ESRF	**Experiment title:** **Investigation of GaAs and CdTe/CdZnTe sensor layers for the Medipix1 pixel detector**	**Experiment number**: ME 803
Beamline: ID 19	**Date of experiment**: from: 10th June to: 14th June	**Date of report**: 01. Sept 2005
Shifts: 15	**Local contact(s)**: Petra Pernot	*Received at ESRF:*

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Aims of the experiment and scientific background

The experiment ME803 was aimed at characterising both Medipix1 and Medipix2 assemblies bumpbonded to Si, GaAs and CdTe/CdZnTe sensor layers. Silicon samples were added to compare the Rocking Curve Imaging (RCI) results with the results from a *"perfect"* crystal and well understood charge transport properties inside the sensor.

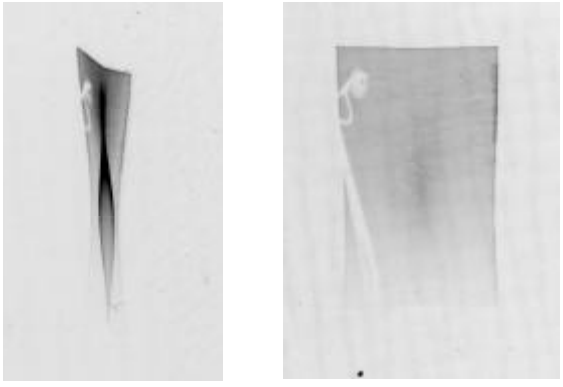
Experimental methods

The following samples have been investigated:
a) 3 GaAs sensor bumpbonded to Medipix1.
b) 1 CdTe sensor bumpbonded to Medipix2, and additional pieces of CdTe which were not bumpbonded
c) 1 Si sensor bumpbonded on Medipix2

Photographic film and the FRELON camera with 7.5 µm pixel size has been used as a detector for the topography and RCI measurements, respectively.
Planned experiments to map the response of single pixels (55 µm size) were not possible, however, because the beam collimation (provided by the ID19 white-beam precise slits) did not allow for beams smaller than ~ 70µm.

White-beam topography

White beam topoographs showed a strong strain in the GaAs sensor layer at room temperature. Heating the sensor layer to 210 °C lead to a relaxation of the GaAs crystal (see Fig. 1). This confirms that the source of the strain is the bump-bonding process (at 300°C), that fixes the silicon readout chip to the GaAs sensor layer. As the temperature expansion coefficient of those two materials differs by a factor of 2.6 , the difference in thermal expansion of the GaA and Si crystals can be calculated to approximately 10 µm.



25 °C **210 °C**

Fig. 1 Identical reflection of the white-beam topographs for two different assembly temperatures.

Rocking-curve imaging

Rocking curve imaging was carried out to assess the crystal deformation and local quality. Experimental parameters for one particular scan were: GaAs 080 reflection (transmission geometry), 7.46 µm pixel size and energy 60 keV.

Fig.2 shows raw images and resulting maps calculated from the image series [1]. The strong crystal deformation is again confirmed and can be quantified by calculation of the peak position: a tilt variation of 0.12 degrees over the crystal width is measured.

The calculation of the peak width (FWHM) shows the known mosaic structure of LEC-grown GaAs crystals.

Furthermore, the raw images suggest a local lattice misorientation around the bump bonds, visible by the light contrast next to the crystal being in the diffraction condition [1].

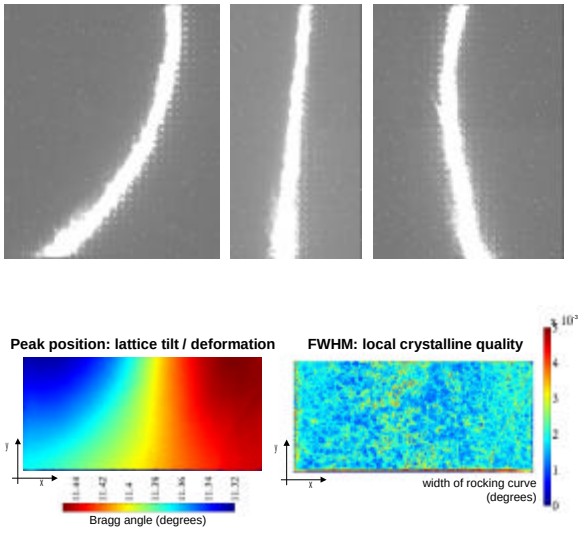


Fig. 2 A series of three raw images of RCI (top) under different rocking angles. Parameters calculated from the series (bottom): peak position (left) indicating lattice deformation and peak width (FWHW, right) indicating local crystal quality.

***In situ* observation of dynamical diffraction**

The high SNR of the Medipix2 allowed the in-situ observation of diffraction in the sensor layer of the detector chip [2]. To observe the formation of a scattered beam the collimated incident beam entered horizontally from the edge of the sensor, so that the pixels of the Medipix detector map the intensity of the incident and diffracted beam along its path (see Fig. 3). An X-ray energy of 50.5 keV was chosen, yielding an absorption length of about 17.6 mm in the silicon sensor. An acquisition for a part of the rocking scan of the (3 -3 1) reflection is shown in Fig 4. The logarithmic colormap allows one to see both the intensity loss in the incident beam and the emerging of the diffracted beams. The presence of strain can be clearly observed as diffraction occurs at various points in the sensor for various angular positions. An estimate of the strain is ? d/d = 7.1 10^{-5}. The corresponding radius of curvature is approximately 110 m.

Influence of fluorescence on detector resolution

The effect of fluorescence was investigated for energies slightly above and below the K-edge of Cd (26.7 keV) for the CdTe detector [3] (see Fig. 5). Crossed tungsten combs were utilized to yield small beams of ˜ 70 µm diameter. Increasing the energy above the K-edge of Cd causes loss of spatial resolution due to fluorescence photons in the detector.

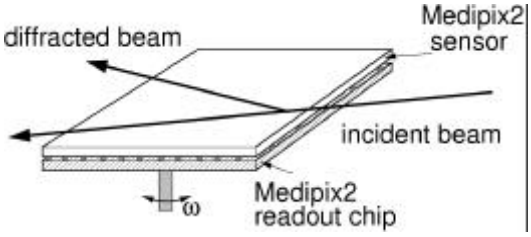


Fig. 3. Setup for direct observation of diffraction

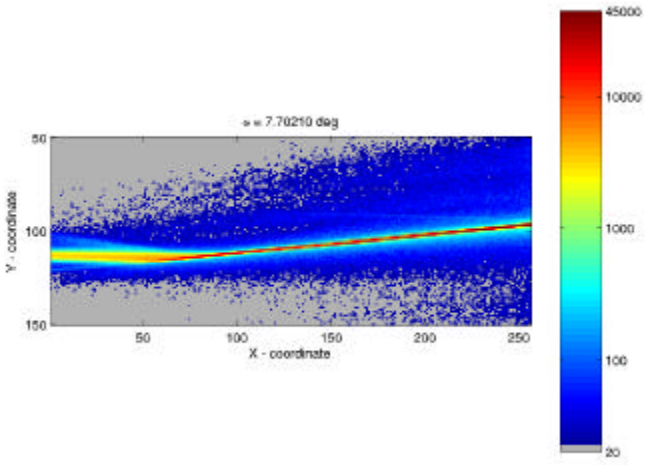


Fig. 4 Signal recorded by the detector, recording the beam entering from left. Diffraction occurs approx. at coordinate X =70.

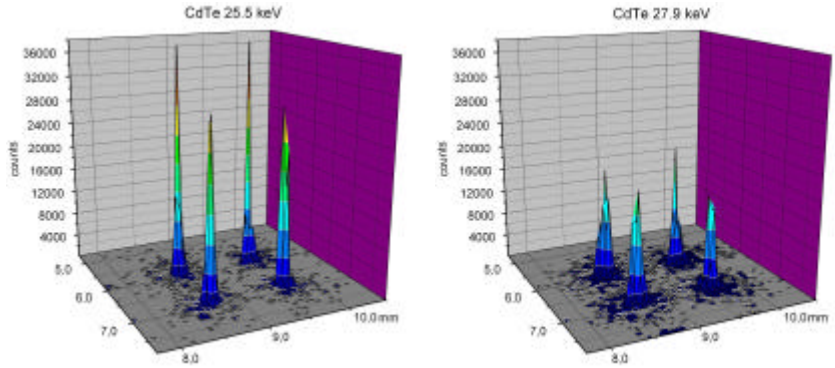


Fig. 5: Two acquistions just above and below the K-edge of Cd.

References

[1] L. Helfen *et al.*, Proceedings of IWORID7, Grenoble 2005, full paper to be submitted to *Nucl. Instr. Meth. A*

[2] M. Mitschke, P. Pernot, L. Helfen, S. Scherzer, A. Zwerger, T. Baumbach: „*In-situ Observation of Dynamical Diffraction by means of Medipix2 Sensor Crystal fulfilling Bragg Condition*“, *Nucl. Instr. Meth. A*, **546**, 135-139 (2005)

[3] A. Zwerger, J. Ludwig, *Characterization of CdTe and GaAs Pixel Arrays, Readout by the Medipix PC*, 14th International Workshop on Room-Temperature Semiconductor X- and Gamma-Ray Detectors, October 18-21, 2004