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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 via the User Portal:

https://wwws.esrf.fr/misapps/SMISWebClient/protected/welcome.do

Reports supporting requests for additional beam time

Reports can 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.

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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	**Atomic structure of the multiferroic interface Co/ Pb (Ti,Zr) O_3**	**Experiment number**: HC-1753
Beamline:	**Date of experiment**: from: Feb 25, 2015 to: Mar. 3, 2015	**Date of report**: Jul. 28, 2015
Shifts:	**Local contact(s)**: R. Felici	*Received at ESRF:*

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Report:

It was the aim of the experiment to study the atomic structure of the Co/Pb(Zr,Ti)O_3 (Co/PZT) interface using surface x ray diffraction. The experiments were carried out very successfully and new insights into the interface structure could be obtained which are important for a deeper understanding of the magnetoelectric coupling across the interface. In the following we provide a short overview over some results, a more detailed discussion will be provided elsewhere [1].

The Co/PZT/LSMO/STO heterosystem represents a prototype of a multiferroic tunneling system [LSMO:= (La, Sr) MnO_3; STO=: $SrTiO_3$], where Co and LSMO serve as ferromagnetic (fm) electrodes separated by a ferroelectric (fe) tunneling barrier PZT. In addition to the mutual orientation of the fm electrodes, the fe barrier opens a new degree of freedom for the manipulation of the tunneling conductance. An open question is the detailed interface structure which is important for the development of a theory of the magntoelectric coupling [2,3].

The two unit cell thick PZT film was grown on 20 nm thick LSMO on bulk STO(001) by pulsed laser desposition. SXRD data were collected for the pristine and the cobalt covered samples at the beamline ID03 using a photon energy of 24 keV and a two-dimensional pixel detector. Figure 1 shows as a representative example the (31L) crystal truncation rod for samples with different cobalt thicknesses as expressed in monolayers (ML). Experimental and calculated structure factor amplitudes, |F|, are represented by symbols and lines, respectively. High quality fits could be obtained for all rods

(typically 6-8 symmetry independent rods being equivalent ot approximately 1200 reflections.

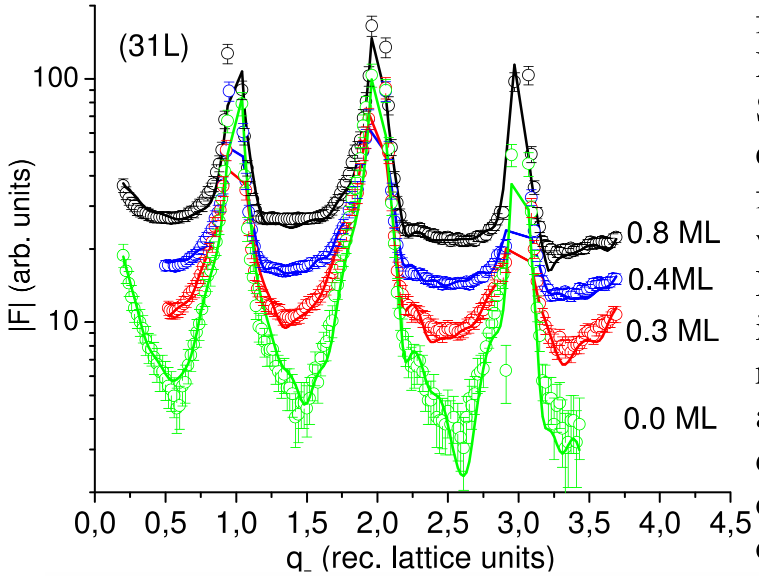

Fig.1: The (31L) crystal truncation rod for the pristine and cobalt covered PZT/LSMO/STO(001) samples. Symbols and lines represent experimental and calculated structure factor amplitudes, respectively. Un-weighted residuals are in the 15% range. Data sets consist of six to eight independent rods comprising about 1200 reflections in total. Successive curves are shifted by five units in |F|. Note the distinct increase of |F| with cobalt coverage close to the anti-phase condition.

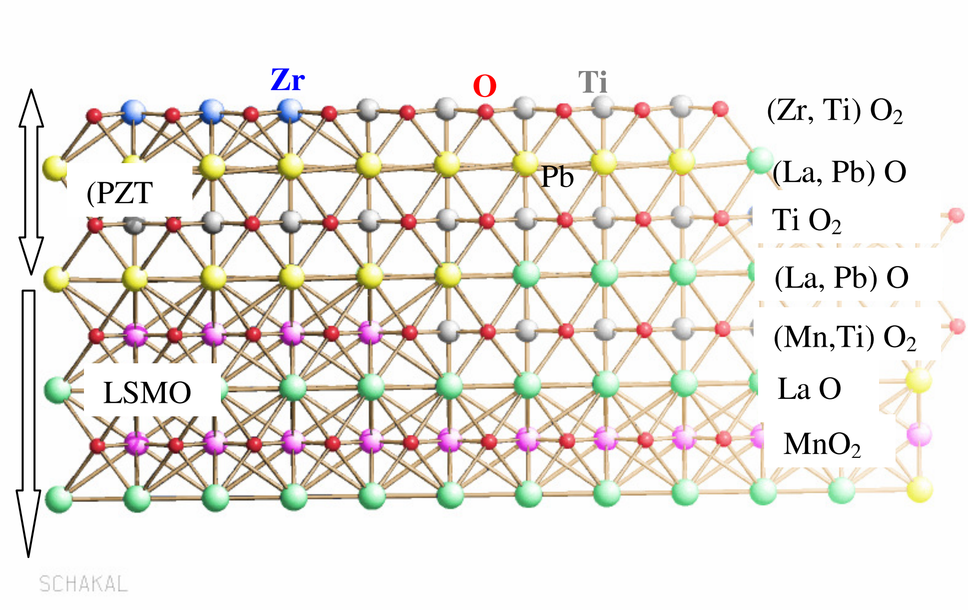

Fig.2 Structure model of the near surface structure of the pristine PZT/LSMO/STO (001) sample. Atoms are labelled. The PZT film is terminated by a (Zr,Ti) O_2 layer, while some intermixing across the PZT/LSMO interface is oberved. In agreement with Ref.[3] the PZT film is positively polarized

Figure 2 shows the structure model for the pristine sample. The PZT film is terminated by a (Zr,Ti)O_2 layer while some intermixing between Pb and La is observed at the PZT/LSMO interface. Adsorption of cobalt involves the initial formation of a cobalt oxide layer (not shown), which bears many resemblances with the AO-type layer observed in the perowskite structure [1]. Our results are important for the understanding of the magnetoelectric coupling involving the cobalt induced magnetization of the PZT top layer titanium atoms [1].

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References:

[1] H. L. Meyerheim, K. Mohseni, A. Ernst, A. Quindeau, and S. Roy, unpublished

[2] V.S. Borisov, S. Ostanin, I.V. Maznichnko et al., Phys. Rev. B 89, 054436 (2014)

[3] D. Pantel, S. Goetze, D. Hesse, and M. Alexe, Nat. Mat. 11, 289 (2012)