Appendix to SCT-BM-FDR-5.1:

Detector Technical Specification

Supply of Silicon Microstrip Detectors for the ATLAS SemiConductor Tracker (SCT)

Extracted from the 1999 Tender and Contract Documents, using the example of CERN being the Contract partner.

1 Technical Description

Unless stated explicitly otherwise, all dimensions quoted are those to be found in the processed devices, not the dimensions on the mask designs which may vary between suppliers. The technical description is separated into four sections. The first (article 3.1 below) gives the specifications that are in common for all the 6 detector shapes and the 2 different detector thicknesses that make up the total ATLAS requirement of 20,000 detectors. The second (article 3.2) defines the geometrical details of the barrel detectors, and the third (article 3.3) those of the forward detectors. The fourth (article 3.4) specifies the performance required of detectors after irradiation.

1.1 Specifications Applying to all Detector Shapes and Thicknesses

1.1.1 Mask Requirements

The Contractor shall be responsible for the final mask designs and shall produce engineering drawings or mask designs to be submitted to CERN for approval in writing before the start of Pre-series and Series production.

- *Number of metallised implanted strips*: 768+2 (the edge strip on each side may be coupled to the bias ring either directly or via a bias resistor).
- *Number read out*: 768.
- *Read-out implant strip width*: in the range 16µm to 20µm wide, high doped *p*-implants. (As stated above, these are the dimensions in the device).
- *Read-out strips*: Aluminium, capacitively coupled (see below) over the *p*-implant strips; width in the range 16µm to 22µm.
- *Polysilicon*[#] *bias resistors*: Either overlapping the implanted strips or running beside the implanted strips.
- *Reach-through protection*: Strip to low bias voltage difference to be limited by a reach-through protection structure (5µm - 10µm gap as processed from end of implanted strip to grounded implant).
- *Sensitive region to cut edge distance*: 1mm.
- *Outermost edge termination structure to cut edge*: >300µm.
- *High Voltage Contact*: Large metalised contactable *n*-layer on back.
- *Read-out*: 200×56µm bond pads, ≥ two rows, daisy-chainable. See articles 3.2 and 3.3 for their geometrical positioning for barrel and forward detectors.

[#] (Footnote added August 2000: Implant resistors for detectors manufactured by CiS)

- *p-bias contacts*: Available at each corner. See articles 3.2 and 3.3 for their geometrical definitions for barrel and forward detectors.

- *Probe pad contacts*: Provided to every read-out strip implant at contact point to bias resistor. Probe pad contact to inner guard also provided. See articles 3.2 and 3.3 for their geometrical definitions for barrel and forward detectors.

- *Passivation*: Detectors to be passivated on the strip side and un-passivated on the backplane.

- *Identification*: Every 10^{th} strip to be clearly numbered, starting at **1** for the first read out strip. Identification pads to be used for detector labelling and agreed alignment marks required for module optical metrology. See articles 3.2 and 3.3 for details for the barrel and forward detectors. The detector labelling is to be marked on the identification pads by the Contractor (see article 5.1.3).

1.1.2 Wafer Test Structures

***(a) Miniature detector*:**

A percentage of the main detectors in every processed batch are to be accompanied at delivery by a fully-diced miniature detector test structure from the same wafer. These fully-diced miniature detectors will be used by ATLAS Institutes for routine quality control of post-irradiation performance during the delivery period (see article 5.2). The percentage of main detectors to be accompanied by fully-diced miniature detectors is expected to be in the region of 5-10%, the exact figure being established by CERN during the Pre-series and Series production phases. The dicing of the miniature detectors is included as a purchase option in article 5.2 of the Tender Form.

The miniature detector shall have a similar design to the main detector apart from the differences consequential on a reduced sensitive area and, in the case of forward detectors, on a rectangular geometry. The miniature detector has outer dimensions of 10mm×10mm, with 98 readout strips, 8mm long and at 80μm pitch. The miniature detector mask design is to be approved in writing by CERN before the start of the Pre-series and Series production.

(b) ***Further Test Structures (subject to negotiation):***

CERN requests access to further (undiced) miniature detectors and other monitoring test structures, if these can be made available without additional cost. They are to be delivered to the ATLAS Institutes with the main detector from the same wafer (see article 6). They will be used to help in the rapid identification of any processing changes, and to provide diagnostic capability should problems arise. Detailed designs of a large diode, large capacitor, MOS capacitors, test resistors (polysilicon, implants, aluminium) will be supplied to the Contractor.

If these further test structures are not delivered to the ATLAS Institutes, the Contractor is asked to retain the undiced miniature detectors and his own, or the ATLAS, processing test structures at his premises at the disposal of CERN for a period to be determined by CERN and which shall not be less than two years following completion of the contract.

1.1.3 Detector Mechanical/Optical Properties

- *Quality of cut edges*: Edge chipping to be avoided and all cut edges to be clean and smooth. No chips or cracks should extend inwards by more than 50µm.

- *Thickness:* 285±15µm for detectors for barrels 2,3 & 4 and forward detectors to be mounted on the middle and outer disk regions.
  260±10µm for detectors for barrel 1 and forward detectors to be mounted on the inner disk regions.

- *Uniformity of thickness within one detector*: 10µm.

- *Mask alignment tolerances*: ≤3µm misalignment with respect to any other mask. Specific values are the responsibility of the Contractor.

- *Damage and defects:* Device free from scratches and other defects that ATLAS Institutes judge could compromise the detector performance during the lifetime of the experiment. The criteria are to be established in collaboration with the Contractor during the Pre-series production.

- *Bond Pads*: Metal quality, adhesion and bond pad strength to be such as to allow successful uniform bonding to all readout strips of the detector using standard microstrip detector bonding techniques, and without causing a degradation in strip quality.

- *Alignment Fiducials*: All fiducial marks situated between the cut edges and the bias line (see articles 3.2 and 3.3) to be fully visible.

- *Flatness*: The detectors should be flat (when unstressed) to within 200µm.

1.1.4 Detector Electrical Properties

- *Strips*: *p*-implant <200KΩ/cm.

- *Read-out strips*: Aluminium <15Ω/cm.

- R_{BIAS} *(Polysilicon):* 1.25±0.75MΩ resistor bias.

- $R_{inter\text{-}strip}$: >2×R_{BIAS} at operating voltage after correcting for bias connection.

- *Interstrip Capacitance*: Capacitance between a strip and its nearest neighbour on both sides <1.1pF/cm at 150V bias measured at 100 kHz.

- $C_{coupling}$: ≥20pF/cm, measured at 1 kHz.

- *Processing reproducibility*: ***To be monitored by Contractor*** on test structures (V_{FB}, t_{ox}, polysilicon resistivity, aluminium sheet resistance, etching uniformity, dielectric strength). A sample of the miniature detectors supplied will be irradiated by ATLAS Institutes to check that gross characteristics are unaltered.

- *Initial Depletion voltage*: $V_{depletion}$< 150V.

- *Total initial leakage, including guard, normalised to 20ºC*: <6µA at 150V and <20µA at 350V ***to be verified by Contractor*** (see article 5).

- *Leakage current stability*: Current to increase by no more than 2µA during 24 hours in dry air at 150V ***to be verified by ATLAS Institutes*** (see article 5).

- *Percentage of good strips (i.e. those conforming to the Technical Specification)*: A mean of ≥99% good readout strips per detector required in each delivery batch, with no detector having less than 98% of good strips.

  Definition of bad strips (i.e. those not conforming to the Technical Specification):

  Any of the following 4 types of fault will cause a strip to be counted as bad:

  1. *Coupling dielectric*: Shorts through dielectric with 100V applied between the metal and the substrate.
     Measured by Contractor, see article 5.

  2. *Defective metal strips*: Metal breaks or shorts to neighbours.
     Measured by Contractor, see article 5.

  3. *Defective implant strips*: Implant breaks or shorts to neighbours.
     Monitored by ATLAS Institutes on a sample of detectors, see article 5.

  4. *Resistor connection*: Implant strip connection via resistor to bias rail broken.
     Monitored by ATLAS Institutes on a sample of detectors, see article 5**.**

1.2 Geometrical Specifications for the Barrel Detectors

The barrel detectors all have the same geometrical specification apart from thickness. Detectors for the innermost barrel (called B1 detectors) are 260±10µm thick. All the remaining (called B2) barrel detectors are 285±15µm thick.

1.2.1 External Cut Dimensions for Barrel Detectors

- *Length:* 63960±25µm, distances of cut edges to fiducial marks to be within ±25µm of specified values (see appended drawing).

- *Width*: 63560±25µm, cut symmetric about the centre line of the detector to ±25µm.

- *Thickness*: 260±10µm for B1 detectors; 285±15µm for B2 detectors.

1.2.2 Mask Requirements for Barrel Detectors

- *Length*: 64mm *nominal* centre cutting line of scribe to centre cutting line of scribe. The exact value determined to give the cut mechanical dimension specified in article 3.2.1 above.

- *Width*: 63.6mm *nominal* centre cutting line of scribe to centre cutting line of scribe. The exact value determined to give the cut mechanical dimension specified in article 3.2.1 above.

- *Read-out implant strip dimensions*: 16μm - 20μm wide, 62mm long, 80μm pitch, high doped *p*-implants. (As stated above, these are the dimensions in the device).

- *Locations* of bias contacts, bond pads, probe points, alignment features, identification marks, *etc* are indicated in the appended drawing.

1.3 Geometrical Specifications for the Forward Detectors

There are 5 different types of forward wedge detector. They are referred to as W12, W21, W22, W31, W32. Their geometrical specifications are shown in the appended drawings. W21 + W22 are used together to make one type of module, and W31 + W32 form a pair for a second type of module. W12 is used by itself for a third module type. The W12 detectors are 260±10μm thick. All the remaining forward detectors are 285±15μm thick.

1.3.1 External Cut Dimensions for Forward Detectors

The dimensions of the forward detectors are such as to allow the processing of any of the following combinations together on a 6″ wafer: W21+W22; W31+W32, two W12 detectors.

- *Lengths and Widths:* The external cut dimensions of the 5 detector shapes are given in Table 1.

  The tolerance on all cut lengths and widths is ±25μm.

  The detectors must be cut symmetrically, to within ±25μm, about the centre lines of the sensitive region of the detector. Along their lengths, distances of detector cut edges to fiducial marks must be within ±25μm of the specified values.

Detector Type	Cut Length (mm)	Outer Width (mm)	Inner Width (mm)
W12	74.060	55.488	43.659
W21	65.085	66.130	55.734
W22	54.435	74.847	66.152
W31	65.540	64.635	56.475
W32	57.515	71.814	64.653

Table 1: *External Cut dimensions of the 5 forward detector shapes*

- *Thickness:* 260±10μm for W12, 285±15μm for W21, W22, W31, W32.

1.3.2 Mask Requirements for Forward Detectors

The mask requirements for the five wafers are summarised in the appended drawings.

1.4 Required Detector Performance During and After Irradiation

All delivered detectors must meet both the pre-irradiation specifications and the post-irradiation requirements up to a fluence equivalent to ~ 3×10^{14} cm^{-2} 24 GeV/c protons. The pre-irradiation properties will be measured by the Contractor and the ATLAS Institutes as described in article 5. The post-irradiation requirements cannot be tested on a device by device basis, but will be monitored by ATLAS Institutes during production. This is foreseen as the regular irradiation (approximately monthly) of miniature detectors to check bulk properties, and the irradiation of approximately 1% of the main detectors, sampled through the production, for full performance characterisation (see article 5.2).

No main detector is suitable that does not satisfy the requirements listed below during and after irradiation. During the irradiation the detectors are maintained at a temperature of about -8ºC and biased to 100V, with their implant strips biased to 0V and their aluminium readout strips grounded. Their total leakage current is monitored throughout the irradiation.

Performance during the irradiation:

- The detector leakage current should increase in a stable and monotonic fashion during the irradiation.

Post-irradiation Performance:

The figures below assume an annealing period of 7 days at 25ºC after completion of the irradiation:

- *Maximum operating voltage required for >90% of maximum achievable charge collection efficiency*: 350V. (Checked after connection to readout electronics with an effective peaking time of 25ns).

- R_{BIAS} *(Polysilicon):* to remain within the pre-irradiation acceptance limits.

- $R_{inter\text{-}strip}$: >2×R_{BIAS} at 350V after correcting for bias connection.

- *Interstrip Capacitance*: Capacitance between a strip and its 2 nearest neighbours on both sides <1.5pF/cm at 350V bias, measured at 100 kHz.

- *Total Leakage Current*: <250μA at -18ºC up to 450V bias.

- *Leakage current stability*: Current to vary by no more than 3% during 24 hours at 350V and –10ºC (after correction for any temperature fluctuations).

- *Micro-discharge*: There must be <5% increase in the measured noise of any channel due to this effect on raising the detector bias from 300V to 400V. (Checked after connection to readout electronics with an effective peaking time of 25ns).

- *Bad strips*: After irradiation, the number of strips failing the pre-irradiation criteria (article 3.1.4) should remain within the pre-irradiation acceptances at 350V bias.

2 Qualified Prototypes and Consistency of Substrate Material and Processing

2.1 Qualified Prototypes

One of the Qualification Criteria of the CERN Market Survey MS-2612/EP/ATL is that several prototype detectors already supplied by a Bidder have been proven by ATLAS Institutes to be satisfactory for use in the experiment both before and after irradiation up to fluences of ~3×10^{14} cm^{-2} 24 GeV/c protons.

These are the *Qualified Prototypes* of the Bidder and their serial numbers are listed in the Tender documents.

2.2 Consistency of Substrate Material and Processing during Production

The objective of the Contractor shall be to maintain the same processing, passivation and substrate material properties as those used to produce the Qualified Prototypes throughout the Pre-series and Series production. The conditions applying if this objective is not met are set out in article 10 of the Tender Form.

3 Quality Control, Inspection, Acceptance Tests and Data Sheets

3.1 Quality Control, Inspections, Acceptance Tests to be performed by the Contractor

3.1.1 General

The Contractor is required to perform sufficient checks to ensure consistency of processing and to maintain all electrical parameters within the ATLAS specifications defined in article 3. The properties of the polished silicon substrate material used must be tightly controlled to ensure uniformity over the production. Adequate evidence of this must be provided in the Technical Questionnaire and, prior to manufacturing, in the Production and Quality Plan. Different detector batches must be easily identified with particular silicon substrate batches.

The Contractor shall set up a Production and Quality Plan, to be supplied to CERN for approval within four weeks of the notification of contract, specifically including:

- definition, size and identification of production and delivery batches ensuring traceability;
- raw material control;
- acceptance testing, measuring methods;
- labelling;
- format of data supplied with delivered detectors.

Any proposed changes with respect to the approved Production and Quality Plan incurred during production must be subject to prior approval by CERN in writing.

3.1.2 Acceptance Test Measurements

The Contractor is required to perform the following test measurements on every detector, and to supply the measurement results to ATLAS Institutes with the delivered detector:

1. Detector IV up to 350V bias, measuring the current in 10V steps as the voltage is raised from 0V up to 350V, with a maximum of a 10 second delay time between steps.

2. Strip dielectric shorts for all strips with 100V across the strip dielectric. Immediately after this test the strip metal is to be returned to the ground potential in order to remove residual charge.

3. Strip metal breaks for all strips.

4. Strip metal shorts to neighbours for all strips.

If possible the Contractor should use Row C of the strip pads and bias contacts for probing tests for Barrel detectors and Row B for Forward detectors (see appended drawings), as these pads are not used during any stage in the module construction. However, if this is too inconvenient due to standard procedures, the standard probing pattern is acceptable.

3.1.3 Special Labelling

1. A unique binary-coded decimal ATLAS identification number (1 to 99999) for each detector is to be marked on the detector identification pads by the Contractor. This will require in most cases a simple modification to the strip test prober software. The details of this labelling process and the identification numbers to be used are to be agreed by CERN and the Contractor before the manufacture of the Pre-series.

2. Any test structures being delivered in addition to the fully-diced miniature detector (article 3.1.2), should be supplied undiced as a test structure quadrant with the Contractor's serial number of the associated detector clearly marked on the surface on an unused part of the quadrant. The packaging of the diced miniature detector must be clearly marked with the associated detector serial number.

3.1.4 Data Supplied by the Contractor

The following data are required from the Contractor for each detector:

1. The detector serial number, which should identify the processed batch, and the ATLAS identification number.

2. Detector type (B1, B2, W12, W21, W22, W31 or W32).

3. Detector thickness.

4. Substrate description (ie origin, orientation, approximate resistivity and any special comments, which should include information, coded if necessary, to ensure traceability of the substrate and polishing).

5. IV data up to 350V bias, including the value of the current at 150V and 350V.
6. Temperature of IV measurement.
7. List of strip numbers of oxide pinholes with 100V across the oxide.
8. List of strip numbers with strip metal discontinuities.
9. List of strip numbers with strip metal shorts to neighbours.
10. Depletion voltage (usually measured by the Contractor using a diode).
11. Typical polysilicon bias resistance value(s) for the detector, or range for the processed batch.

The data are to be provided both on paper and on a PC-formatted disk to a pre-agreed format for uploading into the ATLAS database by the ATLAS Institute. The database entries to be provided by the Contractor are summarised in Appendix 2.

3.2 Tests carried out by the ATLAS Institutes

The ATLAS Institutes will carry out tests on the detectors. The test procedures to be used throughout the Series production will be finalised and agreed with the Contractor during the Pre-series production phase.

When a batch is delivered to an ATLAS Institute the detector packages will be inspected for damage and stored in an inert atmosphere.

A visual inspection and an electrical IV measurement will be carried out on all detectors by the ATLAS Institutes.

The ATLAS Institutes will carry out more detailed measurements on a representative sample of delivered detectors using the procedures outlined in Appendix 1, both to verify the Contractor's measurements and to measure additional properties, as indicated in article 3.

The measurements of current made by the Contractor and the ATLAS Institutes on a given detector and the bad strips identified must agree to within defined tolerances. The tolerances for the initial Pre-series measurements will require that the measured currents agree to within 2μA at 150V bias and 4μA at 350V bias, and that a maximum of 2 bad strips are differently identified. The values for these tolerances to be used throughout the Series production will be agreed with the Contractor during the Pre-series measurements.

The post-irradiation detector performance will be monitored by the ATLAS Institutes by irradiating samples of both detectors and miniature detectors and carrying out the test measurements detailed in Appendix 1, article 2.

CERN will notify the Contractor in writing of any delivered detectors failing the specifications or performance requirements in ATLAS Institute measurements, or where results differ by more than the agreed tolerances (refer to article 10).

4 Packing and Transportation of Delivery Batches

Packing and the method of delivery must ensure adequate protection against damage (including theft, loss etc) during handling and transportation.

The detectors are to be individually packed, with their surfaces protected, in envelopes and/or boxes, which are sealed and packed within boxes for transportation. Each individual detector package must be clearly labelled with the Contractor's serial number and the ATLAS identification number (article 5.1.3) of the detector. Labelling in bar code format in addition to alphanumerical form is preferred.

The miniature detectors that are fully-diced are also to be individually packed, and each package clearly labelled with the serial number and ATLAS identification number of the associated main detector. The undiced miniature detectors and additional test structures, if supplied, are to be packaged on a per-wafer basis and clearly labelled with the serial number and ATLAS identification number of the associated main detector.

The transportation boxes are to be externally labelled with the Packing List showing the delivery batch number and quantities it contains, and clearly identified as fragile.

The batches for both the Pre-series and Series production are to be delivered directly to ATLAS Institutes listed in Annex B. The particular destination for each detector shape will be notified to the Contractor before delivery of the Pre-series.

The Contractor shall carry out whichever customs and other formalities may be necessary for the importation of the detectors into the country of the premises of the ATLAS Institute concerned, including any advance requests for the authorisation of temporary importation. CERN shall provide to the Contractor any pro forma invoice and all documentation reasonably required by the Contractor to enable him to carry out the above obligations.

In case the detectors are delivered to another country than the one in which they have been manufactured transport shall be by air, otherwise transport shall be by a recognised courier service.

CERN reserves the right to order detectors on an ex-works basis and to organize the transport itself. This does not a-priori exclude use of the Contractor's sub-contractors.

5 Pre-Series

CERN shall require the Contractor to produce a Pre-series to demonstrate his ability to comply fully with this Technical Specification. This Pre-series shall be produced with the same processing and substrate material properties as for both the Qualified Prototypes and the Series. The Pre-series will consist of approximately 5% of the total contract. Manufacture of this Pre-series is intended for testing:

- the quality of the produced detectors: these will be tested by the Contractor and the ATLAS Institutes (see article 5).
- the inspection and acceptance tests carried out by the Contractor and the supplied documentation and data;
- the production capability of the Contractor;
- the ability of the Contractor to comply with the delivery schedule;
- the effectiveness of the labelling, packing and transportation methods.

CERN's written notification of Provisional Acceptance of the Pre-series is required before the start of the Series production.

6 Delivery Schedule

The required delivery schedule and the conditions attached to late delivery are detailed in articles 7 and 8 of the Tender Form.

7 Provisional Acceptance

The conditions for Provisional Acceptance of detectors are set out in article 11 of the Tender Form.

8 Non-Compliant Detectors

The conditions in case a detector does not comply with the specifications and requirements as set out in these Tender documents are detailed in article 12 of the Tender Form.

11 Documentation

To be supplied with the Invitation to Tender:
Technical Questionnaire IT-2612/EP/ATL dated August 1999, duly filled in.

To be supplied for approval four weeks after notification of contract:
Detector engineering drawings or mask designs for at least one detector shape;
Production and Quality Plan (article 5.1.1) and schedule for delivery of the Pre-series.

To be supplied with each delivered batch during Series production:
Test data defined in article 5.

12 List of Drawings Appended

Drawing of the Barrel Detector	http://hepwww.ph.qmw.ac.uk/~beck/picb8a4.ps
Drawing of the Forward W12 Detector	http://hepwww.ph.qmw.ac.uk/~beck/w12a4.ps
Drawing of the Forward W21 Detector	http://hepwww.ph.qmw.ac.uk/~beck/w21a4.ps
Drawing of the Forward W22 Detector	http://hepwww.ph.qmw.ac.uk/~beck/w22a4.ps
Drawing of the Forward W31 Detector	http://hepwww.ph.qmw.ac.uk/~beck/w31a4.ps
Drawing of the Forward W32 Detector	http://hepwww.ph.qmw.ac.uk/~beck/w32a4.ps
Drawing of Alignment and Identification Marks	http://hepwww.ph.qmw.ac.uk/~beck/alida4.ps

Appendix 1: Acceptance Tests to be carried out by the ATLAS Institutes

1 Tests on Detectors as delivered

The role of the ATLAS Institutes during production testing is mainly that of a visual inspection and of an electrical IV measurement on every detector as a check on the basic quality. However, on a subset of detectors (expected to be 10-20% initially, but reducing to ~5% with experience during production), a thorough evaluation of detector (and test-structure where possible) characteristics will be performed as a check on processing consistency and as a verification of the Contractor's tests.

1.1 Tests on every detector

1.1.1 Visual inspection

Aim: To ensure the detector is free from physical defects and scratches.

Procedure: Place the detector on a probe-station chuck and scan it visually using a microscope.

Acceptance: The detector is free from significant scratches and blemishes. The cut edge is straight, clean and free from chipping. No chips or cracks should extend inwards by more than 50μm.

1.1.2 IV Curve

Aim: To perform a basic check of detector quality, to cross-check with Contractor data and to ensure there has been no transit damage.

Procedure: This test requires a voltage source/picoammeter (SMU). The detector backplane is placed on the chuck of a probe-station and the IV characteristic between the bias rail and the backplane measured using the SMU. The detector bias may be applied via a front edge contact instead of via the detector backplane if appropriate. The current is measured in 10V steps from 0V up to 350V[#], with a 10 second delay between steps. The temperature of the probe-station environment should be recorded.

Acceptance: The detector displays a characteristic at 20°C which is below 6μA at 150V and below 20μA at 350V, and which agrees with the Contractor's data to within the agreed tolerances.

1.2 Tests on a detector subset

These tests are a verification of the measurements performed by the Contractor. If any of these tests fail, this is an indication of either a variation in processing and/or a possible failure in the testing procedures of the Contractor. Further samples from the batch should then be tested and contact made immediately with the Contractor.

[#] Updated February 2000 to the value of 500V

1.2.1 Detector depletion voltage

Aim: To determine the depletion voltage and verify the Contractor's data.

Procedure: This measurement requires a CV meter equipped (if necessary) with an external bias adaptor and a voltage source. Place the detector backplane on the chuck of a probe-station and contact the bias rail with a probe needle. Connect the probe needle to the AC output of the CV meter bias adaptor, and the backplane to the voltage output of the CV meter bias adaptor. Alternatively the capacitance can be measured between the bias rail and the front edge contact if appropriate. Record the capacitance in 10V steps up to 350V, with a 10 second delay between steps. Use 1 kHz with CR in SERIES. Plot the data as $1/C^2$ ($1/nF^2$) vs bias (volts), and extract the depletion voltage.

Acceptance: Depletion < 150V

1.2.2 Strip integrity[#]

Aim: Check each strip for punch-throughs to the oxide, for shorts between strip metals, and for discontinuities in the strip metals as a verification of Contractor supplied data and to check that the strip defects are within specifications.

Procedure: This test requires a volt source / picoammeter (SMU) to check for oxide punch-throughs, a CV meter to measure capacitance, and a switching matrix. The detector is placed on the chuck of an automatic probe-station, and strip metal pads corresponding to Row C for Barrel detectors or Row B for Forward detectors are probed under computer control with the light on. Punch-throughs across the strip oxide are determined by a measurement of current between the strip metal and backplane with -100V on the needle and the detector backplane at ground potential. A series resistor of ~2-5Mohm should be used to limit the current in case of pinholes. The following technique for each strip measurement has been demonstrated to work well without any damage to the detector, and is therefore recommended, though alternative techniques are acceptable:

1.Switch the probe-needle to the high output of the SMU sourcing 0V, and the backplane to grounded low output of the SMU.

2.Step to strip n and raise the chuck

3.Increase the SMU source to -10V, wait 1 second and measure the current to determine electrical continuity across the oxide. If there is electrical continuity (ie a pinhole exists at low volts) skip steps 4 and 5 and go to step 6.

4.If there is no electrical continuity, increase the SMU source to -100V (no ramp), wait 1 second and recheck the electrical continuity.

5.Decrease the SMU source to 0V (no ramp).

6.Switch the probe-needle to ground (ie short the needle to the detector backplane) and wait for 500ms

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[#] Updated February 2000, see Annex D

7.Switch the probe-needle to the AC output of the CV meter, and the backplane to the voltage source of the CV meter (with the CV meter sourcing 0V).

8.Wait 1 second and measure the capacitance (at 1kHz, with CR modelled in SERIES)

9.Lower the chuck

10.Repeat the measurement cycle from point 1 above for strip n+1.

The test (as demonstrated on a SUMMIT 10K probe station) takes about 1 hour 10 minutes.

Detector Acceptance: < 2 % bad strips, where a bad strip has electrical continuity between the strip metal and backplane, strip metal short to neighbour or evidence for metal discontinuity.

and agreement with the Contractor on the list of identified bad strip numbers within the agreed tolerance.

Batch Acceptance: The batch is accepted if the mean number of good strips is ≥99% and no detector falls below 98% good strips.

1.2.3 Leakage Current Stability

Aim: To check that any variation in leakage current over a 24 hour period is within specifications.

Procedure: This test requires a voltage source / picoammeter (SMU), a meter for temperature monitoring, an environment chamber, and, if available, a switching matrix. Detector is assembled into a support frame and the backplane and bias rail are bonded to soldable contacts. The backplane and bias rail of the detector are connected to the high and grounded-low outputs of the SMU respectively. The assembly is installed in an environment chamber containing dry air (nitrogen) maintained at 20ºC. The bias is ramped to 150V, and after 60 seconds settling time the current is monitored every 15 minutes over a 24 hour period. Several detectors may be measured in parallel by use of a switching matrix.

Acceptance: Maximum increase in leakage current during 24hours is less than 2μA.

1.2.4 Full Strip Test [#]

Aim: To measure the polysilicon bias resistance and coupling capacitance for every strip, and to check for pinholes, strip metal shorts and opens, implant breaks, and electrical contact between the polysilicon resistor and strip implant.

Procedure: This test requires all 768 strips to be probed while the detector is partially depleted via contacts to the bias rail and backplane. The test requires a voltage source to deplete the detector, a voltmeter/picoammeter (SMU) to check for pinholes, a CV meter for a CR calculation, and a switching matrix. Either mount the detector into a frame and bond the bias rail and backplane to

[#] Updated February 2000, see Annex D

soldable contacts or, if a probe needle manipulator can be fixed to the moving chuck, place the detector directly on to the chuck and contact the detector bias rail with the chuck-mounted probe-needle. If the option of mounting the detector into a frame is used, attach the frame to the probe-station chuck using a jig which permits adjustment of the planarity of the detector so that it is flat with respect to the platen of the probe-station. Switch off the light and apply +20V to the detector backplane with the bias rail at ground potential in order partially to deplete the detector. Under computer control, probe all 768 strip pads along row C for Barrel detectors or row B for Forward detectors according to the following instructions:

1.Switch the high output of the SMU (sourcing 0V) to the probe-needle via a 2-5Mohm series resistor, and switch the low output of the SMU to the detector bias rail.

2.Step to strip n and raise the chuck

3.Increase the SMU source to -10V, wait 1 second and measure the current to determine electrical continuity across the oxide. If there is electrical continuity (ie a pinhole exists at low volts) skip steps 4 and 5 and go to step 6.

4.If there is no electrical continuity, increase the SMU source to -100V (no ramp), wait 1 second and recheck the electrical continuity

5.Decrease the SMU source to 0V (no ramp)

6.Switch the probe-needle to ground (ie short the needle to the detector backplane) and wait for 500ms

7.Switch the probe-needle to the AC source output of the CV meter, and the bias rail to the voltage source output of the CV meter, with the CV meter sourcing 0V.

8.Wait 1 second and measure C and R (at 100Hz, with CR modelled in SERIES)

9.Lower the chuck

10.Repeat the measurement cycle from point 1 above for strip n+1.

The test (as demonstrated on a SUMMIT 10K probe-station) takes about 1 hour 10 minutes. The measured values of R and C yield the polysilicon resistor value and coupling capacitance respectively. Deviations imply a strip defect as listed above. Note the test may be performed at 1kHz if measurements at 100Hz are not possible or are unstable; at 1kHz the coupling capacitance is underestimated by 10-20%.

Acceptance: The number of strips with a significant deviation from the mean of the capacitance and resistance distributions must be <2%.

1.3 Diagnostic Tests

This article lists the recommended procedures for a more detailed evaluation of detector electrical parameters should acceptance tests indicate that some variation in processing has occurred. After any diagnostic tests on the detector, the IV measurement listed in article 1.1.2 should be repeated.

1.3.1 Interstrip Capacitance

Aim: To ensure the interstrip capacitance is within specifications.

Procedure: This test requires a CV meter and a voltage source. Place the detector on the chuck of a probe-station, and contact the bias rail by probe-needle. The backplane and the bias rail should be connected to the high and grounded-low sides (respectively) of the voltage source. Contact three adjacent metal strips (pad row C for Barrel detectors or row B for Forward detectors with probe needles. Contact the central strip to the AC output of the CV meter, and the neighbours to the voltage output (with the CV meter soucing 0V). Measure the capacitance between the central strip and its neighbours on both sides as a function of detector bias up to 150V. Use 100 kHz test frequency with CR in parallel.

Acceptance: Interstrip capacitance < 1.1 pF/cm at 150V bias.

1.3.2 Polysilicon Bias Resistance and Interstrip Resistance

Aim: Determine the bias resistor value is within specifications and that the interstrip isolation is sufficient when under bias.

Procedure: This test requires a voltage source and a volt source/picoammeter (SMU). This measurement yields both the polysilicon bias resistance and the interstrip resistance. Place the detector backplane on the chuck of a probe-station and contact the bias rail and a strip implant by probe-needles. The backplane and bias rail should be connected to the high and grounded-low outputs (respectively) of the voltage source. The strip implant and bias rail should be connected to the high and low outputs (respectively) of the SMU. Perform an IV (using the SMU) up to 1V to determine the resistance between the strip implant and bias rail as a function of bias voltage (increase detector bias from 0 V to 5 V in steps of 0.2 V).

Acceptance: Interstrip resistance is sufficient if the measured resistance vs detector bias plateaus. The plateau level resistance is equivalent to the polysilicon bias resistance, and must be within 1.25 ± 0.75 MΩ.

1.3.3 Metal Series Resistance

Aim: To determine that the strip metal resistance is within specifications (deposited metal is sufficiently thick) and to monitor processing consistency.

Procedure: This test requires an ohmmeter or a voltage source / picoammeter (SMU). Apply an ohmmeter (or perform an IV using the SMU) between the two ends of the appropriate metal line test-structure (if available) or to either end of one of the detector metal strips (if no test-structure available).

Acceptance: Series resistance < 15Ω/cm

1.3.4 Coupling Capacitance

Aim: To determine the coupling capacitance between the strip metal and strip implant, to check that the value is within specification and to monitor processing consistency.

Procedure: This test requires a CV meter. Place the detector backplane on the chuck of a probe-station and contact the metal and implant of a strip with probe needles. Connect the strip metal and implant to the AC and voltage outputs (respectively) of the CV meter, with the CV meter sourcing 0V. Measure the capacitance between the metal and implant at 1 kHz with CR in PARALLEL.

Acceptance: Coupling capacitance ≥ 20 pF/cm

1.3.5 Implant sheet resistance

Aim: Measurement of sheet resistance of p implant, to check that the value is within specifications and to monitor processing consistency.

Procedure: This test requires an ohmmeter or a voltage source / picoammeter (SMU), and requires the use of the appropriate test-structure if available. Contact the ohmmeter (or perform an IV using the SMU) between the two contacts of the sheet resistor test-structure.

Acceptance: Sheet resistance < 200 KΩ/cm

1.3.6 Flat band voltage

Aim: To determine flat band voltage as a monitor of processing consistency.

Procedure: This test requires a voltage source, and a CV meter equipped (if necessary) with an external bias adaptor. The measurement requires a MOS test-structure if available. Place the MOS on a probe-station chuck and contact the MOS with a probe needle. Connect the MOS metal and the backplane to the AC and voltage outputs (respectively) of the CV meter. Measure capacitance across the MOS (at 1kHz with CR in SERIES) as a function of bias up to 50V.

Acceptance: There is no defined acceptance criterion. Flat band voltage is used as a monitor of processing consistency.

2 Post-Irradiation Tests on detectors

A small number (probably around 1%) of full-sized detectors will be selected for irradiation during production, and a thorough evaluation of these detectors will be performed for detailed comparisons with the requirements of the Tender documents and the data from the Qualified Prototypes. It is anticipated that larger numbers of miniature detectors (identical to the full-size detector (of barrel geometry) but only $1cm^2$ in size with 98 strips of 8mm length) will be used for irradiation tests, as their small size means that they can be irradiated more quickly and easily. It is anticipated that the measurement of the post-irradiation IV characteristics of miniature detectors will provide a minimum check of processing consistency.

2.1 Tests before detector irradiation

On delivery the full set of detector measurements described in article 1 of Appendix 1 should be performed to ensure the detector is fully characterised. The detectors are then glued with araldite 2011 to ceramic support cards and bonded to pitch adaptors for compatibility with readout by both binary and analogue readout electronics. During irradiation the strip metals are shorted together (via bonds on the pitch adaptor to a common rail) to simulate the condition of being bonded to readout electronics. The detector bias rail and backplane must be connected to ~3cm long leads (via bonds to the pitch adaptor and/or flexible PCB) terminating in 2-pin SIL connectors for biasing. The IV characteristics should be remeasured after gluing to ensure no deterioration has occurred during assembly.

2.2 Post-Irradiation Tests

Unless otherwise specified, all post-irradiation detector tests are performed cold (-10°C) in a freezer containing dry air, and with the detector ceramics screwed to an aluminium support frame protected by an aluminium cover lid. To ensure good thermal contact, the aluminium support frame should itself be in direct contact with a large thermal mass inside the freezer. Annealing times (when the detector is brought to room temperature for measurements, bonding/soldering work etc) should be recorded in units of days at 25°C equivalent temperature.

2.2.1 Annealing

After irradiation the detectors should undergo a controlled beneficial anneal for 7 days at 25°C, taking them to the minimum region of the depletion voltage.

2.2.2 IV Curve

Aim: To measure the IV characteristic after irradiation.

Procedure: This test requires a voltage source/picoammeter (SMU) to measure the IV characteristic between the bias rail and the backplane. The current is measured at -18°C at every 10V step up to 500V, with a 10 second delay between steps. The temperature of the detector should be recorded (either via a PT100 on the detector ceramic, or a PT100 in contact with the large thermal mass inside the freezer). On a sub-sample of detectors, the IV should be remeasured at -10°C to verify that the current scales in the expected way with temperature.

Acceptance: The detector displays a characteristic at -18°C which is below 250 μA at bias voltages up to 450V.

2.2.3 Strip Integrity

Aim: To check for additional oxide punch-throughs caused by the irradiation.

Procedure: This test requires a volt source/picoammeter (SMU) to check for oxide punch-throughs, and a CV meter to measure capacitance anomalies due to strip metal shorts/opens and pitch adaptor scratches/shorts. The detector is warmed to room temperature and the lid of the aluminium frame is removed. Any bonds still connecting strip metals to the common ground rail of the pitch adaptor must be removed. The frame is attached to a jig on the chuck of an automatic probe-station, and the planarity adjusted such that the pitch adaptor is flat relative to the probe-station platen. All metal pads of the pitch adaptor are then probed (in 4 groups of 128) under computer control with the light on. +10V is supplied continuously by the SMU to the backplane via the voltage output of the CV meter (or the external bias adaptor of the CV meter if applicable), with the needle connected to the AC output of the CV meter. A series resistor may be necessary to limit current if the CV meter external bias adaptor (which usually contains a large series resistance) is not used. The following technique for each strip measurement has been demonstrated to work well without any damage to the detector, and is therefore recommended, though alternative techniques are acceptable:

1. Before the first pitch adaptor pad is probed, source +10V from the SMU and wait several seconds for the SMU current to drop to <1nA (due to the capacitor charging in the CV meter external bias adaptor)
2. Raise the chuck to contact the pad with the probe-needle.
3. Measure the current drawn from the SMU. Currents 1nA indicate an oxide punch-through
4. Measure the capacitance (1kHz, CR in SERIES, 100mV amplitude).

5. In the case of an oxide punch-through, drop the chuck and wait several seconds for the SMU current to resettle to <1nA. If there is not oxide punch-through, no delay is necessary.
6. Move to the next pad, and repeat from Step 2 above.

The test (as demonstrated on a SUMMIT 10K probe-station) takes about 25 minutes.

Acceptance: The number of strip defects (due to oxide punch-throughs and strip metal defects) is < 2%.

2.2.4 Leakage Current Stability

Aim: To check that any variation in leakage current over a 24 hour period is within specifications.

Procedure: This test requires a voltage source / picoammeter (SMU), a meter for temperature monitoring, an environment chamber, and, if available, a switching matrix. The backplane and bias rail of the detector are connected to the high and grounded-low outputs of the SMU respectively. The assembly is installed in freezer containing dry air (nitrogen) maintained at -10ºC. The bias is ramped to 350V, and after 60 seconds settling time the current is monitored every 15 minutes over a 24 hour period. Several detectors may be measured in parallel by use of a switching matrix.

Acceptance: Maximum variation in leakage current during 24hours is less than 3%, after correcting for any temperature fluctuations.

2.2.5 Interstrip Capacitance

Aim: To determine that the interstrip capacitance is within specifications.

Procedure: This test requires a CV meter and a voltage source, and requires the detector aluminium support frame to be attached to a jig to allow for bonding from the strip pads on the pitch adaptor to solderable contacts (eg a piece of PCB with appropriate gold tracking). Remove the bonds (if not already removed) connecting the detector strips to the common ground rail on the pitch adaptor. From one of the rows of 128 pads on the pitch adaptor that corresponds to 6cm strips, bond one strip pad out to a solderable contact on the PCB, and bond the two neighbouring strip pad on both sides to the common ground rail of the pitch adaptor. Bond out from the common ground rail to a second solderable contact on the PCB. The central strip should then be connected (via a cable soldered to the PCB) to the AC output of the CV meter, and the two neighbouring strips to the voltage output of the CV meter (sourcing 0V). The backplane and bias rail of the detector should be connected to the high and grounded-low sides (respectively) of the voltage supply. Measure the capacitance between the central strip and its neighbour on both sides as a function of detector bias up to 500V, using 20V steps. Use 100kHz test frequency with CR modelled in parallel. Note: parasitic capacitance arising from the PCB and its cabling to the CV meter needs to be subtracted from the measured capacitance values. The best way to estimate the parasitic capacitance is to remove the bond between the pitch adaptor and PCB that connects the central strip, and remeasure capacitance.

Acceptance: Interstrip capacitance < 1.5 pF/cm at 350V bias.

2.2.6 Polysilicon Bias Resistance and Interstrip Resistance

Aim: Determine the bias resistor value is within specifications and that the interstrip isolation is sufficient when under bias.

Procedure: This test requires a voltage source and a volt source / picoammeter (SMU). This measurement yields both the polysilicon bias resistance and the interstrip resistance, and must be performed cold (-10ºC). The backplane and bias rail should be connected to the high and grounded-low outputs (respectively) of the voltage source. The DC contact to a strip implant and bias rail should be connected to the high and low outputs (respectively) of the SMU (it is necessary to bond from the strip DC contact to a track on the pitch adaptor. Some bonds from the strip metals to the pitch adaptor will need to be removed to provide space for this). Perform an IV (using the SMU) from -5V to +5V to determine the resistance between the strip implant and bias rail as a function of bias voltage (increase detector bias from 0 V to ~300V or until the measured resistance plateaus).

Acceptance: Interstrip resistance is sufficient if the measured resistance vs detector bias plateaus. The plateau level resistance is equivalent to the polysilicon bias resistance, and should be within 1.25 ± 0.75 MΩ.

2.2.7 Charge Collection Efficiency

Aim: To determine the onset of the plateau in charge collection efficiency vs detector bias up to 500V.

Procedure: Bond one group of 6cm 128 channels to an analogue readout chip with an effective peaking time of 25ns and measure the signal collected vs bias triggered using a Ru^{106} beta-source.

Acceptance: The onset of the plateau matches the value observed for the Qualified Prototypes and the operating voltage required for >90% of maximum achievable charge collection efficiency is < 350V.

2.2.8 Strip Quality vs Bias

Aim: To determine the number of strips with excess noise due to microdischarge.

Procedure: Bond all channels of the pitch adaptor to either binary or analogue readout electronics with an effective peaking time of 25ns, and measure the noise per channel vs detector bias at 200V, 300V, 400V and 500V bias.

Acceptance: There is < 5% increase in the measured noise of any channel due to microdischarge on raising the detector bias from 300V to 400V.

<u>Appendix 2</u>: Database entries to be provided by Contractor[#]

The Contractor shall provide the data required below on a PC-formatted disk to a pre-agreed format for uploading into the database by the ATLAS institute. The following table summarises the database entries to be provided by the Contractor. The "Entry Example" column lists typical values only and does not correspond to a particular detector.

Parameter	Type	Units	Entry Example
Contractor's Name	Text	N/A	
Detector Type	Text	N/A	W21

[#] Updated February 2000, see ATLAS SCT/Detector PRR/00-3

Serial Number	Text	N/A	Contractor's S.N.
Identification Number	INTEGER	N/A	ATLAS ID number
Substrate Origin (or code)	Text	N/A	
Substrate Orientation	Text	N/A	111 or 100
Substrate Resistivity	Text (range)	KΩ-cm	3-5
Special Comments	Text	N/A	Substrate batch ID
Thickness	INTEGER	Microns	290
Depletion Volts	FLOAT	Volts	85.0
Polysilicon Bias Resistance	Text (range)	MΩ	1.22-1.67
Oxide pinholes	Text (List)	N/A	23,301,510
Metal Shorts	Text (List)	N/A	610,611,612
Metal Opens	Text (List)	N/A	701
IV Characteristics	Data (List Volts, nA)	N/A	Example
IV Temperature	FLOAT	^{o}C	20.2

Annex D: Updates to Appendix 1, dated February 2000

Exact definitions of PINHOLE and OXIDE-PUNCHTHROUGH defects in the strip tests have been included, modifying sections 1.2.2 and 1.2.4. The changes are shown below in italics:

1.2.2 Strip integrity

Aim: Check each strip for punch-throughs to the oxide, for shorts between strip metals, and for discontinuities in the strip metals as a verification of Contractor supplied data and to check that the strip defects are within specifications.

Procedure: This test requires a volt source / picoammeter (SMU) to check for oxide punch-throughs, a CV meter to measure capacitance, and a switching matrix. The detector is placed on the chuck of an automatic probe-station, and strip metal pads corresponding to Row C for Barrel detectors or Row B for Forward detectors are probed under computer control with the light on. *Pinholes in* the strip oxide are determined by a measurement of current between the strip metal and backplane with *–10V or* -100V on the needle and the detector backplane at ground potential. A series resistor of *~10* Mohm should be used to limit the current in case of pinholes. The following technique for each strip measurement has been demonstrated to work well without any damage to the detector, and is therefore recommended, though alternative techniques are acceptable:

1.Switch the probe-needle to the high output of the SMU sourcing 0V, and the backplane to grounded low output of the SMU.

2.Step to strip n and raise the chuck

3.Increase the SMU source to -10V, wait 1 second and measure the current to determine electrical continuity across the oxide. *If the current exceeds 50nA (which defines the existence of a pinhole at low volts),* skip steps 4 and 5 and go to step 6.

4.*If the measured current is less than 50nA,* increase the SMU source to -100V (no ramp), wait 1 second and recheck the *current*.

5.Decrease the SMU source to 0V (no ramp).

6.Switch the probe-needle to ground (ie short the needle to the detector backplane) and wait for 500ms

7.Switch the probe-needle to the AC output of the CV meter, and the backplane to the voltage source of the CV meter (with the CV meter sourcing 0V).

8.Wait 1 second and measure the capacitance (at 1kHz, with CR modelled in SERIES)

9.Lower the chuck

10.Repeat the measurement cycle from point 1 above for strip n+1.

The test (as demonstrated on a SUMMIT 10K probe station) takes about 1 hour 10 minutes.

Detector Acceptance:

Both:

< 2 % bad strips, *where a bad strip is defined by either of the following:*

- *a current exceeding 50nA is measured when either –10V or –100V is applied between the strip metal and backplane with a 10 Mohm series resistance. The defect is defined as a PINHOLE if observed at –10V, and an OXIDE-PUNCHTHROUGH if observed at –100V.*
- *the measured capacitance indicates a strip metal short to a neighbour or a discontinuity in the strip metal, with the defect defined as a SHORT or OPEN, respectively.*

And:

agreement with the Contractor on the list of identified bad strip numbers within the agreed tolerance.

Batch Acceptance: The batch is accepted if the mean number of good strips is ≥99% and no detector falls below 98% good strips.

1.2.4 Full Strip Test

Aim: To measure the polysilicon bias resistance and coupling capacitance for every strip, and to check for pinholes, strip metal shorts and opens, implant breaks, and electrical contact between the polysilicon resistor and strip implant.

Procedure: This test requires all 768 strips to be probed while the detector is partially depleted via contacts to the bias rail and backplane. The test requires a voltage source to deplete the detector, a voltmeter/picoammeter (SMU) to check for pinholes, a CV meter for a CR calculation, and a switching matrix. Either mount the detector into a frame and bond the bias rail and backplane to soldable contacts or, if a probe needle manipulator can be fixed to the moving chuck, place the detector directly on to the chuck and contact the detector bias rail with the chuck-mounted probe-needle. If the option of mounting the detector into a frame is used, attach the frame to the probe-station chuck using a jig which permits adjustment of the planarity of the detector so that it is flat with respect to the platen of the probe-station. Switch off the light and apply +20V to the detector backplane with the bias rail at ground potential in order partially to deplete the detector. Under computer control, probe all 768 strip pads along row C for Barrel detectors or row B for Forward detectors according to the following instructions:

1.Switch the high output of the SMU (sourcing 0V) to the probe-needle via a *~10* Mohm series resistor, and switch the low output of the SMU to the detector bias rail.

2.Step to strip n and raise the chuck

3.Increase the SMU source to -10V, wait 1 second and measure the current to determine electrical continuity across the oxide. *If the current exceeds 50nA (which defines the existence of a pinhole at low volts),* skip steps 4 and 5 and go to step 6.

4. *If the measured current is less than 50nA,* increase the SMU source to -100V (no ramp), wait 1 second and recheck the *current*

5.Decrease the SMU source to 0V (no ramp)

6.Switch the probe-needle to ground (ie short the needle to the detector backplane) and wait for 500ms

7.Switch the probe-needle to the AC source output of the CV meter, and the bias rail to the voltage source output of the CV meter, with the CV meter sourcing 0V.

8.Wait 1 second and measure C and R (at 100Hz, with CR modelled in SERIES)

9.Lower the chuck

10.Repeat the measurement cycle from point 1 above for strip n+1.

The test (as demonstrated on a SUMMIT 10K probe-station) takes about 1 hour 10 minutes. The measured values of R and C yield the polysilicon resistor value and coupling capacitance respectively. Deviations imply a strip defect as listed above. Note the test may be performed at 1kHz if measurements at 100Hz are not possible or are unstable; at 1kHz the coupling capacitance is underestimated by 10-20%.

Acceptance: < 2 % bad strips, *where a bad strip is defined by any of the following:*

- *a current exceeding 50nA is measured when either –10V or –100V is applied between the strip metal and backplane with a 10 Mohm series resistance. The defect is defined as a PINHOLE if observed at –10V, and an OXIDE-PUNCHTHROUGH if observed at –100V.*
- *the measured capacitance indicates a strip metal short to a neighbour or a discontinuity in the strip metal, with the defect defined as a SHORT or OPEN, respectively.*
- *a significant deviation is seen in the capacitance and/or resistance distributions, indicating either a break in the strip implant or a break in the baissing resistance (defined as either an IMPLANT BREAK or RESISTOR BREAK, respectively).*