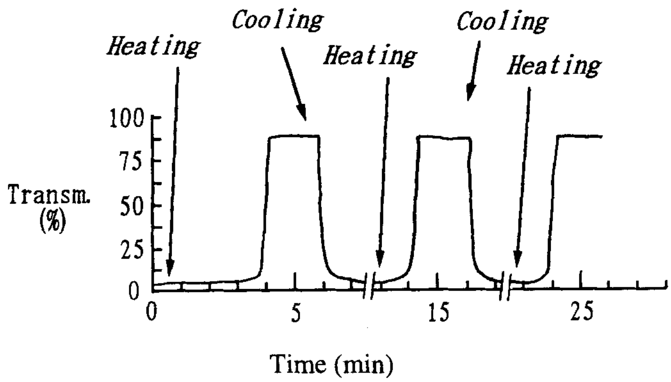


FIGURE 1 Transmittance change of SCLCP by repeated heating and cooling(25°C <--> 150°C, 25°C/min)

Effect of Film Thickness, Writing Power, Writing Speed and Mark Length on CNR(Carrier to Noise Ratio)

Four samples with different thickness but with same dye concentration(5 wt% of SCLCP) were recorded with variance of recording power from 3 to 9mW under same recording speed(1.2m/sec) and power modulation(720KHz). Figure 2 shows the effect of recording layer thickness and writing power on recording signal.

In thick samples, CNR showed a plateau value at high writing power. These tendencies were able to explain that thick films contained much dyes and laser absorbance of these films increased. Therefore more phase transition(illustrated in Scheme 1) was occurred by absorbed light which finally transferred to heat and then the difference of reflectance between recorded and unrecorded region became large. Such effect contributed the increment of CNR.

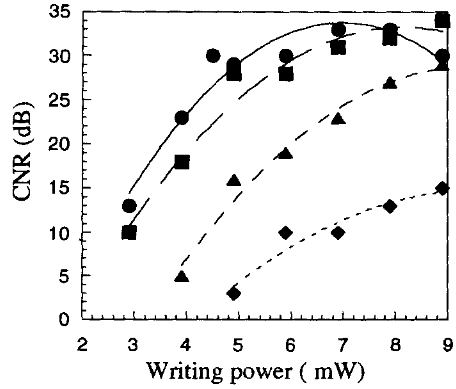


FIGURE 2 Effect of film thickness and writing power on CNR. Laser source; 830nm. Spin coating conditions(thickness of coated layer): •; 500rpm (1.0μm), ■; 1000rpm(0.5μm), ▲; 2000rpm(0.4μm), ◆; 4000rpm (0.3μm).

Next, the effect of writing speed on CNR was investigated and Figure 3 shows the result.

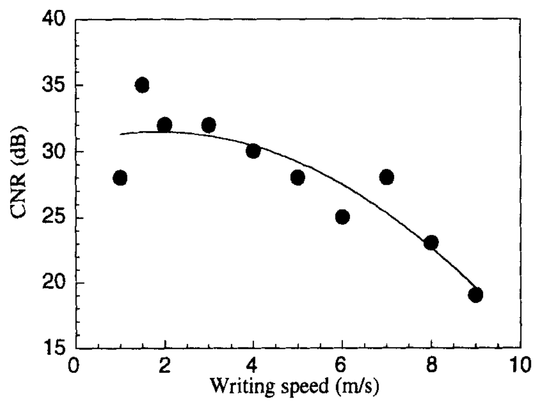


FIGURE 3 Effect of writing speed on CNR of 500rpm sample(about 1μm thickness). Writing power; 8.9mW. Laser source; 830nm.

CNR of 500rpm sample decreased with an increase of writing speed. In case of inorganic phase transition materials for recording, CNR data remained initial value in spite of increasing writing speed. But the tendency of decreasing CNR in high writing speed in Figure 3 was often observed in organic recording materials, because the boundary region of recorded part was not quite distinct compared with inorganic material owing to poor heat transfer characteristics of SCLCP and the decrease of absorbed laser energy per unit recorded region owing to high writing speed. Similar results was shown in Figure 4.

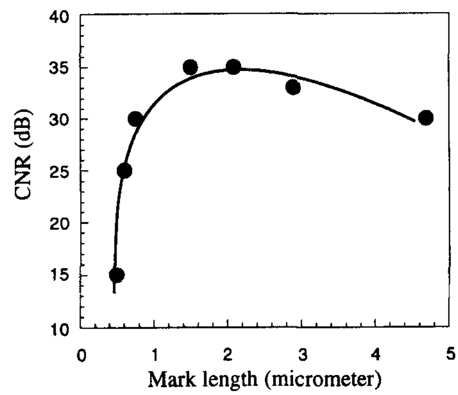


FIGURE 4 Effect of mark length on CNR of 500rpm sample(about 1μm thickness). Writing power; 8.9mW. Laser source; 830nm.

Mark length was determined by the Eq(1) under various conditions of writing speed and modulation frequency.

$$\text{Mark length } (\mu m) = \frac{\text{Writing speed } (\mu m/sec)}{\text{Frequency (MHz)} \times 2} \qquad \text{Eq (1)}$$

Relatively high CNR data was detected above 0.8μm length of recorded region. This means that optically dense recording is possible in organic recording media. The decrease of CNR data in spite of increasing length of recorded region was similarly evaluated with the case of Figure 3. The result of repeated recording/erasing is shown in Figure 5.

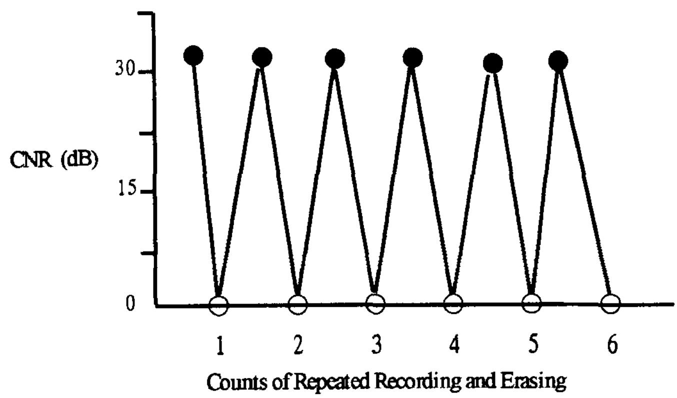


FIGURE 5 Optical recording and thermal erasing characteristics of SCLCP film. •; Signals after recording, o; Signals after erasing.

After laser-recording(7mW, 830nm) of 500rpm sample, detected signal of SCLCP disk was observed up to 32dB and the signal was completely diminished by heat treatment of this disk in convection oven(85°C, 30sec) during repeated experiment for 6 times. These results illustrate the possibility of optical recording/erasing system by changing of laser irradiation power of same laser source.

Transmittance differences of recorded/unrecorded regions were estimated with polarized microscope and its microscopic views were shown in Figure 6.

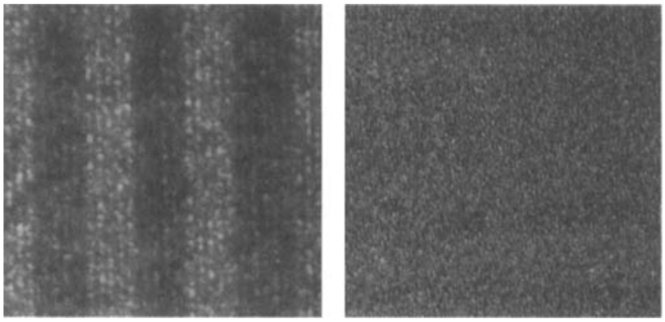


FIGURE 6 Polarized microscopic views of recorded(left) and unrecorded(right) of SCLCP disk. Dark region; recorded part, Bright region; unrecorded part.

In recorded region, all of the LC moieties of SCLCP layer were isotropic phase and transparent state. Therefore polarized laser beam was fully transmitted through the recorded region, but final microscopic view was dark because of cross polarizer in polarized microscope. In unrecorded region, the LC moieties of SCLCP layer were oriented and might formed micro domain structures. Therefore polarized incident beam was scattered and some parts of scattered beam were transmitted cross polarizer, then dotted bright regions were appeared in microscopic views.

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