Phase-change control of ferromagnetism in GeTe-based phase change magnetic films

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We focus on the structure and magnetic properties of a phase change material $Ge_{50-x}Fe_xTe_{50}$ by pulsed laser deposition. It shows a rapid and reversible control of optical, electrical and magnetic properties by phase change. The *in-situ* deposited crystalline $Ge_{50-x}Fe_xTe_{50}$ thin film has a rhombohedral structure with preferred c-axis orientation and column growth. The microstructure analysis by Raman scattering reveals a significant change of the main vibration modes in crystalline GeTe due to Fe incorporation. A distinct blue-shift of the long Ge-Te (3.13 Å) happens with Fe incorporation while an enhancement of the short Ge-Te (2.80 Å) and a nearby new Fe-related vibration mode are apparent. We compare it with amorphous GeTe and find that the change of Raman spectrum for crystalline GeTe after Fe incorporation, which induces the weak bonds to be weaker and strong bonds to be stronger, is most likely the Raman features for amorphous GeTe. Thus, the amorphous state of $Ge_{50-x}Fe_xTe_{50}$ will be more stable than that of GeTe and the crystalline temperature will increase, which is similar for Co doped GeTe. Spin is effectively injected into GeTe through Fe incorporation. The magnetic state for the ferromagnetism has been discussed in detail and is found to be related to the particular growth of the crystalline thin film. Furthermore, the $Ge_{50-x}Fe_xTe_{50}$ thin film exhibits different ferromagnetic property as well as electrical property between amorphous and crystalline phases, which indicates that a fast control of ferromagnetism by phase change can be realized. The measurement of temperature dependent magnetization shows a long range ferromagnetic interaction in ordered crystalline phase and a short range ferromagnetic interaction in frustrated amorphous phase, which is consistent with the characteristics of crystalline and amorphous structures. This result shows that the ferromagnetism is consistent with a certain state during phase change even the crystallinity differs somewhat when the state is crystalline. We may expect a new multi-functional spintronic device once this phase change magnetic material is used as the switching area in a phase change random access memory.

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