STUDY OF COMPOSITIONAL INHOMOGENEITIES IN MAGNETIC Fe-Si AND Co-Si AMORPHOUS FILMS BY GRAZING INCIDENTE SMALL ANGLE SCATTERING (GISAXS)

Javier Díaz[(a)], Carlos Quirós[(a)], Francois Fauth[(b)], Alessandro Mirone[(b)] and Jose María Alameda[(a)]

[(a)]Departamento de Física, Universidad de Oviedo, Avenida de Calvo Sotelo s/n, 33007 Oviedo, Spain

[(b)]European Synchrotron Radiation Facility, 6 rue Jules Horowitz, BP 220, Grenoble Cedex, France

javidiaz@condmat.uniovi.es

GISAXS is a powerfull technique to determine density inhomogeneities at the nanometer scale in a medium like amorphous alloys, where borders between grains are extremely undefined due to the important diffusion between alloy components. Inhomogeneities in this kind of films have typical sizes of the order of tens of nanometers, resulting to be elusive to regular microscopical techniques like SEM, TEM, STM or AFM. However, they are easy to detect and measure by GISAXS. In the present work, the distribution, average size and shape of density inhomogeneities were extracted from the GISAXS spectra of magnetic Fe-Si and Co-Si amorphous films 20 nm thick by reproducing the experimental data (figure 1), calculating the x-ray scattering of alloy islands with different shapes embedded in Si using the Distorted Wave Born Approximation (DWBA). Fe-Si and Co-Si amorphous thin films owe their excellent soft magnetic properties to their extraordinary atomic disorder, which has been demonstrated by EXAFS spectroscopy [1]. Despite this atomic disorder, they have uniaxial magnetic anisotropy when Si is deposited at oblique incident angles, with the magnetic easy axis in the plane, and with anisotropy energies two orders of magnitud smaller than bcc Fe [2]. The same EXAFS studies showed the precipitation of Si rich transition metal environments. GISAXS demonstrated that the distribution of these environments was anisotropic, with their anisotropy axis linked to the magnetic easy axis found in the films. Si rich regions were observed mainly at the side of the islands exposed to the incident Si, resulting in a columnar growth of that side of the island with the magnetic silicide columns leaning toward the Si evaporator. This effect was stronger in the Co-Si films as a consequence of the lower interdiffusion of their elemental components as compared to Fe-Si [1]. Their magnetic easy axis was always parallel to this side of the islands. In the case of the Fe-Si films, the homogeneity of the films tested by GISAXS was significantly higher along their magnetic easy axis than in the hard axis direction.

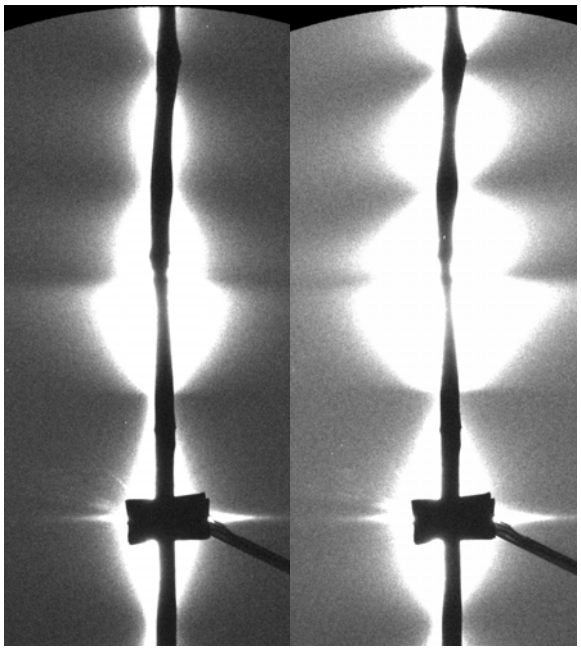

Figure 1. GISAXS images from a Co-Si amorphous 20 nm thick film. Left image, incident x-ray beam was perpendicular to the magnetic easy axis of the film. Right image, incident x-ray beam was parallel to the magnetic easy axis of the film.

References

[1] J. Díaz, R. Morales, M. Valvidares, and J. M. Alameda. Phys. Rev. B 72 (2005) 144413.1-15
[2] J. Díaz, M. Valvidares, R. Morales, and J. M. Alameda. Phys. Status Solidi A 203 (2006) 1409-1414