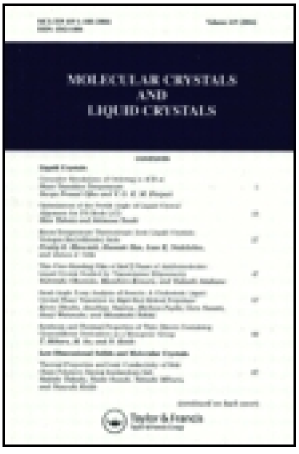


Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Characteristics of Bump Type Erasable Organic Optical Recording Media

Kyung Sun Min [a] , Hee Tae Chung [a] , Ok Kyung Cho [a] , Gwon Young Kim [a] & Kyung Yoon Park [a]

[a] Samsung Advanced Institude of Technology, San #14, Nongseo-Ri, Kihung-Eup, Youngin-Gun, Kyungki-Do, Korea
Version of record first published: 04 Oct 2006.

To cite this article: Kyung Sun Min , Hee Tae Chung , Ok Kyung Cho , Gwon Young Kim & Kyung Yoon Park (1994): Characteristics of Bump Type Erasable Organic Optical Recording Media, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 247:1, 161-171

To link to this article: http://dx.doi.org/10.1080/10587259408039201

Mol. Cryst. Liq. Cryst. 1994, Vol. 247, pp. 161–171
Reprints available directly from the publisher
Photocopying permitted by license only

Printed in the United States of America

CHARACTERISTICS OF BUMP TYPE ERASABLE ORGANIC OPTICAL RECORDING MEDIA

KYUNG SUN MIN, HEE TAE CHUNG, OK KYUNG CHO, GWON YOUNG KIM AND KYUNG YOON PARK.
Samsung Advanced Institude of Technology, San #14, Nongseo-Ri,Kihung-Eup, Youngin-Gun, Kyungki-Do, Korea.

Abstract Rewritable organic optical-recording media which are composed of dye-polymer bilayers were prepared and the effect of their structures on the recording properties was investigated. The recording layer consists of thermal-curable poly-urethane resin and a cyanine dye, and the retention layer consists of poly-styrene resin and a quinone dye. The carrier to noise ratio(CNR) of the recording media increased as the thickness of the retention layer decreased. The composition of the media was varied to find out the optimal point. The complex refractive indices of the media were calculated to simulate the marked bump height and the temperature distribution of the media. Here we discussed the effect of bump height and the thermal expansion coefficient(α) on CNR of the media.

INTRODUCTION

Organic dye-polymer material have several advantages over metallic materials as the recording layer of rewritable optical recording media; e.g.,high recording sensitivity, spin-coatability, and nontoxicity.[1]

The erasable optical data storage media proposed by Optical Data,Inc.(ODI) have dual polymer layers of an expansion layer and a retention layer.[2,3] Each layer contains dye which selectively absorb light in relatively spective narrow wavelength bands. The absorbed laser energy is converted into heat which causes expansion layer to expand against retention layer and deform. The retention layer has higher glass transition temperature than cross-linked expansion layer, and is capable of undergoing viscoelastic shear deformation. Then, Data can be recorded and read by the reflectance differences between the deformed and undeformed regions. There have been several reports on the recording mechanisms and recording characteristics of the fixed layer structure and composition.[4,5,6,7]

In this paper, we have studied the effects of layer structure and composition upon the recording sensitivity. The thickness and dye concentration of retention layer ,and dye concentration and the composition of expansion layer were varied. The CNR of these samples were measured and the results were compared with the numerical calculations.

EXPERIMENT

Sample Preparation

The polymers and dyes used in this study are listed in Table 1. The polymethine dye IR 820 and quinone dye SIR 114 were purchased from Nippon Kayaku Co. and Mitsui Toatsu Dyes. LTD., repectively. The dye-polymer film was fabricated on polyester substrate using spin coating method. The coating solution for expansion layer was prepared by mixing -OH terminated polyurethane(CA 236), Isocynate (L-75), dye (IR 820) in the weight ratio of 2.0/1.0/0.3 in cyclohexanone(g/5ml).

The solution was spun on 75μm polyester substrate at 1,000 rpm for 20 sec and cured in 80℃ oven for 24 hrs. Retention layer was prepared after expansion layer. The weight ratio of polystyrene / dye (SIR 114) was 25/1 and toluene was used as the solvent. After spin coating by 1,000 rpm for 20 sec, the film was dried in a 50℃ vacuum oven for 8 hrs. In this study we varied i) the concentration of dye in retention layer from 0 to 5 wt%, ii) the thickness of retention layer from 0.23 to 0.85 μm, iii) the amount of dye in expansion layer from 10 to 20 wt%, iv) the polymer composition of expansion layer(CA236/L75) from 1/1 to 7/1 in weight ratio.

TABLE 1 Description of the polymer and dye specimens.

Expansion layer	Polymer	Urethane (OH terminated:Morthane CA236) Isocynate (Desmodur L75)	T_g=9℃ M_w=80,000
	Dye	Polymethine dye IR 820	λ_{max} = 816nm
Retention layer	Polymer	Polystyrene	M_w = 50,000
	Dye	Quinone dye SIR 114	λ_{max} = 750nm

Recording Test

In order to evaluate the CNR of the media, optical disk driver DDU-1000 manufactured by PULSTEC was used. A laser diode of 830nm wavelength was used as the recording and reading source. The numerical aperture of objective lens is 0.5, and the recording speed can be controlled up to 12 m/sec. Figure 1 shows the schematic diagram of experimental arrangement for evalulating CNR. The signals generated from function generator are recorded on the media through the driver and the recorded data are analyzed by spectrum network analyzer. In this study, recording and reading power were fixed at 8mW and 1mW, repectively, while the recording speed was varied.

Computer Simulation

The geometry of the layer structure is axisymmetric. Finite element method with a mesh of modes and elements was used for the simulation of the temperature distribution and bump height of the optical recording media. The nodes define the model geometry and the elements which connect the nodes define the material properties. More nodes were placed in the high strain region where the heat is applied, while less nodes were placed in the region which is close to the substrate and away from the center. The laser beam was incident on the retention layer. The followings are assumed for the simulation. The laser beam has a wavelength of 830nm with a Gaussian radial profile and an exp(-1) power radius of 0.8 μm. The laser was operated with a power of 10 mW for a total time of 100 ns, with an initial and a shut-down ramp of 10 ns. The media layer modeling is performed in three separate steps. First, the complex refractive index of each layer was calculated from

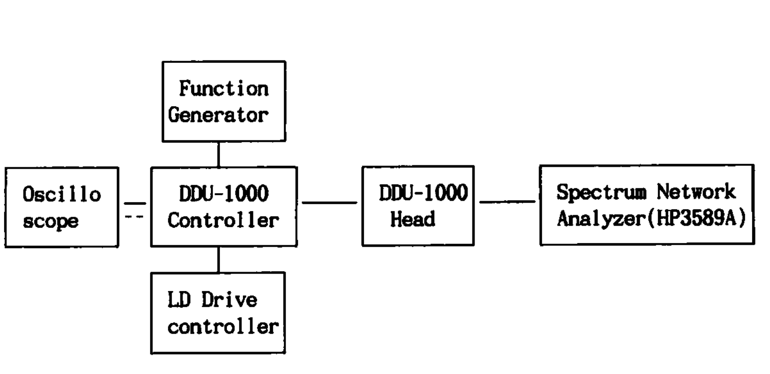


FIGURE 1 Schematic diagram of experimental arrangement for evalulating CNR.

implicit relation. Two equations with two unknowns of the form

$R_{th}(n,k)-R_{exp}=0, \quad T_{th}(n,k)-T_{exp}=0$

(R_{th}, T_{th} : Theoritical value of reflectance and transmittance

R_{exp}, T_{exp} : Experimental value of reflectance and transmittance)

can be solved numerically if reflectance and transmittance with known thickness can be exactly measured.

From the complex refractive indices numerically obtained, we simulated the reflectance variation with the thickness of the layer. The simulation of layer design is performed by characteristic matrix method which is generally used in interference phenomena of multilayer film.[8] Next, we simulated the absorption of energy through the films. An attempt is made to accurately calculate the absorption of energy through the film, based on the work of Mansuripur et al. in which a general solution is provided for the Poynting flux at each point through a multilayer system of different refractive indices. The Poynting flux is calculated at a depth of z in each layer.[9]

Finally, the Poynting flux was used to solve the time dependent heat conduction equation using a well-validated finite element package. The temperature of the layer determined in the previous step was again used as the input data of static force model analysis. The temperatures and deformations at each point of the finite element grid were obtained as function of predetermined time steps.

RESULT AND DISCUSSION

The Concentration of Dye in Retention Layer

In order to study the effect of dye concentration in retention layer, the concentration of dye was varied from 0 to 5 wt% at 0.5 μm thickness. The composition of the expansion layer(CA236/L75/IR820) was fixed to 2.0/1.0/0.3 by weight ratio.

These samples were recorded at 4 mW and 50 cm/sec, and the recorded bump heights were measured by Nanosurf. Figure 2 shows the typical Nanosurf data of 3 wt% sample which has nearly 0.25 μm averag bump height.

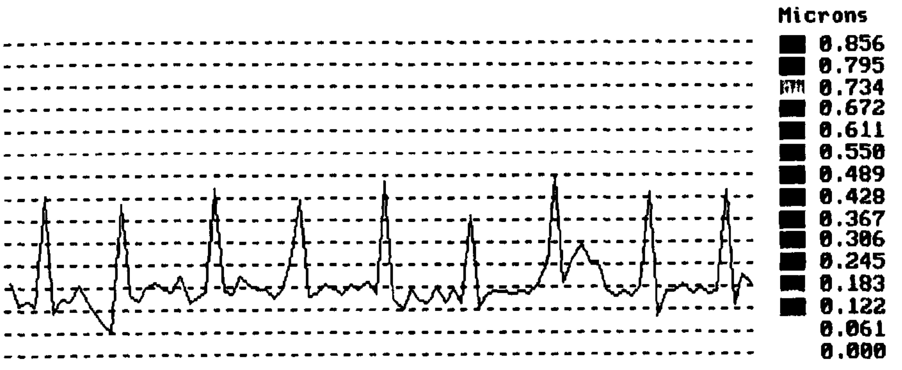


FIGURE 2 The surface deformation of media after recording measured by Nanosurf.

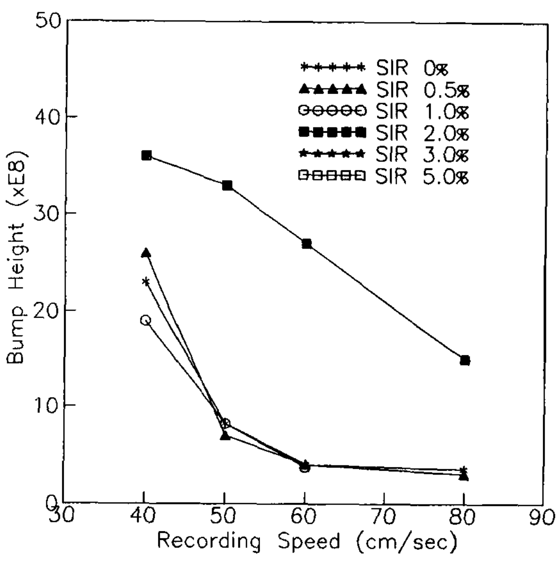
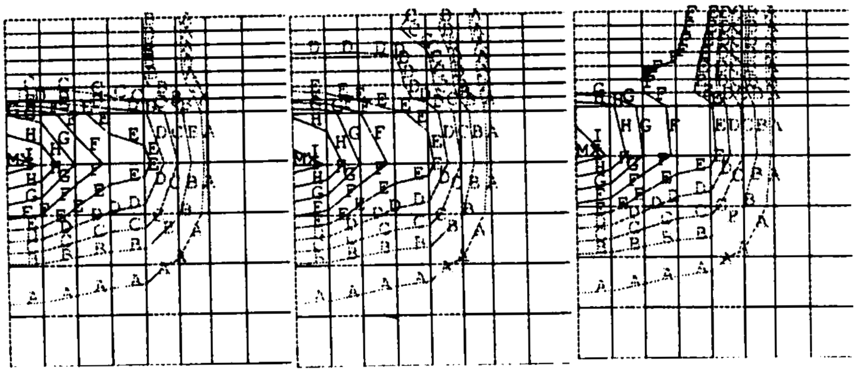


FIGURE 3 The variation of bump height as a function of the recording speed and dye concentration (Recording power = 4 mW).

Figure 3 shows the variation of bump height as a function of the recording speed of the samples. In Figure 3, the 2 wt% sample shows the highest bump height. To investigate this reason, the temperature of the retention layer was simulated. Figure 4 shows that 1, 3, and 5 wt% samples are heated to about 80, 125, and 230℃



a) b) c)

FIGURE 4 The simulated temperature profiles of a) 1 wt% b) 3 wt% c) 5 wt% dye concentration in retention layer(A=42℃, B=76℃, C=110℃, D=110℃, E=145℃, F=213, G=247℃, H=277℃, I=316℃)

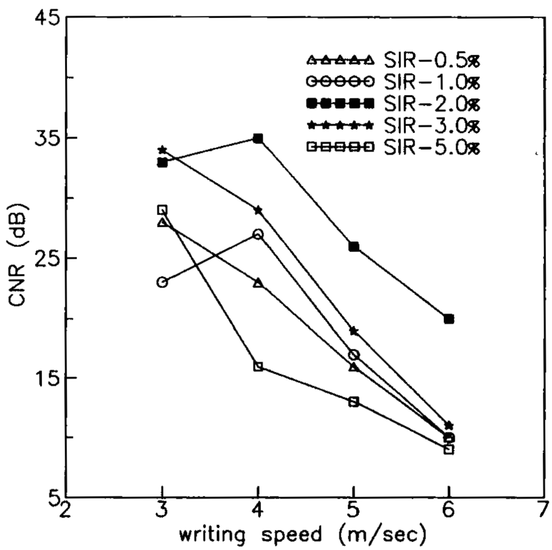


FIGURE 5 The variation of the CNR as a function of the recording speed and dye concentration.

,respectively. From these results, we could confirm that the retention layer of 1 wt% sample was not heated enough to reduce modulus of the layer. While, the 5 wt% sample was overheated to melt the polystyrene in the retention layer so that the media could expand easily , but it is shrinked easily also. But 2~3 wt% samples were heated in such a way that the temperature of the retention layer becomes close to the T_g of polystrene, and the modulus of retention layer is reduced to easily expand and speedily quenched. So these samples can be recorded with the highest bump height. In Figure 5, the 2 wt% sample shows the highest CNR and bump height. This shows that the higher bump resulted in the higher CNR.

<u>The thickness of retention layer</u>

The thickness of retention layer was varied from 0.23 to 0.85 μm at 2 wt% dye(SIR 114) concentration.

Figure 6 shows the reflectance change against retention layer thickness. The Figure shows the constructive-destructive interfernce pattern of reflected light between air/retention layer and retention/expansion layer interfaces. The simulated reflectance of the sample is also shown in Figure 6.

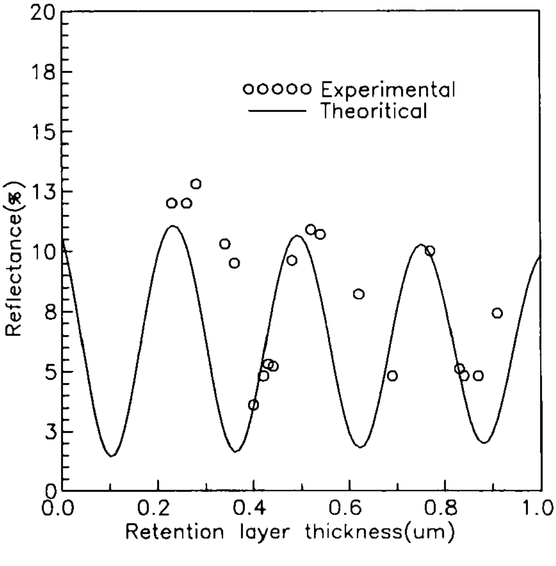


FIGURE 6 The reflectance change vs retention layer thickness.

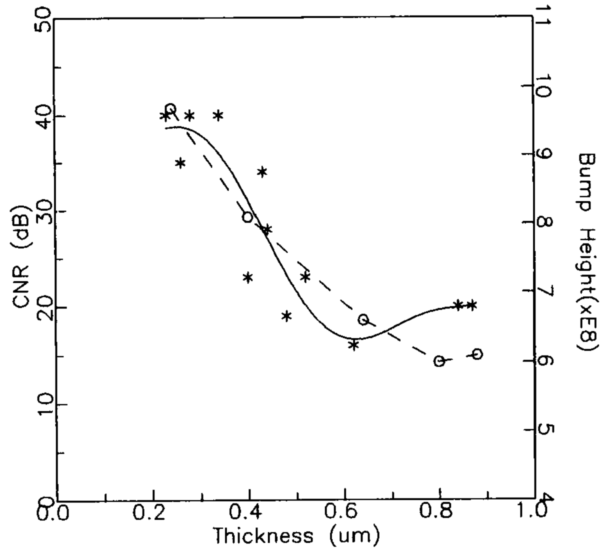


FIGURE 7 The measured CNR(*) and simulated bump height(o) against the thickness

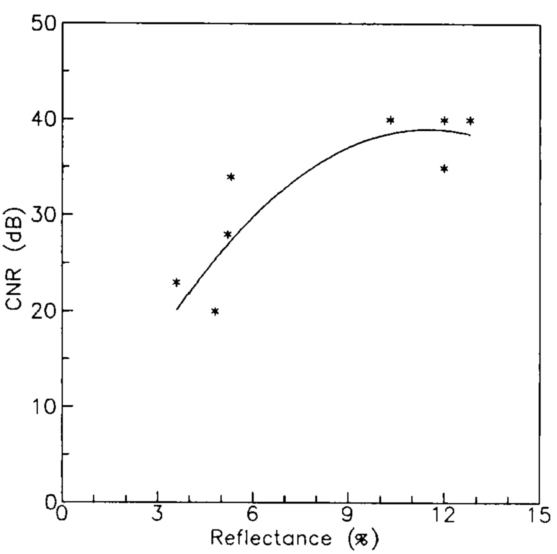


FIGURE 8 The variation of the CNR as a function of reflectance.

of retention layer. These results also show that higher bump height resulted in higher CNR. The reflectance vs CNR of these samples is plotted in Figure 8. This plot shows the media with the higher refectivity resulted in higher CNR. These results show that the CNR of recorded data can be enhanced by changing the retention layer thickness to have constructive interference.

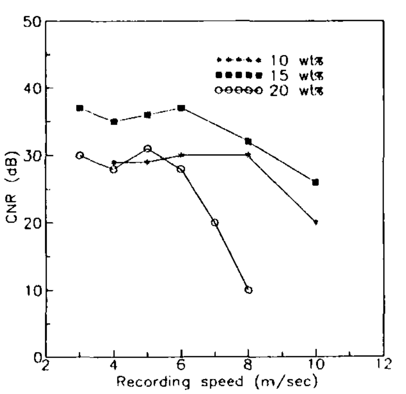
The Concentration of Dye in Expansion Layer

To study the effect of dye in expansion layer, the amount of dye(IR 820) in expansion layer (CA236/L75 = 2/1) was varied from 10 to 20 wt% with the fixed retention (0.25μm, SIR 114 2 wt%) composition.

Figure 9 shows the measured CNR and simulated bump height against the dye content. The 15 wt% sample shows the highest bump height and the hishest CNR. This result can be explained by the skin depth and temperature. The skin depth is inversely proportion to dye content(c), and the temperature is proportion to [1-exp(-c)]. The bump height is a function of skin depth and temperature ; [1- exp(-c)] /c , is maximized at a certain dye content and at 15 wt% in this study.

The change of thermal expansion coefficient of polymer in the expansion layer

To investigate the effect of thermal expansion coefficient(α), the ratio of [CA236] / [L75] in expansion layer was varied from 1/1 to 7/1 in weight ratio. Their thermal



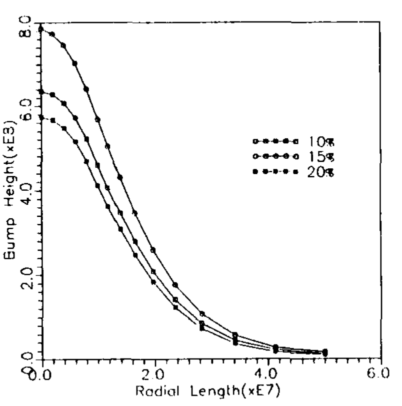


FIGURE 9 a)The measured CNR and b)simulated bump height against the dye concentration of the expansion layer.

characteristics are listed in Table 2. The thermal expansion coefficient and shear modulus was incresed as the amount of L75 increased. Figure 10 shows that the CNR and bump height is proportion to thermal expansion coefficient. This shows high thermal expansion cofficient should be used to obtain high CNR.

TABLE 2 The thermal characteristics of polymers in expansion layer.

[CA 236] / [L 75] (weight ratio)	Thermal Expansion Coefficient (um/mm/℃)	Shear Modulus (Log G')
1 / 1	0.37	7.79
2 / 1	0.33	6.90
3 / 1	0.31	6.66
5 / 1	0.22	5.94
7 / 1	0.27	6.28

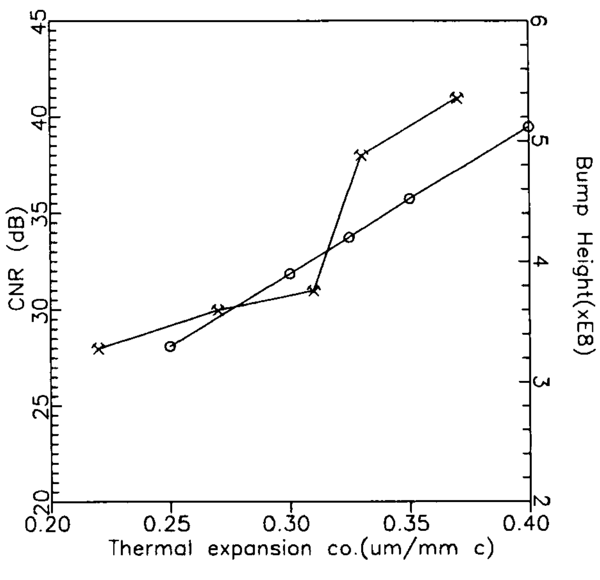


FIGURE 10 The CNR(x) and simulated bump height(o) against thermal expansion coefficient of polymer in the expansion layer.

CONCLUSION

We have studied the effect of media structure and composition on recording sensitivity. The recording sensitivity is very depedent on the bump height and the reflectance of the media. The bump height can be controled by changing the thickness and dye concentration of retention layer, and the thermal expansion coefficient and dye concentration of expansion layer. The reflectance can be maximized by adjusting the retention layer thickness to have constructive interference of reflected light. From this results the optimal recording media could be designed.

Reference

1. M.Emmelius, G.Pawlowski and H.W.Hollman: Angew.Chem.Inc.Ed.Engl.28(1989)1445
2. M.A. Lind, J.M. Halter, US PATENT No. 4780867
3. M.A. Lind, W.E. Skiens. US PATENT No. 4852075
4. W.E. Iwamoto, J.M.Halter, Ploymer Preprints,29(2), September(1988)
5. W.E. Skiens, G.A. Russell, Polymer Prinprints,29(2), September(1988)
6. J.M. Halter, N.E. Iwamoto, Proceedings of SPIE-Int.Soc.Opt.Eng., 899, 201(1988)
7. J.S. Hartman, M.A. Lind, Proceedings of SPIE-Int.Soc.Opt.Eng., 1078, 308(1989)
8. M. Born and E. wolf, Principles of Optics, Pergamon, New York, pp.55 - 70.(1975)
9. M. Mansuripur, G.A.N.Connell and J.W.Goodman, Appl. Opt. 21, 1106(1982)