ESRF	**Experiment title:** Spatial high-resolution mapping of three-dimensional lattice tilt misorientation in wafers for electronic devices	**Experiment number:** MI-608
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Report:

We have recently developed the method named *synchrotron area diffractometry* (alias *rocking curve imaging*), which combines x-ray diffractometry and x-ray diffraction topography [1]. By recording digital topographs at a series of different rotation angles along the rocking curve of a crystalline sample, it allows to quantitatively characterize the homogeneity of the crystalline lattice and the spatial distribution of defects inside the sample.

The aim of experiment MI-608 was to test further improvements of the method on a series of GaAs wafers. Ingots of GaAs grown by the LEC method sometimes contain macrodefects which extend along the main ingot axis and perturb the perfection of a large number of wafers cut from the same ingot. While some information on the shape and size of these defects can be gained in the laboratory by etching and optical inspection of the wafer surface, X-ray diffraction is a much more appropriate technique to study the nature of the defects: It is non-destructive and can be used to quantify the degree of misorientation (both in-plane (twist) and out-of-plane (tilt)) of the crystal lattice in the perturbed region with respect to the surrounding matrix. This information is crucial from an application point of view, since only a certain amount of tilt and twist can be tolerated without perturbing the functioning of the microelectronic devices that are to be grown on top of the wafer.

For this experiment, eight GaAs wafers had been cut at various heights from two different ingots. For each sample, the adjacent wafer from the same ingot was etched, and an optical microscope image of the defect structure at the surface was available for initial orientation and for comparison with the X-ray results.

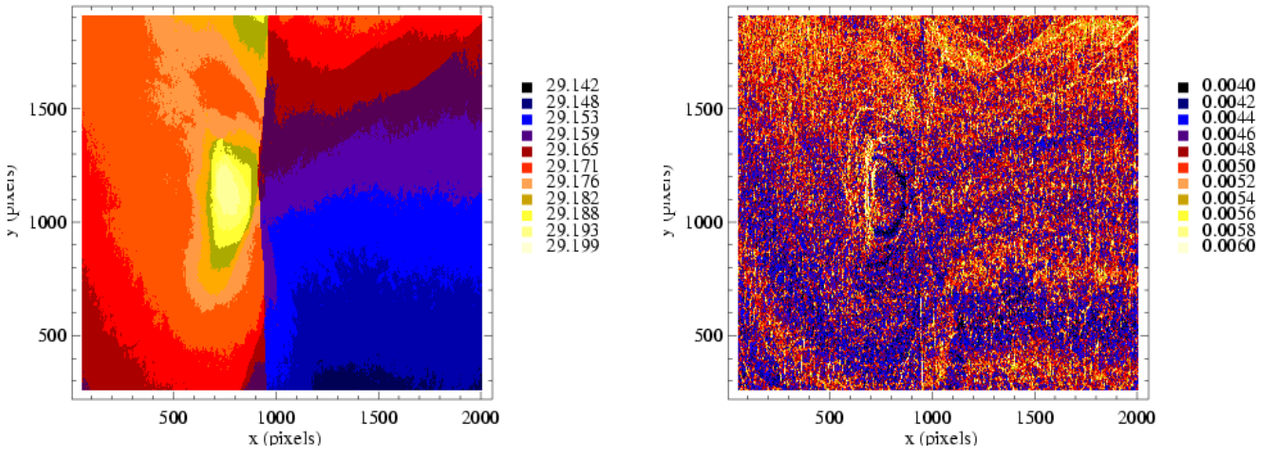

Figure 1: Results of area diffractometry scans on a GaAs wafer, measured at the 004-reflection: Map of local Bragg peak position (left) and rocking curve FWHMs (right). Both scales are in degrees; axes are in units of pixels (7 μm).

An X-ray energy of 9 keV was used, together with a FReLoN-2000 camera with 7 micron pixel size optics. For each sample, area diffractometry scans were performed at three different reflections in Bragg geometry. Thanks to recent advances in our analysis software, the scans could be preliminarily analyzed "in real time" during the experiment. The results were represented as maps of peak intensity, angular peak position and rocking curve half width. A typical result is shown in Fig. 1. In this way, we could both visualize the defect shapes and quantify the lattice misorientation. The information available from the three scans of each sample are combined into a three-dimensional misorientation picture for each defect along the lines discussed in [2].

Additionally, recent advances in our data evaluation method have made it possible to carry out two more types of analysis: By combining two scans measured at the same reflection in different azimuths, one can experimentally distinguish between lattice misorientations and changes in Bragg angles (strain). A preliminary analysis has shown that strain values are indeed mostly very small (some 10^{-5}), and that variations in peak positions are thus predominantly due to lattice tilts. Similarly, by combining yet another set of scans in two different azimuths and applying an elasticity theory calculation, one can quantify the density of dislocations lines crossing the sample surface. A first evaluation of this type has been finished and shows very promising results. A complete analysis is under way and will be published shortly in a comprehensive paper.

References

[1] Lübbert, D., Baumbach, T., Härtwig, J., Boller, E., and Pernot, E. *Nucl. Instr. Meth. B 160*, 4 (Apr. 2000), 521–527.

[2] Mikulík, P., Lübbert, D., Korytár, D., Pernot, P., and Baumbach, T. *J. Phys. D: Appl. Phys.* (2003), in press.