

Silicon sensor specifications for DØ Layer 0 Project

○ Project description

To mitigate the negative effects from radiation damage and to improve the physics capabilities of the current silicon tracker, the DØ collaboration is building a new single layer silicon tracker system, the Layer Ø detector, which is to be inserted into the current silicon tracker. The design calls for a single layer detector with two sublayers, 0A and 0B at radii of approximately 18mm and 20mm, respectively. Sensors in sublayer 0A will have 71 µm pitch, whereas sensors in sublayer 0B have 81 µm pitch. Segmentation in z calls for eight sensors along z, symmetrically distributed around z=0. The two sensors closest to z=0 are 70mm long; the outermost sensors are 120mm long. The detector is expected to become operational in mid 2005 and continue to take data until 2009. Reliable operation of the silicon sensors in a high radiation environment is critical to the experiment's success. Over the operation period, this detector may be subject to a fluence of as high as 1×10^{14} 1 MeV equivalent neutrons per cm².

○ Wafers

- 320 ± 20 µm thick, n-type, phosphorus doped, <100> crystal orientation
- wafer warp < ±50 µm. This specification is on a best effort base. However, we will return individual sensors having a warp exceeding ±75 µm.
- cutting accuracy ± 10 µm with respect to nominal dicing line
- cutting lines parallel to ± 5 µm with respect to nominal dicing line

○ Detectors (general)

All detectors are p+n, single sided, AC coupled, polybiased silicon microstrip detectors. L0 sensors need to withstand a dose of 1×10^{14} 1 MeV equivalent neutrons per cm². The detector break down voltage must exceed 700V after the irradiation. The exact location of fiducial marks and bond pads, as well as the strip numbering definition has to be in accordance to the drawing. Four separate drawings are provided:

- Drawing number 3823.210-ME-434043, sensors 71 µm readout pitch, 70 mm long
- Drawing number 3823.210-ME-434045, sensors 81 µm readout pitch, 70 mm long

- Drawing number 3823.210-ME-434055, sensors 71 μm readout pitch, 120 mm long
- Drawing number 3823.210-ME-434056, sensors 81 μm readout pitch, 120 mm long

The sensor has a 20-field scratch pad for a unique identification. The sensor serial number is to be encoded in a serial binary format in this scratch pad (details provided below).

- **L0 sensor characteristics**

- **Layer 0A short sensors**

- 70.000 mm cutting length,
- 67.960 mm minimum acceptable active length,
- 511 strips,
- 256 readout strips, 255 intermediate strips,
- 35.5 μm strip pitch,
- 71 μm readout pitch,
- readout strips metallized, intermediate strips have only DC pads
- 20.216 mm cutting width,
- 18.176 mm active width,
- AC and DC bond pads according to drawing,
- every 10th strip numbered as indicated on the drawing,
- fiducial marks and scratchpad according to drawing,
- number of devices: 30
- tentative schedule – delivered by July 2004

- **Layer 0A long sensors**

- 120.000 mm cutting length,
- 117.960 mm minimum acceptable active length,
- 511 strips,
- 256 readout strips, 255 intermediate strips,
- 35.5 μm strip pitch,
- 71 μm readout pitch,
- readout strips metallized, intermediate strips have only DC pads
- 20.216 mm cutting width,
- 18.176 mm active width,
- AC and DC bond pads according to drawing,
- every 10th strip numbered as indicated on the drawing,
- fiducial marks and scratchpad according to drawing,
- number of devices: 30
- tentative schedule – delivered by July 2004

○ Layer 0B short sensors

- 70.000 mm cutting length,
- 67.960 mm minimum acceptable active length,
- 511 strips,
- 256 readout strips, 255 intermediate strips,
- 40.5 μm strip pitch,
- 81 μm readout pitch,
- readout strips metallized, intermediate strips have only DC pads
- 22.776 mm cutting width,
- 20.736 mm active width,
- AC and DC bond pads according to drawing,
- every 10th strip numbered as indicated on the drawing,
- fiducial marks and scratchpad according to drawing,
- number of devices: 30
- tentative schedule – delivered by July 2004

○ Layer 0B long sensors

- 120.000 mm cutting length,
- 117.960 mm minimum acceptable active length,
- 511 strips,
- 256 readout strips, 255 intermediate strips,
- 40.5 μm strip pitch,
- 81 μm readout pitch,
- readout strips metallized, intermediate strips have only DC pads
- 22.776 mm cutting width,
- 20.736 mm active width,
- AC and DC bond pads according to drawing,
- every 10th strip numbered as indicated on the drawing,
- fiducial marks and scratchpad according to drawing,
- number of devices: 30
- tentative schedule – delivered by July 2004

○ Detector Specifications for L0 type sensors

- Depletion voltage $40\text{ V} < U_{\text{dep}} < 300\text{V}$
- Biasing scheme: poly-silicon resistors on both ends:
for intermediate strips at the end where DC pads are located; for readout strips at the opposite end
- Poly resistor values: $0.8 \pm 0.3\text{ M}\Omega$
- Passivation: $\text{SiO}_2 > 0.25\text{ }\mu\text{m}$ thick or an equivalent passivation material like polyimide
- Unpassivated regions: Passivation windows around fiducial marks, bias/guard rings etc. as specified in drawing
- Implant strip width: $6\text{ }\mu\text{m}$ suggested; to be determined by HPK
- Metal strips: Al, C coupled over the p-implant
- Al strip width: $2 - 3\text{ }\mu\text{m}$ metal overhang on each side
- Al strip thickness: $> 1\text{ }\mu\text{m}$
- Al strip resistance: $< 30\text{ }\Omega/\text{cm}$
- Coupling capacitance: $> 10\text{ pF}/\text{cm}$
- Junction breakdown: $> 700\text{V}$
- Micro-discharge breakdown: $> 700\text{V}$
- Coupling capacitor breakdown: $> 100\text{V}$
- Total detector current: $< 50\text{ nA}/\text{cm}^2$ (at RT, full depletion voltage+20V)
- Total detector current at 700V: $< 1.0\text{ }\mu\text{A}$
- Leakage current rise: the leakage current rise $\Delta I_{\text{leak}}/\Delta V$ in the range between U_{dep} and 700V should not exceed the average batch value of $\Delta I_{\text{leak}}/\Delta V$ by a factor 5.
- Interstrip resistance (DC): $> 2\text{ G}\Omega$
- Total interstrip capacitance: $< 1.2\text{ pF}/\text{cm}$
- Defective channels: $< 1\%$

Definition of defective channels:

- Pinholes – current through capacitor $> 10\text{ nA}$ at 80 V and RT
- Short – coupling capacitor > 1.2 times the typical value
- Open - coupling capacitor < 0.8 times the typical value
- Leakage current above $10\text{ nA}/\text{strip}$ at FDV and RT (measured by buyer)
- Strips with bias and interstrip resistance values out of the specifications defined above shall be included in the defective channel count and list.

Tests performed by supplier.

On each sensor

- IV to 800 V ($RT = 25 \pm 3^{\circ}\text{C}$, $RH < 50\%$)
- Optical inspection for defects, opens, shorts and defects, mask alignment (better than $\pm 2.0 \mu\text{m}$)
- Depletion voltage measurement (C-V method)

On each strip

- AC Capacitance value measurement and Pinhole determination
- Use the smaller AC pads near the sensor edge for probing. They are labeled as AC test pads in the corresponding drawing.

On test structure

- Polyresistor mean and RMS value
- Implant resistance value
- Aluminum resistance value
- Coupling capacitor breakdown voltage

The corresponding quality control data of the applied tests from the supplier shall be provided together with each sensor on paper and in a computer readable format that is agreed upon by both parties. In addition we would request the C-V data of the C-V measurement to determine the depletion voltage. Furthermore we request that the test structure measurement and the test structures on the wafer have to be supplied. We expect the supplier to define in the bid response what exact kind of testing structures on the wafer they will incorporate.

Sensor details are provided in drawing 3823.210-ME-434043 for sensors with 71 μm pitch, 70mm long, drawing number 3823.210-ME-434045 for sensors 81 μm readout pitch, 70 mm long, drawing number 3823.210-ME-434055 for sensors 71 μm readout pitch, 120 mm long and drawing number 3823.210-ME-434056 for sensors 81 μm readout pitch, 120 mm long. The sensor contains a scratch pad field consisting of $5 \times 4 = 20$ pads as specified in the drawings. The vendor is expected to provide a unique serial numbering for each sensor. We suggest to the vendor, based on our prior experience, to use binary decimal numbering. Each set of 4 pads should represent a digit of the decimal sensor serial number. The encoding on each set of 4 pads is binary. The remaining $1 \times 4 = 4$ pads are reserved by the buyer for QC pass/fail marks.

Terms of agreements

The initial acceptance of the sensors will be based upon the results of the measurements performed by the supplier, according to the criteria described above. For a sub sample of the delivered sensors, these measurements will be confirmed by independent measurements at Fermi National Accelerator Laboratory or at universities. Based upon the results of these measurements, we reserve the right to reject a sensor within 6 months after delivery. The manufacturer will be notified and upon request the sensors will be returned for re-measurement. Both parties can agree upon the acceptance of individual sensors if specifications are missed only marginally. We request to obtain mechanical grade devices, as available, at no charge.

Disclaimer

We invite the companies bidding on the sensors to take specific exceptions to specifications, which they feel are not appropriate to their process as long as the performance of the detector is not compromised. These exceptions should be considered in the bidding process.