1 Sensor Quality Control and Acceptance Tests

A large number of silicon microstrip sensors which meet our specifications are being fabricated for several experiments such as for ATLAS and CMS silicon detectors. Table 1 summarizes the specifications of ATLAS and CMS silicon sensors.

Table 1
Specifications of ATLAS and CMS Barrel silicon sensors

item	ATLAS SCT	CMS SST
wafer type (orientation)	n-type	n-type ($< 100 >$)
wafer resistivity		1.25-3.25 kΩcm
thickness	285± 15 μm	320± 20 μm
strip pitch	80 μm	80/120 μm
size (width)×(length)	61.4 mm×64.0 mm	63.4 mm×119 mm
guard design	single metallized p^+	single or multi-metallized p^+
metal strips overhang	by 3 μm on each side	by 4 μm on each side
depletion voltage	<150 V	<300 V
implant strip resistance	<200 kΩ/cm	<200 kΩ/cm
metal strip resistance	< 15 Ω/cm	<18 mΩ/square
poly-Si resistance R_{bias}	1.25±0.75 MΩ	1.5±0.3 MΩ
interstrip resistance	>2×R_{bias}	>1 GΩ
breakdown voltage	>350 V (<20 μA@350V)	>500 V (<10 μA@450V)
defective strips	<2%	<1%

The above specifications have been qualified: series production has started for the ATLAS sensors.

1.1 QC by manufacturers

For Run2b silicon sensors, the test items on every sensor which are to be carried out by manufacturers are:

- Visual inspection, verifying that no significant scratches, blemishes, and edge chipping

- IV up to 500 V bias, measuring the leakage current in 10 V steps as the bias voltage is raised from 0 up to 500 V
- Depletion voltage, determined from CV
- Strip dielectric shorts for all strips with 120 V across the strip dielectric
- Strip metal breaks for all strips
- Strip metal shorts to neighbors for all strips

The followings are the items which are to be measured on a batch basis:

- Implant strip breaks for all strips
- Implant strip shorts to neighbors for all strips
- Typical poly-silicon resistance values, or the range for the processed batch

Hamamatsu Photonics is deliverying production sensors for the ATLAS SCT. Two statistics plots of the first 1000 sensors are given here. Figure 1 shows the leakage current distribution measured at 350 V. Most of the sensors populate in the region 0.1 to 0.2μA. The leakage currents are quite small compared with the double-sided sensors such as of ISL and SVX-II. Figure 2 shows the distribution of defective channel numbers. More than 80% of the sensors have no defect and the fraction of the defective channels is at most $\sim$ 1% (ATLAS sensor has 768 readout channels).

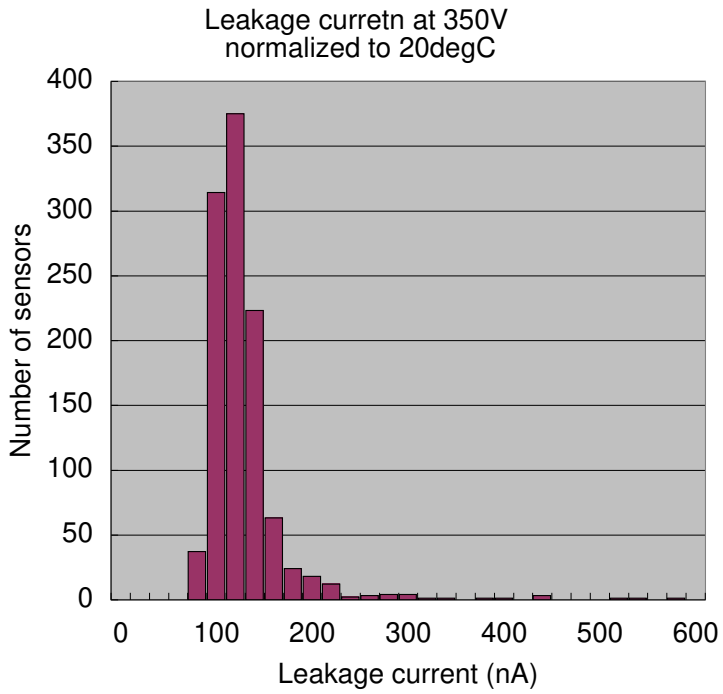

Fig. 1. Leakage current distribution of ATLAS silicon sensors measured at 350 V bias voltage.

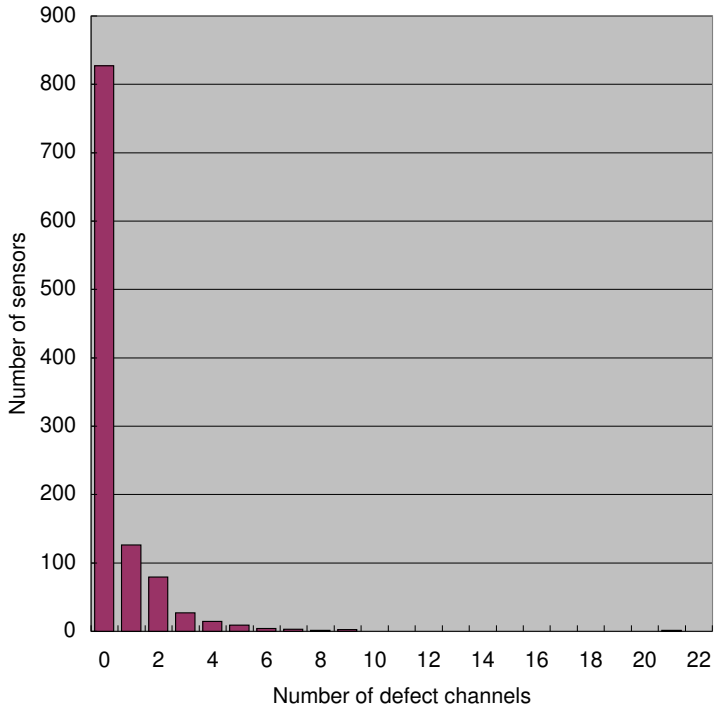

Fig. 2. Distribution of numbers of defect channels of ATLAS silicon sensors.

1.2 QC by CDF institutes

From our experience with LHC silicon sensor production, as given above, the defective strips identified by the manufacturer are very few, and in very good agreement with the measurements done by institutes. Therefore, we do not foresee to carry out a thorough strip test on delivered sensors. Through the QC by CDF institutes, we aim at checking any problems which are not identified by the manufacturers. For this purpose, we will receive periodically sensors rejected for IV or defective strip fraction and carry out an intensive electrical characterization. A small fraction of the delivered sensors are also to be tested to further ensure the quality.

The test items are essentially same as those done by the manufucturers but we will employ different methods of measurement. One of the candidate manufacturers, Hamamatsu Photonics, characterizes the strip integrity from transition properties to rectangular pulses injected through the bulk silicon. The pulses are 120 V high with a duration of 1/6 seconds. A diagram of a strip test system is shown in Fig 3. This thorough strip scan will probe each of the Al pads with the bias-ring grounded. By measuring the impedance between these with an LCR meter, the coupling capacitance and bias resistance can be measured directly. Also a set of two relays disconnect the LCR and connect an ammeter and voltage system, which then measures the leakage current through the

coupling capacitance when a voltage of 100 V is applied.

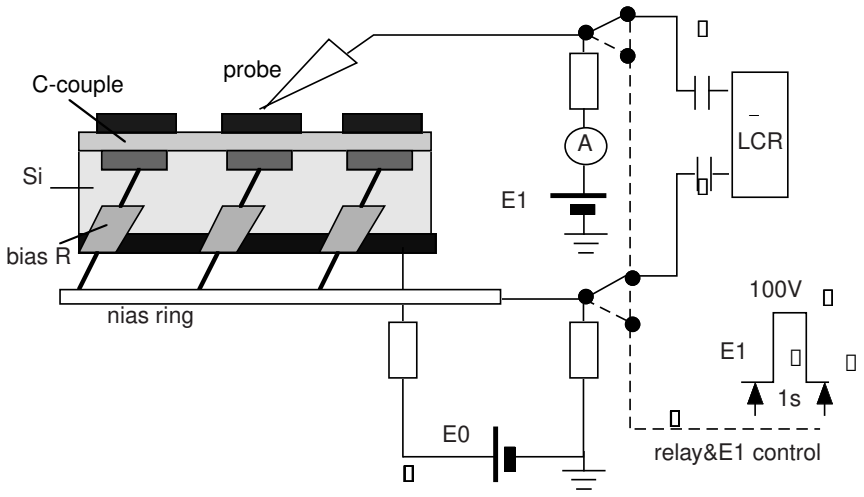

Fig. 3. Diagram of a strip test system.

Other charactersitics such as interstrip capacitances, CV and IV are also to be measured.