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Superlattice-like Sb-Ge thin films for high thermal stability and low power phase change memory

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Abstract

The thermal properties of Sb-Ge superlattice-like thin films have been experimentally studied for phase change memory. The Sb-Ge superlattice-like thin films have a high crystallization temperature (223 °C). The interdiffusion coefficient D_{λ} was determined by measuring the intensity of the low-angle X-ray diffraction arising from the modulation as a function of annealing time. The temperature dependence in the temperature range 80-200 °C is described by $D_{\lambda}=8.3 \times 10^{-24} \exp(-0.42 \text{ eV/kT}) \text{ m}^2/\text{s}$. The thermal stability of Sb-Ge superlattice-like thin films can also dramatically be improved with the increase of the temperature. The density variation of Sb-Ge superlattice-like thin films changes by only around 8% between amorphous and crystalline states, which is very important for device reliability. The threshold current and threshold voltage of a cell based on Sb-Ge are 8.15 μA , 1.07 V, respectively. The lower RESET power is presented in the PCM cells of Sb-Ge superlattice-like thin films, benefiting from its high resistivity.

Keywords: thermal property, Sb-Ge, superlattice-like, thin films

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1. Introduction

Phase change materials (PCM) have been extensively studied in the field of nonvolatile memories (such as flash memory and dynamic random access memory) for decades as they combine high speed, excellent data retention and low switching power[1-4]. Phase change memory is based on reversible switching between amorphous and crystalline states for solid state devices. The most representative materials are nucleation-dominant $\text{Ge}_2\text{Sb}_2\text{Te}_5$ (GST) [5-8] and growth-dominant Sb-based compositions.[9-11] The Sb-based phase change materials have encouraging phase transition characteristic of fast speed. However, the thermal stability especially its amorphous stability which affects the data retention.of this kind of materials are poor, The doped Sb binary phase change compounds, such as: Al [12-13], In [14], Mg [15], Ga [16-17], C [18], Si [19], Er [20],Ti [21] and ternary phase change compounds such as SiC [22] are found to exhibit better thermal stability over wide composition ranges than that of GST. Besides, superlattice-like (SLL) PCM materials have been paid more attention for its low thermal conductivity and small grain size [23]. Such as superlattice-like SnSb_4/Ge films have been affirmed to have a rapid crystallization

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