EUROPEAN SYNCHROTRON RADIATION FACILITY

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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:** **Charge Density Waves and tunnel coupling in epitaxial Cr/MgO/Cr trilayers**	**Experiment number**: HE3330
Beamline:	**Date of experiment**: from: june 23rd, 2010 to: june 29th, 2010	**Date of report**: July, 2010 *Received at ESRF:*
Shifts: 18	**Local contact(s)**: Javier Herrero-Martin	

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Report:

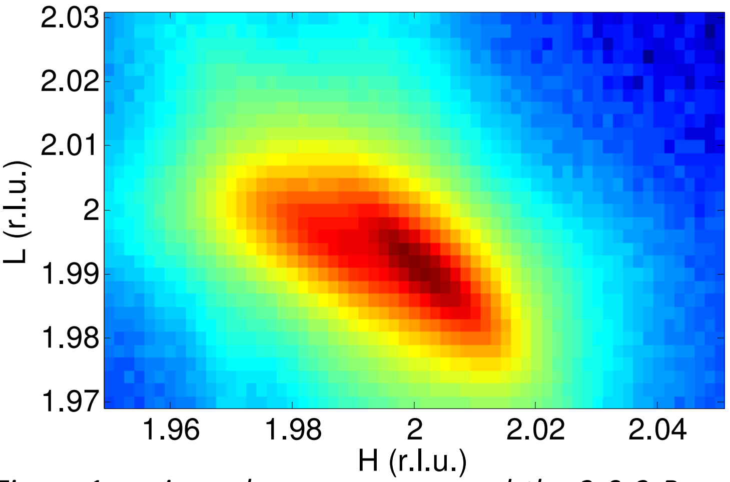

Figure 1: reciprocal space map around the 2 0 2 Bragg position of Cr, for a Cr/MgO/Cr trilayer. Two peaks can be distinguished, each corresponding to a Cr layer

Aim of the experiment

The experiment aimed at studying charge density waves in nanometric Cr/MgO/Cr trilayers through high resolution X-ray diffraction. Previous neutron diffraction experiments had shown the existence of two distinct magnetic regimes at low (T<100K) or high temperatures (T>200K) in these trilayers with, for each, peculiar magnetic signal signatures. While each layer of the trilayer experiences a different strain state, an anomalous increase of the expansivity of the top layer was observed in the transition temperature regime (100K-200K) with laboratory X-ray diffraction. To shed further light on this phenomenon, this experiment was focused on determining :

- the presence or absence of the charge density waves (CDW) satellites associated to the magnetic signatures observed with neutron diffraction.
- the location of the incommensurate CDW phases and the precise values of the CDW periods.
- the precise strain evolution with temperature for each layer.

The study of the CDW peaks evolution in our samples is extremely challenging since both high resolution and high flux were required as the intensity of the CDW peaks is four orders of magnitude smaller than Bragg peaks in bulk Cr, and even smaller in our trilayers. Moreover, the resolution had to be sufficient to enable the deconvolution of the Bragg peaks of the 2 layers and a precise measurement of the CDW peaks positions.

Experimental conditions

The photon energy (12.3 keV) was chosen in order to have a facilitated access to the sought reciprocal space positions given the diffractometer configuration, and to optimize the beam flux. A LiF(440) crystal analyzer was used ; it was the best compromise to suit our samples mosaïcity (about 0.2°) and the chosen energy. We used a displex cryocooler enabling the study of our samples on a wide temperature range (12K to 252K). These experimental conditions appeared to be very satisfactory and allowed running the experiment in very good conditions.

Experiment

We were able to carry out exhaustive measurements of the CDW satellites and of the strain state of the layers for three different samples :

- a reference sample constituted of a 80 nm thick Cr film on a MgO(001) substrate, capped with MgO.
- a Cr/MgO/Cr trilayer, with a thin (3 monolayers) MgO barrier.
- another Cr/MgO/Cr trilayer with a thick (10 monolayers) MgO barrier.

The measures were taken for temperatures from 12K to 252K, with temperature steps around 10K-15K.
For eachtemperatures and for all samples, we determined the precise positions of the 002, 004, 103, 204, 202 Bragg peaks for both Cr layers . This necessitated mesh scans for non azimuthal reciprocal space positions (see Figure 1). These measurements enable to deduce the macroscopic residual strain in each layer, and to correlate it to the existing magnetic phases.
Besides, scans around the 002 Bragg position in the L-direction (film normal) showed the expected weak CDW satellites at 002±2δ, of which position we were able to determine precisely. No visible evolution of their position was to be observed in the low temperature regime, while significant changes occurred above 180K (see Figure 2).

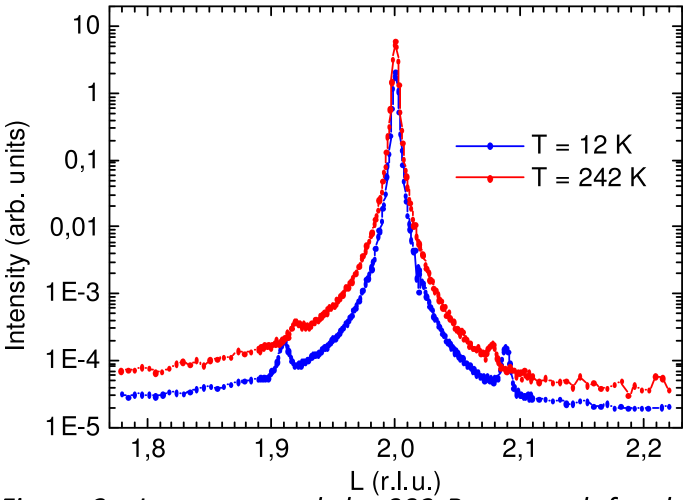

Figure 2 : L-scan around the 002 Bragg peak for the reference layer, showing the displacement of the satellites at high temperatures

Conclusion

Thanks to the good performance of the beam line , we were able to measure with very good precision the weak signal coming from the CDW and obtain an exhaustive study of its evolution with temperature and for different barrier thicknesses. These data, together with the structural properties we also measured during this experiment, will enable us to better understand the correlation of magnetism and strain states of thin films in our system. In summary the experiment was very successfull and the proposed experimental program has been satisfactorily fulfilled