Phase segregation in Fe-Si and Co-Si ferromagnetic alloys deposited by magnetron sputtering and the origin of their magnetic anisotropy

Javier Díaz, Rafael Morales, S. Manuel Valvidares and Jose María Alameda

Departamento de Física, Universidad de Oviedo, Avenida de Calvo Sotelo s/n, Oviedo-33007, Spain.

Fe-Si and Co-Si thin films were studied with different Si concentrations and crystallinities by x-ray absorption spectroscopy (XAFS), and the analysis was confronted to their magnetic properties of coercivity and anisotropy. Segregation of Si to the surface was observed in all the films, indicating the strong affinity of the TM to be surrounded by Si atoms, and suggesting possible fluctuations in Si concentration within the films. The analysis of the XAFS spectra detected the segregation of TM-Si_2 environments with increasing Si concentration. It also showed a higher disorder in the amorphous Fe-Si films than in the Co-Si films and a larger degree of clustering of Co atoms, in consistency with the higher heat of alloying of Fe-Si with respect to Co-Si alloys. A model is proposed for the anisotropy in these films based on the detected segregation of Si rich environments. Si concentration would be anisotropically distributed in the films due to the oblique incidence of Si atoms during film deposition. The strong uniaxial magnetic anisotropy found in the analyzed amorphous films would be the consequence of the resulting anisotropic exchange between magnetic regions. Figures 1 and 2 compares EXAFS spectra of the polycrystalline and amorphous samples. Note the higher decrease and variation in amplitude of the spectra of the amorphous Fe-Si films compared to those of the amorphous Co-Si films.

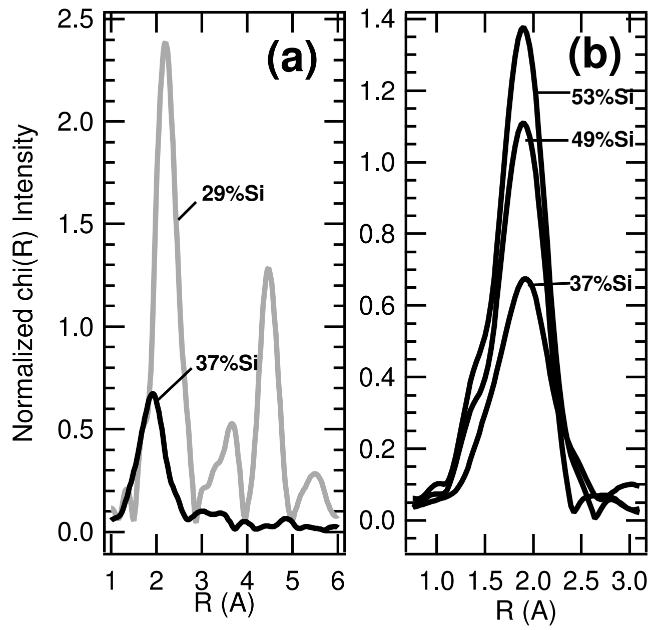

Figure 1: (a) Comparison of the $\chi(R) = F[k^2\chi(k)]$ spectra of the polycrystalline Fe-Si thin films with 29% at. Si concentration (grey line), and that of the amorphous Fe-Si thin film with 37% at. Si concentration (black line). (b) Comparison between the $\chi(R)$ spectra of the amorphous Fe-Si thin films with different at. Si concentrations.

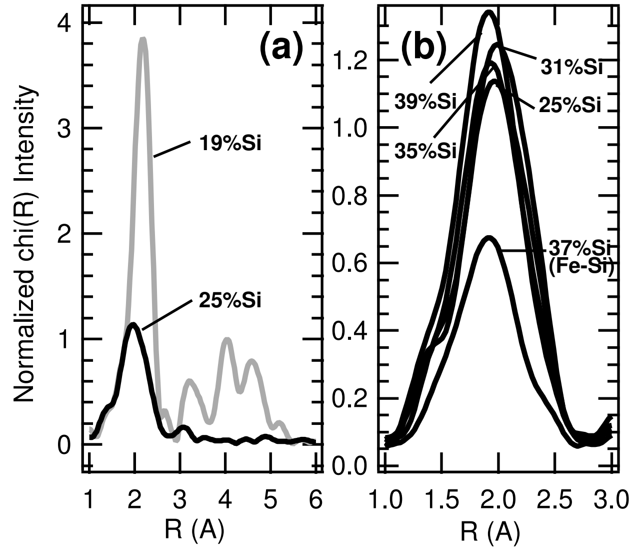

Figure 2: (a) Comparison of the $\chi(R) = F[k^2\chi(k)]$ spectra of the polycrystalline Co-Si thin films with 22% at. Si concentration (grey line), and that of the amorphous Co-Si thin film with 25% at. Si concentration (black line). (b) Comparison between the $\chi(R)$ spectra of the amorphous Co-Si thin films with different at. Si concentrations and that of the amorphous Fe-Si thin film with 37% at. Si concentration.