EFFECT OF Sn AND Zn DOPING ON PHASE-CHANGE MATERIALS FOR OPTICAL AND ELECTRICAL MEMORIES

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Phase – change materials are very successfully utilized as an information recording media in the several generations of optical disks. Continuous research on these materials currently is concentrated on further increasing of the recorded information density and the data transfer rate. The crystallization speed is one of the crucial properties for realizing these research and development goals. Recently there is increasing interest on the application of the phase change materials in the non-volatile random access memory. The strong technological interest on this class of materials is due to their unique properties. In this contribution we will present some experimental results on so-called Sb – based phase change materials for high – speed reversible optical storage as well as the influence of Sn and Zn doping on the properties of $Ge_2Sb_2Te_5$ (GST) relevant to the non – volatile electrical memory application.

Antimony based phase – change compositions combine fast crystallization with high amorphous state stability [1]. Among them Ge-Sb and In–Sb possess a number of attractive properties. GeInSb based thin films and optical disks with IPIM stack structure are prepared and the influence of the Sn and Zn doping on the writing/erasing characteristics and crystalline structure is studied. Fig.1 shows CNR and erasability behaviour of disks with GeInSbSn phase-change layer as a function of the writing power at different ε ratios (Pe/Pw). More than 47 dB CNR and 25 dB erasability are obtained by using wide ε margin from 0.33 to 0.50. Good CNR and erasability is measured even at relatively lower writing powers for Zn doped GeInSb disks as shown in Fig.2. The low Pw operation is important in blue laser recording. XRD analyses of crystalline Zn and Sn doped GeInSb films reveal only Sb hexagonal phase, however the existence of other phases could not be ruled out completely and need further clarification. The measured average grain size between 20 and 30 nm suggests that low media noise should be expected with these kinds of materials.

$Ge_2Sb_2Te_5$ is up to now most studied material for the application in non-volatile memories. Although possessing numerous attractive properties this material is operating by using high reset current as well as the stability of the amorphous state is not sufficient [2]. The influence of Zn and Sn doping on the electrical resistance, crystallization and structure of the doped GST is studied. Fig.4 shows a typical resistance vs. temperature curve for GST and doped GST films on glass substrate. More than 2 orders of magnitude decrease of the resistance is observed during the amorphous to crystalline phase transformation. The crystallization onset shift measured at different constant heating rates is used for calculation of the crystallization activation energy (Ea) using the so-called Kissinger analyses (inset in Fig.4). Figs. 5 and 6 present the measured and calculated data for the crystallization onset temperatures and Ea of materials with different doping level. Tx and Ea increase as Zn doping to GST increases and Ea is not significantly changed while Tx decreases with Sn doping. On the graphs 10, 12 and 15 mean the sputtering power on the doping element target rather than the atomic % concentration in the GST: doping element films. The actual doping concentration is lower than these numbers. The crystalline grain size approximately 40 nm is measured after annealing to 150 °C and grain size slightly increases in the films annealed to 300 °C. Single crystalline NaCl-type phase is formed after annealing to 150 °C and this phase is not changed also after annealing to 300 °C in our experiments using the doping levels marked on the Figs. 7 and 8.

The influence of Zn and Sn doping on the performance and some basic properties of the phase change materials for both optical storage and electrical memory applications is studied. These dopants in appropriate concentrations influence on the behavior of basic GeInSb and $Ge_2Sb_2Te_5$ compositions so the overall performance of the doped phase change material could be tuned for the specifically targeted application. More details will be presented at the meeting.

References:

1. L. van Pieterson, M.H.R. Lankhorst, M. van Schijndel, A.E.T Kuiper and J.H.J. Roosen, J. Appl. Phys., 97(8) 2005, pp.1-7.
2. A. L. Lacaita, Sol. State. Electron., 50 (1) 2006, pp.24-31.

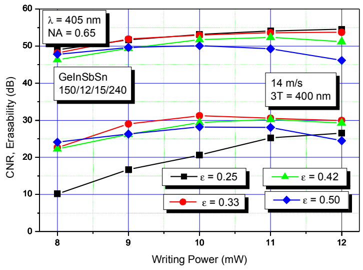

Fig.1. Pw dependence of CNR and DC erasability of GeInSbSn disk at different ε ratios.

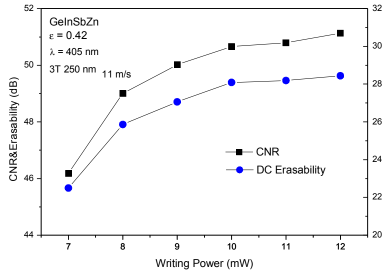

Fig.2. Writing power dependence of CNR and DC erasability of GeInSbZn disk

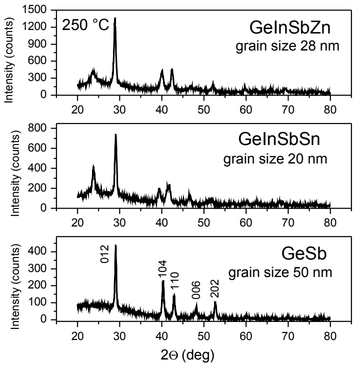

Fig.3. XRD of some antimony based thin films

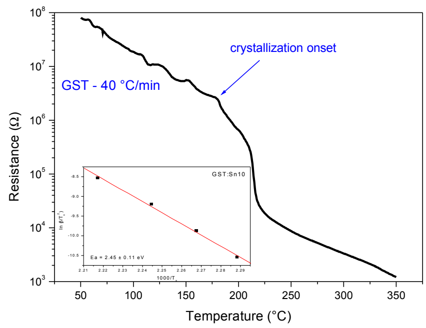

Fig.4. Typical resistance vs temperature curve. Kissinger plot for Ea determination (inset).

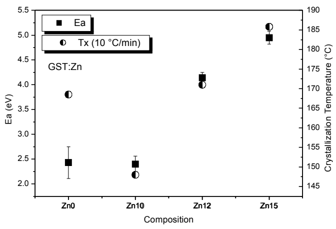

Fig.5 Crystallization temperature and activation energy dependence on Zn doping

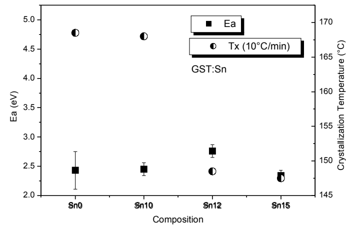

Fig.6 Crystallization temperature and activation energy dependence on Sn doping

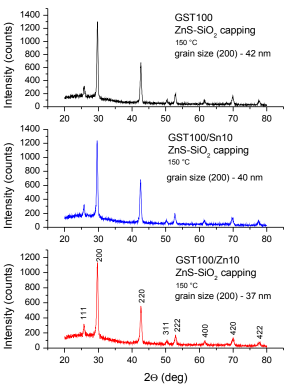

Fig.7. XRD patterns of Sn and Zn doped GST after annealing to 150 °C.

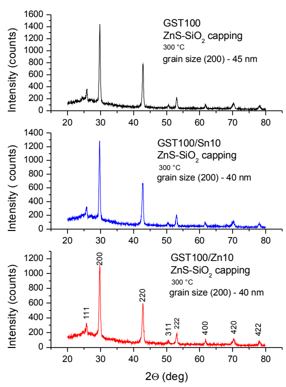

Fig.8. XRD patterns of Sn and Zn doped GST after annealing to 300 °C.