Ge/Al Bilayer Thin Film for Optical Write-once Media

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Abstract: Ge/Al bilayer thin films are prepared by magnetron sputtering. Thermal analysis shows that the phase change of the film occurs at 275 °C. Contrasts at 650 nm and 405 nm wavelength are 71.4% and 31.1% respectively.
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1. Introduction

At present, recording medium of write-once optical disc is mainly made by organic dye. Since environmental pollution issues are difficult to resolve for organic dye, the inorganic recording medium was introduced to replace the organic materials recent years. Various inorganic recording media for Blu-ray disc (BD), High definition DVD (HD DVD), and forward versatile disc (FVD) had been proposed. AgSb binary alloy[1] had been investigated that its carrier to noise ratio (CNR) was 45 dB at 657 nm. Using groove and "High to Low" recording mechanism, the jitter value of Bi-Ge nitride[2] was found only 5.7% under 36 Mbps ~ 72 Mbps writing speed. Te-O-Pd [3] was proposed as a 4 layers recording media for 100Gb BD system. The crystallization temperature of sandwiched structure a-Si:H/Ag/a-Si:H [4] was found lower than that of a-Si/Ag/a-Si. The bilayer structure, such as a-Si/Ni[5], Si/Cu [6], Sb/Se[7] and a-Si/(Cu, Al) [8] were also been studied for the inorganic recording media recently.

In this paper, optical and thermal properties of inorganic Ge/Al bilayer recording thin films are investigated. It is shown that the Ge/Al bilayer has a phase change temperature around 275 °C by the measurement of the variation of resistance with temperature. Dynamic tests show that Ge/Al bilayer structure is suitable for high recording speed write-once optical disc.

2. Experiments

The layer structure of the Ge/Al bilayer write-once disk is shown as figure 1. A polycarbonate substrate with 0.64 μm track pitch was used, the films were sputtered in an order of lower dielectric layer(60nm), Ge/Al (10nm/10nm) recording bilayer, upper dielectric layer(20nm) and Ag reflective layer(80nm) by commercial sputtering system (Modulus, SINGULUS). After that, the 0.6mm thick polycarbonate (PC) substrate was bonded on the top. On the other hand, nature oxidized (110) silicone substrate was used for the thermal analysis sample. Relationship of reflectivity with wavelength was measured by spectrometer (ETA-RT, Optik's high sensitive spectrometer). Variation of resistance with temperature was investigated by 4-probe resistance test system in vacuum. The jitter value was evaluated by using a dynamic tester (DDU1000, PULSTEC), the testing conditions are shown in table 1. Laser beam with wavelength of 650 nm is used, the numerical aperture (NA) of the objective lens is 0.65, and linear velocity is 42m/s.

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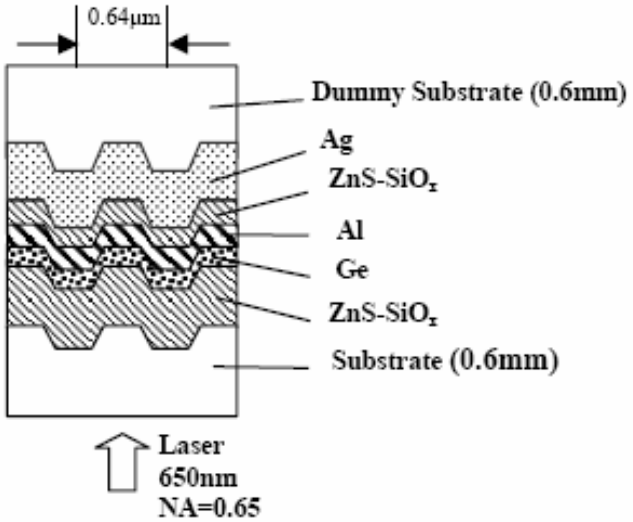

Fig.1. Ge/Al bilayer structure of the write-once disc.

Table 1. Evaluation conditions

User capacity	5.4GB
Thickness of substrate	0.6mm
Wavelength	650nm
N.A.	0.65
Modulation code	8/16
Track pitch	0.64μm
linear velocities	42 m/s
Recording format	Groove only

3. Results and discussion

Figure 2 shows the changes of reflectivity with wavelength. Under 650 nm red laser condition, the as-deposited and recorded Ge/Al film's reflectivity are about 28.5% and 8.5%, respectively. On the other hand, at 405 nm blue laser condition, the reflectivity of as-deposited and recorded Ge/Al films are about 20.3% and 29.5%, respectively. The corresponding contrasts at 650 nm and 405 nm are 71.4% and 31.1%, respectively.

Phase change temperature for write-once optical medium was suggested to be in the range between 150°C and 400 °C for the medium stability and sensitivity [9]. The phase change temperature of Ge/Al thin films was evaluated by measuring the electric resistance from room temperature to 420 °C. The schematically diagram is shown as figure 3.

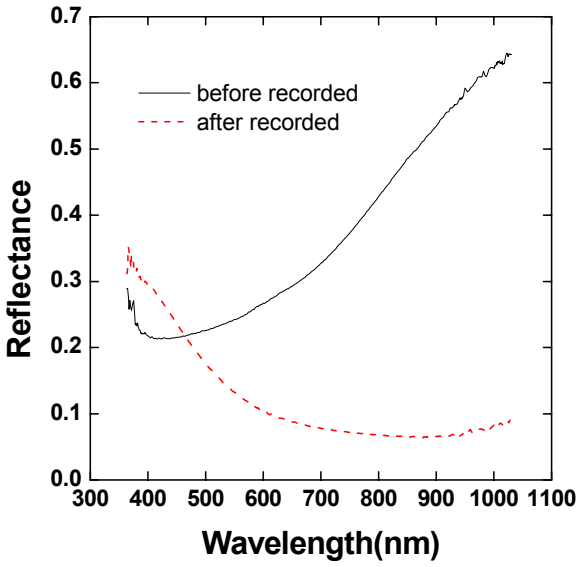

Fig.2. Reflectivity changes with wavelength of as-deposited and recorded ZnS-SiOx/Ge(10nm)/Al(10nm)/ZnS-SiOx/Ag films.

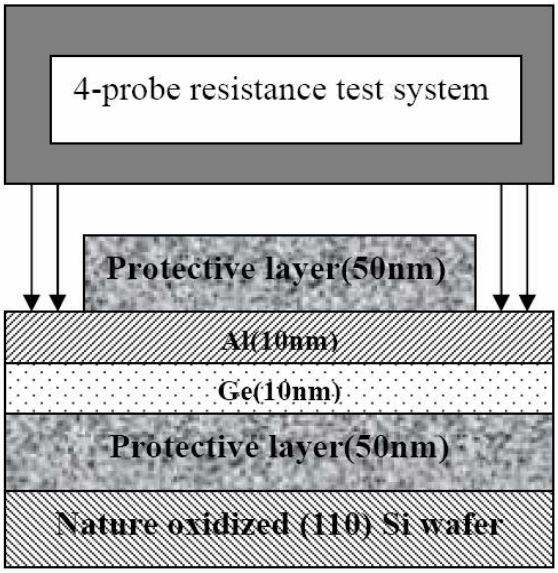

Figure 3. Schematically diagram of 4-probe resistance test system.

The Ge (10nm)/Al (10nm) bilayer was sandwiched by ZnS-SiO_x protective layers (each 50nm), and the edge of Al layer was exposed to vacuum for the resistance measuring. As the temperature is increased, a sharp increasing of resistance is found at 275 °C, as shown in figure 4. The resistance is further increased slightly from 275 °C to 340 °C. After that, resistance is decreased from 340 °C to 380°C, and then the resistance keeps at constant to 420 °C. Al-Ge alloy phase was found forming at 275 °C[10]. The increase of resistance is owing to the thickness decrease of Al layer. On the other hand, the increase and decrease of resistance from 275 °C to 380 °C is owing to the reamorphization and

segregation of Ge and Al grain, this result is the same as a-Si/Al bilayers[8]. The GeAl has a simple eutectic curve and an eutectic line at 420 °C, as shown in the GeAl phase diagram of figure 5 [11]. It can be seen that the crystallization temperature of Ge is reduced from 473 °C to 275 °C in the Ge/Al bilayer structure due to the metal induced crystallization (MIC) mechanism.[4, 8, 10, 12]

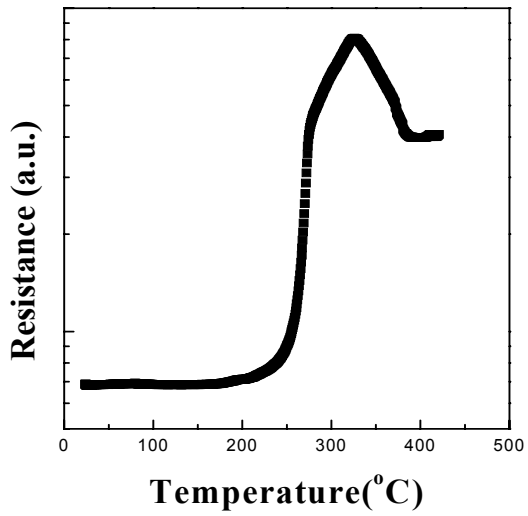

Fig.4. Relationship between electric resistance and temperature.

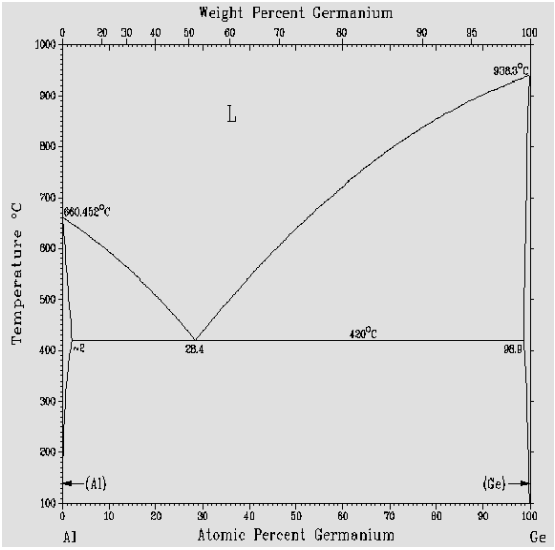

Fig.5. The phase diagram of GeAl alloy.[11]

The recording characteristics of Ge/Al bilayer were measured at different recording powers. As shown in figure 6, the modulation of the Ge/Al bilayers is increased from 0.69 to 0.73 as the writing power is increased from 30.0 mW to 34.0 mW. The optimum jitter value is 7.69 % which is obtained at 32.0 mW, 42 m/s recording speed. This means that

the Ge/Al bilayer films can be applied to high speed write-once disc.

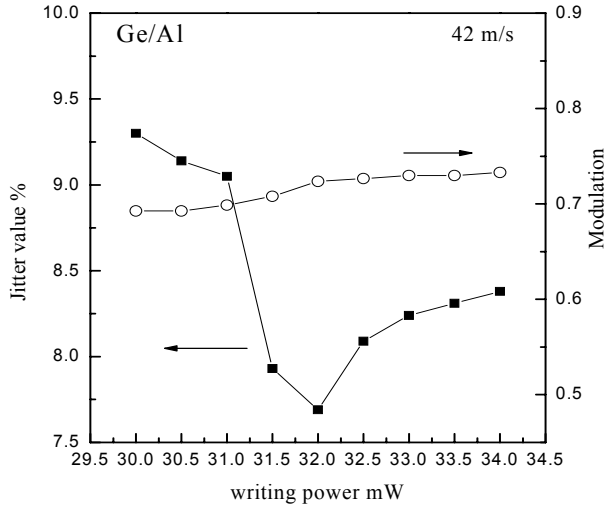

Fig.6. Characteristics of jitter value for 42 m/s recording speed (track pitch 0.64μm).

4. Conclusion

Recording properties of Ge/Al inorganic write-once optical media had been studied. From the resistance measurement, it is found that the crystallization temperature of Ge will be reduced from 473°C to 275°C by metal induced crystallization in Ge/Al bilayer. Dynamic tests show that the minimum jitter value was 7.69 % under 42 m/s recording speed.

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