

Experimental report of the beamtime MA-2958

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Beamline BM25-A

Scheduled time: 01/Jul/2016@08H00 - 05/Jul/2016@08H00

Summary

This proposal aims the investigation of Tb-Fe-Ga ternary compounds by means of XAS to establish the electronic structure of Tb, Fe and Ga and the local environment of Tb and Ga atoms in sputtered thin films and the relation with the displayed magnetic properties. The objective is to study the correlation between the composition and the sputtering parameters with the local ordering. These structural and chemical data are fundamental for the understanding of the magnetic properties of these compounds, which will determine their applications.

Experimental procedure

Standard XAFS experiments were carried out in Tb-Fe-Ga thin films grown under different sputtering regimes. XAFS spectra were acquired in the Tb L3-edge, Fe and Ga K-edges in fluorescence yield mode and in transmission for the powder and foil references.

We satisfactory got good quality spectra merging from 3 to 4 single spectra. The EXAFS spectra were acquired upon photoelectron wavenumber values of 15 \AA^{-1} for the Fe and Ga K-edges and upon 10 \AA^{-1} in the Tb L3-edge. In spite of a noisier Tb EXAFS experimental data, the global good quality of the spectra from all the elements makes possible to obtain valuable information from all of them.

Preliminary Results

We have preliminary analyzed the XAS spectra in order to determine the local structure differences between Tb, Ga and Fe and their relation with both growth conditions and relative atomic contents in the alloy. We found noticeable differences in the three edges correlative to the growing conditions. For instance, Fe K-edge shows distortions in the pre-edge shoulder, related to distortions in the bonding geometry of the Fe, and in the white line (fig.1). Similar distortions have been observed in all the edges, but currently we have not performed a detailed structural analysis of the XANES or carried out simulations in order to envisage the origin of such distortions.

The analysis of the EXAFS gives more information about the local structure in the ternary alloys (fig.2). For instance, in the Fe-K-edge we observe that the second neighbor correlation observed in the low power evaporated ternary alloys vanishes for the high power (high-Tb content alloy). Thus, we speculate at this point that either the increase of

the Tb content or the growth rate amorphize the structure. We have also studied binary Tb-Fe and Fe-Ga alloys for further comparisons. For the Tb-Fe compounds, the growth rate seems to have a rather small effect in the local disorder. This result is also observed in the Ga K-edge, where the Ga local structure for binary alloys deposited with a high power is relatively distorted respect to the other conditions.

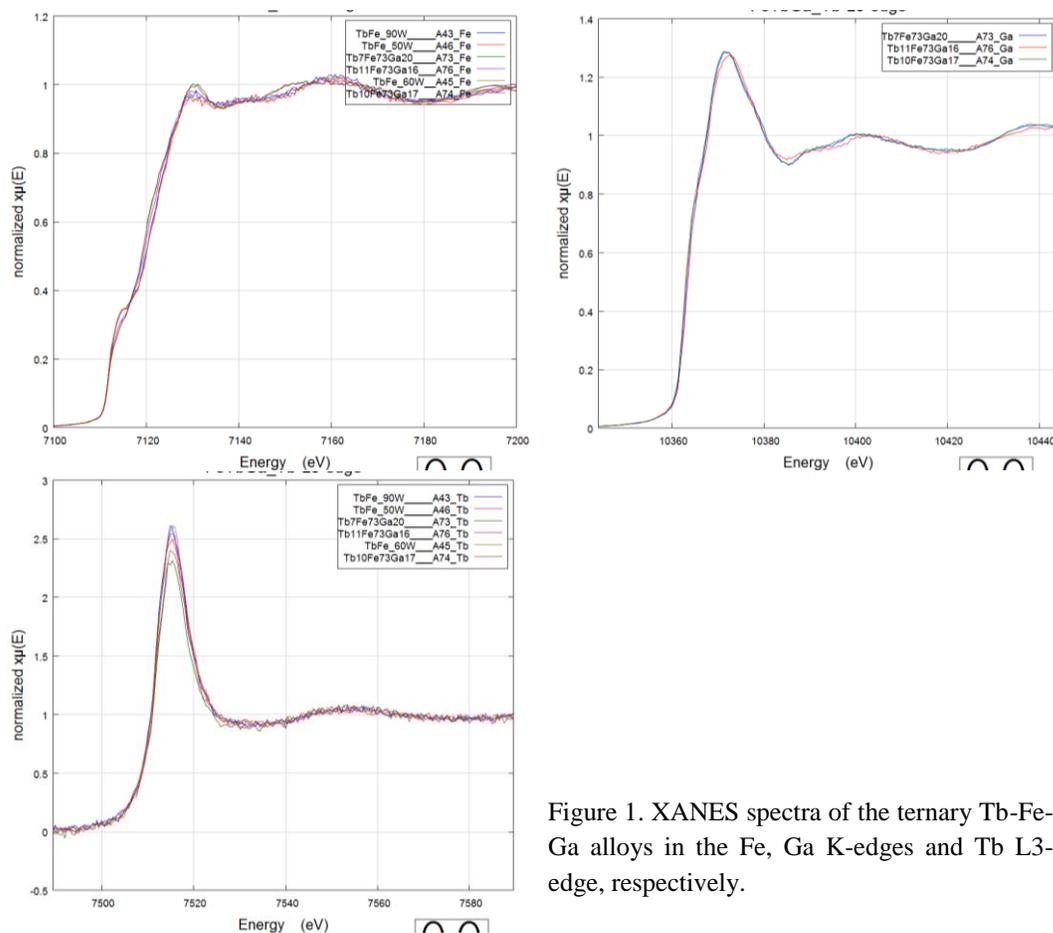


Figure 1. XANES spectra of the ternary Tb-Fe-Ga alloys in the Fe, Ga K-edges and Tb L3-edge, respectively.

Another interesting point to remark is the intensity increase of the first neighbor in the Tb L3-edge with the growth power. This makes us to speculate that the high rate evaporation for Tb promotes the formation of aggregates that in turn, difficult the formation of a crystalline Fe-Ga matrix.

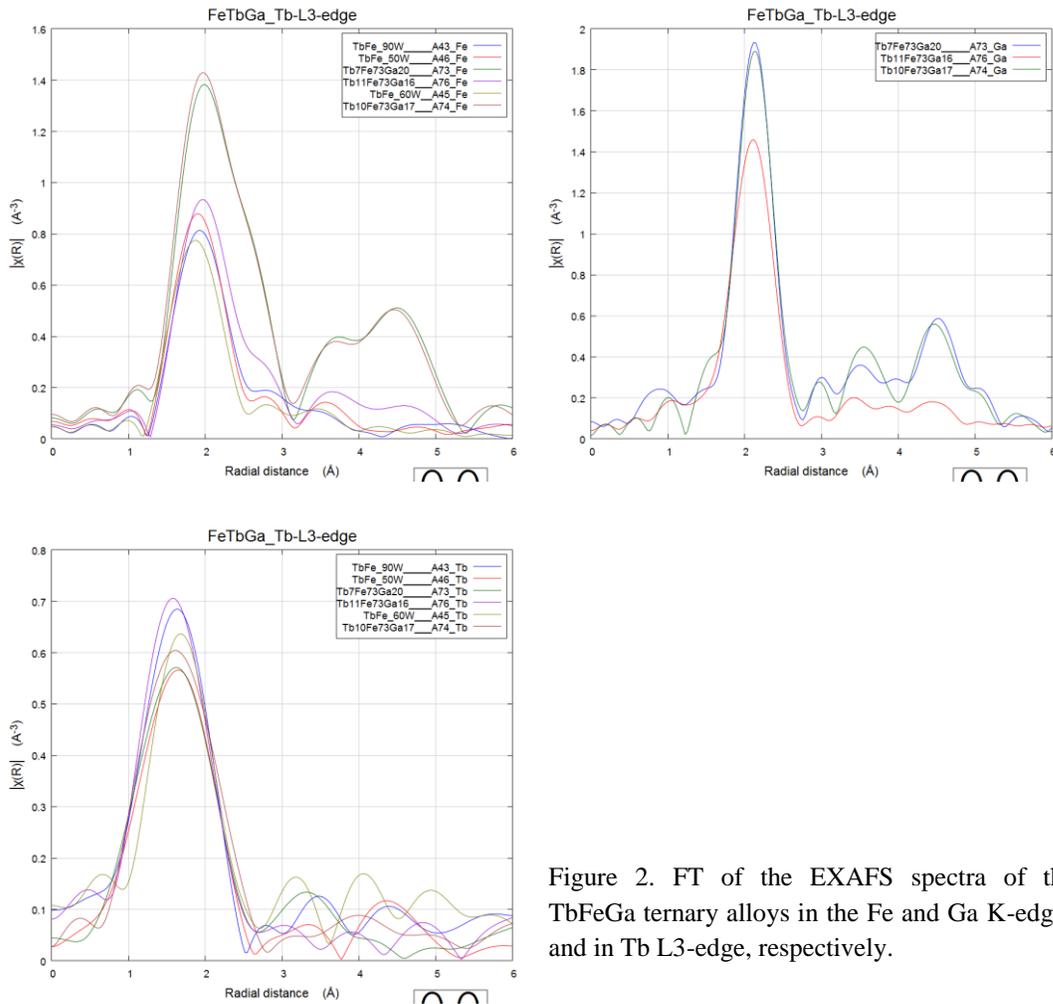


Figure 2. FT of the EXAFS spectra of the TbFeGa ternary alloys in the Fe and Ga K-edges and in Tb L3-edge, respectively.

Discussion

We plan to correlate the structural data obtained by XAS with magnetic information we have obtained from magnetic force microscopy (MFM) and vibrating sample magnetometry (VSM). We have found an out-of-plane component of the magnetization that correlates with the growth power used in each case (figure 3). Conventional x-ray diffractometry did not show relevant difference between samples being therefore essential the use of XAS to correlate structural and magnetic properties.

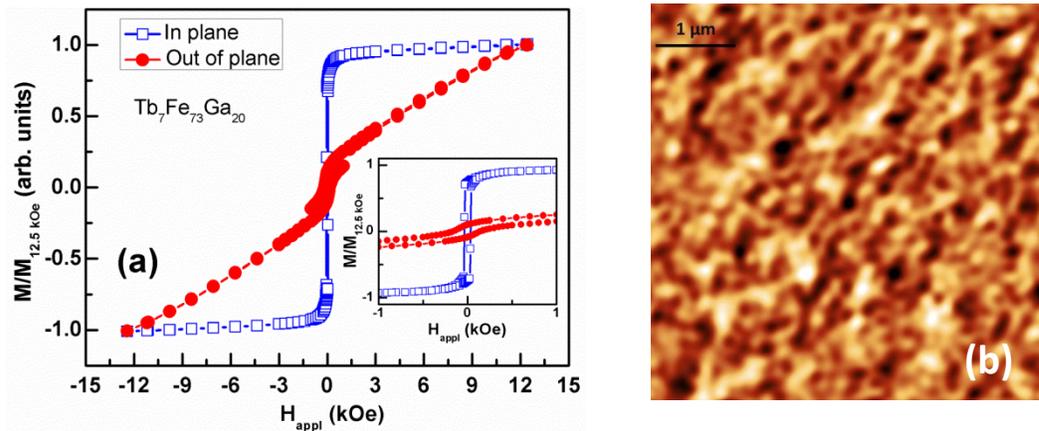


Figure 3. (a) VSM hysteresis loops showing the in-plane and out-of-plane components of the magnetization. (b) MFM image at remanence.

Conclusions and perspectives

The XAFS analysis of the ternary alloys shows: i) the feasibility of this technique for studying these systems, ii) there exist noticeable differences in the local structure of the ternary alloys deposited at different growth powers, iii) the segregation of Tb when using high power can be related to the observed XAFS features.

Due to the success of the current experiment, we are planning to perform a similar study with polarization dependent-XAFS in order to determine if the Tb segregation in the FeGa matrix happens isotropically respect to the substrate plane or has any preferential direction. Following previous experiments in Tb-Fe amorphous alloys [¹,²], we plan to study the relation of anisotropy development (if any) with the Tb content in the ternary alloys.

Problems

There was not any problem during the scheduled beam time.

References

¹ Harris et al. Phys Rev Lett. 69 (1992) 1939.

² Harris et al. Phys Rev. Lett. 87 (2001) 067207.