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ESRF

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: **Element-selective hysteresis loops in $DyFe_2/YFe_2$ superlattices**	**Experiment number**: HE 967
Beamline: ID 12A	**Date of experiment**: from: 11 July 2001 to: 17 July 2001	**Date of report**: 20 June 2002
Shifts: 18	**Local contact(s)**: Andreï ROGALEV	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

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Report:

$DyFe_2/YFe_2$ superlattices are composite systems constituted of two intermetallic compounds with very different magnetic properties: $DyFe_2$ is a hard ferrimagnet (moment of $6\mu_B$ along the Dy moments) whereas YFe_2 is a soft ferromagnet (moment $4\mu_B$ along the Fe moments). The interface negativ magnetic coupling between the net magnetization in $DyFe_2$ and YFe_2 makes the system behave as a kind of giant ferrimagnet. The magnetic configuration stabilized under an external magnetic field results from the balance between interface coupling, Zeeman energy and magnetocrystalline energy, thus leading to extremely rich magnetization reversal processes [1].

The aim of the experiment was to measure separately $DyFe_2$ and YFe_2 hysteresis loops (XMCD signals at Dy L_3 and Y L_3 edges) in superlattices with typical magnetic behaviours, in order to elucidate the magnetization reversal processes. For this purpose, the detection in fluorescence mode has been chosen because it is particularly suitable for superlattices deposited on a thick substrate (sapphire) that are thus difficult to observe in transmission mode. A specific sample holder has been used, so that the external magnetic field can be applied along the in-plane [110] easy magnetization direction.

Following the HE-625 experiment [2], we focussed on two superlattices with thin $DyFe_2$ layers: [$DyFe_2$(30 Å)/YFe_2(130 Å)] and [$DyFe_2$(50 Å)/YFe_2(200 Å)]. For this latter sample, the macroscopic magnetization measurements (SQUID) have revealed an unexplained drastic change in magnetic behavior between 100K and 200K (figure 1, top curves (white circles)).

The XMCD results (bottom curves in figure 1) have brought a clear image of the thermal evolution of the reversal process, showing especially a switch from hard to soft behaviour in the $DyFe_2$ layers.

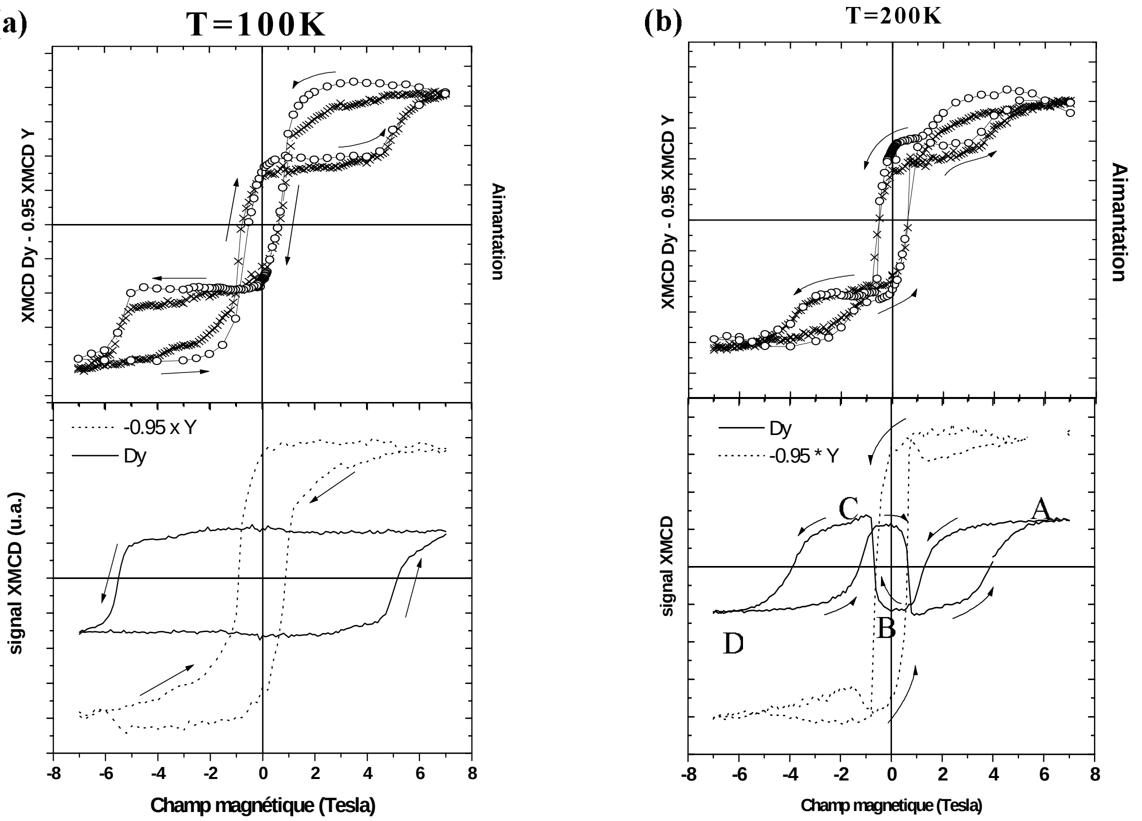

Fig. 1 : Measurements performed at 100K (a) and at 200K (b) for the superlattice [$DyFe_2$(50 Å)/YFe_2(200 Å)]
The top curves correspond to macroscopic magnetization measurement (white circles) superimposed to a linear combination of Y and Dy dichroïc signals (crosses). The bottom curves correspond to the loops obtained in measuring the XMCD signal at the Dy (continuous lines) and Y (dotted lines) absorption edges.

At 100K, the XMCD results reveal a square loop and a high negative coercive field for the hard $DyFe_2$ layers. Because of the negative interface coupling, magnetic domain walls develop in the soft YFe_2 layers as soon as the magnetic field is decreased from +7T, leading to a positive coercive field in YFe_2. Let us underline the extremely good agreement between a linear combination of these two loops (crosses in the top curves) and the magnetization measurements (white circles).

At 200K, the XMCD results clearly show that the YFe_2 magnetization now remains in the field direction when it decreases from +7T, whereas the $DyFe_2$ one shifts in order to satisfy the interface exchange coupling (AB). The reversal of the YFe_2 magnetization under a negative field (due to the Zeeman contribution) also induces the $DyFe_2$ reversal (BC) and finally, the magnetic walls compress in $DyFe_2$ when the negative field increases (CD). At this temperature where the magnetocrystalline anisotropy is reduced compared to 100K, the thin $DyFe_2$ layers thus behave as a soft material in which the magnetic walls develop, because the dominant Zeeman contribution arises from the thicker YFe_2 layers. Let us again underline the good qualitative agreement between XMCD and magnetization measurements.

We have performed a detailed thermal study at both edges in order to analyse the penetration of magnetic walls into the $DyFe_2$ layers and the simultaneous evolution of the coercive field in the YFe_2 layers.

[1] K. Dumesnil, M. Dutheil, C. Dufour, Ph. Mangin, Phys. Rev. B 62, 1136 (2000)

[2] K. Dumesnil, C. Dufour, Ph. Mangin, A. Rogalev, Phys. Rev. B 65, 094401 (2002)