New semiconductor 2D position-sensitive detector

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Outline:

Recalling the charge division principle
Description “proof of concept” prototypes
Laser and \(^{90}\text{Sr}\) source characterization
Results from test beam @ SPS (CERN)
Few words about second Prototype
Next steps & Conclusions
Charge division principle

- Charge division in wire chambers is used to determine the coordinate along the sensing wire

- Electrodes with slightly resistive material produce same effect in microstrips silicon detectors
First prototype and main characteristics

* The first prototypes of the new sensors have been designed and produced at the IMB-CNM facilities

* Standard planar technology p-on-n, 300 μm thick

* Highly doped polysilicon as resistive electrode

* Strip length = 14 mm

* 68 strips/detector

* 2 prototypes with different strip widths: (20,40) μm

* Aluminum via to drive the contact pads at the same edge of the detector. **Only 1 chip to readout the detector!!!**
Electrical characterization

<table>
<thead>
<tr>
<th>Strip Width</th>
<th>$V_{dp}$</th>
<th>$V_{td}$</th>
<th>$R_{bias}$</th>
<th>$R_{int}$</th>
<th>$C_{int}$</th>
<th>$C_{cap}$</th>
<th>$R_{electrode}$</th>
<th>$R_{electrode}$ /µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>20µm</td>
<td>40 V</td>
<td>&gt; 400 V</td>
<td>1,31 MΩ</td>
<td>&gt; GΩ</td>
<td>1,32 pF</td>
<td>248 pF</td>
<td>400 Ω/□</td>
<td>20 Ω/µm</td>
</tr>
<tr>
<td>40µm</td>
<td>40 V</td>
<td>&gt; 200 V</td>
<td>1,37 MΩ</td>
<td>&gt; GΩ</td>
<td>1,60 pF</td>
<td>487 pF</td>
<td>400 Ω/□</td>
<td>10 Ω/µm</td>
</tr>
</tbody>
</table>

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Readout electronic: ALIBAVA

Portable system
Beetle chip

Daughter board & detectors
Chips calibration

* **Chip1** Did not perform the calibration

* No data for detector with a width of 40μm

* Linearity on the response
Laser characterization.

Test stand

* 3D stage platform. \( \sim 5 \mu m \) accuracy
* \( \lambda = 1080 \) nm
* Gaussian profile. Microspot width \( 2\sigma \) \(< 10 \) \( \mu m \)
* Pulse duration \(< 1 \) ns
* Pulse energy \( \sim 10\% \) gaussian fluctuation
Laser longitudinal scan

At position 0: $S2 \neq 0$

Are not perfectly antisymmetric!
Coupling effect?

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Charge division. experimental results

\[
\left( \frac{S_2 - S_1}{S_2 + S_1} \right) < 1
\]

\[
-1 < \frac{S_2 - S_1}{S_2 + S_1} < 1
\]

**Table:**

<table>
<thead>
<tr>
<th>Model</th>
<th>Polynomial</th>
<th>Value</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adj. R-Sq</td>
<td>0.9999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Intercept</td>
<td>5.610</td>
<td>0.01471</td>
</tr>
<tr>
<td>D</td>
<td>B1</td>
<td>7.801</td>
<td>0.04391</td>
</tr>
<tr>
<td>D</td>
<td>B2</td>
<td>-0.453</td>
<td>0.0645</td>
</tr>
<tr>
<td>D</td>
<td>B3</td>
<td>2.598</td>
<td>0.11251</td>
</tr>
</tbody>
</table>

3\(^{rd}\) degree polynomial fit
Charge division. experimental results

With this detector, the coordinate along the strip can be determined in a range of 100 μm.

Fit residuals within ±50 μm band
Simulation & data comparison

* Circuital model: (N, Bachetta et al., IEEE, Vol 47, NO 4, August 1995)

Five strips ($R_{str}$, $C_{cou}$, $R_{met}$). Interstrip circuital elements ($C_{int}$, $R_{int}$, $C_{m}$, $C_{p}$).
Bulk representation ($R_{sub}$, $C_{sub}$)

* Overall shape reproduced

* Signal excess in S2, caused for coupling between resistive electrode and metal wire
Radio source characterization.

Averaged noise Chip 2 = 2.18 ADCs

SNR ~ 15
Test beam @ SPS

During the first week of October testing at SPS pion (120GeV) beam in parasitic mode

Alibava DAQ (LHCb beetle chip)
Test beam data

Noise:
Chip 2 = 900 ENC

SNR ~ 15
Test beam @ SPS

Inside EUDET mimosa telescope

* APV25 DAQ system
* T. Bergauer et al.

HEPHY institute (Vienna)

*Analyzing data with telescope tracker

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Second prototype

* New 2D strip sensor of large area produced at CNM (3 cm strip length). 6 Wafers.

* Electrically characterized

  * Different electrical test structures
  * Standard strip detector
  * 2 fanout integrated sensors
Second prototype &
Some electrical Characteristics

* No - Aluminum via. Contacts at both strip ends to be read out by two independent FE chips

* New Sensor board produced at CNM adapted to ALIBAVA

  \[ \text{Vfd} \sim 40 \text{ V} \]
  \[ \text{Cint} \sim 0.4 \text{ pF} \]
  \[ \text{Rint} > G\Omega \]
  \[ \text{Rbias} = 2.5 \text{ M}\Omega \]

\[ 2 \text{ wafers } R_{\text{electr.}} = 90 \text{ }\Omega/\text{ sqr} \]

\[ 4 \text{ wafers } R_{\text{electr.}} = 380 \text{ }\Omega/\text{ sqr} \]
Short term plans

* 2 New prototypes already bonded. 128 channels each

* Preparing setup to be tested with laser and radioactive source

* Next test beam at SPS on August 2011

Bonding done at: UNIVERSITY of LIVERPOOL
Conclusions

* We have demonstrated the feasibility of the charge division method in microstrip sensors to determine the coordinate along the strip
* Resolution in the determination of the strip coordinate much better that 100 um
* We have used the standard (cheap) technology to produce this genuine 2D single sided strip detector

Possible application targets:

- Future detector outer trackers (trigger capable modules)
- Ions tracking systems.
- Neutron imaging (+ conversion element).
- Space applications.
THANKS FOR YOUR ATTENTION!
SPICE model

D. Bassignana (CNM-Barcelona)

Circuital model:
\((N, \text{Bachetta et al., IEEE, Vol 47, NO 4, August 1995})\)

- \(n\): node number
- \(m\): pulse impact
- \(R\): electrode resistance
- \(R_{\text{imp}}\): implant resistance
- \(R_{\text{sub}}\): substrate resistance
- \(C_{\text{sub}}\): substrate capacitance

Unit Cell, a chain of them represents a strip
Laser delay studies

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Transversal scan