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:** Evaluation of a new type of ultra-thin silicon detectors as intensity monitors for X-ray monitoring	**Experiment number**: MI-541
Beamline: ID21	**Date of experiment**: from: 12/11/2001 to: 16/11/2001	**Date of report**: 26/08/2002
Shifts: 9	**Local contact(s)**: Wolfgang Ludwig	*Received at ESRF:*
Names and affiliations of applicants (* indicates experimentalists): Ray Barrett (ESRF), P. Bergonzo (CEA), E. Snidero (CEA), P. Delacour (CEA)		

Report:

Introduction

The aim of the experiment was to study the performance of ultra-thin silicon detectors, fabricated from standard silicon-on-insulator (SOI) substrates, for the intensity monitoring of low energy X-ray beams. Earlier experiments on semi-transparent detectors for X-ray beam intensity and position monitoring have attracted considerable interest as a new tool for beam characterisation in the low energy domain [1,2]. In fact, conventional detectors exhibit high cross sections to low energy x-rays, whereas devices made from diamond or ultra-thin silicon enable the fabrication of semitransparent detectors, with interests in the low energy domain. Of these, the fabrication of thin chemical vapour deposited (CVD) diamond detectors was studied at ESRF and led to the fabrication of beam position and profile monitors [1,2]. However, one inherent problem associated with CVD diamond synthesis is the formation of a polycrystalline material. The crystal structure is far from homogeneous, and average grain size lies in the order of a tenth of the film thickness. This results in a non homogeneous detection efficiency with respect to the position of interaction of a focused X-ray beam [3]. For other applications where high resolution in quantifying the intensity of low energy X-ray beams is required, e.g. for polarisation dependant X-ray spectroscopy, XAFS on ultra dilute samples, or also on microscopy beam lines where the beam spot dimensions are small with respect to the non-uniformities of the material, we propose to use a new type of devices based on ultra-thin silicon technology (5-20 µm).

To date, commercially available thin silicon detectors, namely as fabricated by SINTEF, rely on the use of thin silicon membranes manufactured via chemical etching of thicker silicon substrates. However, this technique only enables a low uniformity of the thickness, of the order of few percents. When small beam displacements occur during the measurement, this non-uniformity results in non-linear errors on the intensity measurements. We then propose to use devices fabricated from SOI substrates since the fabrication process enables selective etching to the thin surface layer and therefore high uniformity in thickness, typ. below 1nm from standard commercially available optically polished SOI substrates. When ultra-thin thicknesses are used, silicon exhibits a high transmission to soft X-rays, from 75% at 5keV to 32 % at 3 keV for a 5 µm layer. These devices have already been fabricated and used successfully for the detection of ionising radiations [4], and the fabrication process has also been patented by CEA [5].

Tests were performed on thin SOI-based devices made from high resistivity silicon, exhibiting thicknesses of the active layer from 30 to 3.5 µm. On top of the thin Si layer was also deposited a 1µm thick SiO_2 layer for passivation. Two types of configuration were tested as presented in Figure 1, with "vertical" or "horizontal" structures according to the direction of the electric field with respect to the device cross section. In order to deplete the material, pin jonctions, obtained from the implantation of p and n regions (typ. 1µm in depth), or schottky diodes were fabricated.

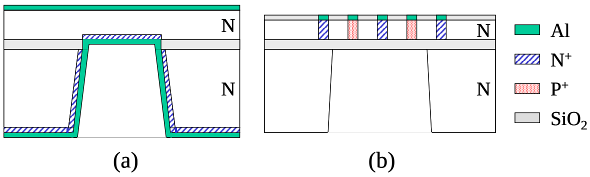

Figure 1 : SOI based membrane devices, in "vertical" (a) and "horizontal (b) configurations

The tests consisted in varying the beam energy (around a mean value of about 6 keV), flux, and beam size, and in studying the variations of the signal with respect to that measured with a calibrated reference silicon diode (Eurisys Mesures) placed behind the semitransparent SOI device. The beam spot size was focused down to typically 10 µm and enabled the measurement of the field profile in the "horizontal" devices [6]. Temporal evolution of the signal is shown in Figure 2. It appears that a weak variation of the ratio $I_{SOI}/I_{ref\text{-}SI}$ was observed, of the order of 0.5± 0,05 %. This variation could be explained by EMC noise as created in both tested and reference non-shielded Si diodes and would benefit from an improvement of the device mounts.

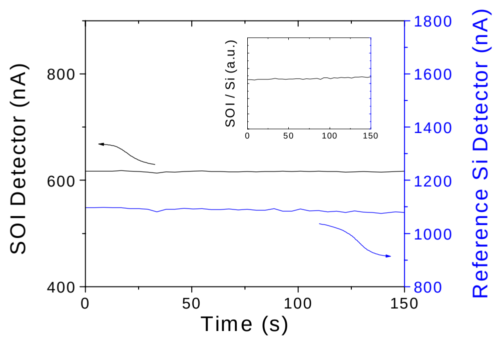

Figure 2 : Time evolution of a SOI I0 monitor

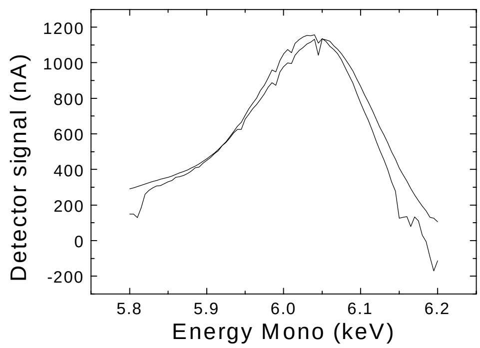

Figure 3 : Rocking curve measured with SOI I0 monitor

One of the interests of this type of semitransparent devices is their use as a tool for absorption spectroscopy. The Figure 3 shows the variation of the device response while the energy is varied around a mean value of 6 keV (2 non-successive scans). Clearly it appears that small glitches are observed, relative to the cristalline nature of the front SOI thin device. These glitches can appear as detrimental for specific measurements such as fine absorption spectroscopy in ultradiluted samples. They can be of minor importance for most I0 measurement requirements but also motivate the use of polycristalline materials such as CVD diamond (see MI-347, MI-380, or MI-452). This latter aspect was also studied during this experiment where the non-uniformity of sensitivity of a polycristalline diamond detector was probed in order to be compared with the cristalline structure of the material [7].

References

[1] P. Bergonzo, A. Brambilla, D. Tromson, R.D. Marshall, C. Jany, F. Foulon, C. Gauthier, V.A. Solé, A. Rogalev, J. Goulon, J. Synchrotron Rad. (1999) 6, 1-5

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[4] F. Foulon, L. Rousseau, L. Babadjian, S. Spirkovitch, A. Brambilla, P. Bergonzo, IEEE-Trans. Nuc. Sci. 46, (1999) 218

[5] L. Babadjian, F. Foulon, S. Spirkovitch, "Thin film Shcottky diode detector for detection of ionising radiation", patent WO9723003

[6]."Réalisation et Caractérisation de détecteurs semiconducteurs ultra-minces à base de substrats SOI" - CNAM Thesis, Philippe Delacour, Paris 2002, to be submitted.

[7] P. Bergonzo, D. Tromson, C. Mer, E. Snidero, R. Barrett, W. Ludwig, A. Tromson-Carli , R. Chiron, JP Kleider, J. Alvarez, to be presented at Diamond'2002 meeting, Grenade, sept. 2002