ROBL-CRG	**Experiment title:** Interfacial roughness in GMR multilayers	**Experiment number**: 20_02_013
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Report:

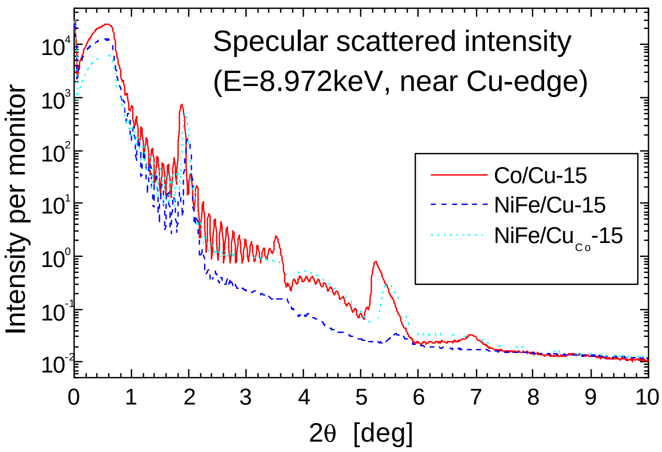
To investigate multilayer systems showing giant magnetoresistance (GMR), it is of interest to correlate layer and interfacial properties of such systems both with parameters of the sample preparation and with the resulting GMR. In the present study samples with different combinations of Co-, Cu- and NiFe-layers of about 2 nm thickness corresponding to the second maximum of the GMR were prepared by DC magnetron sputtering. The layer properties like layer thickness and interface roughness and the lattice properties like strains and crystallographic texture of the different samples were compared using methods of X-ray reflection and wide angle diffraction, respectively. The high brilliance and tunable wavelength of the synchrotron radiation at the ROBL beamline allowed to improve the contrast for the different material combinations by setting the X-ray wavelength to the absorption edge of one of the layer materials (in most cases Cu) and to measure the diffuse scattering with intensity sufficient for evaluation.

An example of the specular scattering experiments is given in Fig. 1a. Both the values of the rms interface roughness and of the layer thickness were found to be correlated with the layer combination. For instance, the Co/Cu layer combination shows smaller roughness and larger layer thickness compared with the NiFe/Cu system.

Apparently, the larger adhesion between Co and Cu does not only increase the layer thickness but also reduces the interface roughness. A similar interpretation may be obtained from the measurement of samples containing additional thin layers of a third material between the main components of the multilayer. We found that thin additional Co layers of about 0.3 nm thickness reduce the roughness of the interfaces in NiFe/Cu multilayers, whereas additional NiFe layers in the Co/Cu system reduce the thickness of the Co and Cu layers; apparently due to the smaller adhesion between NiFe and the other two multilayer components.

Though the specular part of the scattering in the low angle region shows significant differences between the samples, the diffuse scattering looks rather similar for all samples. Lateral correlation lengths of about 10nm and values of the Hurst parameter of about 0.6 result from transverse and offset scans independent of the layer composition. The corresponding characteristics of the interface morphology seem to be influenced more by the sputtering technique than by the multilayer composition.

Wide angle diffraction measurements reveal a preferred {111}-orientation of the lattice planes parallel to the interfaces with a half width of the texture of FWHM≈30° and profile shapes influenced by size-strain-effects for all samples (Fig. 1b). A lower limit of the mean crystallite size was estimated to be about 10 nm, which is larger than the layer thickness and indicates the columnar structure of the grains. This structure can also be deduced from the multilayer peaks of the {111}-reflection. The satellites of already the first order are very weak due to internal strains and interface roughness. A comparison of the measured profiles with those calculated using a kinematical model including interface roughness indicates the presence of coherence strains diminishing the lattice mismatch at the interfaces.



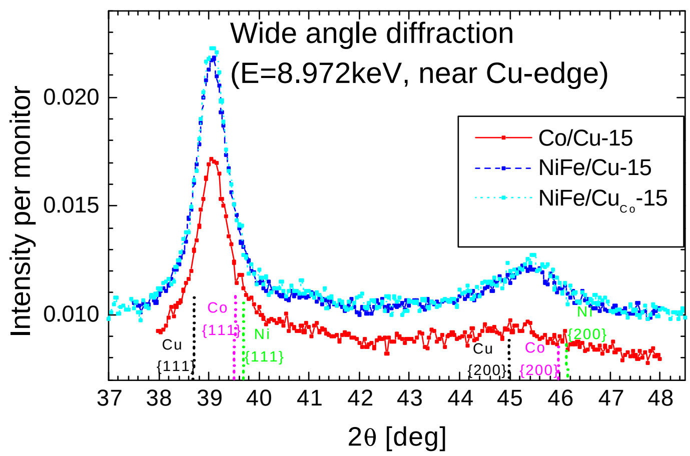


Fig. 1: Scans of a Co/Cu-multilayer (red), a NiFe/Cu-multlayer (blue) and a NiFe/Cu-multilayer with a thin additional Co-layer at the interfaces (cyan) in the low angle region (a, left) and in the wide angle region (b, right). The bilayer number of the multilayers is 15.