ESRF	**Experiment title:** X-ray microscopy and microdiffraction experiments with X-ray waveguides (Long Term Project 2001/I - 2002/II)	**Experiment number**: MI490
Beamline: ID32	**Date of experiment**: from: 3/10/2001 to: 10/10/2001	**Date of report**: 28/2/2003
Shifts: 21	**Local contact(s)**: B. Cowie	*Received at ESRF:*

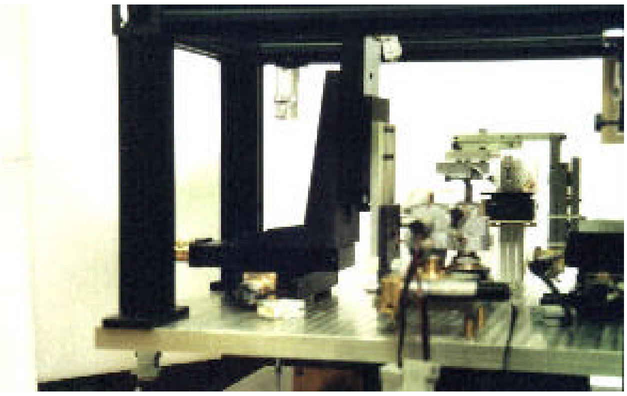
Names and affiliations of applicants (* indicates experimentalists):

Dr. Stefano LAGOMARSINO	**IFN - CNR Roma (Italy)**
Dr. Alessia CEDOLA	IFN - CNR Roma (Italy)
Dr. Silvia DI FONZO	Sincrotrone trieste (Italy)
Dr. Cinzia GIANNINI	IC - CNR Bari (Italy)
Dr. Werner JARK	Sincrotrone trieste (Italy)
Dr. Vesna STANIC	Ist. Scienze Fisiche - Un. Ancona (Italy)
Dr. M. Burghammer	ESRF
Dr. C. Riekel	ESRF

Report:

The run was part of a Long Term Proposal involving experiments at ID13, ID32 and BM5. The critical aspect of the mechanical stability, and the complexity of the alignment procedures which often require an important fraction of the scheduled shifts, convinced us about the need to build a dedicated instrument with the necessary characteristics of stability, accuracy and precision, and that would allow a kind of off-line pre-alignment. We therefore designed and build an instrument with these characteristics. A first version was tested in the first run at ID32 (3-10 oct. 2001). It consisted of an aluminum plate which holds three main elements: an holder for the monochromator with 5 degrees of freedom (three motorised), an holder for the waveguide with six DOF (five motorised) and an holder for the sample with six DOF, all motorised. Two TV cameras allow to accurately control the distance sample-waveguide and the proper positioning of the sample in the beam. All the motors are DC motors with encoder with high demultiplication. The staff of ID32 was extremely helpful and collaborative in interfacing the motor control with SPEC. This first version required however the use of the large diffractometer installed on the beamline to hold the detector, with some difficulties in proper alignment. Though the overall test of the apparatus was satisfying, we suffered of strong instabilities mainly due to the beamline monochromator. A second run was carried out at ID32 from 6th to 11th march 2002 with an improved version of the instrument that now carries also a detector arm and therefore is a complete and independent diffractometer. The instabilities of the monochromator were quite completely suppressed and the apparatus behaved very satisfactorily in terms of stability, accuracy and precision.

Figs. 1 and 2 present a view of the instrument.



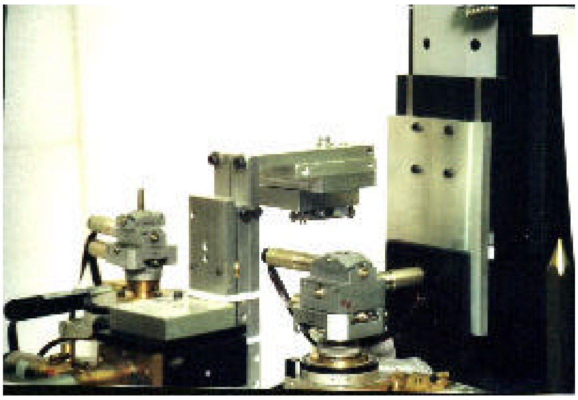


Fig.1 General view of the X-ray micro-diffractometer. The goniometer holding the detector arm is not visible

Fig. 2 Detailed view of the three main elements of the micro-diffractometer. From left to right: monochromator holder, waveguide holder and sample holder.

Concerning measurements, the main goal was the determination of strain in SiGe quantum wires, and the measure of strain induced by processing in Shallow Trench Isolation (STI) Si structures. The first part failed, because we didn't get evidence of signal coming from the SiGe wires. Perhaps this was due to some failure in sample preparation. Instead, the second part of the scheduled measurements was successful. Samples similar to those measured in BM5 were analyzed, but with much greater accuracy due to the higher flux. Fig. 3 shows an example of the diffraction curve in the strained stripes, together with a reference diffraction profile taken in an unstrained part of the sample. In order to properly analyze data we developed a fitting algorithm of the rocking curves which is able to extract the strain depth profile even without an input model. This allowed us to successfully determine strain in 0.22 μ STI structures. Fig. 4 shows the result.

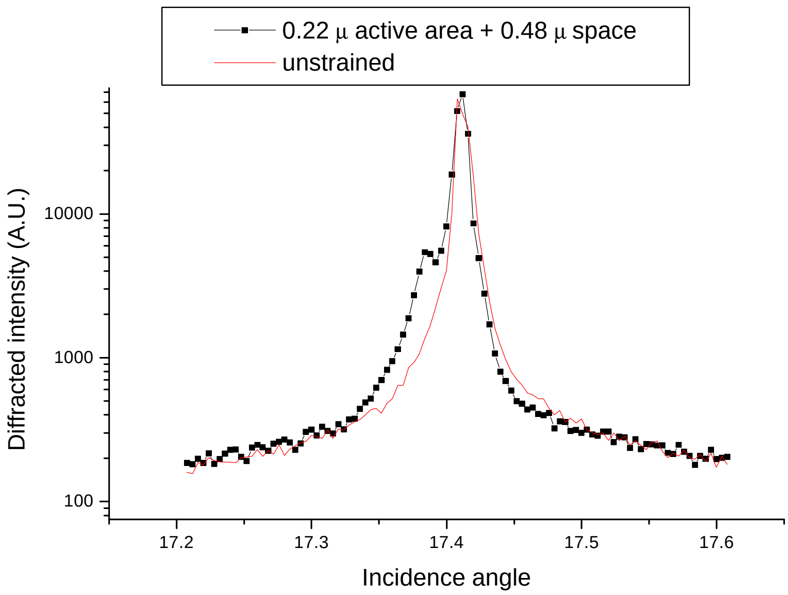


Fig. 3 Example of a diffraction curve on a 0.22 μ active area stripe (closed squares). Solid line: diffraction curve from an unstrained part of the sample which is used as a reference.

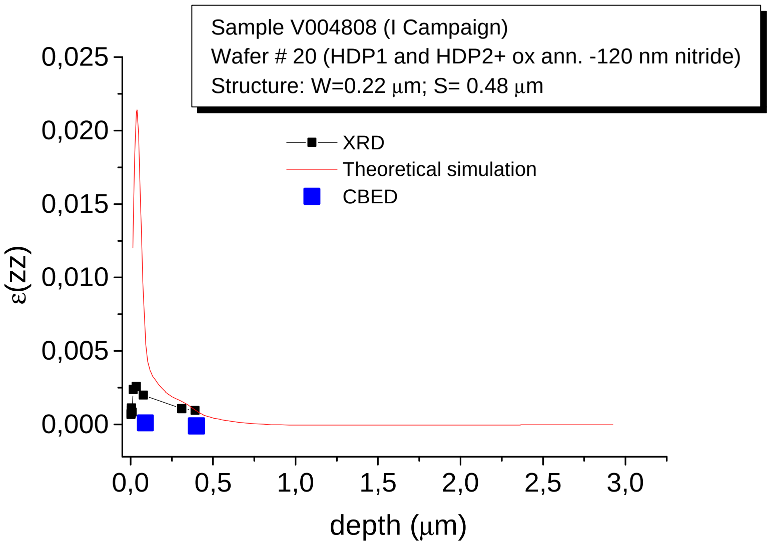


Fig. 4 Strain depth profile (closed squares) derived by diffraction curve in fig. 3 compared to the result of CBED (Convergent Beam Electron Diffraction) and numerical simulations.

The result taken at ID32 allowed us to successfully conclude the European Project STREAM with the demonstration that X-ray microdiffraction measurements can give important contribution on the assessment of strain induced by processing in microelectronics.

It is worth to note that the instrument tested on ID32 can easily be installed and aligned on any beamline. The only requirement is a free space of about 1 m^2 and a support with a rough control in height. This instrument gives therefore the possibility to run experiments with waveguide (and in general with optical elements requiring careful alignment procedures and good stability) in many other beamlines.