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Special Electrical Characteristics of Superlattice Phase Change Memory

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Phase Change Memory (PCM) is a promising candidate for next generation non-volatile memory devices. Alloy materials such as $Ge_2Sb_2Te_5$ (GST) have been widely used for PCM. The advantages of PCM are that it provides an ideal scaling path for $4F^2$ using cross point topology and that stackable cells enable further integration. However, it should be pointed out that using $Ge_2Sb_2Te_5$ alloy for further integration may lead to miss SET or RESET of the neighboring cells due to the heat.

Recently, a new phase change mechanism was proposed in which the electric resistivity and optical indices are greatly modified by only the switching of the Ge atoms in GST1). Furthermore, using this model, the superlattice phase change was proposed, in which power consumption during recording dramatically reduced. This method uses the periodical thin film layers (superlattice) of $GeTe/Sb_2Te_3$2), superlattice PCM. We fabricated high-quality superlattice films and investigated the special electrical characteristics of a superlattice PCM compared to that of a conventional alloy PCM. We used $Ge_2Sb_2Te_5$ as the conventional alloy PCM.

Figure 1 shows the X-ray diffraction (XRD) spectra of two types of superlattice films. The lower XRD spectrum is that of our first superlattice film, and the upper one is that of the optimized superlattice film. The figure also shows transmission electron microscopy (TEM) images of the corresponding films. The peak intensity of the lower one is smaller than that of the upper one, and an interference fringe of the lower one is not as clear as that of the upper one. These show that the lower superlattice has low crystalline quality. We found that some sub peaks around the peak originated from Sb_2Te_3 in the upper superlattice. We believe that these are reflected from the superlattice structures, but there has been no detailed analysis.

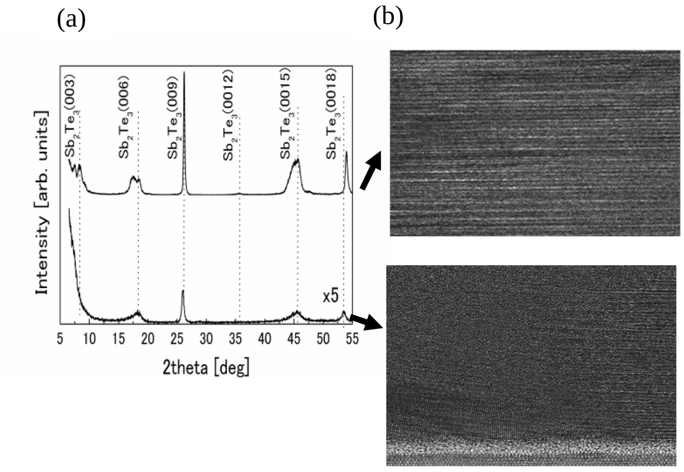

Figure 1 (a) XRD spectra of superlattice films with our first attempt (lower) and optimized one (upper). (b) TEM images of superlattice films.

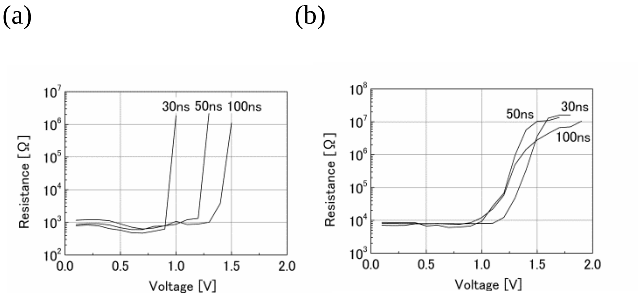

Figure 2 RESET characteristics with various pulse widths of superlattice PCM (a) and alloy PCM (b).

Figure 2 shows the pulse width dependence of (a) the superlattice PCM and (b) the alloy PCM on RESET operations. The superlattice PCM exhibited a strong dependence on the reset pulse width, but the alloy PCM exhibited no dependence. We assumed that the lower resistance state was more stable than the higher resistance state on the superlattice PCM, and the longer pulse width resulted transition to the lower resistance state after the transition to the higher resistance state in one pulse. We measured the lower resistance at lower voltage with a longer pulse. However, the high voltages with the longer pulse resulted more transition to the higher resistance state from the lower resistance state. We found that the resistance was fixed to the higher resistance state. With the alloy PCM, phase change occurred between the crystalline phase and the amorphous phase. In SET operation on the alloy PCM, longer pulse is needed for the transition, and no change occurred on shorter pulse such as from 30ns to 100ns.

We discussed the XRD spectrum of high-quality superlattice films and the special electrical characteristics of the strong pulse width dependence on the RESET operations.

Acknowledgement

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