ROBL-CRG	**Experiment title:** XR-study of ion beam induced mixing effects in Co/Cu-multilayers	**Experiment number**: 20_02_016
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Report

The study of ion-beam modification of Co/Cu multilayers (Co/Cu ML) is part of investigation of the intermixing properties of Co-Cu systems [1], [2]. Two types of C/Cu MLs, $Si/SiO_2/8x[Co(4nm)/Cu(4nm)]$ and $Si/SiO_2/4x[Co(8nm)/Cu(8nm)]$, were investiga-ted in the 'as-deposited' state and after ion-beam mixing. The MLs, prepared by crossed beam pulsed laser deposition (CB PLD), were implanted with low ($2.5x10^{15}$ Cu^+/cm^2), medium ($5x10^{15}$ Cu^+/cm^2) and high ($2x10^{16}$ Cu^+/cm^2) doses of 150 keV-Cu^+ ions. 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 material.
Information about the changes in density, layer thickness and interface roughness due to mixing by ion bombardment come from the reflecitvity (XXR) of the 'as-deposited' and the implanted specimens. Specular (Fig.1) and non-specular (diffuse) XXR were measured on both types of samples at the K-edge energy of Co (7.708 keV) and Cu (8.9737 keV), respectively. With these two independent data sets of the same samples, the accuracy of the simulations, obtained from the codes REFSIM (Siemens) and/or REFS (Bede Scientific), could be improved by the cross-check of the fitted parameters.

Results

As expected, due to the ion-beam mixing the Co-Cu-interface regions increase and the ML-structure is successively dissolved. Certainly the used modelling, based on the Paratt formalism and the Névot-Croce roughness model, must be stressed to describe such an extended interface

Table 1 Results from specular XRR of Co/Cu-MLs (Charge 2)

		'as deposited'			low-dose Cu^+ implanted		
ML type	single layers	d (nm) d_{Co}/d_{Cu}	ρ (g /cm^3)	σ_{RMS} (nm)	d (nm) d_{Co}/d_{Cu}	x Co_xCu_{1-x}	σ_{RMS} (nm)
4x[8/8]	Co	16.95	8.6	1.5	16.55	0.8	2.4
	Cu	1.08	8.8	1.5	1.03	0.2	2.3
8x[4/4]	Co	8.0	8.4	1.2	8.0	0.50	1.45
	Cu	1.05	8.8	1.15	1.05	0.15	1.35

Table 2 Results obtained from diffuse scattering (transversal scans) of Co/Cu-MLs (Charge 1)

	'as-deposited'				after high-dose Cu^+-implantation			
ML type	σ_{RMS} (nm)	ξ (nm)	h	$\sigma_{COR}/\sigma_{RMS}$	σ_{RMS} (nm)	ξ (nm)	h	$\sigma_{COR}/\sigma_{RMS}$
4x[8/8]	Co Cu	4000	0.25	0.4	{CoCu} 3.4	100	0.6	0 uncorr.
8x[4/4]	Co 1.25 Cu 0.82	4200	0.25	0.5	{CoCu} 3.3	100	0.6	0 uncorr.

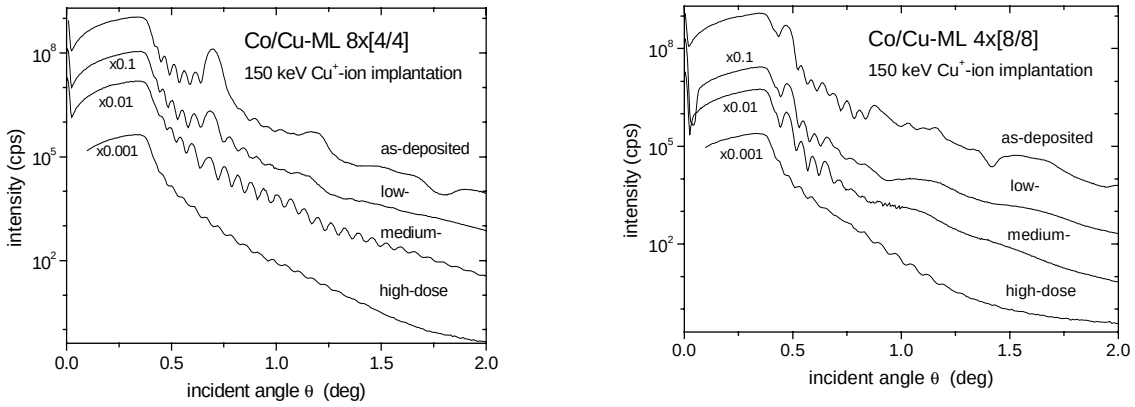

Fig.1 Specular XXR of Co/Cu-8x[4/4]MLs (on the left) and Co/Cu-4x[8/8] MLs (on the right) in the 'as-deposited' state and after low-, medium-, and high-dose 150 keV Cu^+-ion implantation

structure. Nevertheless, useful information about σ_{RMS}-roughness and interface topology follows also from these rough simulations. Besides the formation of graded interfaces (Co_xCu_{1-x}) the initally jagged layers will be smoothed by ion-impact processes as shown by the strong decrease of the h- and ξ-paramters. With increase of the graded interfaces the ML roughness conformity disappears.

References

[1] D.E.Joyce, et al., Phys.Rev.B **58** (1998) 5594-5601

[2] Ping Wu et al., phys.stat.sol.(a) **161** (1997) 389- 397