Phase Change Material for Write-Once Blue Laser System

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ABSTRACT

New inorganic phase changes write-once material has been developed for blue laser high density DVD. Experimental result shows that the recording characteristics of PRSNR and SbER are obtained to be respectively 18dB and 6×10^{-7} in groove track for 2x-speed.

Key words: phase change, write-once, blue laser, high speed

1. INTRODUCTION

Overview the developing history of optical recording media, CD-R and DVD-R are found to be the most popular recordable optical discs in the market. Write-once media are primarily useful for their data security which is especially appropriate for the storage of important data. To cope with the new trend of digital family electric products (such as HD-TV) and the requirement of high capacity recording media in personal computer system, blue laser write-once optical disc will become major product of market in the future.

There are many reports on the mechanism of write-once optical disc. Some reports indicated that the phase-transform could be used for write-once recording layer. It was doped few metal to improve the switch speed[1)], and to reduce the cross-writing[2)], i.e., TeO_x doped Pd, amorphous[3)] Si dope Cu, and the other researchers used this mechanism to make multilevel write-once disk[4)]. The hole formation is the other mechanism to make write-once disk[5)], they made the recording layers from Sb_2Te_3. Pioneer used the optical contrast of Bi-Ge-N metal nitride is decomposed to make write-once disk[6)]. The bi-layer alloy is a popular method and was adopted by many R&D teams, for example, the Cu-Si double layer was made by TDK[7)], the Ge/Au bi-layer by ITRI[8)], the Ge-Sb-Te/Bi-Te bi-layer by MEI[9)], the WO_3/Al-Ti by Toyota[10)], and Phase Change type[11)] by Hitachi Maxell.

Our objective is to study phase change write-once media. Experimentally, we have fabricated write-once discs which have a new reaction layer between phase-change recording layer and dielectric layer. During data recording, blue laser irradiation provides the energy for the reactive material which diffuses into recording layer, and changes the composition of phase change material. So the recording marks transit irreversibly from crystalline state with high reflectivity to amorphous state with low reflectivity. After optimizing the layer structure on substrate, we can obtain a high density write-once disc with blue laser recording. A phase change write-once media was introduced for high speed recording in this paper.

2. EXPERIMENTS

Figure 1 shows the cross-sectional view of the invented write-once disc. Firstly, we prepare a 0.6mm thickness polycarbonate substrate with track pitch of 0.4 µm and 30nm groove depth. Then, a five layers, including a lower protective layer (ZnS-SiO_2), a phase change recording layer, a reaction layer, an upper protective layer (ZnS-SiO_2) and a reflective layer (Ag), is deposited on the substrate by commercialized sputtering system (Modulus, SINGULUS). Finally, this deposited substrate is bonded with a dummy substrate of 0.6mm thickness.

The partial response signal to noise ratio (PRSNR) and simulation bit error rate (SbER) are evaluated to verify the performances of the disc by using a dynamic tester (ODU1000, PULSTEC), of which wavelength is 405nm and the numerical aperture (NA) of the objective lens is 0.65. The evaluation conditions are summarized in

Table 1. The modulation code is eight-to-twelve modulation (ETM) with RLL (1, 10). The data was recorded and evaluated in the groove area. The linear velocity of 1x-speed is 6.61m/s and the channel clock of 1x-speed is 64.8 MHz. Inter-symbol interference (ISI) is observed to exist in the signal with shorter data bit. Thus, the partial response maximum likelihood (PRML) process is needed for signal recovery. In general, the signal to noise ratio after PRML process would rise to more than 15dB. To guarantee the less data error rate, the SbER should be less than 5×10^{-5}.

3. RESULTS & DISCUSSION

Figure 2 shows PRSNR and SbER as a function of the write power for 2x-speed recording with different thickness of upper dielectric layers. The value of PRSNR increases as write power increases initially. After PRSNR approaches to the maximum, PRSNR would decrease as write power increase. The minimum write power decreases as thickness of upper dielectric layers increases. The minimum write power is 7.7 mw, 7.3mw and 7.1mw respectively for dielectric layer thickness of 13nm, 15nm and 17nm. The power margin of 13nm- and 15nm-thick upper dielectric layers is about 0.9mw. However, the power margin for 17nm-thick sample is only 0.6mw. The maximum PRSNR for these three cases are all greater than basic criteria of 15dB. Inspection of results, with increasing write power, SbER first decrease, then increases. The minimum SbER values are $1\text{x}10^{-6}$ for 13nm, $6\text{x}10^{-7}$ for 15nm and $2.5\text{x}10^{-5}$ for 17nm. The optimal write power is 7.7mw, 7.4mw and 7.3mw, respectively. Obviously, under the criteria of $5\text{x}10^{-5}$ for SbER the write power margin is 0.8mw, 1.4mw and 0.5mw for the thickness of upper dielectric layers 13nm, 15nm and 17nm, respectively. From the results of PRSNR and SbER, we found that the best layer structure of 2x-speed is 15nm-thick sample.

Figure 3 shows eye pattern from oscilloscope without signal equalization processing. The RF signal from 2T is obviously blur. The signal would be processed through PRML scheme. The adopted write strategy is similar to that of rewritable HD-DVD format (three write level). The recording peak power is set below 8 mW for 2x-speed. Figure 4 shows the 1x PRSNR (open symbols) and SbER (solid symbols) as a function of write power. From this figure, we found the maximum PRSNR and minimum SbER for 15nm thickness occur both at 6mW of write power. Comparison with Figures 2 and 4, 1x-speed recording is found to have more narrow power margin, lower PRSNR value and higher SbER value than 2x-speeds. It indicates 1x-speed recording with worse read channel signal for this kind of phase change material. Figure 5 shows the comparisons of read channel signals between 1x and 2x-speeds of 15nm-thick upper dielectric layer samples. For the evaluation result we found the PRSNR and SbER can fit the requirement of 15dB and 5×10^{-5} respectively under 1x- and 2 x-speed recording.

4. CONCLUSION

The reflectivity is changed from high level (crystalline state) to low level (amorphous state) after data recording. The optimal dielectric layer thickness of 15 nm is found for this phase change material in our study. The PRSNR of 18dB and SbER of 6×10^{-7} were obtained under the write power of 7.3mW and 7.4mW, respectively for 2x-speed recording in groove area. It proved that phase change material is suitable for blue laser write-once media.

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Table 1, Evaluation conditions

User capacity	*15 GB*
Thickness of substrate	*0.6 mm*
Wavelength	*405 nm*
N.A.	*0.65*
Modulation code	*ETM, RLL (1, 10)*
Track pitch	*0.4 µm*
Recording format	*Groove recording*
Channel clock frequency	*64.8MHz*
Linear velocity	*6.61 m/s*
User bit rate	*36.55 Mbps*

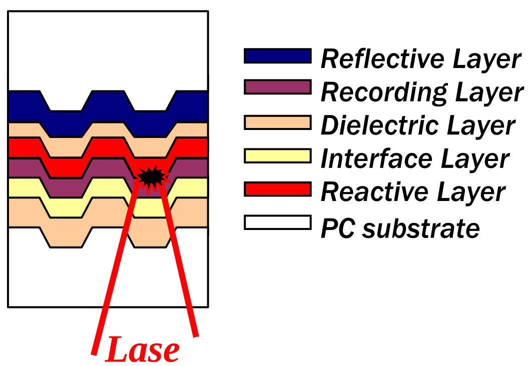

Figure 1, shows the cross-sectional view of the invented write-once disc

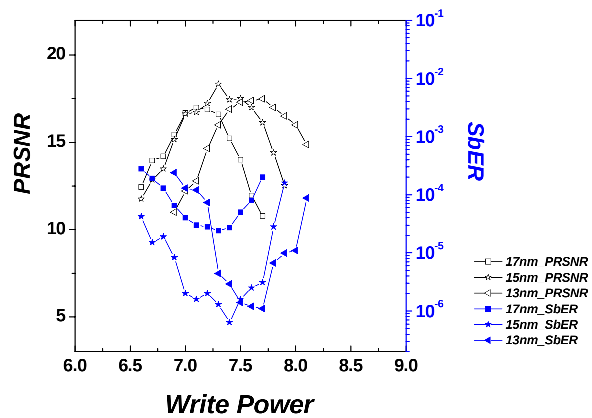

Figure 2, shows PRSNR and SbER as a function of the write power for 2x-speed recording with different thickness of upper dielectric layers

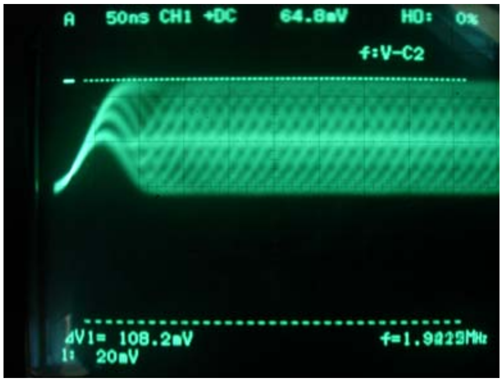

Figure 3, shows eye pattern from oscilloscope without signal equalization processing

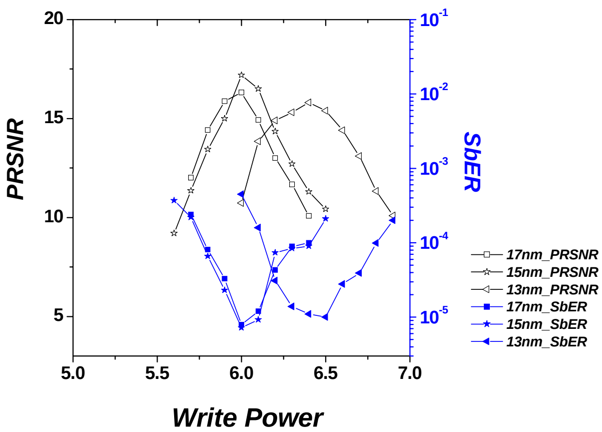

Figure 4, shows PRSNR and SbER as a function of the write power for 1x-speed recording with different thickness of upper dielectric layers

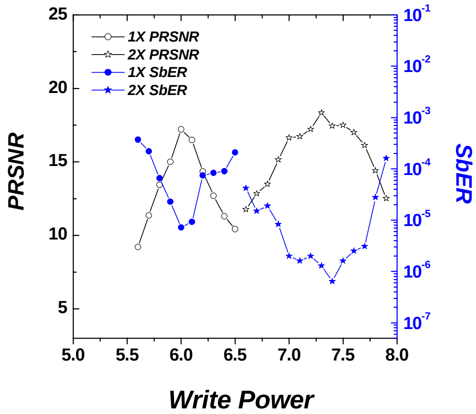

Figure 5, shows the comparisons of read channel signals between 1x-speed and 2x-speeds of 15nm-thick upper dielectric layer samples

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Biography

Po Fu Yen received his Master degrees in the Department of Material Science and Engineering from National Cheng Kung University, Taiwan, in 1995. He also has a bachelor science degree in Physics from Chung Yuan Christian University. He has been working for the ITRI since 1997. During this period, he has focused his research on material properties for use in thin film optical recording makings and analysis of thin films, and optical storage products. He has participated in the national optical storage technology development project held by the Ministry of Economic. He has also been assigned as the leader in various collaborative research development projects. Many of his projects have been awarded for their outstanding achievement including the research achievement awards presented by the Ministry of Economic Affairs, ITRI, and “Excellent Contribution on Optical Technology Award” from the Optical Engineering Society of the Republic of China (ROCOES) in 2002 and 2003.

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