ROBL-CRG	**Experiment title:** Diffuse scattering on Co/Cu multilayers near absorption edges	**Experiment number**: 20_02_007
Beamline: BM 20	**Date of experiment**: from: May 5th, 1998 to: May 7th, 1998 from: Sept. 6th, 1998 to: Sept. 7th, 1998	**Date of report**: July 20th, 1999
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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: $Si/SiO_2/8x[Co(4nm)/Cu(4nm)]$ and $Si/SiO_2/4x[Co(8nm)/Cu(8nm)]$ were investigated in the 'as-deposited' state and after tempering at 500°C for 2h. The ML were prepared by crossed beam pulsed laser deposition (CB PLD) technique. The layer properties like thickness and interface roughness of the different samples were studied using specular and non-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 of the incident beam and by use of a sufficiently small receiving aperture the angular resolution of the detected beam could be matched to resolve adequately the specular peak from the diffuse scattering. The high intensity of the beam allows to measure the distribution of the diffuse scattered intensity over wide regions of the reciprocal space. Assuming that the roughness structure of surface and interfaces in the Co/Cu-MLs is sufficiently self-affine, it can be described besides the rms-roughness σ_{RMS} by two additonal parameters [3]. In Sinha's representation of the height-height autocorrelation function the correlation length x and the Hurst parameter h characterize

the lateral cut-off length and the surface jaggyness, respectively. From coherence effects in the diffuse scattering, occuring in MLs, the roughness correlation between the layers can be estimated and by this the part of the correlated roughness (σ_{COR}) included in σ_{RMS}-roughness ($\sigma_{RMS}^2=\sigma_{COR}^2+\sigma_{UNCOR}^2$) is quantified.
Table 1 shows the results obtained (using Bede REFS Code) from the two typs of the CB PLD-prepared MLs in the 'as-deposited' state and after tempering .

Table 1 Simulation results for the Co/Cu MLs in the 'as-deposited' state and after tempering

	'as-deposited'				after tempering at 500°C 2h			
ML type	σ_{RMS} (nm)	x (nm)	h	$\sigma_{COR}/\sigma_{RMS}$	σ_{RMS} (nm)	x (nm)	h	$\sigma_{COR}/\sigma_{RMS}$
4x[8/8]	Co 1.4 Cu 1.2	4000	0.25	0.4	Co 1.20 Cu 0.80	20	0.6	0.10
8x[4/4]	Co 2.3 Cu 0.8	4200	0.25	0.5	Co 1.60 Cu 0.85	15	0.7	0.05

Additionally, from the position of the Yoneda peaks (see Fig.1) the critical angle θ_C of the surface layer is well defined. It can be used for determination of the mass density r using the relation $\theta_C \propto \sqrt{r}\,l$.

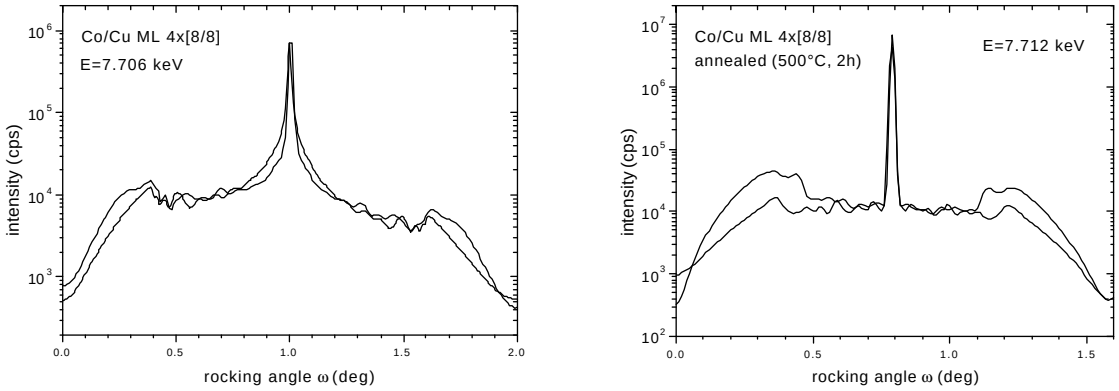

Fig.1 Diffuse scattering (transversale scans) of Co/Cu 4x[8/8]-MLs in the 'as-deposited' state (on the left) and after tempering at 500°C for 1h (on the right). (measured curves - thick lines; simulations - thin lines)

Results

Whereas in the 'as-deposited ' state the structure of the interface is characterized by a high jaggyness, which means that the fractal dimension ($D=3-h$) reaches values of about 2.75, after tempering the interface is smoothed and the lateral correlation length is drastically shortened. This is accompanied by a reducing of the roughness conformity.

References

[1] B.D. Fulthorpe, D.E. Joyce, T.P.A. Hase, B.K. Tanner, P.J. Grundy, *XTOP 98* , 9.-11. 9. 1998 Durham UK (Abstracts) P3.31 and *Phys. Rev. B* **58 ,** 5594 (1998)
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[3] S.K. Sinha, *J. Phys. III France* **4**, 1543- 1557 (1994)