ESRF	**Experiment title:** **INVESTIGATION OF LONG RANGE STRAIN FIELDS IN THE UPPER SILICON FILM OF "SMART-CUT" SOI MATERIALS**	**Experiment number:** **HS-254**
Beamline: **ID 19**	**Date of experiment:** from: 29.4.1997 to: 1.5.1997	**Date of report:** 28.8.1997
Shifts: 6	**Local contact(s):** Jose Baruchel	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Moriceau, Hubert, LET1 *
Härtwig, Jürgen, ESRF *
Kohler, Stefan, ESRF *
Guilhahnec, Caroline, LET1 *
Ohler, Michael, ESRF *
Ludwig, Wolfgang, ESRF *

Report: Compared to the classical bulk silicon technology, silicon on insulator (SOI) structures offer considerable advantages in many microelectronics applications, as for SO1 based devices with improved speed, for low voltage use and low power consumption [l]. Several processes are now developed to manufacture such SO1 structures, among them the **"Smart cut'"** technology patented by LETI. It is based on **wafer bonding,** using implantation and thermal annealing effects to elaborate a thin upper Si film on a thin amorphous silicon oxide layer situated on a thick silicon substrate [2].

In order to be attractive for **ULSI applications** (ultra large scale integration), high crystalline quality of the upper thin silicon film has to be reached. Three kinds of effects which decrease the perfection of that layer have to be investigated: (i) dislocations and their strain fields, (ii) voids or non bonded areas, and (iii) long range strain fields with spatial frequencies in the order of hundreds of micrometers. After the last experiments it appeared, that the third kind is in the moment the most important to investigate, because it gives the main contribution in the deformation (see report to experimentHC-67).

TEM observations are no more useable for this kind of deformation due to its large scale (low spatial frequency). Thus, we used X-ray diffraction topography which allowed the visualisation and the quantitative characterisation of the weak long-range strain fields in bulk single crystals and thin layers. Using short wavelengths, which are accessible only at the ESRF, it was possible to improve the sensitivity for detecting weak deformations. On the basis of a) the observed contrasts in white beam and double crystal (monochromatic) topographs, b) the contrast behaviour as a function of the thickness of the bonded layer, and c) the observed strain relaxation in the neighbourhood of artificial cavities or grooves at the bonding interface (similar like in [3]) it could be stated that the geometrical form (surface morphology) of the two bonded surfaces is the origin of the observed strain fields as already proposed in [4]. By means of 1) focusing effects observed in white beam topographs taken for different sample to detector (film) distances, 2) the quantitative analysis of double crystal topographs, and 3) parallel measurements with optical interferometry a quantitative estimation of the strain field at the interface could be found. It consists of a relatively weak orientation part (inclination of lattice planes in the order of 10 arcsec) and of a strong lattice parameter variation (Ad/d $\approx 10^{-3}$). The main components have spatial frequencies in the order of 100 µm and a waviness (“roughness”, displacements perpendicular to the interface) in the order of 10 nm. The spatial frequency depends only weakly on different process and sample parameters. We estimated that these strains and the resulting shear stresses are to weak to lead to dislocation gliding or generation. Till now we could not find an effective possibility to reduce these long range strains.

References

[l] A. J. Auberton, B. Aspar, J. L. Pelloie, Semicon East Conference Proceedings, SEMI, Tokyo (1994)

[2] M. Bruel, Electronics Letters, 31, 120 (1995)

[3] I.V. Grekhov, T. S. Argunova, L. S. Kostina, T. V. Kudryatzeva, E. D. Kim, S. C. Kim, Electronics Letters 31,20 (1995)

[4] W. P. Maszara, B.-L. Jiang, A. Yamada, G. A. Rozgonyi, H. Baumgart, A. J. R. de Kock, J. Appl. Phys. 69,257 (1991)