Laboratory Measurements of Stiched Passive CMOS Strip Sensors

16th (Virtual) "Trento" Workshop on Advanced Silicon Radiation Detectors

Marta Baselga, Leena Diehl, Ingrid-Maria Gregor, Marc Hauser, Tomasz Hemperek, Jan-Cedric Höning, Sven Mädgefessel, Ulrich Parzefall, Arturo Rodriguez, Surabhi Sharma, Dennis Sperlich, Tianyang Wang, Liv Wiik-Fuchs
First stitched strip sensors produced on 8" wafer by a commercial high volume foundry.

- L-Foundry 150 nm process (deep N-well/P-well)
- Up to 7 metal layers
- Wafer Resistivity: > 2 kΩ·cm
- Float-Zone silicon

Frontside process: Reticle stitching ⇒ larger sensors

Two different batches:
- low concentration backside implant and not metallization
- higher concentration backside implant and metallization

Two sensor lengths:
- 2 cm (short sensor)
- 4 cm (long sensor)
CMOS Passive Strip Detectors

- Strip sensor implemented in 1/2A
- Stitched every ~1 cm along strip length
- Strip pitch: 75.5 μm

Stitching crucial for large area sensors
CMOS Passive Strip Detectors

- 40 strips for each side
- Three types of implants per sensor
- Four total combinations

Wide implant (two widths)

- 7 um
- 10 um
- 30/55 um
- 75.5 um
- 4 um

Thin implant

- 15 um
- 18 um
- 75.5 um
- 4 um

~1 cm (Not to scale)
**IV Results**

**First batch** ⇒ low concentration backside implant, no metallization
- Early breakdown for both designs
- Thin design shows strong increase in leakage current at low voltages
- Poor stability for Wide design

**Second batch** ⇒ higher concentration backside implant and metallization
- Breakdown above 220 V (improved)
- Wide design more stable along the range of voltages
CV Results

- Full depletion voltage around 25-40 V for both designs
- Different full depletion capacitance for thin and wide design ⇒ Different effective thickness
- More homogeneous capacitance
- Strong strip impact on capacitance for thin design at low voltages up to 10 V
- No negative effect from stitching visible
Interstrip capacitance

- Two different strip implants visible on the “wide” design
- No effect from stitching visible

### First batch

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Capacitance/Length (fF/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“wide” left</td>
<td>62 ± 0.2</td>
</tr>
<tr>
<td>“wide” right</td>
<td>144 ± 0.4</td>
</tr>
<tr>
<td>“thin”</td>
<td>37 ± 0.1</td>
</tr>
</tbody>
</table>
Source Measurements

- Both strip designs bonded to one chip
  - Maximum bias voltage 100 V
- Twelve voltages measured:
  - 5 - 40 V in 5 V steps
  - 50, 60, 80 and 100 V
- Only sensors from first batch tested

⇒ Move source to scan each stitched area
Source Measurements Results - Signal

- No evidence of any effect of stitching on the charge collection for the thin implant design
- No differences between long and short sensors
No evidence of any effect of stitching on the charge collection for the thin implant design

Low signal-to-noise ratio
No evidence of any effect of stitching on the charge collection for the wide implant design

Need to understand effect of the 2 different strip designs used in the “wide” sensor
Source Measurements Results - Noise

- No evidence of any effect of stitching on the charge collection for the wide implant design
- Low signal-to-noise ratio
Summary and outlook

- Successful design, production and measurements of first passive CMOS strip sensors
- “Wide” sensor design is better suited to withstand high voltages
- Breakdown voltage for good sensors is larger than 250 V
- **No negative effect from the stitching could be observe in the measurements conducted**
- First batch with backside processing issues showed electrical problems ⇒ *solved in the second batch*
- Charge collection measurements for the second batch are currently performed
- Irradiation studies are planned
- Sensor were measured at the DESY test beam facility and analysis is ongoing
Thanks for your attention
Source Measurements - Setup

- Radioactive source housed in a plexiglas cylinder
  - Collimates the electrons towards the silicon sensor
  - Provides shielding

- Two plastic scintillator-photomultiplier combinations
  - Trigger for the readout of the sensor
  - Area of 4 x 4 mm² and 45 x 45 mm²
  - 4 mm thickness