Process Integration of Superlattice PCM to be Embedded in BEOL

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ABSTRACT

We examined the sputtering temperature to form a superlattice phase change memory (PCM) for embedding in the back end of line (BEOL) of the CMOS process. High quality superlattice film was obtained at the deposition temperature of 240 °C. Moreover, we also discuss the dry etching rate and selectivity to a mask TiN of the superlattice film and compared them to those of GeTe, Sb2Te3 and Ge2Sb2Te5 alloy.

Key words: superlattice PCM, XRD, retention, switching

Superlattice phase change memory (Superlattice PCM)[1)] is a promising candidate for next generation non-volatile memory devices. Alloy PCMs, such as $Ge_2Sb_2Te_5$ or doped- $Ge_2Sb_2Te_5$, are difficult to scale for $4F^2$ using cross point topology, because integration may lead to miss SET or RESET of the neighboring cells due to the heat. We investigated the fabrication process for embedding superlattice PCM in the back end of line (BEOL) of CMOS process. The key processes are temperature to deposit the superlattice the crystalline state and dry etching to form sub-nm structures.

Figure 1 shows the x-ray diffraction (XRD) spectra for depositing single Sb2Te3 (a) and single GeTe (b) films on silicon (Si) substrate from 180 to 230°C by the sputtering. The XRD measurements were carried out using the Cu-K□ line. The Sb2Te3 film was in a crystalline state from 180 to 220°C, and the GeTe film was in a crystalline state from 200 to 220°C. Figure 2 (a) shows the superlattice films deposited on Si substrate from 180 to 260°C. We observed that the superlattice films were in crystalline states from 180 to 260°C. We observed that almost all peaks originated from the Sb_2Te_3 and no peaks originated from the alloy such as the $Ge_2Sb_2Te_5$ alloy[2)]. Fine peaks were also observed from 4 ° to 10 ° of 2 theta, which is signified with the arrow in the figure, and they differed from each other due to the deposited temperatures. We assumed that they were reflected on the superlattice structures, but the detailed structures of these films are not known yet. Strong peaks were observed for the sample deposited at 240°C. Figure 2(b) shows the transmission electron microscopy (TEM) image of the superlattice PCM deposited at 240°C. We obtained high-quality superlattice film.

Figure 3(a) shows the dry etching rates of GeTe, Sb2Te3, $Ge_2Sb_2Te_5$, and superlattice films. The GeTe etching rate was about 50% and that of Sb_2Te_3 was about 30% that of the $Ge_2Sb_2Te_5$. This was due to the difference in etching products between GeTe and Sb_2Te_3 compared to that of $Ge_2Sb_2Te_5$. The etching rate of the superlattice films was about 20% that of the $Ge_2Sb_2Te_5$. The etching products originating from both GeTe and Sb2Te3 restrained the etching. We also investigated the selectivity of the superlattice to a TiN hard mask, and obtained over a 1 for the superlattice, as shown in Fig. 3(b).

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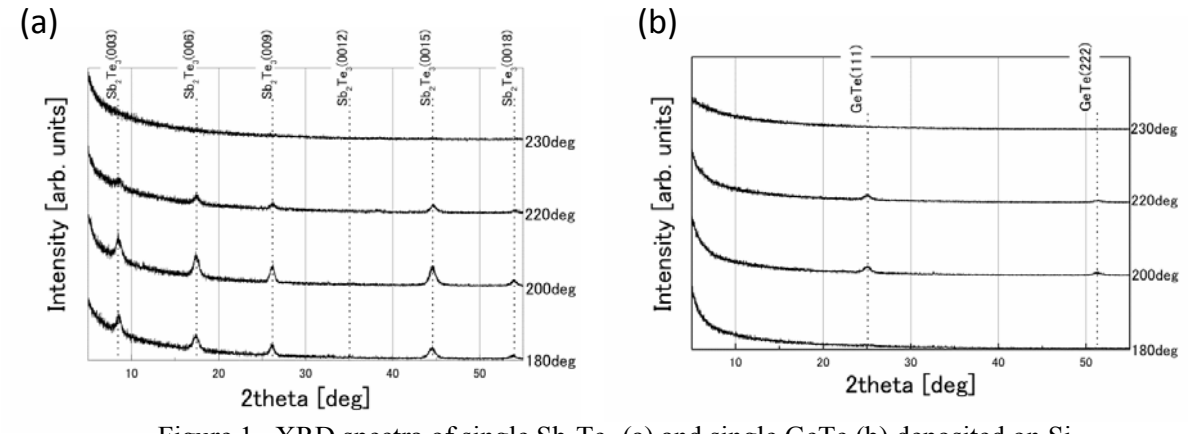

Figure 1 XRD spectra of single Sb_2Te_3 (a) and single GeTe (b) deposited on Si substrates at the temperature from 180 °C to 230 °C .

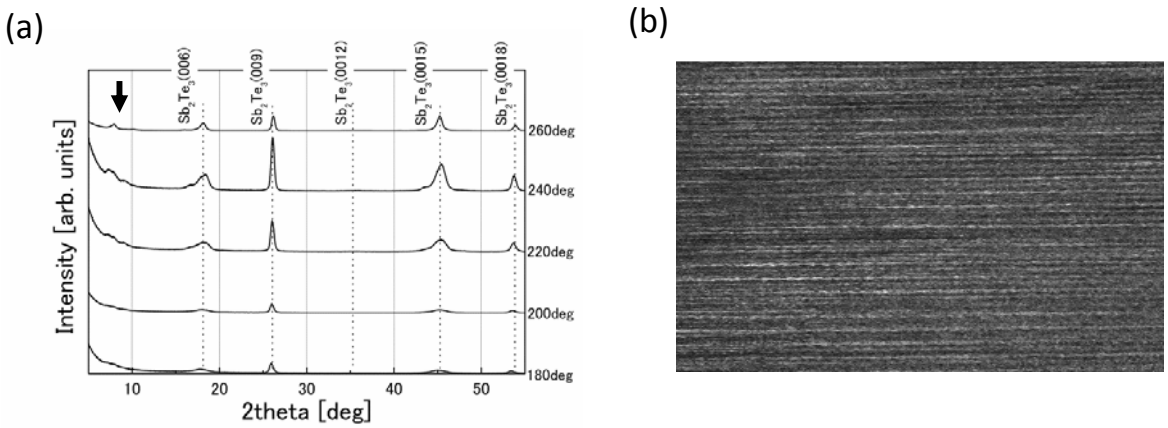

Figure 2 (a) XRD spectra of superlattice films deposited on Si substrates at the temperature from 180 °C to 230 °C (b) TEM image of the superlattice film deposited at 240 °C.

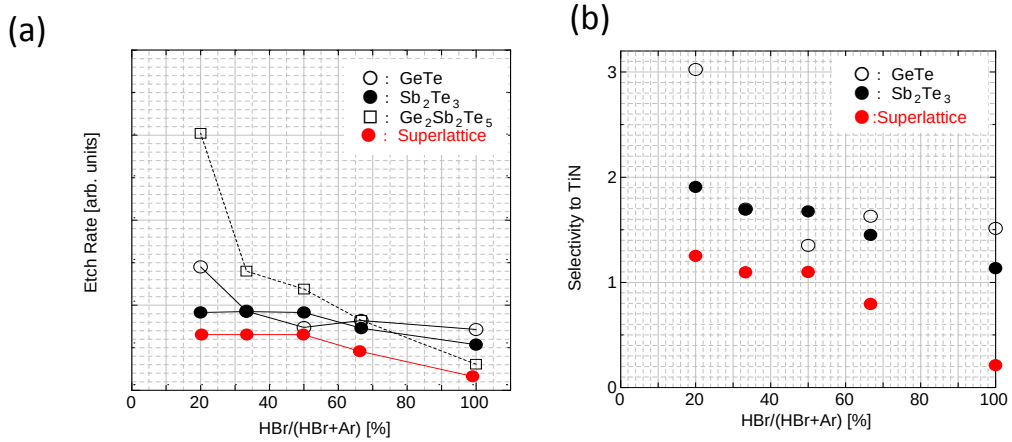

Figure 3 (a) Etching rate of single GeTe, single Sb2Te3, alloy Ge2Sb2Te5, and the superlattice (b)Selectivity of the single GeTe, single Sb 2Te3, and the superlattice to the TiN.

References

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