ESRF	**Experiment title:** **Investigation of the perfection of diamond, adequate for coherence preserving Bragg-diffracting X-ray optical elements**	**Experiment number**: Mi-857
Beamline:	**Date of experiment**: from: 12.10.2006 to: 16.10.2006	**Date of report**:
Shifts:	**Local contact(s)**: J.Härtwig	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

S. Ballestrero* Wits University, Johannesburg
S.Connell* Wits UIniversity, Johannesburg
D. Dube* University of Johannesburg and Wits University, Johannesburg
J. Härtwig* ESRF
F. Masiello* ESRF
P. Van Vaerenbergh* ESRF

Report:

Bragg diffracting X-ray optical elements that conserve coherence should have a high degree bulk and surface perfection of perfection. Concerning the bulk defect propertiesd this means that in larger crystal regions no dislocations, micro-defects, inclusions and precipitates should be present and the relative lattice parameter changes should be in the order of about 10^{-8}. There are only few methods known that are able to measure strain inhomogeneities in nearly perfect crystals with the above mentioned necessary strain sensitivity. Sophisticated double crystal diffraction topography methods like plane wave topography may be used. At ID19 an instrument exists that allows to work with increasing strain sensitivity. The idea is to use a non-dispersive (n,-m)-setup with a bendable silicon monochromator, combined with high-order reflections [1]. In this way rocking curves (autocorrelation function of sample and monochromator reflectivity curves) with extremely steep flanks may be obtained what results in an extreme strain sensitivity when working on the steepest part of the flanks. So we planned to push the detection level of about 10^{-7} (what is a more "classical" case), down to about 10^{-8}.

The present experiment was aimed to check to possibilities of the instrument, to approach step by step a higher strain sensitivity and to establish a measuring and adjustment procedure to reduce the ather considerable measuring timenot. This was done using samples of one of the most recent growth experiments. Figure1 demonstrates the strain sensitivity in three different experimental set-ups. The visibility of the defects and in particular the extension of the related long-range strain fields which create the defect image, are different. Crystal parts that appear to be homogenous in the first two topographs start to be inhomogeneous tue to the very high strain sensitivity in the right topograph, taken with a set-up with a theoretical detection limit of about 1.2×10^{-8}. An avantage of such kind of double crystal is the possibility (under certain conditions) of quantitative strain (effective misorientation) determinations from topographs, that is to calculate strain maps [2, 3]. Figure 2 shows one result.

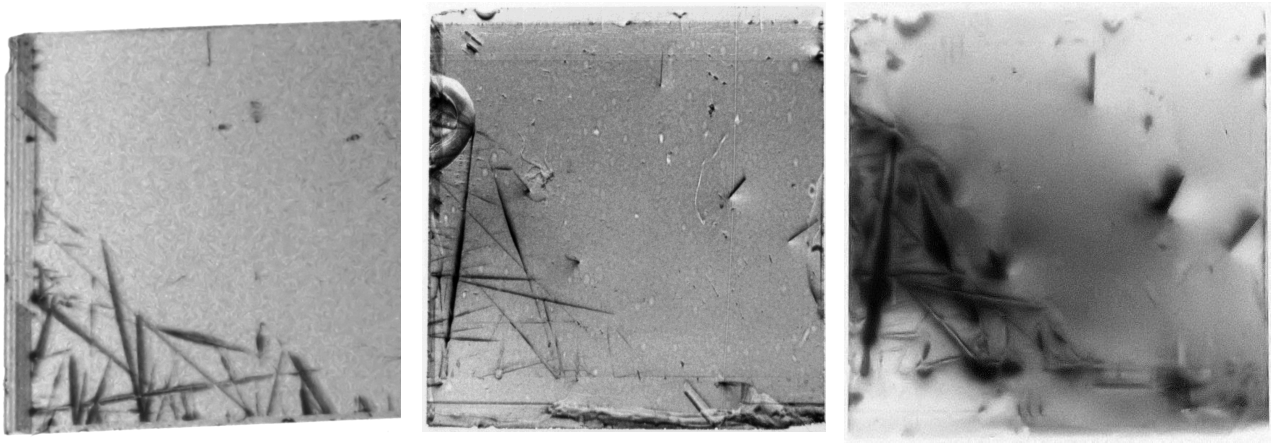

Fig.1: Comparison of three topographs taken with different set-ups from a highly pure Type IIa, 100-oriented diamond (5x5mm^2). The low-left part was not polished to the end and shows several scratches. The rest is nearly defect-free, showing mainly three isolated single dislocation. The left image is a white beam topograph, the other two are double crystal topographs, with all crystals in Bragg-(reflection-) geometry. The middle one was taken at 12keV, with the 444-reflection of the silicon monochromator (Darwin width 1.00″) and the -115-reflection of the diamond sample (Darwin width 1.02″), theoretical detection limit is about 4x10^{-8}. The right one was taken at 20keV, with the 800-reflection of the silicon monochromator (Darwin width 0.31″) and the 800-reflection of the diamond sample (Darwin width 0.25″), theoretical detection limit is about 1.2x10^{-8}.

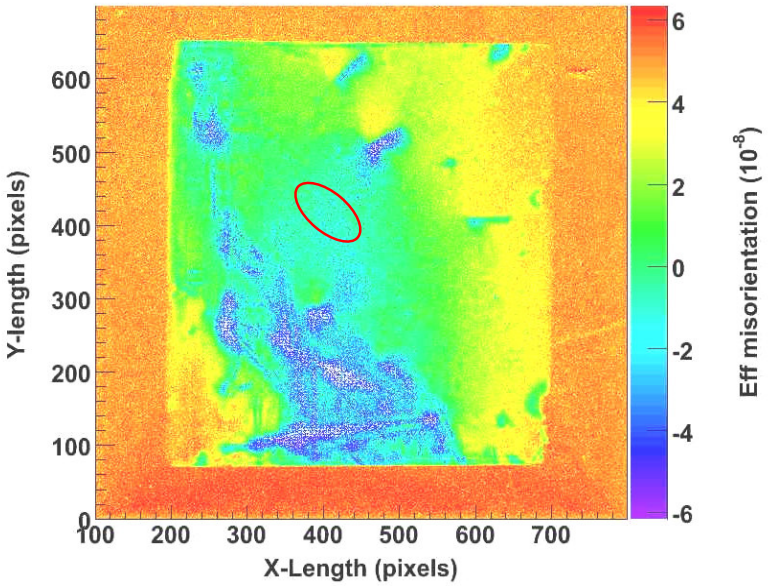

Fig. 2: Quantitative strain (effective misorientation) map taken from the right topograph in figure 1, showing regions (e.g. in red ellipse) with local strain close to 3x10^{-8}.

References

[1] D Altin, J Härtwig, R Köhler, W Ludwig, M Ohler and H Klein, *X-ray diffraction topography using a diffractometer with a bendable monochromator at a synchrotron radiation source*, Journal of Synchrotron Radiation **9**, 282-286 (2002)

[2] K.D. Bowen and B.K Tanner, *High Resolution X-Ray Diffraction and Topography*, CRC Press, (1998).

[3] V. Lerche, P. Dörnfelder and J. Härtwig, *Direct backward calculation from X-ray double crystal topographs*, Phys. Stat. Solidi (a) **128** (1991) 269.