A novel two-dimensional microstrip sensor for charge division readout

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Outline

- Sensor’s working principle.
- Prototype manufacturing.
- Electrical characteristics.
- Laser and radioactive source characterization.
- Test beam @ SPS.
- Conclusions and outlook.
Charge division concept

- Charge division used in wire chambers to determine the coordinate along the sensing wire.
- Same concept with conventional microstrips with slightly resistive electrodes.

\[ S_1 = f(y) \]
\[ S_2 = f(L-y) \]
Concept Demonstrator: P-Si sensor

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Designed and produced at IMB-CNM.

- strip length = 14 mm.
- Two different prototypes with different strip widths: 20 $\mu$m and 40 $\mu$m.
- Metal guides to drive the contact pads at the same edge of the detector.
- Implant pitch = 160 $\mu$m
- Read out pitch = 80 $\mu$m
- Multiple guard rings.

Resistive material = highly doped polysilicon.

Standard technology of silicon microstrip detectors. P-on-n, 300 $\mu$m thick detectors.
### Electrical Characterization

<table>
<thead>
<tr>
<th>Strip Width</th>
<th>$V_{\text{depl}}$</th>
<th>$V_{\text{bd}}$</th>
<th>$R_{\text{bias}}$</th>
<th>$R_{\text{int}}$</th>
<th>$C_{\text{int}}$</th>
<th>$C_{\text{coupl}}$</th>
<th>$R_{\text{electrode}/\square}$</th>
<th>$R_{\text{electrode}/\mu m}$</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; 200V</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>
ALIBAVA SYSTEM – Sensors P20 & P40 bonded at IFIC
FE chip calibration

Chip 1 did not perform calibration

400 electrons/ADU

P20 channels 68

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Laser characterization: test stand

Laser head on 3D platform (~ 5 um accuracy):

- Gaussian profile with microspot width $2\sigma < 10\mu m$
- Wavelength 1080 nm
- Pulse duration < 1ns
- Pulse energy ~ 10% gaussian fluctuation.
Laser Longitudinal scan

- Laser scanned along the polysilicon electrode

- Poly-Si Electrode Near Side

- Al via Far Side
Longitudinal coordinate from $Q_{\text{div}}$

– Naïve computation of position along the strip:

\[ y = \frac{Q_{\text{far}} - Q_{\text{near}}}{Q_{\text{far}} + Q_{\text{near}}} \]

Fit residuals within ± 50 μm band !!!
Longitudinal coordinate:
Simulation vs. measurement

Spice simulation using electrical parameters

- five strips ($R_{str}$, $C_{cou}$, $R_{met}$).
- interstrip circuitual elements ($C_{int}$, $R_{int}$, $C_m$, $C_p$).
- bulk representation ($R_{sub}$, $C_{sub}$).

- Overall shape reproduced.
- Bias introduced by direct coupling of the pulse to the Al via.
SNR determination

– Laser characterization demonstrated the soundness of the charge division method for strip sensors.
– Increased level of noise but not much (900 ENC)
– In the real world:

What signal/noise ratio we should expect for a MIP particle?

↓

Sr90 beta source
120 GeV Pion test beam at SPS.
Sr90 Beta source

- Collimated (1mm) $\beta$-source, at the strip center
- Signal / Noise $\sim 15$

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Test Beam @ SPS

- During the first week of October testing at SPS pion beam in parasitic mode:
  - Standalone Testing (ALIBAVA daq) around 800Kevt.
  - Inside the EUDET mimosa telescope (APV25 daq)
- SPS beam very stigmatic along the longitudinal (strip) direction.
- Last run with ALIBAVA as DUT inside EUDET telescope (BUT TLU too long trigger delay)
Signal Spectrum & pulse shapes
Short term plans

– Almost all the data to be analyzed from the test beam: ALIBAVA & AVP25 (Including EUDET telescope tracking).
– New 2D strip sensor of larger dimensions (~3 cm) already produced at CNM.
– Designed with contacts at both strip ends to be read out by two independent FE chips.
A longer demonstrator

- Each wafer: one reference sensor, poly sensor and two DML integrated PA sensors
- Reduced polysilicon resistivity (366 and 84 Ohm/□)
- Modified ALIBAVA daughter board to boh side read out
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 about few tens of micron.

– 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)
  - Ion tracking systems.
  - Neutron imaging (+ conversion element).
  - Space applications.

– New few cm long demonstrator under preparation
THANK YOU
Signal directly induced in the metal via from sensor far side (1)
Signal directly induced in the metal via from sensor far side (2)

Polysilicon strip
Signal directly induced in the metal via from sensor far side (3)
Signal directly induced in the metal via from sensor far side (4)

Polysilicon strip. Near Area

![Graph showing charge vs. delay with laser in and signal in far labels.]

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