Phase change media for high-speed and high-density recording

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Abstract

This paper describes the phase change media for 4X HD DVD-RW in which the data transfer rate is about 146 Mbps. We have found that In added to Ge-Sb-Te based nucleation dominant recording films is effective in raising crystallization temperature, while maintaining crystallization speed. The newly developed media have sufficiently low cross-erase as well as high erase ratio at high-speed recording. It has been shown that PRSNR of higher than 15 and SbER of less than 5.0e-5 can be achieved at 4X recording.

Keywords: Nucleation dominant recording film, Cross-erase, PRSNR, SbER, 4X HD DVD-RW

1. Introduction

There have been many studies of high-speed and high-density recording using phase change media[1-3]. For data transfer rate of higher than 100 Mbps, Sb-Te based growth dominant recording films have quite often been used. Although the high crystal growth rate allows high speed recording, it causes several issues such as high recording power and the decrease of the modulation due to the re-crystallization during writing. Because the increase of the recording power due to the re-crystallization causes severe cross-erase, the recording film with high crystal nucleation frequency and low growth rate is suitable for the high-density (especially for high-track density) recording at the high data transfer rate.

This paper describes the phase change media for 4X HD DVD-RW in which the data transfer rate is about 146 Mbps. We have found that In added Ge-Sb-Te based nucleation dominant recording films have sufficiently low cross-erase as well as high erase ratio at high-speed recording.

2. Experimental

Phase change media whose structure is depicted in Fig. 1 was deposited by magnetron sputtering onto 0.6-mm-thick polycarbonate substrate. The track pitch in L/G recording is 0.34 μm. The minimum bit length was 130 nm/bit using ETM code[4]. Read/write characteristics were measured with the optical head of λ=405 nm and NA=0.65. The data was retrieved by Partial Response Maximum Likelihood (PRML) detection with the PR equalization which can improve SNR[5] by exploiting the noise characteristics[6].

3.Results and discussion

3-1. Effect of additive In

The media design concept is schematically explained in Fig. 2. In order to achieve the fast crystallization speed, one has to increase the nucleation frequency and/or the growth rate. The high growth rate is not preferable in terms of cross-erase, as described in the Sec. 1. Thus, we selected the Ge-Sb-Te recording film with high nucleation frequency as the base composition. However, even for the recording film with the high nucleation frequency, the cross-erase may be a critical issue. We addressed this problem by increasing the crystallization temperature. We have found that addition of the In is effective in increasing crystallization temperature, while maintaining the crystallization speed.

The addition of In has another improvement of R/W characteristics. The change of the optical constants associated with the phase change generally decreases as the wavelength decreases, and it results in the decrease of the modulation. We also have found that the addition of the certain amount of In can improve the modulation. Table 1 summarizes the improvements obtained by adding In.

3-2. Write strategy in high-speed recording

As the clock frequency increases, the rising/falling time of LD becomes comparable to the width of the recording pulse. This leads to the unpreferable power increase and results in the degradation of cross-erase. In order to effectively heat the recording film under such conditions, we used the two-level write strategy. This strategy can be applied due to the low crystal growth rate of the newly developed film. As will be described in the following subsection, the high modulation cannot be obtained for the film with the high growth-rate without cooling pulse (3-level-strategy).

Figure 3 shows the comparison of the temperature increase in the recording film between the 2-level and the 3-level strategies. It can be found that the recording power can be reduced by using the 2-level strategy.

3-3. R/W characteristics of the newly developed recording film

Figure 4 shows the dependence of the DC erase ratio on the linear velocity on the newly developed phase change recording film. As can be seen from Fig. 4, the crystallization speed is high enough to achieve the erase ratio of higher than 26 dB around 22.4 m/s (4X speed). The feature of the newly developed recording film is low crystal growth rate as well as high crystallization speed. Figure 5 shows the dependence of the modulation on the linear velocity for the different recording pulse waveforms, *i.e.*, rectangle and multi-pulse. For the comparison, the characteristics of the growth-dominant recording film are also shown. If the crystal growth rate is significantly high, the modulation decreases for the rectangle recording pulse. This is because the cooling rate is so low that the recording film re-crystallizes from the molten state. The fact that the comparable modulation for both two recording pulse waveforms can be obtained even at 11.2 m/s (2X speed) implies the low crystal growth rate.

Figure 6 shows the dependence of cross-erase on the recording power on the adjacent tracks. (The power is normalized by the nominal write/erase power.) The cross-erase was measured after 10 DOW on both adjacent tracks. Increase of the crystallization temperature by additive In and the low crystal growth rate effectively suppress the cross-erase, and thus it remains less than 1 dB even for +15% recording power.

The signal qualification measures of PRSNR and SbER used in HD DVD are shown in Fig. 7. These measurements were carried out under the recording conditions of 10 DOW on the target track with the cross-erase by 10 DOW on both adjacent tracks. It has been confirmed that the values of the two measures are better than the HD DVD specifications (15 and 5.0e-5, respectively).

3-4. Dual layer recording

Also found is that the addition of In is effective in suppressing the reduction of crystallization speed in the thin (6~7 nm) recording film. This makes easier the media design of L0 in dual layer recording. Figure 8 compares the dependence of the erase ratio on the linear velocity between with/without In addition. The reduction of erase ratio can be suppressed by adding In. Also can be found from Fig. 8 is that the sufficient erase ratio of higher than 26 dB can be obtained without using the interface layer. Erase ratio can be further improved by the use of the different protective film. We have confirmed that the PRSNR of higher than 20 can be achieved in dual layer recording.

4. Summary

We have newly developed phase change media for 4X HD DVD-RW. The In added Ge-Sb-Te based nucleation dominant recording film has not only high crystallization speed but low cross-erase. It has been shown that PRSNR of higher than 15 and SbER of less than 5.0e-5 can be achieved at 4X recording.

References

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Biographies

I obtained MS degree at Keio University in Japan in 1989, and joined NEC. Since then, I have been involved in developing phase change media. Recently, I have been concerned in making the physical specification of HD DVD. My special field is media technology, and signal processing.

Table 1: Comparison of optical constants and crystallization temperature

	Δn ($\lvert n_a - n_c \rvert$)	Δ($\lvert k_a - k_c \rvert$)	Crystallization temperature (K)
GeSbTe	0.65	1.35	453
InGeSbTe	1.15	1.3	478

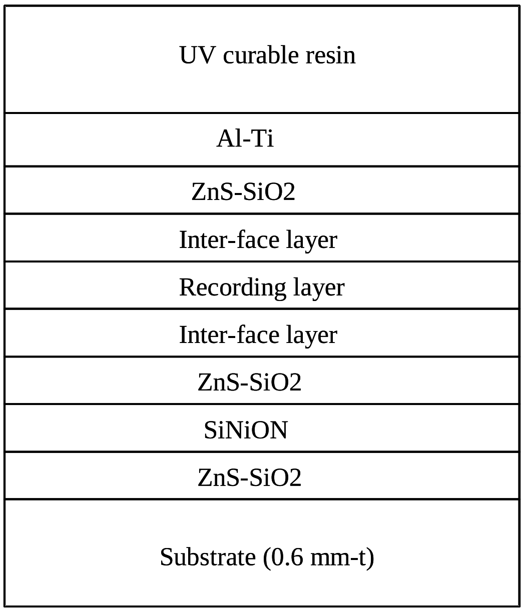

Fig. 1 : Cross-sectional view of the disk structure.

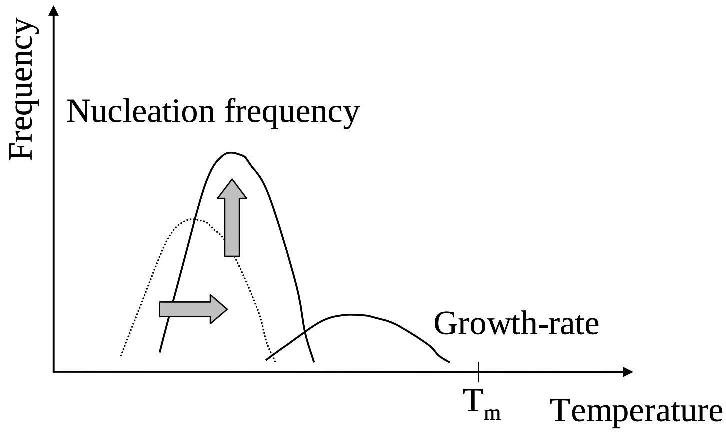

Fig. 2: Schematic explanation on the crystallization characteristics.

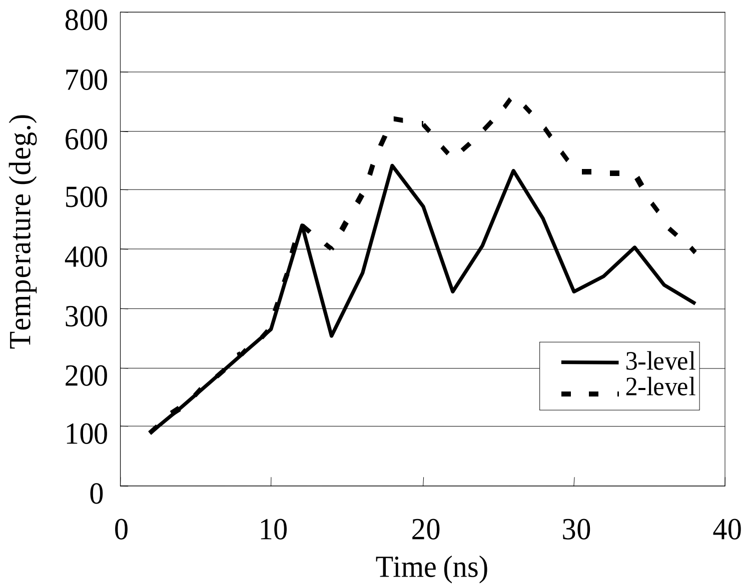

Fig. 3: Comparison of temperature increase in recording film.

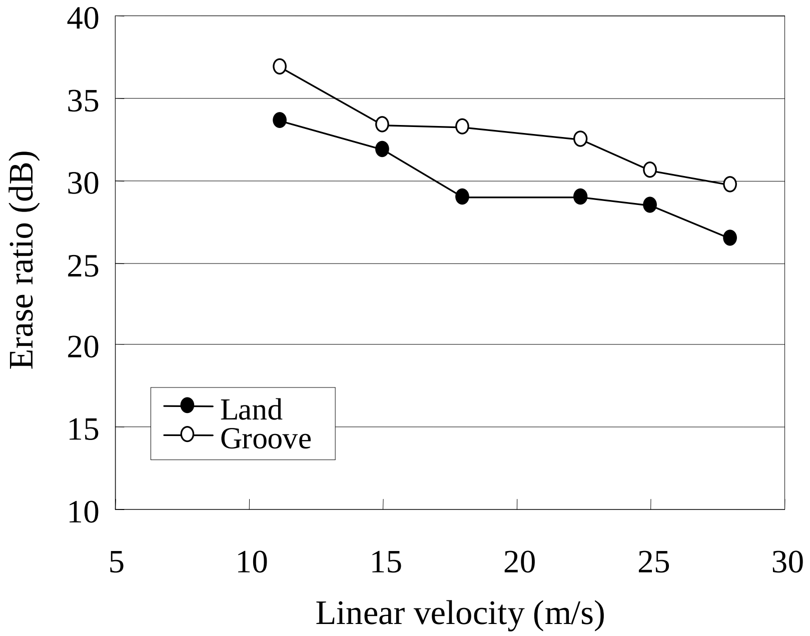

Fig. 4:   Dependence of erase ratio on linear velocity.

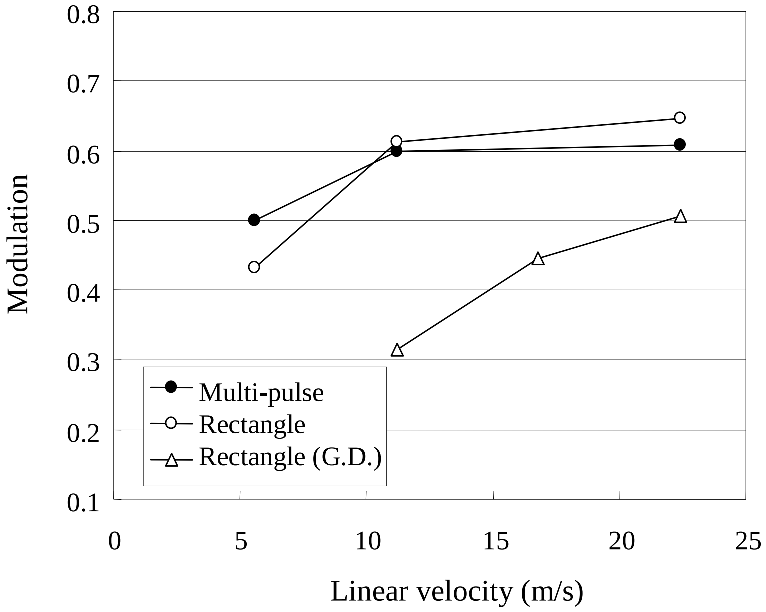

Fig. 5:   Modulation vs linear velocity.

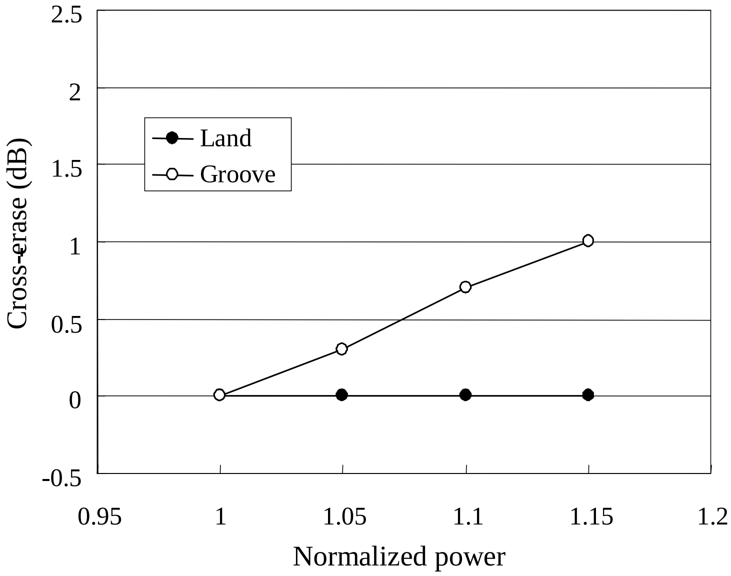

Fig. 6:   Cross-erase characteristics on 4X media.

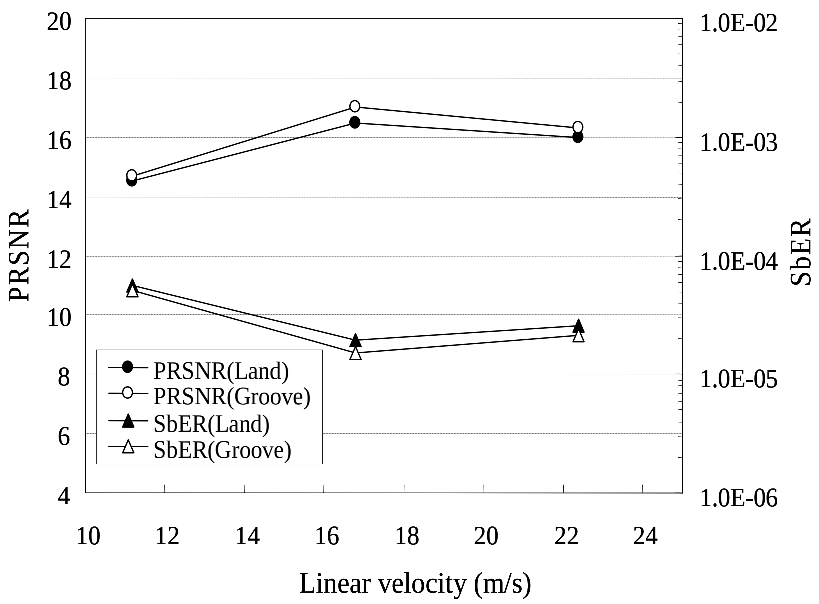

Fig. 7:   PRSNR/SbER vs linear velocity.

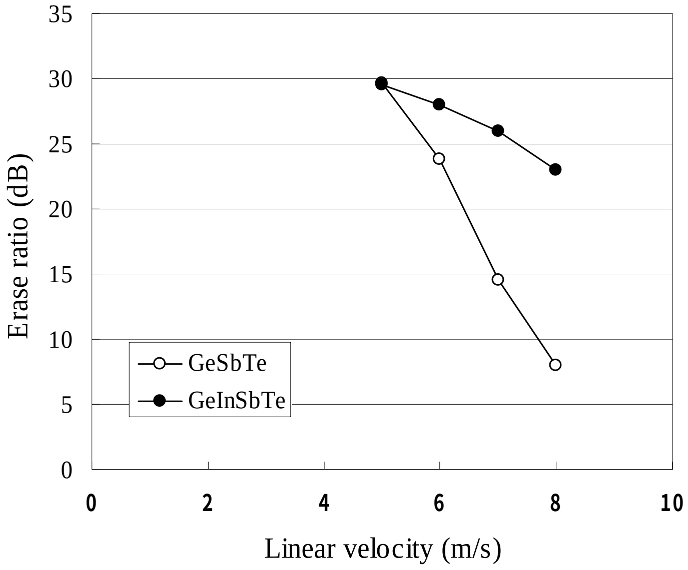

Fig. 8: Comparison of DC erase ratio in L0.