Superlattice-like Phase Change Random Access Memory

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Abstract

Phase change random access memory (PCRAM) is one of the best candidates for the non-volatile memory beyond 45 nm. PCRAM is based on the principle of chalcogenide-based phase change induced by electric pulses. To achieve high performance PCRAM, various factors have to be considered during device design. For example in order to increase the write speed of PCRAM, material with a high crystallization speed is desired. However, such material is normally unstable. In application, some opposite requirements for the materials have to be balanced. The main objective of this work was to use "superlattice-like" (SLL) structure to engineer the device so as to achieve a high write speed and meanwhile keep the high stability. A SLL structure incorporating two non-promising phase change materials was applied to PCRAM. One material of this SLL structure has a high phase change speed but a poor stability, whereas the other has a good stability but a low phase change speed. Neither of them could meet the requirement of PCRAM when used alone. However, a properly designed SLL structure could balance both the phase change speed and stability. In this work, the PCRAM with SLL structure exhibited reduced programming current. The fastest working time of 5 ns was observed for both RESET and SET. A methodology and TEM were used to evaluate the retention of the SLL structure and the result showed that the retention of the SLL structure is about 10^7. The performance of the SLL PCRAM was found to be related to the compositions of the phase change element materials, such as the ratio and film thicknesses. The main reason for these excellent performances is related to the difference in the thermal conductivities between the SLL and bulk materials.