ROBL-CRG	**Experiment title:** Specular reflectivity on Co/Cu multilayers near absorption edges	**Experiment number**: 20_02_002
Beamline: BM 20	**Date of experiment**: Feb. 6th , 1998 from: May. 10th, 1998 to: May. 12th, 1998	**Date of report**: July 20th, 1999
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Names and affiliations of applicants (* indicates experimentalists):

* Dr. F. Prokert, FZ-Rossendorf , FWIS
* Dr. W. Matz, FZ-Rossendorf , FWIS
* Dr. N. Schell, CRG ROBL at ESRF, Grenoble and FZ- Rossendorf

Report:

For multilayer (ML) systems showing giant magnetoresistance it is of interest to study layer and interfacial properties [1],[2]. Two types of samples with different layer thicknesses of Co- and Cu-layers: Si/SiO_2/8x[Co(4nm)/Cu(4nm)] (Co/Cu-ML 8x[4/4]) and Si/SiO_2/4x[Co(8nm)/Cu(8nm)] (Co/Cu-ML 4x[8/8]) were investigated in the 'as-deposited' state. The MLs were prepared by crossed beam pulsed laser deposition (CB PLD) technique. The layer properties like thickness, mass density and interface roughness of the different samples were studied using specular X-ray reflection (XRR). The high brilliance and tunable wavelength of the synchrotron radiation at ROBL allowed to improve the low contrast for this material combination by setting the X-ray wavelength to the absorption edge of one of the layer materials. Due to the small divergence and the high intensity of the incident beam the angular resolution of the detected beam could be matched to resolve adequately the ML Bragg peaks and the Kiessig fringes. The decrease of intensity could be followed over seven orders. The specular XXR were measured on both types of samples at the K-edge energy of Co (7.708 keV) and Cu (8.974 keV), respectively. With two independent data sets of each sample, the accuracy of the results, obtained from the simulation codes REFSIM (Siemens) and/or REFS (Bede Scientific), could be improved by a cross-check of the fitted values.

Besides mass density (r) and thickness (d) of the layers, we get the rms-roughness values (σ_{RMS}) of the surface and the ML interfaces. The quality of the fits (see Fig. 1) could be improved by introducing a copper oxide capping layer. Further was found that the first Co-layer on the substrate and the last Cu-layer on the top differ in their parameters from the other layers which could be simulated as Co/Cu-stack by a common parameter set. Table 1 shows the results obtained from MLs of two different charges both prepared by CB PLD.

Table 1 Simulation results of two charges of Co/Cu-MLs

		CB PLD samples charge 1			CB PLD samples of charge 2		
ML type	single layers	d (nm) d_{Co}/d_{Cu}	r (g /cm^3)	σ_{RMS} (nm)	d (nm) d_{Co}/d_{Cu}	r (g /cm^3)	σ_{RMS} (nm)
4x[8/8]	Co	13.68	8.4	2.8	17.05	8.7	1.6
	Cu	1.58	8.8	0.8	1.07	8.7	1.6
8x[4/4]	Co	6.67	8.5	1.33	8.2	8.4	1.3
	Cu	1.39	8.8	0.55	1.10	8.4	1.3

(layer thickness $d = d_{Co} + d_{Cu}$, r - mass density , σ_{RMS} - rms-roughness)

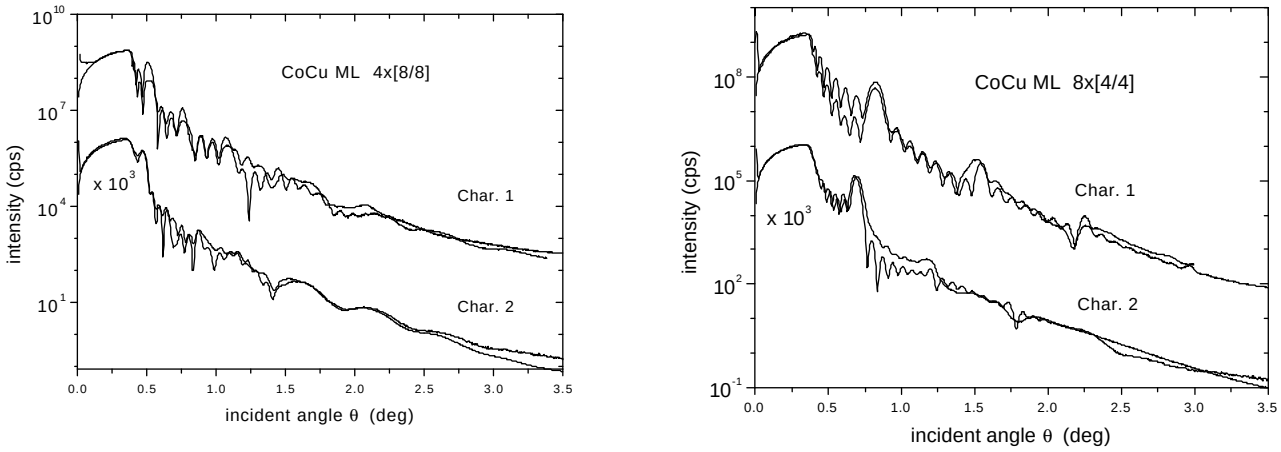

Fig.1 Measured (thick lines) and simulated (thin lines) angular dependence of speculare reflectivity of Co/Cu-MLs. (Co/Cu-ML 4x[8/8] on the left, Co/Cu-ML 8x[4/4] on the right)

Results

In the 'as-deposited' state the MLs, obtained by CB PLD technique, have an extended Co/Cu interface. However, the σ_{RMS}-roughness, especially for the Cu-layers, varies strongly with the deposition conditions. The thickness excess and the higher σ_{RMS}-roughness of the Co-layers are also dependent on preparation.

References

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[2] M.A. Parker, T.L. Hylton, K.R. Coffey, J.K. Howard, *J. Appl. Phys* **75**, 6382 (1994)