

Ge₂Sb₂Te₅ Thin Film Doped with Silver

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1. Introduction

The reflectivity and thermal properties were main problems in GeSbTe phase-change disk that should be improved [1-4]. We found that small amount of Ag addition to the Ge₂Sb₂Te₅ film would increase the reflectivity, crystalline temperature, phase-transition temperature of fcc to hcp phase. And the activity energy of amorphous to fcc phase was decreased.

2. Experiment

The (Ge₂Sb₂Te₅)_{100-x}Ag_x films (where x = 0~3 at.%) were co-sputtered on silicon wafer and glass substrates with Ge₂Sb₂Te₅ and Ag targets by DC magnetron sputtering at room temperature. The ZnS-SiO₂ film was used as upper protective layer. The thickness of (Ge₂Sb₂Te₅)_{100-x}Ag_x film and protective layer were 100 nm and 30 nm, respectively. The base pressure of sputtering chamber was 5×10⁻⁷ Torr, and the sputtering Ar gas pressure was maintained at 5 mTorr. After deposition, the films were annealed at various temperatures in vacuum for 10 min then ice water quenched.

The crystallization temperature T_c, and the activity energy of amorphous to fcc phase E_a were measured by the reflective intensity change with temperature at various heating rates. The reflectivity was measured by using a spectrophotometer in the wavelength range of 400-800 nm. The phases and structures of the films were examined by X-ray diffractometer (XRD) with Cu-K α radiation. Composition of the film was determined by energy disperse spectrum (EDS). Thickness of the film was measured by α -step.

3. Results and Discussion

Figure 1 shows the relationship between reflectivity and temperature of the as-deposited Ge₂Sb₂Te₅ film. The heating rate is 60 °C/min. It is found that the reflectivity increases rapidly near 150 °C which means that the phase transition of amorphous to fcc crystal occurred at about 150 °C. The T_c of Ge₂Sb₂Te₅ film estimated from Fig. 1 is about 157 °C by the method of Ref.5. Figure 2 shows the relationship between the T_c and Ag content of the as-deposited (Ge₂Sb₂Te₅)_{100-x}Ag_x films. We can see that T_c of the film is increased with Ag content.

Figure 3 shows the relationship between the E_a and the Ag content of various as-deposited (Ge₂Sb₂Te₅)_{100-x}Ag_x films. The E_a is estimated from the Kissinger plot [6]. It is found that the E_a is decreased with increasing Ag content.

Figure 4 shows the X-ray diffraction patterns of various annealed (Ge₂Sb₂Te₅)_{100-x}Ag_x films. It indicates that the annealed Ge₂Sb₂Te₅ film (x = 0) has been transformed to hcp phase at 450 °C but the annealed (Ge₂Sb₂Te₅)_{100-x}Ag_x film is still in fcc phase as x \geq 0.3. The addition of Ag increases the fcc to hcp phase-transition temperature of the Ge₂Sb₂Te₅ film. This means that the fcc structure of Ge₂Sb₂Te₅ film is more stable after Ag addition.

Figure 5 shows the relationships between the reflectivity and the Ag content of various as-deposited and annealed $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{100-x}\text{Ag}_x$ films. The annealing temperature is 200 °C and the wavelengths are 650 and 430 nm respectively. We can see that the reflectivity is increased with Ag content as $x < 1.8$ and maximum reflectivity occurs at $x \sim 1.8$. Figure 6 shows the reflectivity spectrum and contrast of the as-deposited and annealed $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{98.2}\text{Ag}_{1.8}$ film. The contrast is larger than 15 % and increases at shorter wavelength range.

4. Conclusion

We have shown that the crystalline temperature, reflectivity, phase-transition temperature of fcc to hcp phase, and the activity energy of amorphous to fcc phase can be improved by doping small amount of Ag in the $\text{Ge}_2\text{Sb}_2\text{Te}_5$ film. In addition, the $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{98.2}\text{Ag}_{1.8}$ film can be used in blue laser.

Reference

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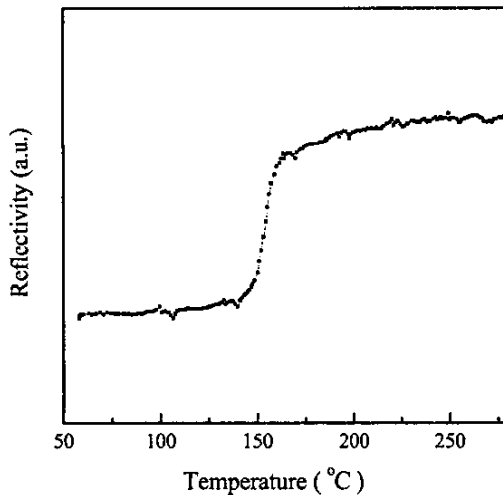


Fig.1 Relationship between the reflectivity and temperature of the as-deposited $\text{Ge}_2\text{Sb}_2\text{Te}_5$ film.

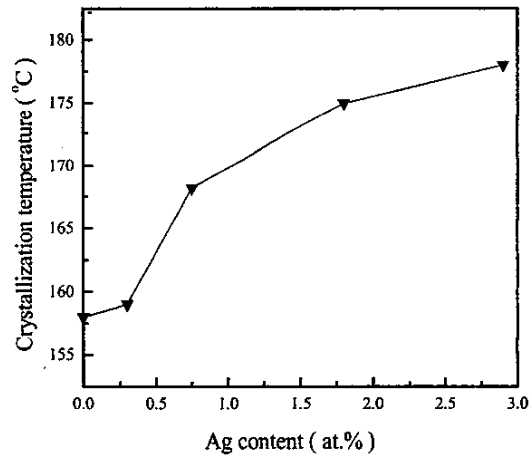


Fig. 2 Relations between the crystallization temperature and the Ag content of various as-deposited $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{100-x}\text{Ag}_x$ films.

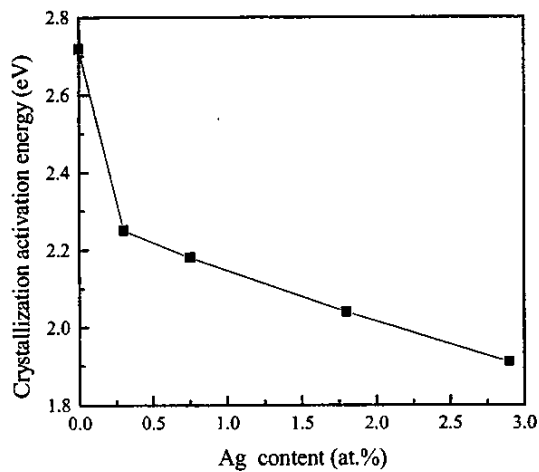


Fig. 3 Relationships between the E_a and the Ag content of various as-deposited $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{100-x}\text{Ag}_x$ films.

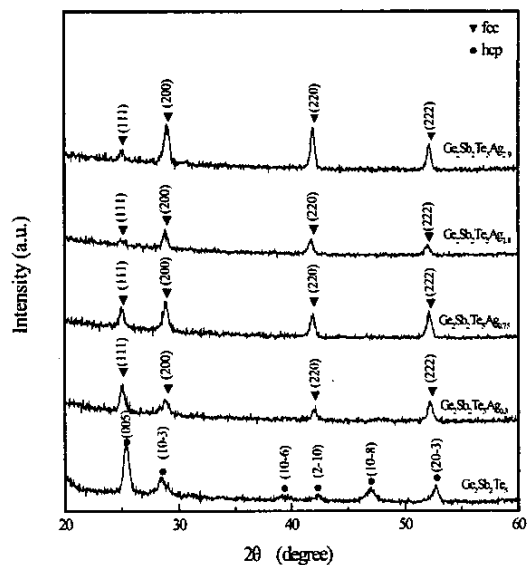


Fig. 4 The X-ray diffraction patterns of various annealed $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{100-x}\text{Ag}_x$ films. These films are annealed at 450°C .

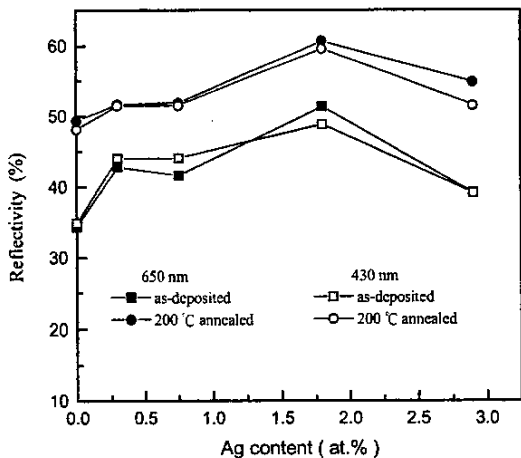


Fig. 5 Relationship between the reflectivity and the Ag content of as-deposited and annealed $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{100-x}\text{Ag}_x$ films.

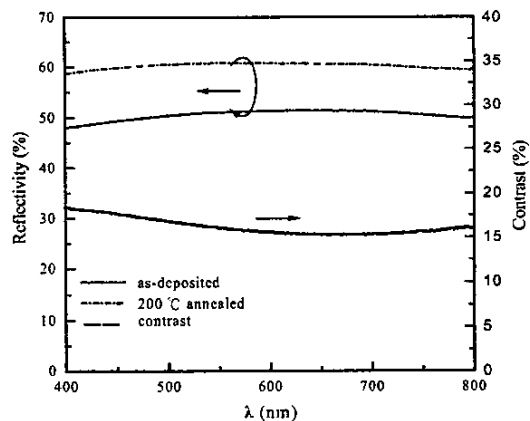


Fig. 6 Reflectivity spectrums and contrast of the as-deposited and annealed $(\text{Ge}_2\text{Sb}_2\text{Te}_5)_{98.2}\text{Ag}_{1.8}$ film. The annealing temperature is 200°C .