ESRF	**Experiment title:** Structural investigation of Co thin films in Ta/Cu/Co/Cu/Ta sandwiches by anomalous X-ray scattering.	**Experiment number:** **HC-352**
Beamline: **D2-D2AM**	**Date of experiment:** from: 08 Dec. 1996 to: 12 Dec. 1996	**Date of report:** **01/03/96**
Shifts: **12**	**Local contact(s):** **Jean-Marc TONNERRE**	*Received at ESRF:*

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Report:

The aim of our experiment is an exploratory investigation to check the possibility of quantitatively characterizing structural defects, such as twinned crystallite and stacking faults, in sputtered Co thin films using X-ray diffraction. Such defects are believed to be potential spin-dependent scattering centers in giant magnetoresistance multilayer. For such structures, a sufficiently large diffracted intensity is obtained with conventional x-ray sources, due to the number of layer repetitions but the structural quality is known to vary along the multilayer stack. Our study is therefore focused on single Co layers in magnetron-sputtered Si(l11)/Ta 50Å/Cu 50ÅCo (20Å or 75Å)/Cu 50ÅTa 50Å sandwiches. A Si(l11) instead of a Si(001) substrate was chosen to take advantage of the common <111 $>_{fcc}$ orientation for both the substrate and the Cu/Co/Cu layers. The upper and the lower Ta layer are the capping and the buffer layer respectively. For each type of sandwich, we also measured samples annealed just below (360°C) and above (440°C) the martensitic transition temperature.

HRTEM observations on these sandwiches indicate an epitaxial growth of the Cu/Co/Cu layers, with a columnar morphology and a strong <11 texture perpendicular to the Si substrate. As shown on the topview diffraction pattern taken along the Si<l11> direction (Fig. 1), the Cu/Co/Cu columns are randomly oriented in the layer plane giving rise to a diffraction ring. The Ta layer shows short-range ordering characterized by randomly oriented stacks of a few atomic planes.

Anomalous x-ray diffraction measurements were carried out in an asymmetric geometry. The scans showed an acceptable S/N ratio even in the diffuse regions in the case of the 20Å Co thickness sample. This demonstrates the feasibility of these quantitative investigations with the high brilliance ESRF source. Also measurements at the XυKα and XυKα absorption edges allowed the satisfying elemental contrast which we expected.

The measured φ–σχανσ confirmed the random orientation of the Cu/Co/Cu columns but revealed that part of this layer stack presents a simple epitaxial relationship to the Si substrate, with parallel Si, Cu and Co (hkl) planes. In addition, Co presents an marked twinning in these epitaxial regions, which is not observed for Cu (Fig. 2). These results show that TEM only gives a partial picture of the structure within the layers. This also addresses the issue about the role of the separating "quasi-amorphous" Ta buffer layer and its role in the Cu and Co layer growth. On the other hand, a number of difficulties could be identified through this preliminary experiment. A main issue is the high intensity of the Si peaks which is a clear limitation for a quantitative interpretation of the results, We have therefore chosen to scan our x-ray diffraction maps in an equivalent area of the reciprocal space. Their interpretation is still in progress. Also the extension of the Co peaks in the φ -scans was found to be rather large, which prevents a proper integration along the truncation rods. Finally an appreciable diffuse intensity was observed in-between the truncation rods, indicating the occurrence of twinning on other {111} planes.

In conclusion, this exploratory experiment allowed us to obtain a number of interesting preliminary results. It confirmed the feasibility of our approach for a quantitative characterisation of stacking faults in very thin layers, emphasizing the high performance of the ESRF synchrotrons source. It also allowed us to define an improved experimental set-up with optimal measurement conditions for further quantitative measurements using anomalous grazing incidence surface diffraction.

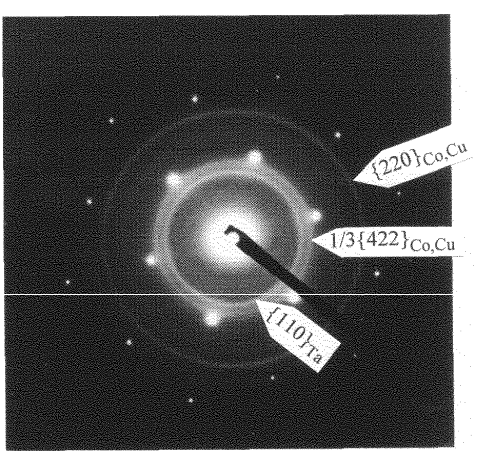

Fig. 1

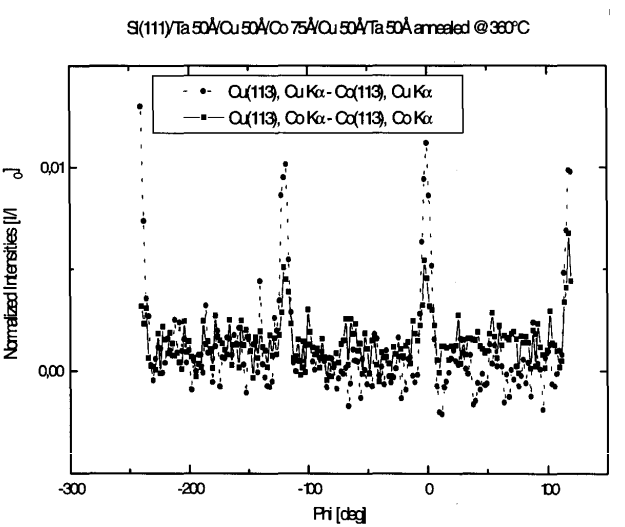

Fig. 2