Experiment Title: EXAFS investigation of the size effects in the phase change properties of sub-10 nm Phase Change Material clusters

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The samples consist in $Ge_2Sb_2Te_5$ clusters (GST) with 6 nm diameter, either in the form of 10 nm thick clusters films cladded with alumina, or multilayers with five repeat of half-monolayers of clusters in alumina. Sputtered $Ge_2Sb_2Te_5$ thin films were also measured to provide standards for analysis.

The set of cluster-based and thin films samples that have been measured at the Ge, Sb, and Te K-edges (unless otherwise specified) is the following:

- 30 nm thin film, as-deposited;
- 5 nm thin films; both as-deposited and 280°C-annealed (Sb K-edge);
- Clusters multilayers, both as-deposited (Ge and Te K-edges) and 280°C-annealed (Sb K-edge);
- Clusters layers, both as-deposited and 280°C-annealed;
- Clusters layer with 15% N_2, as-deposited;
- Clusters multilayer with 15% N_2, as-deposited (Ge K-edge);
- Clusters multilayer in Al (Ge K-edge).

Data are of good quality and will permit a quantitative data analysis.

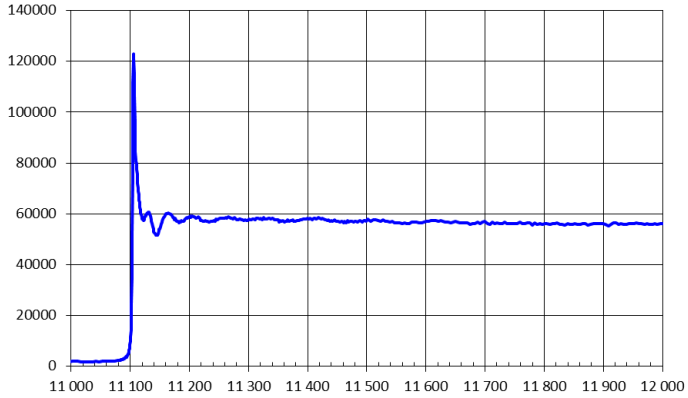

Figure: Ge K-edge of the $Ge_2Sb_2Te_5$ thin film layer cladded in alumina.

The main observation is that a fraction of Ge-O bounds is clearly present in the Ge environment for all the samples. It is related to the interface with alumina, since the Ge-O bound fraction, relative to Ge-Ge, Ge-Te and Ge-Sb bounds is correlated with the interface area of $Ge_2Sb_2Te_5$ with alumina. In the 30 nm thin film the Ge-O contribution is low and corresponds to a 1 nm thick layer on the bottom and on the top of the layer. In the 5 nm layer the contribution is larger, corresponding to a larger relative interface area. In the thick cluster layer it is still larger, and in the multilayers, the Ge-O / Ge-X ratio (with X = Ge, Sb, or Te) is close to 50%, corresponding to a very large contact area between Ge atoms and alumina.

It could not be excluded that a fraction of the Ge-O bounds is due to the exposition of deposited clusters and layers to an oxygen contamination of the sputtering argon gas, or to a residual oxygen pressure in the deposition chamber. After the run however the contamination of argon and the leaks in the chamber were extensively searched which did not confirm these hypotheses. Other hypotheses comprise the onset of an oxygen pressure during the ramping of the RF power before the alumina deposition, or the porosity of the 10 nm alumina layer.

On the other hand in all the groups of samples one sample was annealed in an optical reflectivity setup (visible range), and the crystallization temperature was observed, at the standard $Ge_2Sb_2Te_5$ value for the thick layer.

As for the diluted $Ge_2Sb_2Te_5$ clusters in alumina the EXAFS observations and the fact that half of the Ge atoms are bound to oxygen atoms suggest that the clusters present a Ge-depleted GST core surrounded with a Ge shell which interacts with the cladding. For 6.2 nm diameter clusters the atom number is 3850 from which 850 are Ge atoms and 1000 atoms constitute the outer layer. In the case of a Ge-rich outer shell, it is clear that a large fraction of Ge atoms will be in contact with the cladding material.

The further analysis of these data, correlated with XPS analyses of the layers will give us the opportunity to prepare samples in which the interactions of outer atoms could be minimized, in order to precise the morphology (homogeneous *vs* core-shell) and the environment of atoms in $Ge_2Sb_2Te_5$ clusters, in a future run on this beam line.