ESRF	**Experiment title:** An inelastic X-ray scattering study on amorphous and crystalline phase change materials	**Experiment number**: MA-2031
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Report:

During the beam time allocated for proposal MA-2031 inelastic x-ray scattering on several polycrystalline and amorphous Ge-Sb-Te phase change materials was measured at room temperature.
The experiment was performed at energies of 17.8 keV and 23.7 keV with energy resolutions of 2.9 meV and 1.6 meV, respectively.
Powder samples were produced by scratching off 2 µm thick films sputtered on Kapton foil. Frozen carbon dioxide was used in order to cool the samples while scratching off the films in order to prevent crystallization.
The samples investigated are $GeSb_2Te_4$ as deposited, annealed at 110°C and annealed at 150°C and $Ge_2Sb_2Te_5$ as deposited, annealed at 126°C and annealed at 150°C. The annealing time was 30 minutes with a heating ramp of 2°C/min. Phase purity was confirmed at the beam line using x-ray diffraction. The as deposited and the 110/126°C annealed samples are amorphous while the 150°C samples are in the cubic phase.
The powder-averaged density of phonon states was extracted by using the log-fourier method [1] known from nuclear inelastic scattering and by assuming an average q-dependent recoil energy.
The density of phonon states of $GeSb_2Te_4$ and $Ge_2Sb_2Te_5$ measured at 17.8 keV are shown in Figure 1 and 2. At 23.7 keV the density of phonon states was measured of amorphous and cubic $GeSb_2Te_4$ only due to time constraints. The data is shown in Figure 3.

Combining our ^{121}Sb and ^{125}Te nuclear inelastic scattering (NIS) results for $GeSb_2Te_4$ [2] we can determine the Ge contribution to the density of phonon states. The data analysis in order to extract the Ge element specific density of phonon states is still in progress. A correct normalization of the density of phonon states is crucial and can be performed using the Lamb-Mössbauer factor. While the Lamb-Mössbauer factor for Sb and Te is known from NIS [2] the one for Ge is unknown and ^{73}Ge nuclear forward scattering (NFS) [3] might be of use in the extraction of the Ge element specific density of phonon states.
From the comparison of the density phonon states of the as deposited and 110°C/126°C annealed amorphous phase we can identify a clear change of the optical phonon modes – indicated in Figure 1 and 2 - which might be related to a structural relaxation. Further data analysis is ongoing.

[1] D. Johnson and J. Spence, *Journal of Physics D: Applied Physics* **7** 771 (1974)
[2] T. Matsunaga *et al.*, *Adv. Func. Mater.* **21**, 2232 (2011)
[3] Simon *et al.*, Europhysics Letters **104** 17006 (2013)

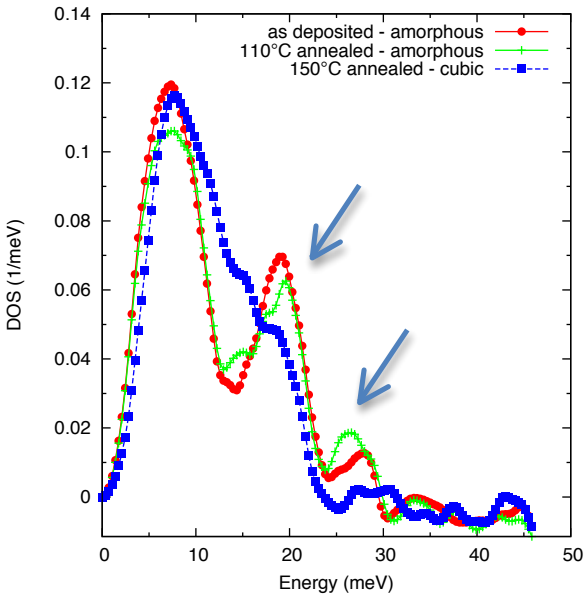

Figure 1: Powder-averaged density of phonon states in amorphous and cubic $GeSb_2Te_4$ measured at 17.8keV.

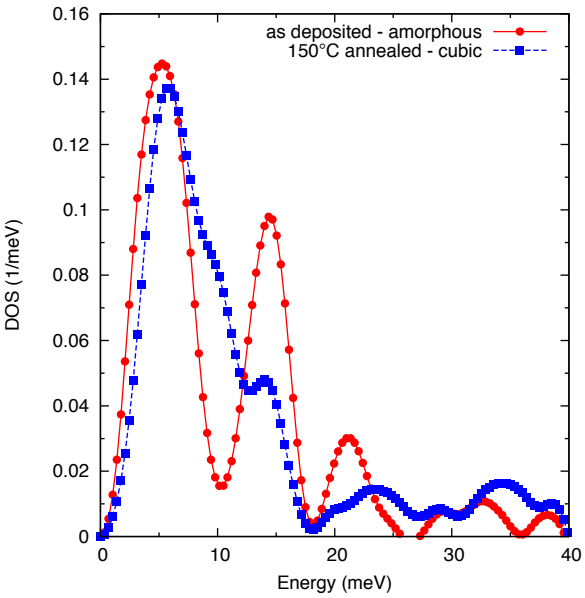

Figure 3: Powder-averaged density of phonon states in amorphous and cubic $GeSb_2Te_4$ measured at 23.7keV.

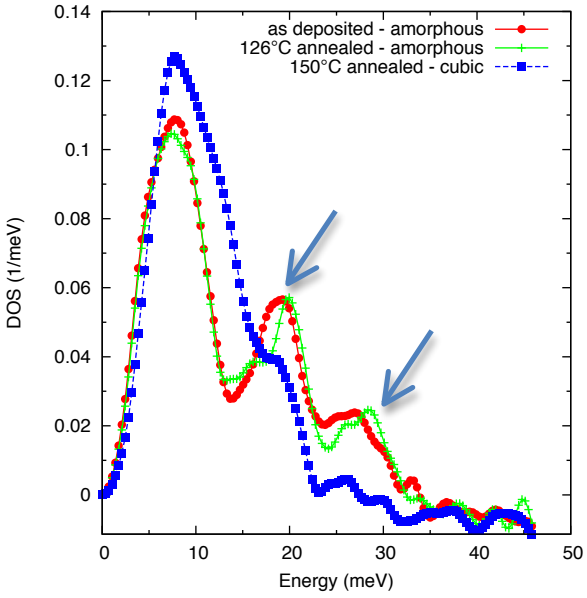

Figure 2: Powder-averaged density of phonon states in amorphous and cubic $Ge_2Sb_2Te_5$ measured at 17.7keV.