GeSbTe 상변화 박막의 선택적 에칭 특성

Selective Wet-Etching Properties of GeSbTe Phase-Change Films

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Abstracts

Phase-change wet-etching technology using GeSbTe phase-change films is developed. Selective etching between an amorphous and a crystalline phase can be carried out with an alkaline etchant of NaOH. Etching selectivity is dependent not only on the concentration of the alkaline etchant but also on the film structure. Specifically, metal films for heat control cause marked effects on the etching properties of GeSbTe film. Surviving amorphous pits can be obtained with Al metal layer, however etched amorphous pits are seen with Ag metal layer. An opposite selective etching behavior can be observed between samples with two different metal layers.

Key Words: wet-etching, phase-change, alkaline etchant, selective etching, survived pit, etched pit,

1. Introduction

Recently, the wavelength of the laser beam recorder (LBR) has been shortened from UV of 351 nm wavelength to deep UV of 257 nm wavelength. The beam size is proportional to the wavelength of the laser so that a principal approach to increase bit density in a mastering process is to reduce the size of writing beam. It is confirmed that the deep UV LBR can cover the capacity of about 25 GB per disc. It means that the mastering technology should be enhanced to cope with the density over that of Blu-ray Disc. Therefore, a lot of works have been done for high density with the electron beam recorder (EBR).[1] In-between the two mastering technologies, several trials are being carried out using a conventional laser beam.[2-5]

Phase-change etching technology seems to be one of the most successful technologies among the emerging ones since a commercialized phase transition mastering system shows a large potential through an application for 25 GB Blu-ray Disc ROM.[2] Additionally, Shintani *et al*. reported that the phase change recording films were useful to fabricate nano-size pits with the selective etching technique using an alkaline etchant.[6] Crystalline phase matrix area was etched out with surviving amorphous pits, which was a selective etching. A thermal mode is a basic recording mechanism in this approach instead of a photon mode, in which the pit size can be determined by the threshold temperature of melting with temperature distribution of a GeSbTe film irradiated by a laser beam.

In this paper, basic properties of the selective etching with single amorphous and crystalline phase GeSbTe films are reported, and survived and etched pits with different media structure and metal layer are discussed.

2. Experimental Procedure

Single GeSbTe films were prepared on Si wafers and polycarbonate substrates to test the basic etching properties between amorphous and crystalline films. Films on Si wafer were used for the optical observation using optical microscope. Surface images of GeSbTe

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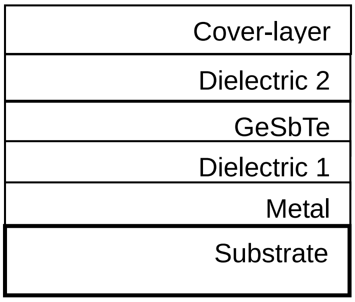
films on Si wafer were monitored during etching process. Crystallization was done for 5 min at 250°C in an oven.

The crystallization process was carried out by an initializer for Blu-ray Disc. All phase-change samples were etched by using NaOH solution.

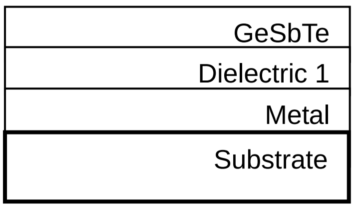
Figs.1 show media structures for writing and selective etching after writing. The media structure for writing is in Fig. 1(a), which is similar to that of Blu-ray Disc with substrate/metal/dielectric 1/GeSbTe/dielectric 2/cover-layer. On the other hand, the film structure for etching after patterning is in Fig. 1(b), in which the cover-layer and the dielectric 2 layer should be removed for etching.

The patterning (writing) was carried out by using a test system for Blu-ray Disc. The pit patterns were observed by a Scanning Electron Microscope (SEM) and the depth of the patterns was determined by an Atomic Force Microscope (AFM).

3. Results and Discussion



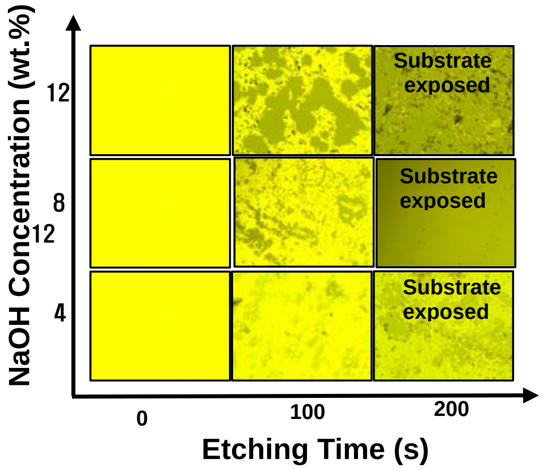
(a)



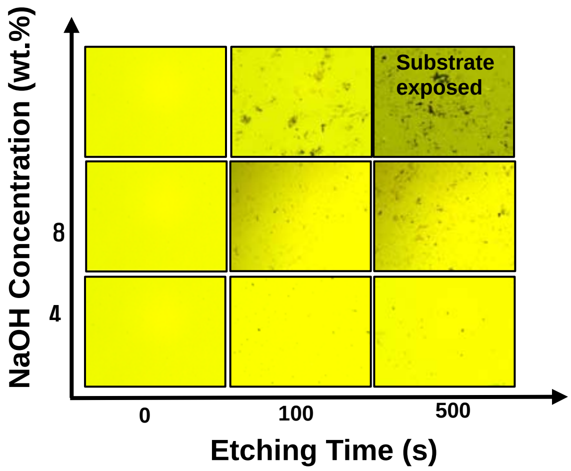
(b)

Fig. 1. Media structure for (a) writing and (b) etching.

Figs. 2 show optical images of amorphous and crystalline films during etching. Fig. 2(a) and Fig. 2(b) are surface images of crystalline and amorphous films, respectively, which are shown as functions of the etching time and the concentration of NaOH etchant. For both phases, it is observed that the degree of etching is proportional to two parameters of the time and concentration. However, it is obvious that the crystalline films in Fig. 2(a) are more easily etched than the amorphous films in Fig. 2(b).



(a)



(b)

Fig. 2. Optical images of (a) crystalline and (b) amorphous films as functions of etching time and NaOH concentration.

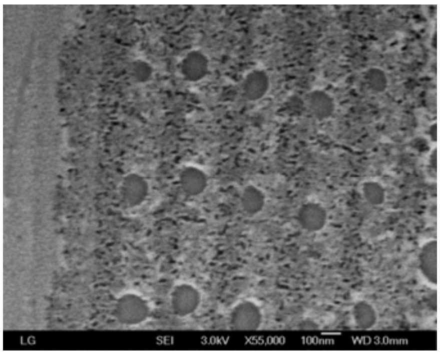


Fig. 3. SEM image of crystalline pits after etching. No metal layer is inserted in the media

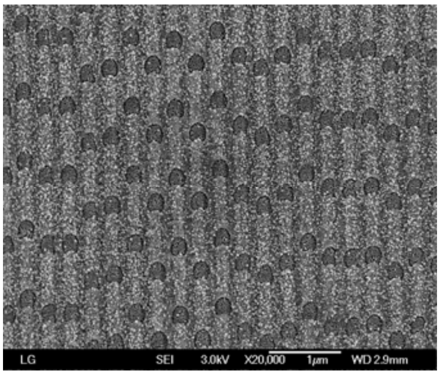


Fig. 4. SEM image of etched amorphous pits after etching. Ag metal layer is used for heat control layer during writing.

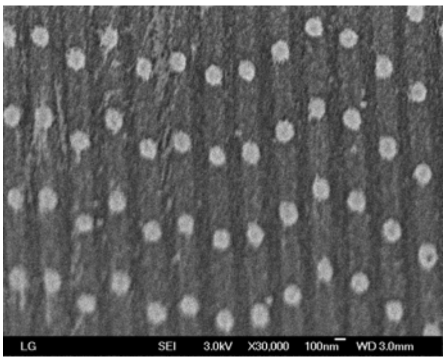
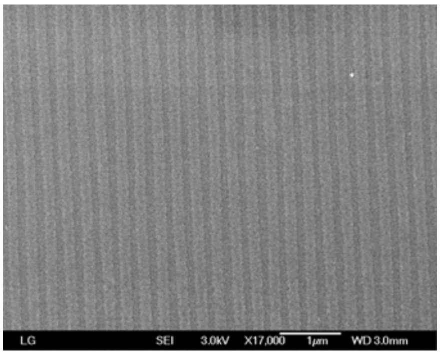


Fig. 5. SEM image of survived amorphous pits after etching. Al metal layer is used for heat control layer during writing.

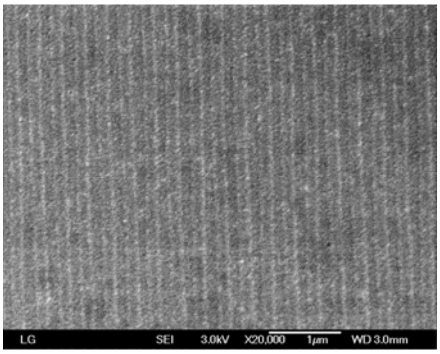
It is observed that the surface of Si wafer substrates is exposed for all crystalline films after 200 s for all concentrations of the etchant. Interestingly, a similar result can be seen for 500 s of etching time at 12 wt% of NaOH concentration for amorphous film. On the other hand, amorphous surface images are hardly changed for low concentration of 4 wt% of NaOH. It is found that the amorphous films are etched also, etching speed is markedly lower than the crystalline phase. Even though the amorphous films are more robust against the etching than the crystalline films, the amorphous films can not avoid etching, either. Therefore, an optimization of etching and good etching conditions should be chosen for the best selective etching.

Fig. 3 shows a basic feature of etched crystalline pits written in the media structure of substrate/dielectric 1/GeSbTe/ dielectric 2/cover-layer. It should be pointed out that no metal layer is inserted in the media structure, thus amorphous pits can not be expected since rapid cooling is an essential condition to form amorphous pits during writing. Crystalline pits were written in the amorphous GeSbTe film which has not experienced the initialization process. It is observed that etched crystalline pits are formed after etching, as expected. However, the matrix area around the pits shows some damages due to the etching, which seems to be partially crystallized by the writing laser during the writing process. It is observed that the boundary between the amorphous and partially crystallized area is formed in the left part of the SEM image in Fig. 3.

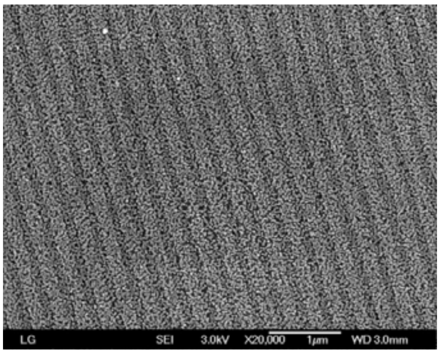
Interestingly enough, etched and survived amorphous pits are formed with the same media structure of Fig. 1 (a), with different metal layers. Fig. 4 shows the amorphous pattern, in which the amorphous pits are etched instead of surviving, the results are similar to the lithography process using the positive photoresist. Ag metal layer, which is a typical heat control metal layer in the other media, for example Blu-ray Disc, is inserted in the media structure. On the hand, survived amorphous pits can be observed by changing the metal layer with Al. Fig. 5 shows the survived amorphous pits after etching, the results are similar to the lithography process using the negative photoresist. It should be mentioned that the



(a)



(b)



(c)

Fig. 6. SEM image of amorphous films (a) without metal layer, (b) with Al metal layer, and (c) with Ag metal layer after etching.

survived amorphous pits in Fig. 5 are more distinctive and clear than etched amorphous pits in Fig. 4. The etching behavior in Fig. 5, in which amorphous phase is surviving, is same as etching results without metal layer, as expected originally.

Even though the etching behavior is opposite between samples with Ag and Al metal layer, the etching selectivity between the amorphous and crystalline phases can be considered. It is not difficult to compare the surface state and the depth or height of the amorphous patterns between Fig. 4 and Fig. 5. In addition to the SEM images, AFM surface profiles showed that the etching selectivity of Fig. 5 with Al metal layer was better than those of the media with Ag metal layer in Fig. 4.

In order to confirm the etching behavior, three amorphous samples with different media structure were prepared and etched simultaneously. Figs. 6 show SEM images of amorphous films after etching for (a) without metal layer, (b) with Al metal layer, and (c) with Ag metal layer. It is easily observed that an amorphous film in Fig. 6(a) is robust against the etching, but that of Fig. 6(c) shows many damages owing to the etching. It is confirmed that the amorphous film with Ag metal layer is easily etched compared to other samples without metal layer or with Al metal layer. Even though the sample of Fig. 6(b) which has Al metal layer seems not to be as strong as the sample of Fig. 6(a) which has no metal layer, it is more robust against etching than the sample of Fig. 6(c) which has Ag metal layer. Main reasons of the opposite etching behavior are not understood yet, but it is clear that survived amorphous pits with good etching selectivity can be achieved with Al metal layer.

4. Conclusion

A selective etching of GeSbTe phase-change films with NaOH etchant was carried out. It is found that the etching behavior of phase-change film is strongly dependent on the metal layer of thermal absorption layer. An opposite etching behavior was occurred between samples with Al and Ag metal layer. Survived amorphous pits and etched amorphous pits could be obtained for samples with Al and Ag metal layer, respectively. An etching selectivity for a sample with Al metal layer was better than that of Ag metal layer.

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