EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

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:** Growth and properties of MgB2 thin films on buffered substrates: effect of compressive or tensile strains	**Experiment number**: **SI-1128**
Beamline: ID1	**Date of experiment**: from: 23 June 2005 to: 28 June 2005	**Date of report**:
Shifts: 15	**Local contact(s)**: Dr. Baerbel KRAUSE	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

* Carlo FERDEGHINI
* Emilio BELLINGERI
* Roberto FELICI
* Valeria FERRANDO
* Chiara TARANTINI

Report:

The first aim of our experiment was to look for tensile strain in magnesium diboride thin films, induced by the presence of an isostructural buffer layer of another diboride; this strain should induce an increase of Tc of MgB_2 [1]. In a previous experiment (HS 2346), we already measured bilayers MgB_2/ZrB_2 and MgB_2/TiB_2 , where the superconducting film was grown by Pulsed Laser Ablation with a two step technique [2], observing a very small increase of the *a* parameter, which did not reflect itself in a appreciable variation of T_c [3]. This was ascribed to the non optimal properties of the starting MgB_2 film, where T_c was already slightly suppressed by intrinsic disorder. For these reasons, in this campaign we measured samples where the MgB_2 film was deposited by Hybrid Physical Chemical Vapor Deposition (HPCVD), which provides extremely clean and reproducible films with T_c above 40 K[4]. In particular, we tested couples of different samples deposited at the same time. The first one was on TiB_2, which has *a* axis smaller than MgB_2 and therefore is not expected to induce tensile strain, and the second one on ZrB_2 which, on the contrary, should enlarge the in plane parameter of MgB_2, having an *a* axis of 3.169 Å compared to 3.086 Å of MgB_2. It is worth noticing that the dimensions of the crystalline cells of these diborides are very similar, and therefore it is almost impossible to distinguish the diffraction peaks by standard XRD, except if the two phases are very well crystallized.
First, we carried out reflectivity measurements in order to have information on the roughness of the interfaces and on the thickness of the layers. Both films grown on titanium and zirconium diborides showed a double periodicity of the oscillations which indicates that the interfaces are sharp with a good roughness and that there is no interdiffusion between the two layers. Secondly, according to the goal of our experiment, we tried to estimate the lattice constants. In this case, due to the good quality of the MgB_2 films, the peaks were narrow enough to distinguish the two diborides phases, and thus the use of anomalous diffraction was not necessary. Anyway, also measurements in GID configuration have been carried out in order to get stronger signal from the uppermost MgB_2 layer. We performed h, k and l scans and maps around different diffraction peaks both in plane and out of plane, putting theoretical MgB_2 as a reference matrix for samples with TiB_2 and ZrB_2 as buffer layers; examples of these measurements are shown in figure 2. The maps clearly indicate the epitaxial growth of both layers in the two samples. Unfortunately, the results on tensile strain were not

the expected ones: in fact, the calculated *a* axes for the MgB_2 films deposited on the ZrB_2 buffer layer was 3.090±0.001 Å, not significantly different from that measured on MgB_2 films on silicon carbide. The good structural quality of these bilayers is anyway promising for the realization of diborides-based heterostructures.

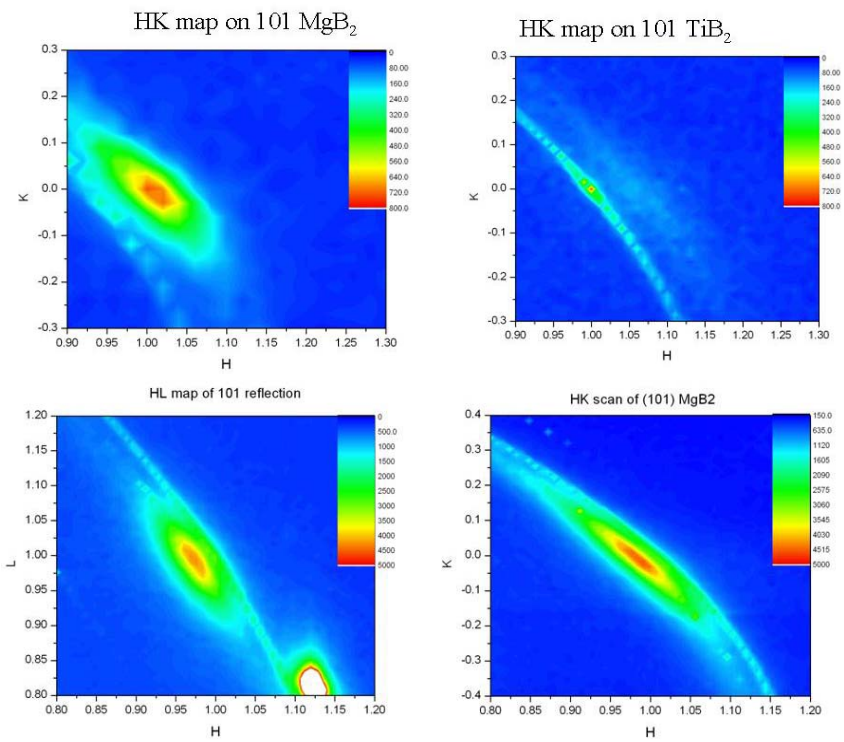

Figure 1

During this beamtime at ID01, we also performed measurements on a couple of neutron irradiated magnesium diboride films grown again by HPCVD, in order to get information on the crystalline structure, lattice parameters and in plane orientation. H, K and L scans on families of peaks were carried out to get the crystallographic axes with a good precision; neutron irradiation in fact induces a progressive enhancement of the *c* axis, while the *a* axis should remain almost constant. These results were confirmed by our measurements on samples with different level of damage. Moreover, by the phi scans we were able to observe also a second in plane orientation, which was impossible to detect by standard diffraction due to its very weak intensity; an example of the measurement is shown in figure 3.

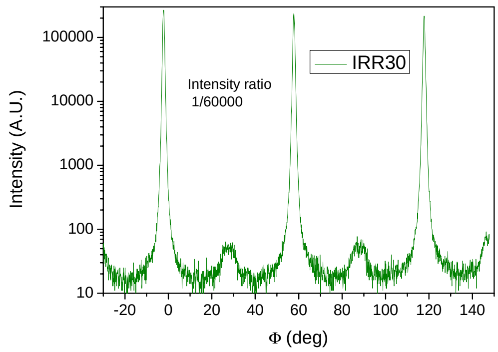

Figure 2

This secondary in plane orientation was observed on both the irradiated samples and it is still not clear whether it was already present in the undamaged film or whether it was induced by irradiation. In any case, it is crucial for the interpretation of transport measurements in high magnetic field of these samples; we are now comparing the data of structural and electrical measurements and the results will be organized in a paper in the next future.

---

[1] A.V. Pogrebnyakov et al., *Phys. Rev. Lett*. 93 (2004) 14.
[2] V. Ferrando et al., *Supercond.Sci. and Technol.* 16 (2003) 241.
[3] V. Ferrando et al., *Supercond.Sci. and Technol*. 17 (2004) 1434.
[4] X. Zeng et al., *Nature Materials* 1, (2002) 35.