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XAFS study of structural changes under hydrostatic pressure in Ge-Sb-Te alloy used in near-field recording with nanometer size marks

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One of the most developing technologies today are those related to multimedia and the internet. These raise demand in several fields one of these being memories that are continuously denser and faster. Rewritability is often another important requirement. There are different approaches to solve the arising problems, one of the most promosing ones being rewritable optical memories that utilise a reversible phase transition induced by laser pules. While the phenomenology of phase-change recoerding is very simple: intense laser pulses melt the initially crystalline recording media that is subsequently transformed into the amorphous state (optical reflectivities of the two phases being different) and optical disks such as digital versatile disks (DVDs) have been commercially available for over a decade, it is only recently that the structural changes underlying the phase transition has been understood [1,2]. As we have demonstrated in a recent Nature Materials publication [1], the phase transition in Ge2Sb2Te5, the material of choice in DVD-RAM, does not consist of disordering of the covalent networkbut primarily consists of a switch of Germanium atoms between octahedral and tetrahedral positions within the Te face-centered cubic (fcc) lattice. We have also demonstrated that when in the crystalline state, the Ge atoms are diplaced from the center of the cell, i.e. the structure is distorted and for this reason there is a net dipole moment.

The same material is used in Super-resolution near-field structure (Super-RENS) optical disks that allow one to achieve bit size well below the diffraction limit staying within thin film technology and using an inexpensive red laser.

The mechanisms of Super-RENS recording and readout are are matter of debates.We have previously proposed that the presence of the dipole moment may be crucial for the Super-RENS readout [3] within the suggested ferroelectric catastrophy model.

Application of pressure changes ferroelectric properties of GST and thus pressures generated in the optical disk during the recording/readout may be crucial for Super-RENS disk performance.

It should also be noted here that when a recorded bit is molten, huge stresses are generated. A simple estomate based on the thermal expantion coefficient demonstrated that pressured up to 10 GPa can be generated that may, and most likley do, influence the disk performance.

In order to investigate the effect of pressure on the structure of the recording media and the disk performance we undertook high-pressure XAFS studies of GST.

Ge K-edge XAFS spectra were taken previously and it was demonstrated that both shorter and longer bonds shrink under pressure in the range 0 to 9 GPa (followed by a blow out).

During this measurement we measured XAFS spectra of GST in the pressure range 0 to 11 GPa at Sb and Te edge as well as also measuring the Ge edge spectra at 10 and 11 GPa.

The samples were 3 um thick films deposited on both sides of a Kapton substrate. To protect the GST layer from oxidation the film was capped on both sides by 10 nm thick SiO2 layer. The samples were anealed at 180°C for 2 hours to induced crystallization. The crystal structure of the sample was checked using laboratory equipment.

The sample for XAFS mesurements was a stack of 12 (for Ge-edge) to 20 (for Sb and Te edges) layers put together and mounted into a high-pressure cell.

Preliminary data analysis was performed using Athena/Artemis package. A typical result is shown in Fig. 1. For Ge-Te bonds as a function of pressure we previously found that both the longer and shorte bond lengths decrease with pressure, the chenge being more pronounced for the longer bonds. Sb-Te bond lengths show a similar trend (Fig 2).

At present a more detailed analysis of the results is being performed concurrently with the x-ray diffraction data that were obtained independently on an identical sample.

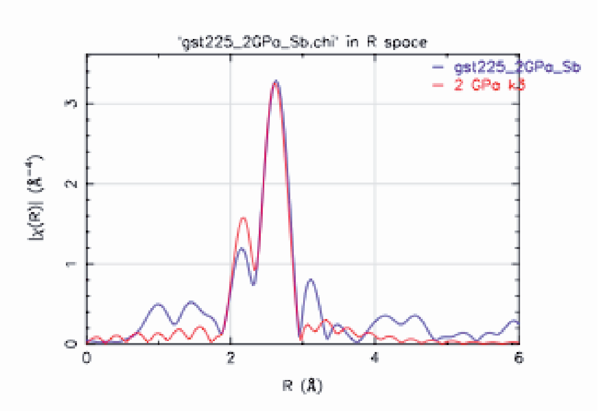

Fig.1 Experimental (blue) and simulated (red) spectra for Sb K-edge at 2 GPa

References

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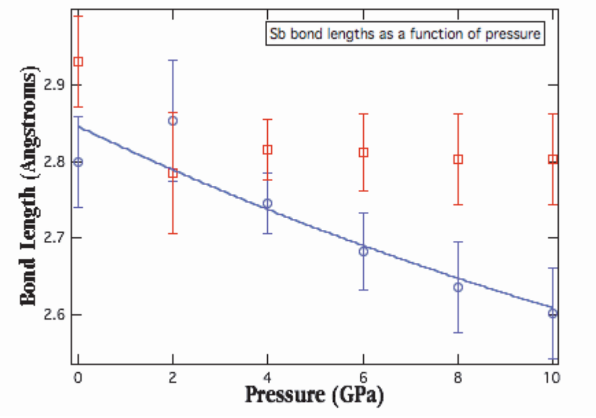

Fig.2 Sb-Te bond length variation with applied hydrostaticpressure (squares and circles correspond to subsets of shorter and longer bonds)