Coherent phonon modes of Polycrystalline and Amorphous GST thin films: a fingerprint of structure and bonding

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ABSTRACT

Key words: $Ge_2Sb_2Te_5$, Raman Modes, pump-probe, polycrystalline, amorphous, COP

Coherent optical phonons (COP) can provide unique insight into the structure and phase change process within materials such as $Ge_2Sb_2Te_5$ (GST) used in data storage applications. A femtosecond (fs) optical pump-probe measurement technique has been used to study as-deposited polycrystalline (37 nm) and amorphous (57 nm) $Ge_2Sb_2Te_5$ (GST) films grown on SiO_2(15 nm)/Si(001) substrates. The linearly polarized pump pulse of 800 nm wavelength, 80 fs duration and fluence of 0.42 – 2.7 mJ/cm^2 was applied at close to normal incidence. A similar s-polarized probe pulse, incident at 45°, with fluence of 0.2 mJ/cm^2 was used to record time resolved reflectance (R) and anisotropic reflectance (AR) signals. Within the AR signals an initial peak of close to 100 fs duration, due to the specular optical Kerr effect (SOKE), is followed by COP oscillations of about 4.5 THz frequency in both films. Measurements were made as pump and probe were polarized at different angles relative to the crystallographic axes of the Si substrate and to each other. The 4.5 THz oscillations were also observed in the R response of both films, and can be associated with either the A_1 optical mode of distorted Te-Te chains [1] or the A_1 optical mode of a Sb_2Te_3 sublattice [2]. Another mode of 2.3 THz frequency was observed in the AR signal from the polycrystalline sample but only when the probe was polarized parallel to the cube edge of the Si substrate. This mode most likely arises from the Si substrate which is sensed through the thinner (35 nm) polycrystalline GST film. Additional Raman microscope measurements confirmed the presence of the modes observed in the pump-probe measurements. After exposure of the films to pump fluences in excess of 2.77 mJ/cm^2, the 4.5 THz mode disappeared and a COP at 3.5 (3.6) THz frequency was observed in both R and AR signals from the polycrystalline (amorphous) films. The 3.5 THz mode has been associated with the degenerate Eg mode of crystalline Sb_2Te_3, for which atoms in the outer Sb and Te layers vibrate parallel to the c-axis [1]. While the modes observed in our pump-probe measurements on polycrystalline and amorphous GST films are similar to those reported previously, our results differ from those of reference 1 in that the 3.7 THz mode was not observed within either the polycrystalline or amorphous as-deposited films. This suggests that substantial differences in coordination and bonding may exist between nominally similar films depending upon their thermal history.

REFERENCES

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Biographies

I am Ashawaraya Shalini, final year "Phd student" in Exeter University, working under the supervision of Prof. Robert J Hicken. My research plan is to study $Ge_2Sb_2Te_5$ (epitaxial/polycrystalline/amorphous) thin films optically and to investigate if non-thermal transition exists in phase switching of phase change materials. I am using time-resolved femtosecond optical pump-probe technique to understand the 'Reflectance' and 'Anisotropic Reflectance' signal of the sample upto few ns delay. The response of the alloy to the polarization of the optical pulse is also explored, since the observation of optically induced birefringence provides a better understanding of the non-thermal nature of the transition.

Prior to phd, I have worked in KLA-Tencor (year 2009), a product-based semiconductor company in bay area. This company builds the inspection and metrology tools to help IC manufacturers to manage yield throughout the entire wafer fabrication process from R&D to final yield analysis. I worked as "Field Application Engineer" to demonstrate the macro-defect detection tools (VIPER 24xx series) capabilities to worldwide customers to help them identify and solve their process issues.

I have received M.Tech degree from IIT Delhi, India (year 2005) with master's project under the joint supervision of Prof M Wuttig (RWTH Aachen, Germany) and Prof S C Kashyap (IIT Delhi, India).