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.

Experiment title: GIXRD to investigate the structure of advanced metal / high-k stacks	Experiment number: HS-3778
Beamline:	**Date of experiment**: from: 12/11/2008 to: 18/11/2008	**Date of report**: 17/02/2011
Shifts:	**Local contact(s): Blanka Detlefs, Jerome Roy**	*Received at ESRF:*

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Understanding the electrical properties of the new "high-k/metal" MOSFET devices requires the use of advanced characterization techniques in order to identify the physical and chemical properties of the gate stack [1]. However the physical limits of XRD or XPS experiments performed with laboratory X-ray sources are often reached. For XRD, the low thickness (< 10 nm) of the layers, correlated to small grain size induces wide peaks and low intensity on diffraction patterns. The use of hard X-rays on a synchrotron facility overcomes this problem thanks to the high brightness of the source. The X-ray wavelength can be tuned in order to optimize resolution in the reciprocal space for studies of stack components of low crystal symmetry. Here we investigate the crystalline structure of TiN/HfO_2 gate stacks using grazing incidence XRD (GIXRD). Analyses were performed on the ID32 beam line at ESRF. 5 nm-thick HfO_2 is shown to be monoclinic with no change after metal gate deposition. 5 and 10 nm-thick TiN is crystallized in the cubic phase (see figure 1). No change of the crystalline structure is observed during the processing steps following the TiN deposition (poly-Si deposition and spike anneal). The evolution of the stress state in the layers is investigated from the diffraction peaks positions. For more details, see reference [2].

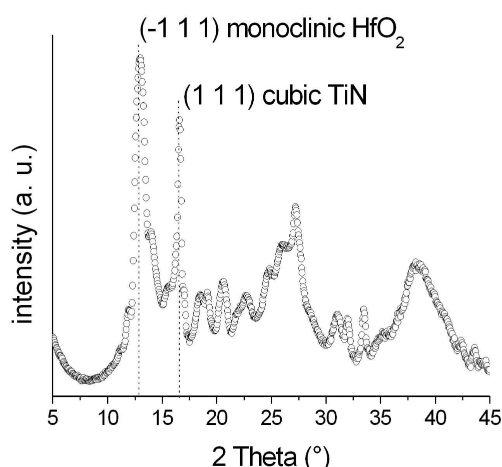

FIGURE 1. GIXRD diagram of a TiN (10nm)/HfO_2 (5nm)/SiO_2 (0.8nm)/Si gate stack measured using a 17.7 keV X-ray beam.

REFERENCES

[1] H. Wong and H. Iwai, *Microelectronic Engineering*, vol. **83**, issue 10, 2006, pp. 1867-1904.
[2] C. Gaumer, E. Martinez, S. Lhostis, F. Fillot, P. Gergaud, B. Detlefs, J. Roy, Y. Mi, J.-P. Barnes, J. Zegenhagen, A. Chabli, "On the use of synchrotron radiation for the characterization of TiN/HfO_2 gate stacks", poster presented at the FCMN09 international conference (Albany, USA, 11-15/05/2009) and paper published in AIP conference proceedings 1173, 40 (2009).