Eutectic-based Phase-change Recording Materials  
for 1-2X and 4X Speed Blu-ray Disc

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ABSTRACT

We report some recent results in the rewritable Blu-ray Disc with enhanced overwrite cyclability by  
using the growth dominant eutectic based Ge(Sb70Te30)+Sb recording layer, GeN interface layer and  
write strategy optimization. We have developed phase-change optical media with appropriate write  
strategy for 36(i.e., 1X)-72Mbps(i.e., 2X) dual speed Blu-ray Disc system and for the future high speed  
optical data storage. For recording layer, eutectic-based Ge(Sb70Te30)+Sb material was used and  
Sb/Te ratio and Ge content were optimized to obtain proper erasability and archival stability of recorded  
amorphous marks. The recording layer is wrapped up in GeN interface layers to obtain overwrite  
cyclability and higher crystallization speed. In addition, we designed appropriate write strategy so called  
Time-Shifted MultiPulse (TSMPl) write strategy where starting position of multipulse parts are shifted  
from reference clock. With this write strategy, the jitter characteristics of the disc was improved and we  
found that leading edge jitter was improved much more than trailing edge jitter in 1X-2X speed recording.  
Finally, we investigated the higher speed feasibility of 144Mbps(i.e., 4X) by adopting some elemental  
doping to the eutectic based Ag-In-Sb-Te recording layer and structural optimization of constitution  
layers in Blu-ray Disc. In the paper, we report the effect of Sn addition for the feasibility of higher speed  
recording. The addition of Sn shows increases of the crystallization speed of phase change recording  
layer.

Key Words : Phase Change, Optical Disc, Blu-ray Disc, Cyclability, Eutectic, GeN, Ge(Sb70Te30)+Sb  
Ag-In-Sb-Te, Crystallization and Jitter

1. Introduction

Optical disc technology with a laser beam for  
data recording and readout is one of promising  
route for high density digital information storage  
in the tremendous multimedia era. Recently, the  
next generation optical disc system based on  
405nm laser wavelength, 0.85 numerical aperture  
and 0.1-mm-thick cover-layer has been developed  
[1] prior to the establishment of Blu-ray Disc  
rewritable format.

The diameter of the concentrated beam is  
defined by the NA value of the objective lens and  
the wavelength, as in the following expression:

\[ \text{Beam Diameter} = \alpha \cdot \lambda/NA \]

\[ \lambda = \text{wavelength}, \ \alpha = \text{a constant} \]
As seen in the above expression, the larger NA is, the smaller the beam diameter, although NA does not exceed 1.0 in the atmosphere. The largest NA values of CDs and DVDs obtainable during mass production were 0.45 and 0.6, respectively. For Blu-ray, an objective lens with an NA value of 0.85 was adopted.

The comparison in the beam size is shown in Fig.1. The first Blu-ray Disc Rewritable (BD-RE) system with 36Mbps of data transfer rate (i.e., 1X-speed) and 23GB of data capacity was introduced in the markets in 2003 using the phase-change media for the application of high-definition digital video recording. And moreover data application for personal computer with BD-RE format will come in near future. A reliable approach to this purpose has two major issues in view of media, one is to have higher direct overwrite (DOW) cyclability and another is to have higher data transfer rate which strongly depends on crystallization characteristics of phase-change material. The recording medium which is the most important layers in phase-change optical disc data storage should provide following characteristics; a) high sensitivity, b) high resolution, c) high signal-to-noise ratio, d) real time recording and instant playback, e) high immunity to defects, f) archival storage allowing permanent recording of data and no degradation under ambient condition or prolonged readouts. It has been known that two alloy systems are promising for the rewritable phase change optical materials including GeTe-Sb2Te3 alloy systems (so called, GeSbTe)[2] and Sb-Te(+) alloy systems (so called SbTe ).[3] These representative phase change material systems are shown in Fig. 2. We have developed BD 1X compatible phase-change optical disc media using eutectic-based Ge(Sb70Te30)+ Sb alloy.[4] In the previous study, we obtained some results in the rewritable BD with enhanced overwrite cyclability at 1X-speed by using the growth–dominant eutectic-based Ge(Sb70Te30)+Sb recording layer and GeN interface layer. But, the higher data transfer rate over 36 Mbps is needed in order to realize the more diversified applications in digital video recording system related with HD-TV content and to be adapted to optical data storage application for personal computer.

In this alloy system, Sb/Te composition ratio is known as a key factor for higher speed overwriting capability of the nucleation–free and growth-dominant for higher crystallization speed, but, higher Sb/Te ratio also causes mark instability or archival stability problem.[5] The mechanism of the increase of crystallization rate is possibly related to the increase of crystalline growth speed from amorphous mark boundaries in case of increase of Sb content in Sb70Te30 eutectic alloy system.[6] Since the melt-quenched crystalline state is based on the hexagonal structure of pure Sb, the increase of Sb concentration may accelerate ordering of hexagonal structure without any other phase, resulting in fast crystalline growth. This quickly frozen solid phase solution without significant phase separation, can realize a fast crystalline growth without significant atomic diffusion.[7] The doping of only a few atomic % of Ge to (Sb70Te30)+Sb binary alloy does not affect the melt-quenched crystalline structure without significant segregation during repeated overwriting,[7] further suppresses nucleation probability and results in the stability of amorphous mark.[8] In this paper, we report BD 1X-2X (i.e., 36-72Mbps) compatible phase-change media by optimizing composition (i.e. Sb/Te ratio and Ge contents) of recording layer and multilayer structure, and by applying the so called Time-Shifted MultiPulse (TSMP) write strategy, where the shift of multipulse laser recording is optimized. With the TSMP write strategy, the media show good overwrite cyclability over 10,000 at both BD 1X and 2X speed, and good jitter values below 6% at BD 2X speed condition. Moreover, the higher speed (ex. 4X) for the next version of Blu-ray Disc application will be necessary in near future. In this paper we also summarized the recent progress of 4X media development by the modification of the phase-change recording layer. We report the effect of Sn addition for the feasibility of higher speed recording.