ESRF	**Experiment title: Interplay between magnetism and ion beam induced roughness in CoSi films and CoSi / Si / CoSi trilayer**	**Experiment number**: MA-198
Beamline: BM05	**Date of experiment**: from: 06-DEC-2006 to: 12-DEC-2006	**Date of report**: 30-JUL-2007
Shifts: 18	**Local contact(s)**: Dr. Luca Peverini	*Received at ESRF:*

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Report:

The aim of the experiment was to study the influence of roughness on (a) magnetic anisotropy of single co-deposited Co-Si alloy films and (b) interlayer exchange coupling of trilayers. In order to do that, several Si(100) substrates were bombarded with an ion gun at different conditions, so that different levels of roughness were induced on them. During the beamtime, after spending some time to solve technical issues related with the sample holder and CCD acquisition and to optimize growth condintions, we could succesfully prepare two 10 nm Co-Si films on top of two different substrates: (a) flat Si(100) (rms roughness of the order of 0.1 nm, as determined by AFM) and (b) ion beam bombarded rough Si(100) (rms of around 0.7 nm). Reflectivity curves were measured for both of them (see Figure 1) and we are currently analyzing them in order to extract the electronic density profile. The qualitative aspect of both curves is similar, although, as expected, the intensity of the rougher one is slightly smaller.

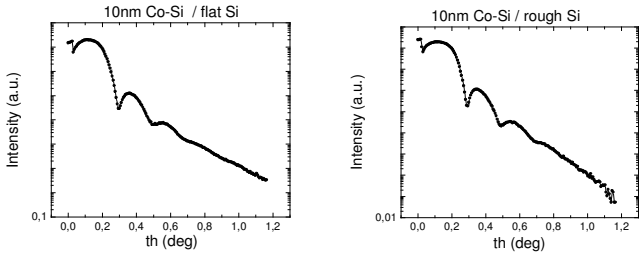

Figure 1. Reflectivity curves from two Co-Si films grown on top of flat or rough Si(100) substrates.

Interestingly, the diffuse scattering images of both films acquiered with the CCD, see figure 2, show clear differences between two orientations of the films, with the x-ray beam either parallel or perpendicular to

the magnetic easy axis. The geometry used is such that the horizontal axis of figure 2 corresponds to out-of-plane q_z direction and the vertical axis to in-plane q_x direction. For the flat sample case, the intensity scattered out of the specular plane is significantly higher in 0º than in the 90º image, confirming that the sample has some degree of structural anisotropy. The case of the rough sample is qualitatively similar, but with more intensity diffused out of the specular plane, as expected for a rougher film. In addition the photons are asymmetrycally scattered at both sides of the specular plane, in the 0º case. It is worth mentioning that the analysis of this images is being carried out in collaboration with A. Mirone, from the theory group of the ESRF, who is developping a model to correlate this diffuse scattering features with the structure and morphology of binary alloy films. The electronic density profiles obtained from figure 1 reflectivity curves and the roughness values obtained from AFM measurements will be incorporated to this model.

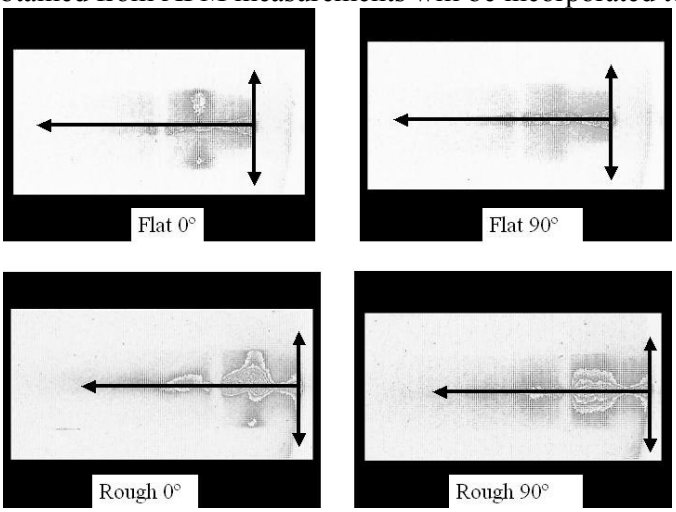

Figure 2. Diffuse scattering images taken with the x-ray beam making an angle of 0º or 90º with respect to the magnetic easy axis.

The corresponding magnetic hysteresis loops are shown in figure 3. The loops indicate that both films are highly anisotropic, with an anistropy field of the order of 1000 Oe. This high value is related to the fact that the Co-Si co-deposition was done with Co atoms at almost grazing incidence from the substrate (since typical values of anisotropy field for amorphous Co-Si films grown at Co normal incidence are 20-30 Oe). Interestingly, both curves show almost the same anisotropy field. The only remarkable difference between them concerns the coercive field, were an increase from about 385 Oe to about 430 Oe has been observed.

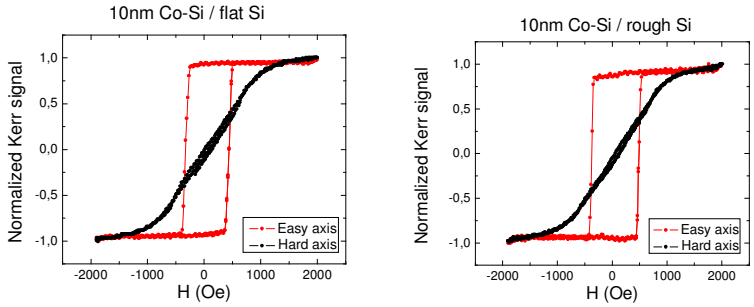

Figure 3. Magnetic hysteresis loops obtained by Kerr effect with the magnetic field applied along the easy or hard axis direction.

These results indicate that the films are clearly anisotropic, both from the magnetic and the structural point of view, and that the effect on magnetic anisotropy of grazing Co incidence is much stronger than that of the ion beam induced roughness, as flat and rough samples have similar magnetic anisotropies. In connection with this discussion, we plan to apply for additional beamtime in order to study more in detail the effect of Co deposition angle both on the diffuse scattering and on the magnetic anisotropy of Co-Si alloys.

Finally, concerning the effect of roughness on the interlayer exchange coupling, we had no beamtime enough to make the in-situ study. However, we have used some of the ion bombarded substrates to prepare different sets of trilayers that have been characterized by Kerr effect and AFM. The preliminary results indicate that a clear enhancement of the coupling strength has been observed for certain roughness values.