Characterization of 75 µm and 150 µm Thin Strip and Pixel Sensors Produced at MPP-HLL

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16th RD50 Workshop
Barcelona May 2010

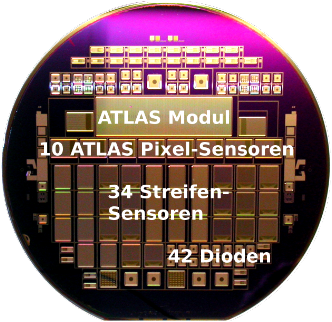
GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

FSP 101 ATLAS

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Reminder - 1st Thin Pixel Production at MPP/HLL

12 × 6″ Wafer

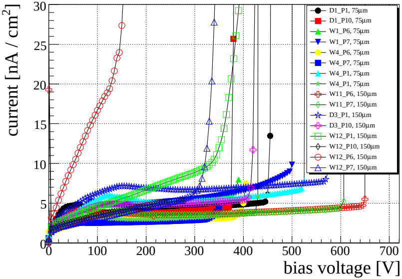


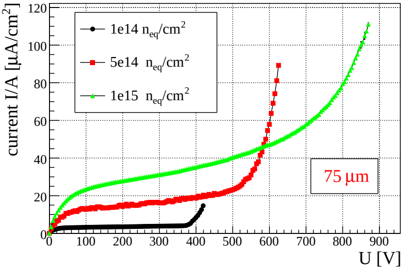
- Four wafers of 150 µm and eight (4×n-in-p &4×n-in-n)wafers of 75 µm active thickness (on handle wafer)
- Proton irradiation with fluences of 10^{14}, $5 \cdot 10^{14}$, 10^{15}, $3 \cdot 10^{15}$ and 10^{16} n_{eq/cm^2} in Karlsruhe (26 MeV)
- Second irradiation at CERN conducted in 11/09 (24 GeV/c)

1. Implant backside on sensor
2. Bond sensor wafer to handle wafer
3. Thin sensor side to desired thickness
4. Process on top side
5. Structure resist, etch backside up to oxide

Characterization of the Sensors Irradiated up to 10^{15} n_{eq}

n-in-p Pixel





- Very good yield: 79/80. Before irrad.: low leakage currents <10 nA/cm^2, very good breakd. behaviour $V_{break} \gg V_{depl}$
- As expected all structures showed improved breakdown behaviour after irradiation: $V_{break} \gg V_{depl}$
- Annealing decreases V_{depl}

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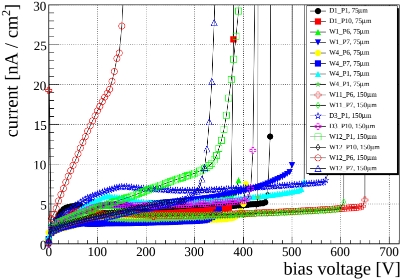

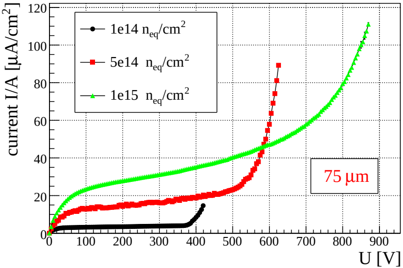

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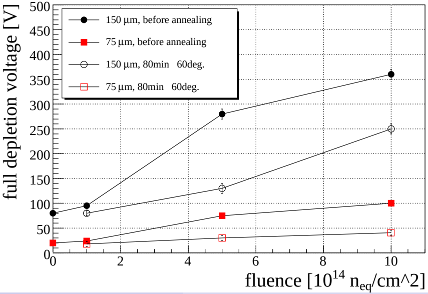
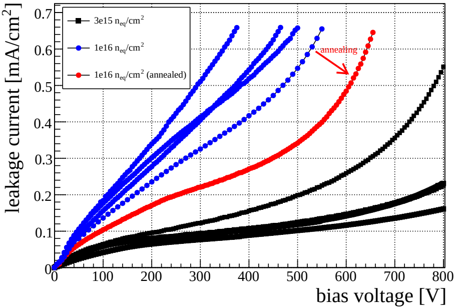
n-in-p Diodes



... of the Sensors Irradiated up to $3 \cdot 10^{15}$ n_{eq} & 10^{16} n_{eq}

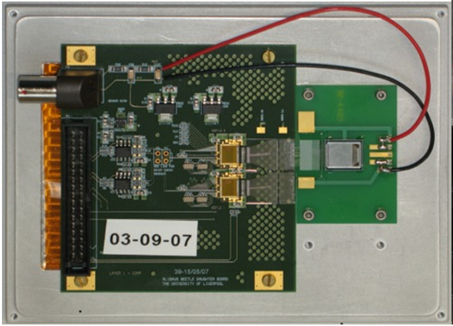
75 µm

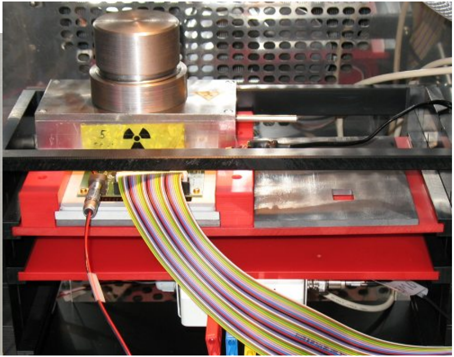


- Four 75 µm & four 150 µm structures were irradiated up to $3 \cdot 10^{15}$ n_{eq} & 10^{16} n_{eq}
- Same trend as for lower fluences (leakage current, breakdown, annealing)
- CV-Measurement was not yet possible for low frequencies needed at T=-10°C

Measurements @ -10°C

CCE Measurements with Alibava - Setup



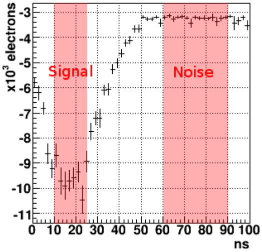


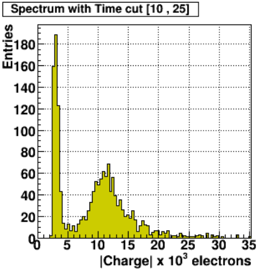
- CCE measurements on irradiated strips, from the same production, (75 and 150) μm, are on-going with the ALIBAVA system and a ^{90}Sr source.
- The strip sensors used in these measurements have exactly the same design as the pixels (punch-through biasing, DC coupling) with the exception of the length (7 mm)
- CCE measurements on pixels only possible after SLID interconnection of sensor and FE-I2 (in preparation)

CCE Measurements with Alibava - Software

Determination of CCE

Time window to determine signal, another window to determine noise.
Example spectrum for 150 µm thick sensor irradiated up to 3×10^{15} n_{eq} @975 V:





For lower voltages signal-landau shifts to lower values. The procedure works nonetheless:
Example spectrum for 150 µm thick sensor irradiated up to 10^{15} n_{eq} @100 V:

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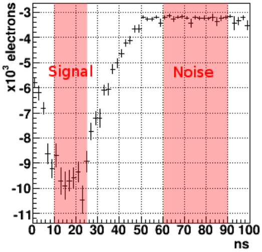

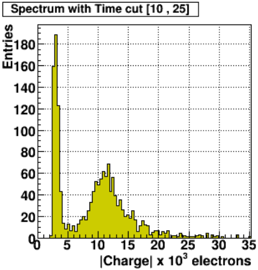

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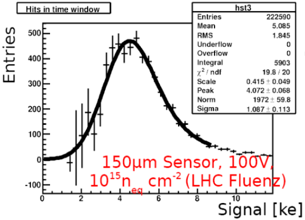
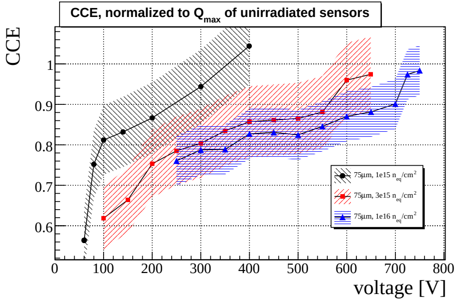
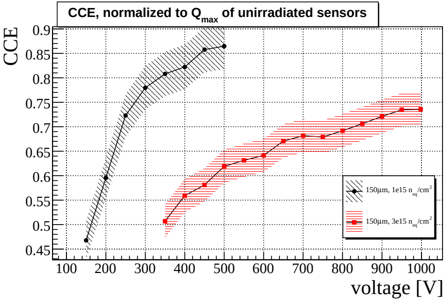


CCE Measurements



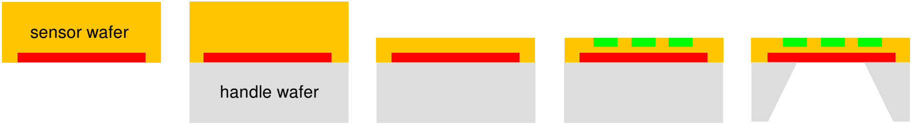


- After irradiation: Signal considerable higher than expected from simulation ($\rightarrow$ Talk by A. Macchiolo, this workshop).

75 µm	Signal height recovered within uncertainties
150 µm	Signal height lower than before irrad. (Higher voltages needed)

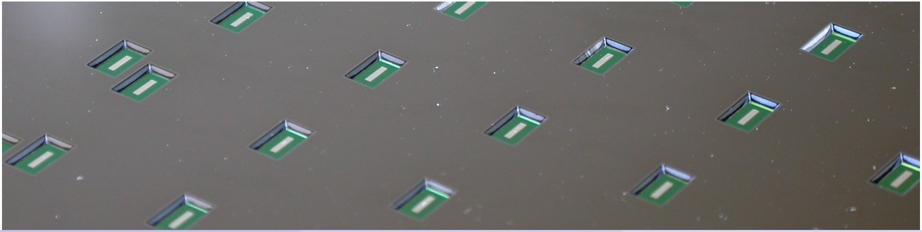
- Uncertainties correspond to 500 e^-, estimated for each point.
- Measurements before any intentional annealing: T=-30 °C ($\phi = 10^{15}$ n_{eq}/cm^2); T=-40 °C & T=-45 °C ($\phi = (3 - 10) \cdot 10^{15}$ n_{eq}/cm^2).

Outlook: MPP-HLL n-in-n Wafers



1. Implant backside on sensor
2. Bond sensor wafer to handle wafer
3. Thin sensor side to desired thickness
4. Process on top side
5. Structure resist, etch backside up to oxide

- To contact n-in-n wafers etching the back side is indispensable.
- Etching of small ($4 \times 2.5\,\text{mm}^2$) contact-holes finished recently.
- First Measurements: Breakdown at roughly 160 V, V_{depl} calculated to be at 80 V.



Second Thin Pixel Production at MPP-HLL

Aim Supply n-in-p pixel sensors for ATLAS Insertable B-Layer (IBL) qualification

- New ATLAS FE-I4 compatible
- Active thickness: 150 µm
- Inactive edges: 450 µm

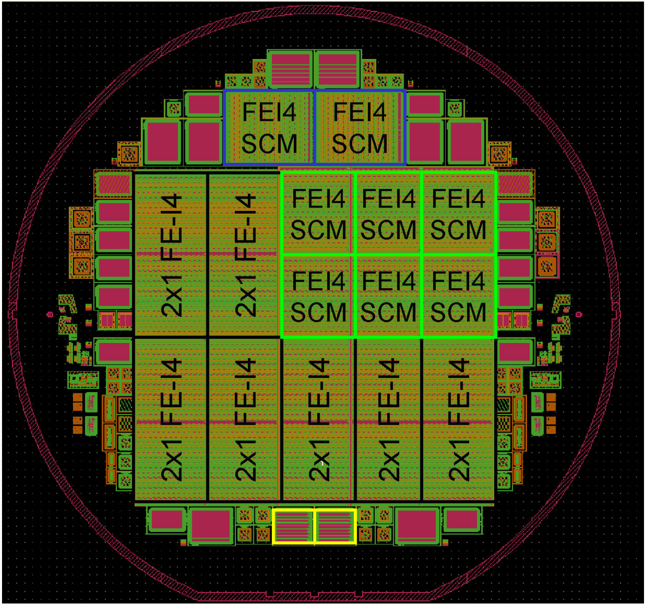
Concept Thinning technology verified in 1st production, reduced GR structure optimized with n-in-p CIS production

Status Five 6" Wafer at Nitride and LTO deposition at the moment

Timeline Finish production by August and testing by September

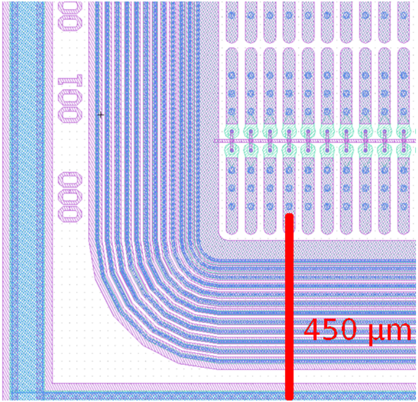
Connection Standard bump-bonding at IZM-Berlin after BCB deposition

Design of Second Thin Pixel Production at MPP-HLL



- 7: 2×1 FE-I4, 450 µm inactive edge
- 6: FE-I4 Single-Chip-Modules (SCM), 450 µm inactive edge
- 2: FE-I4 SCM, standard inactive edge (1 mm)
- 2: FE-I3
- Strip detectors (AC and DC coupled)

Design of Second Thin Pixel Production at MPP-HLL

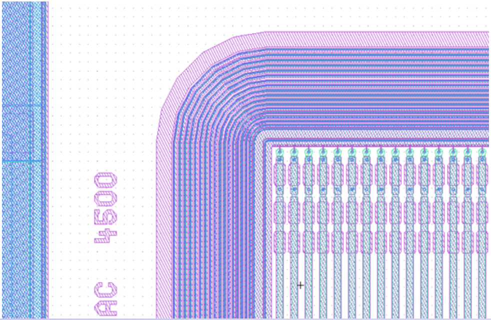


Strip sensors

- Strip sensors were included as in 1st production (→ Alibava)
- AC and DC versions, 80 µm pitch

2×1 FE-I4 Chip Module

- 12 GR with same structure as inner rigs of 1st and CIS production
- 450 µm inactive edge
- no ganged pixels
- two rows of 450 µm long pixels between the two chips
- homogenous p-spray (better before irrad in 1st and CIS, comparable after irrad.)



Summary and Plans

Summary

- IV and CV characterization finished for sensors irradiated up to $3 \cdot 10^{15}\,n_{eq}$ (including annealing studies): Good performance
- Measured CCE for sensors irradiated up to $10^{16}\,n_{eq}$ for 75 µm: Same signal height as before irrad. could be achieved
- Measured CCE for sensors irradiated up to $3 \cdot 10^{15}\,n_{eq}$ for 150 µm: Signal higher than expected from simulation but lower than before irradiation

Plans

- Gather more statistics for CCE measurements
- Quantify influence of decoupling pitch adapter
- 2nd n-in-p pixel production on its way to serve as IBL prototypes

BACKUP

IV-Curves for 75 µm thick sensors irradiated to $3 \cdot 10^{15}$ n_{eq} & 10^{16} n_{eq}