Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

ESRF	**Experiment title:** Interface and Crystallographic structure of Co/Ru Multilayers	**Experiment number**: SI569
Beamline: BM16	**Date of experiment**: from: 3/5/2000 to: 9/5/2000	**Date of report**: 22/8/2000
Shifts: 18	**Local contact(s)**: Eric Dooryhee	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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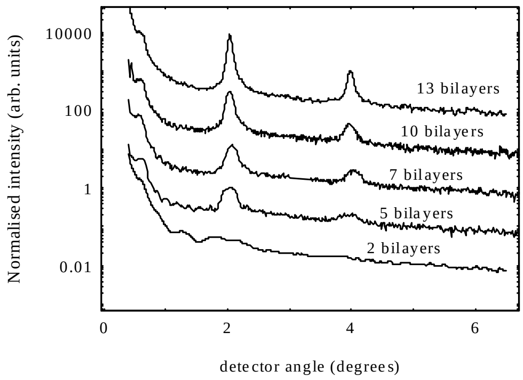
Report:

Strongly antiferromagnetically (a.f) coupled Co/Cu multilayers grown by magnetron sputering exhibit very different magneto-transport behaviour when the layers and interfaces are contaminated with oxygen. Those contaminated at the interfaces showed no change in the Giant magnetoresistance (GMR) while the GMR falls dramatically in those where the contamination was mid-way through the layer. The aim of the work reported here was to study Co/Ru multilayers, which are known to exhibit strong a.f. coupling, and to attempt to relate variations in the magnetotransport behaviour to any changes in interface morphology and conformality or bulk crystallinity on contamination.

A series of off-specular, longitudinal diffuse scatter measurements as a function of bilayer number for the Co/Ru samples grown at the first AF coupling peak are shown in figure 1. For low bilayer numbers the off-specular scan exhibits the same periodic features as the specular, figure 2. The scatter at a momentum transfer vector corresponding to a Bragg peak position is particularly sensitive to the interface morphology within the bilayer. The degree of interface conformality within the bilayer determines how far this coherent scatter extends into reciprocal space. Interface roughness that is highly correlated in nature across the bilayer repeat thickness will generate a diffuse, off-specular, Bragg peak in addition to the specular peak. The presence of off-specular interference fringes, with a period corresponding to the total stack thickness, demonstrate that this conformality extends throughout the whole multilayer stack.

For the maximum bilayer number the off-specular Bragg peak remains but the interference fringes disappear as conformality between the top and bottom layer is lost. Such a trend has been observed previously in Co/Pt [1] where it was possible to define an out-of-plane length scale for conformal growth beyond which no interference fringes were observed in the off-specular scatter.



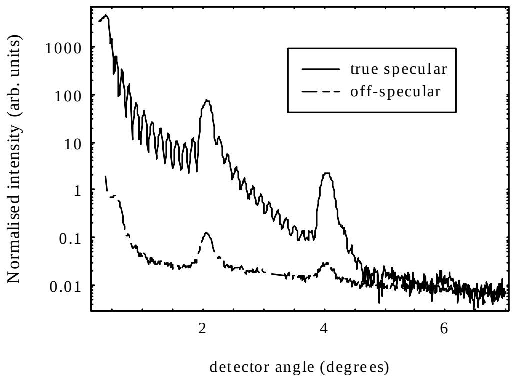
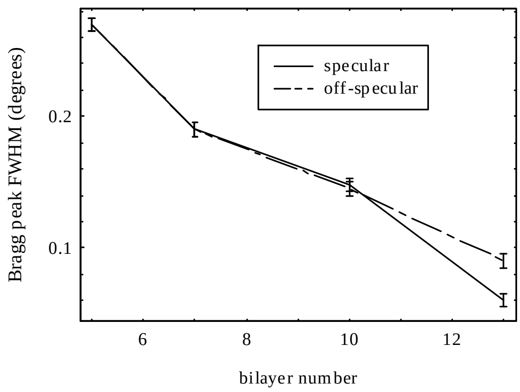


Figure 1. Off specular scatter as a function of bilayer number

Figure 2. Specular and off-specular for the 7 bilayer sample

A measure of the FWHM of the specular and off-specular Bragg peak with increasing bilayer number also shows the point at which conformality is lost, figure 3. The specular Bragg peak becomes systematically sharper with increasing layer number as the number of coherently scattering interfaces increases. The off-specular Bragg peak follows the same trend as long as conformality is retained across the entire stack. For the maximum stack thickness the off-specular FWHM begins to diverge from that of the specular, indicating that the stack thickness has exceeded the vertical length scale for conformal growth which is of the order of 300 to 400Å in these samples.



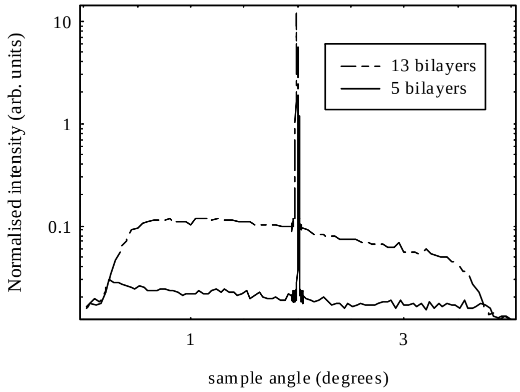


Figure 3. Bragg peak FWHM as a function of bilayer number

Figure 4. Transverse diffuse scatter from the 5 and 13 bilayer sample

Modelling of the specular reflectivity shows that the samples are grown at the correct spacer layer thickness to maintain a constant coupling strength. Initial measurements on the transverse diffuse scatter for the 5 and 13 bilayer samples would suggest that the interface roughness is greater in the 13 bilayer sample but that the roughness is highly correlated and of comparable lateral correlation length in both samples, figure 4. The profile of the diffuse scatter would also suggest the fractal parameter does not change with increasing layer number.

Analysis is continuing as to whether the loss of interface roughness conformality with increasing bilayer number observed here is a feature of both the gas contaminated and clean samples. All samples have a spacer thickness matching that of the intended a.f coupling fraction so it is entirely possible that the variation in the GMR is driven by anomalies in the interface profile. All samples were found to be poorly textured with no apparent differences in the bulk crystalline properties.

[1] B.D.Fulthorpe *et al*. J.Phys.:Condens. Matter **11** (1999) 8477-8