# 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: 180° degree domain wall propagation through a [Co/Fe] superlattice: a dynamic study by XMCD** | **Experiment number**: |
|---|---|---|
| **Beamline**: ID 12B | **Date of experiment**: from: 24 Nov 99 to: 30 Nov 99 | **Date of report**: |
| **Shifts:** 18 | **Local contact(s)**: Ohresser Philippe Brookes Nicholas | *Received at ESRF:* |


**Names and affiliations of applicants** (* indicates experimentalists):

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## Report:

Bilayer system $Gd_{40}Fe_{60}$(1000 Å)/$Tb_{55}Fe_{45}$(30Å) was prepared by coevaporation in a high vacuum chamber at the LPM in Nancy. Both (rare earth -transition metal) alloys are amorphous, $Gd_{40}Fe_{60}$ is a soft ferrimagnetic material whereas $Tb_{55}Fe_{45}$ is a hard sperrimagnetic one. For the two alloys the moment held by the rare earth is antiparallel to the iron spin and the net magnetization of both layer is parallel to the moment held by the rare earth. It has been shown that this systems can be considered as an exchange bias system [1] Quasi-static measurements performed on $Gd_{40}Fe_{60}$(1000 Å)/$Tb_{55}Fe_{45}$(30Å) at 30K and 100K after cooling the sample from T=300K under 2000 Oe are shown on figure 1.

At 100K, the magnetization versus field curves can be understood assuming the following scenario: at $H_E$ a Domain Wall (DW) is created in the GdFe layer and is pinned by the TbFe layer (fig.2.a). When the field is decreased the DW is compressed against the TbFe layer (fig.2.b). At Hp the TbFe layer reverses and the DW is annihilated (fig.2.c). To verify the above assumption and to study TbFe magnetization reversal by domain wall compression X-ray Magnetic circular dichroism (XMCD) measurements have been performed on ID12B.

In order to study separately the magnetic contributions of Gd, Tb and Fe in the GdFe/TbFe bilayer system we measured XMCD at the Fe $L_{2,3}$ edges and the Gd, and Tb $M_{4,5}$ edges. The sample was covered with a 15 Å Al layer to avoid oxidation. Using electron yield we probed approximately the first 60Å (meaning the TbFe layer and 30Å of the GdFe layer. We studied the magnetization reversal of the two layers independently and the time dependence of each magnetization layer reversal for different temperatures.

Normalized XMCD signals for the three elements as a function of the applied magnetic field obtained on $Gd_{40}Fe_{60}$(1000 Å)/$Tb_{55}Fe_{45}$(30Å) at high temperature (100K) are presented in figures 3. We can first clearly observe that the moment held by the rare earth is always antiparallel to the moment held by iron. XMCD signal is almost not affected when a DW is created at the interface between the two layers at $H_E$. However, as the DW compresses against the TbFe layer we observe a slow decrease of the XMCD signal for both rare earth elements but the decrease is slower for Tb than for Gd. These observations are consistent with the compression of a domain wall at the interface. As Tb moments are also rotating we can conclude that the domain wall, not only compresses, but also propagates in the TbFe layer. Finally for $H=H_P$ a rapid reversal of the Gd and Tb is observed: the TbFe magnetization layer reverses under the magnetic domain wall pressure. To complete the study, after-effect measurements have been performed at 100K on Gd and Tb $M_{4,5}$ edges at different time scales ranging from 10s to a few hours (fig.4). We first saturated the sample at 2kOe and then we applied a field close to Hp and measured the XMCD signal as a function of time. For all applied field a superposition of the signal from Terbium and Gadolinium is observed. Moreover all the relaxation curves can be fitted by an exponential decays. The typical relaxation time is found to decrease with field. Measurements performed at different temperatures show that this phenomenon is thermally activated. Moreover only one relaxation time is needed to fit the data which shows that a single energy barrier has to be crossed by the domain wall

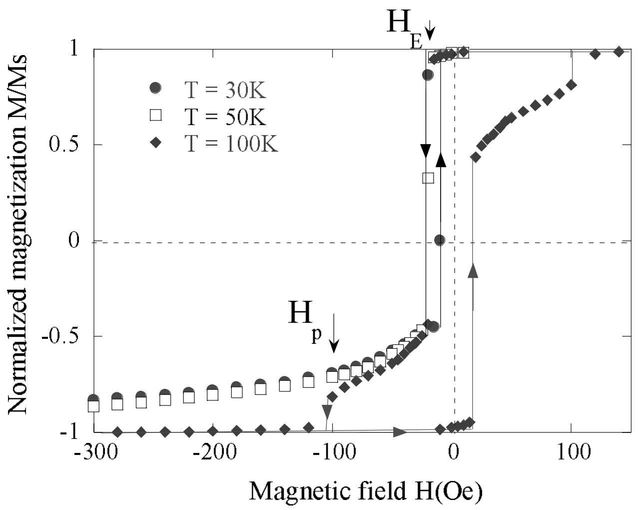


*Figure1: Magnetization versus applied field for three different temperatures on $Gd_{40}Fe_{60}$(1000 Å)/$Tb_{55}Fe_{45}$(30Å .*

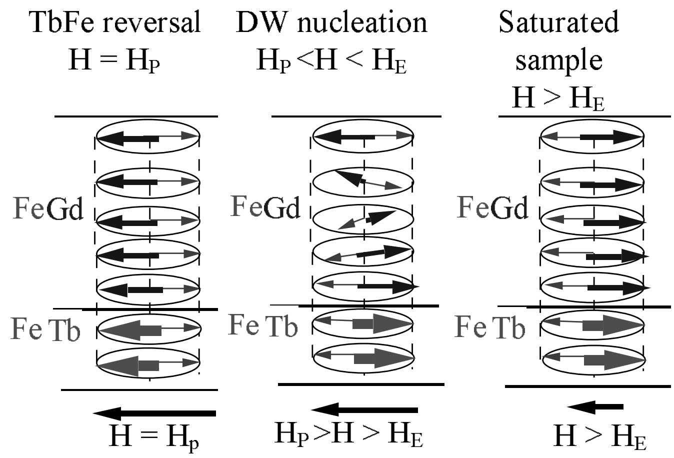


*Figure 2: Magnetic configuration in GdFe/TbFe bilayer for different applied field*

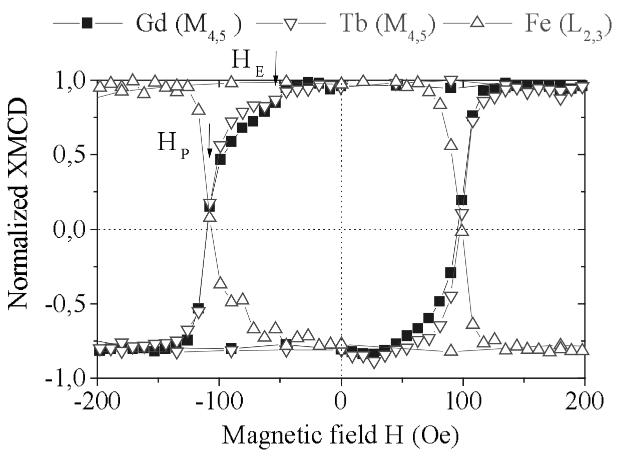


*Figure 3: XMCD signal at the Fe $L_{2,3}$ edges and the Gd, and Tb $M_{4,5}$ edges as a function of the applied field at 100K on $Gd_{40}Fe_{60}$(1000 Å)/$Tb_{55}Fe_{45}$(30Å .*

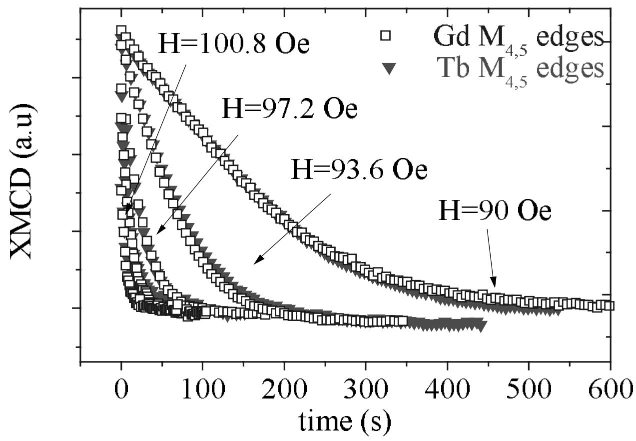


*Figure 4: XMCD after effect measurements for different field: XMCD signal at the Gd, and Tb $M_{4,5}$ edges as a function of time*


[1] S. Mangin, G. Marchal, B. Barbara, Phys. Rev. Lett. **82**, 1999, (4336)