Workshop on QA issues in Si Detectors
CERN, 17-18.5.2001

Strip quality tests used by ATLAS SCT

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Layout

1. Introduction.
2. Simple strip test.
3. Full strip test.
4. Conclusions.

1. Introduction

An essential part of the QA procedure used by the ATLAS SemiConductor Tracker (SCT) for Si strip detectors is the strip quality test. It exists in two versions. A Simple Test measures the values of the coupling capacitors and verifies their ability to withstand a DC voltage up to 100V. It also reveals the breaks and shorts in the external metal strips.

A more complicated, Full Strip Test, does the same but in addition measures the values of polysilicon bias resistors and reveals the breaks in the strip implants and/or in the bias resistors.

The Simple Test can be done in light with a bare unbiased detector put directly on the chuck of the Probe Station, and it requires a single probe needle. The Full Strip Test should be done in darkness with the detector under the bias. Therefore it requires a special fixture to provide the bias contact(s) travelling with the detector. A special lift-search method developed in Lancaster allows corrections for possible deviations of the detector mounted in the fixture from the ideal flatness. This guarantees good contact with minimal scratching of the probing pad.

2. Simple Strip Test

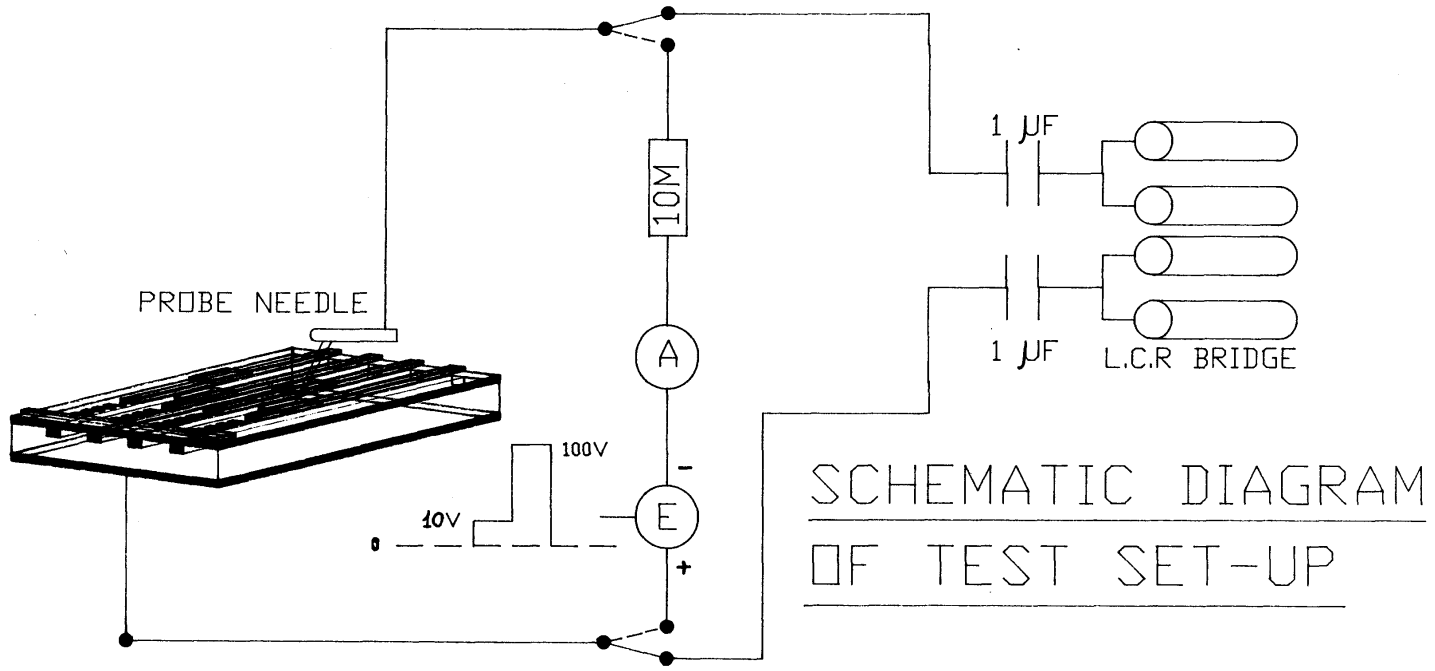
ATLAS SCT uses single sided *p-in-n* Si strip detectors. The backside of the detector represents the n^+ contact completely covered with aluminium. The p^+ strips are connected to the bias rail via polysilicon bias resistors of ~1.5MΩ. The readout is made via coupling capacitors of ~150pF.

Under standard operation conditions both implant and readout strips are at nearly ground potential. However a current surge through the strip and corresponding voltage drop at the bias resistor can produce a considerable voltage difference over the coupling capacitors for a short time. The coupling capacitor insulation was specified to be able to withstand 100V during at least 1 second.

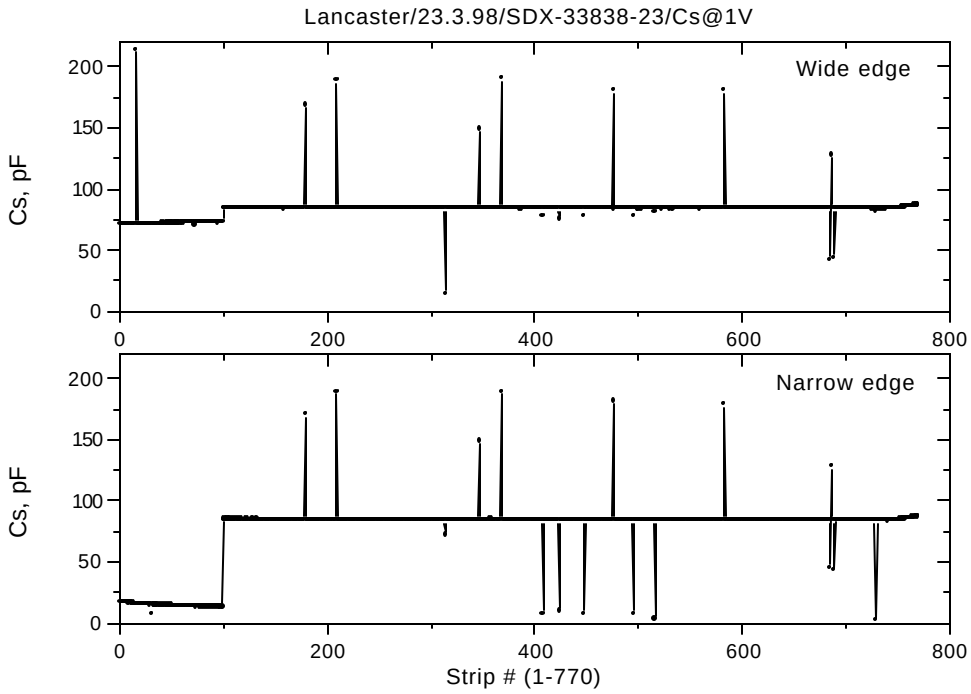
In the Simple Test a bare unbiased detector is put directly on the chuck of the Probe Station in full light. The DC current produced by 10V and 100V and the capacitance are measured between each readout strip and the backside contact.

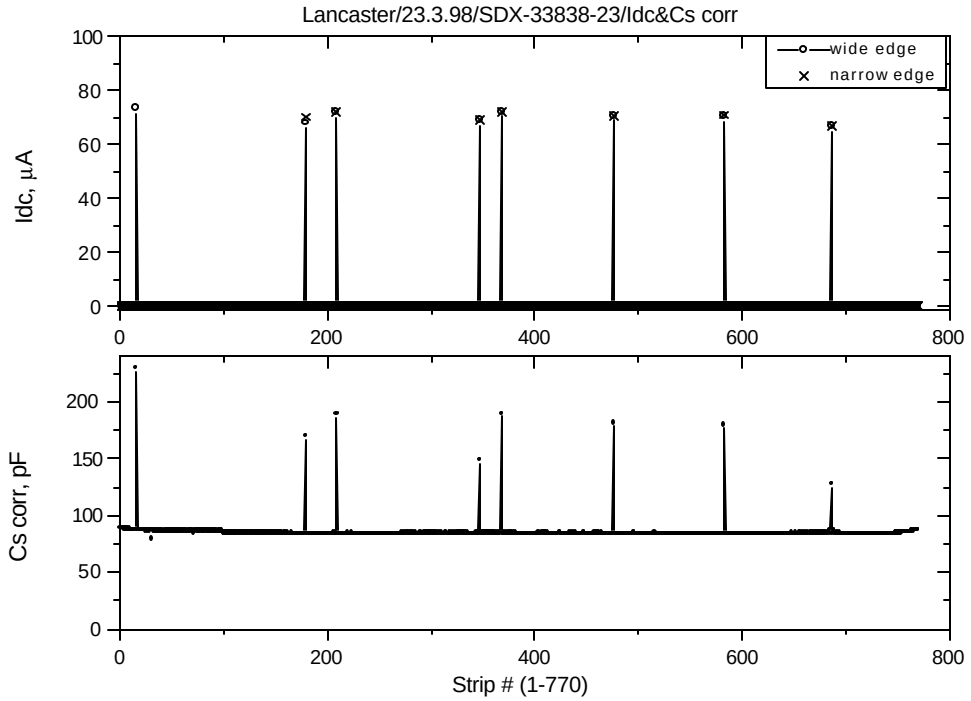
If the DC current exceeds 50 nA at 10V the measurement at 100V is skipped and the strip is identified as having a “pinhole” defect. If the current above 50 nA appears only at 100V this is called “punch-through”.

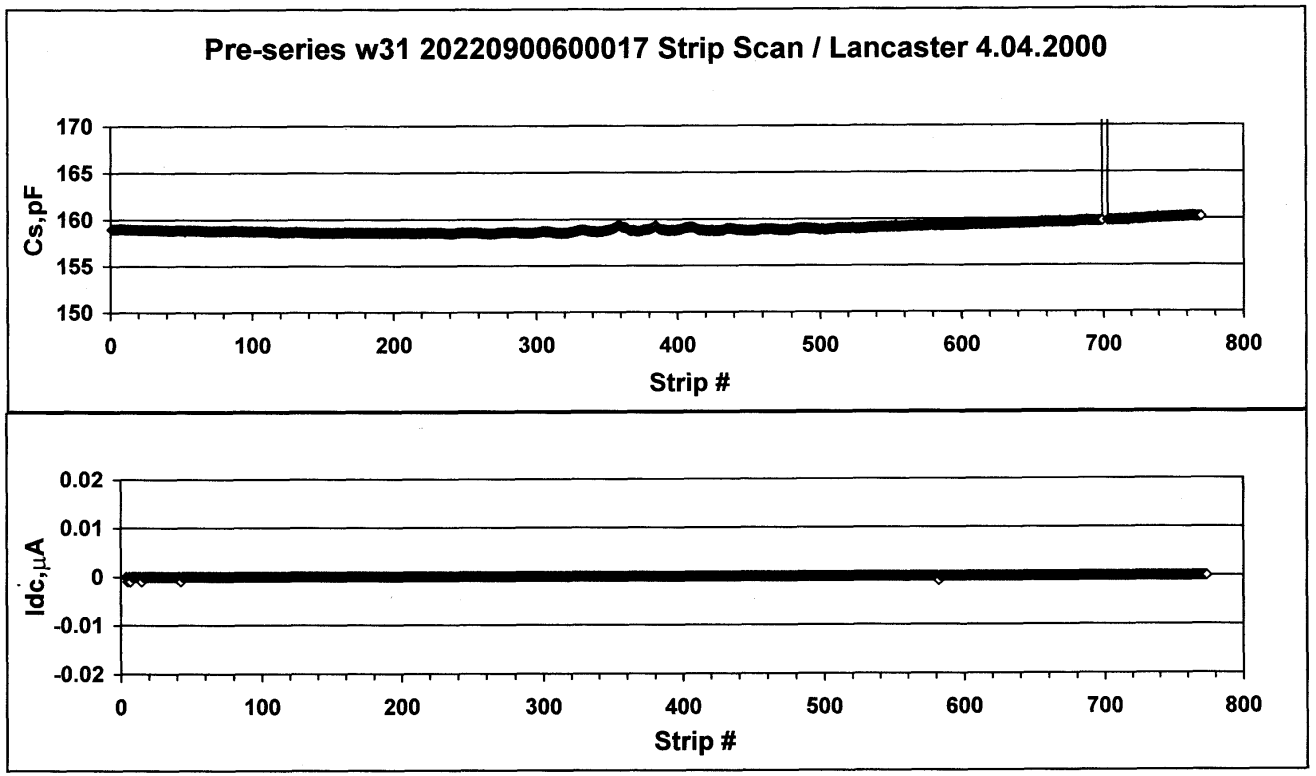
The abnormally low capacitor value indicates the break of the metal strip; the high capacitor value for several neighbouring strips shows the short between them.

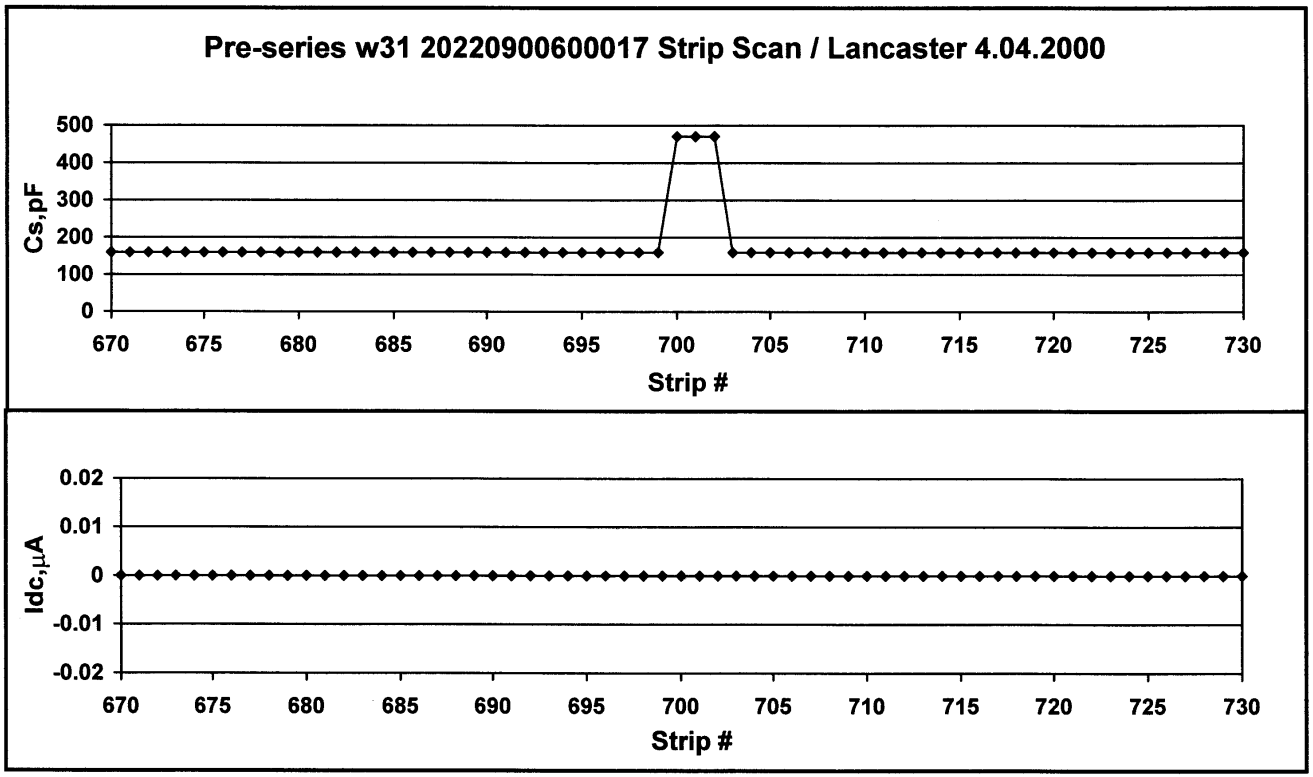


SCHEMATIC DIAGRAM OF TEST SET-UP


Lancaster/23.3.98/SDX-33838-23/Cs@1V
Wide edge
Narrow edge
Cs, pF
Strip # (1-770)


Lancaster/23.3.98/SDX-33838-23/Idc&Cs corr
wide edge
narrow edge
Idc, µA
Cs corr, pF
Strip # (1-770)


Pre-series w31 20220900600017 Strip Scan / Lancaster 4.04.2000
Cs,pF
170
165
160
155
150
0
100
200
300
400
500
600
700
800
Strip #
Idc,μA
0.02
0.01
0
-0.01
-0.02
0
100
200
300
400
500
600
700
800
Strip #


Pre-series w31 20220900600017 Strip Scan / Lancaster 4.04.2000
Cs,pF
500
400
300
200
100
0
670
675
680
685
690
695
700
705
710
715
720
725
730
Strip #
Idc,μA
0.02
0.01
0
-0.01
-0.02
670
675
680
685
690
695
700
705
710
715
720
725
730
Strip #

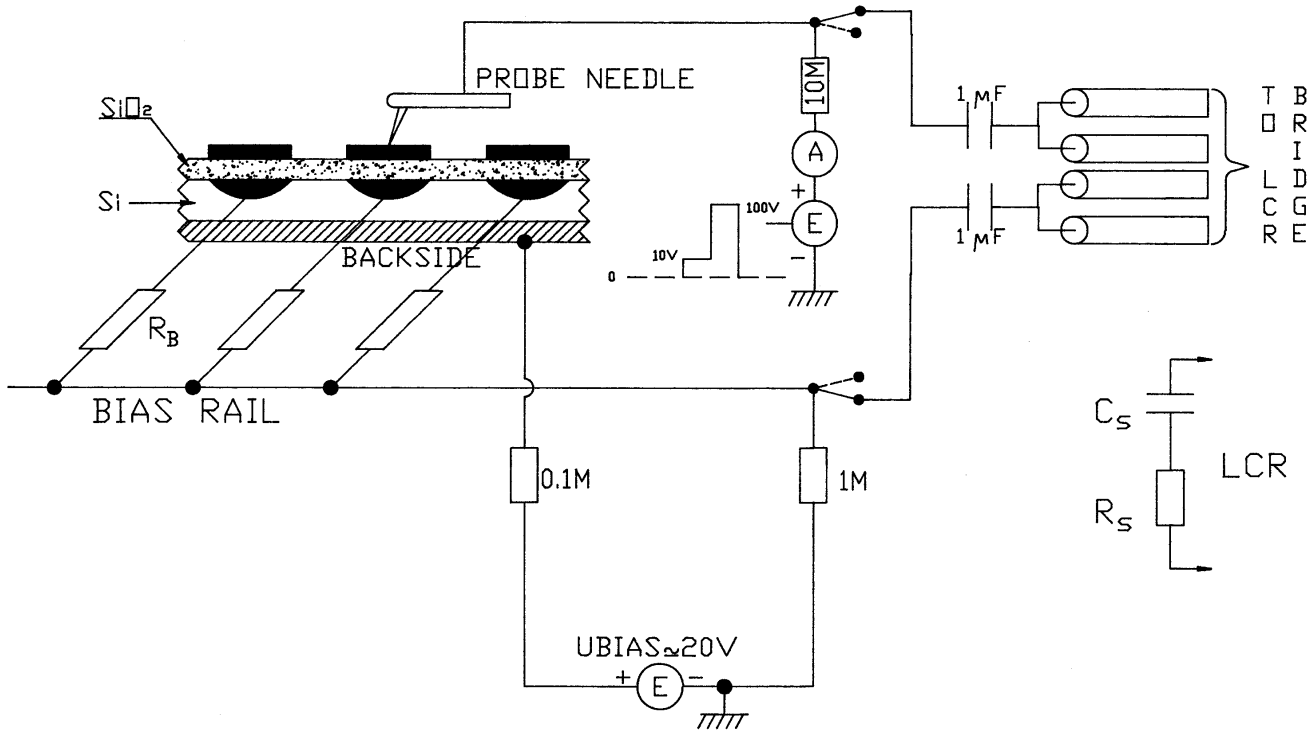
3. Full Strip Test

In the Full Strip Test the detector is put in a fixture allowing its biasing when the detector moves with the chuck. Typically the fixture is a frame with flexible wires connected to the detector via small bonding interface board. The same measurements as in the Simple Test are made between the readout strip and the bias rail without light and with about half of the depletion voltage applied between the backside and the bias rail of the detector.

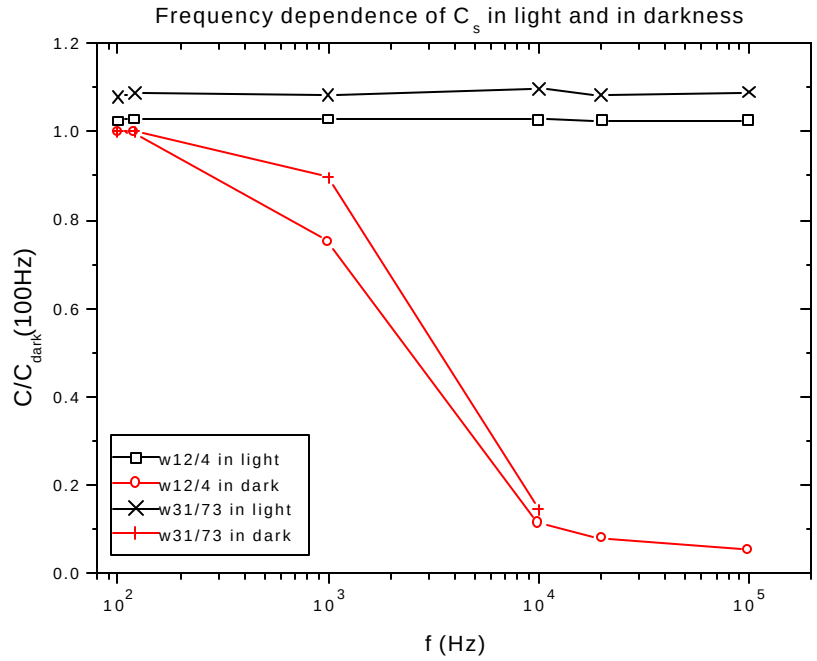
Under these conditions the implant strips and bias resistors are not connected all together as in the Simple Test. Therefore the serial resistor measured by the LCR bridge gives the value of the bias resistor for the strip. The break in the p^+ implant becomes detectable since it produces the same effect as the break in the readout strip.

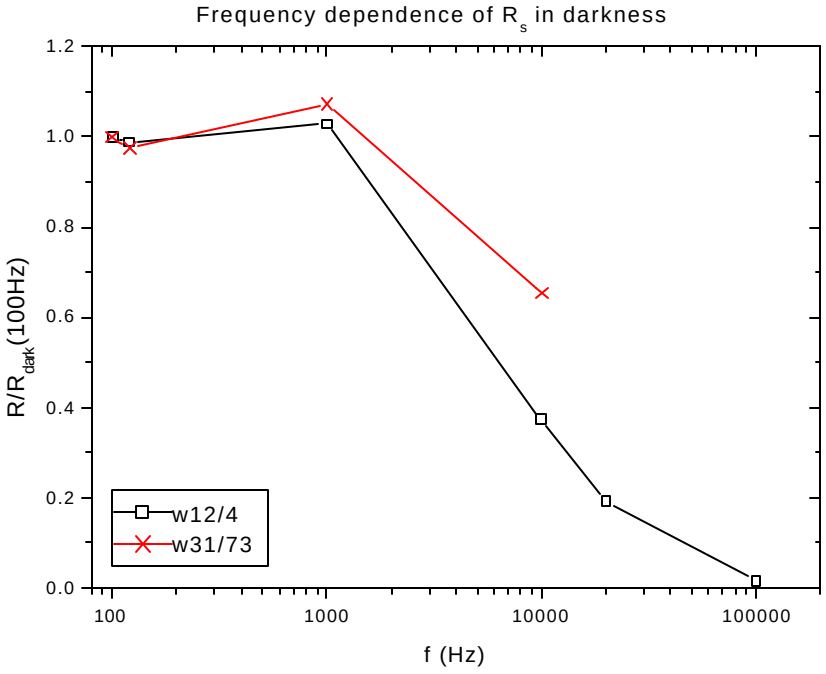
In the Simple Test the capacitance measurement can be made at AC frequency chosen in a wide range: 100Hz-100kHz. For the Full Strip Test the low frequency of ~100Hz is preferable.

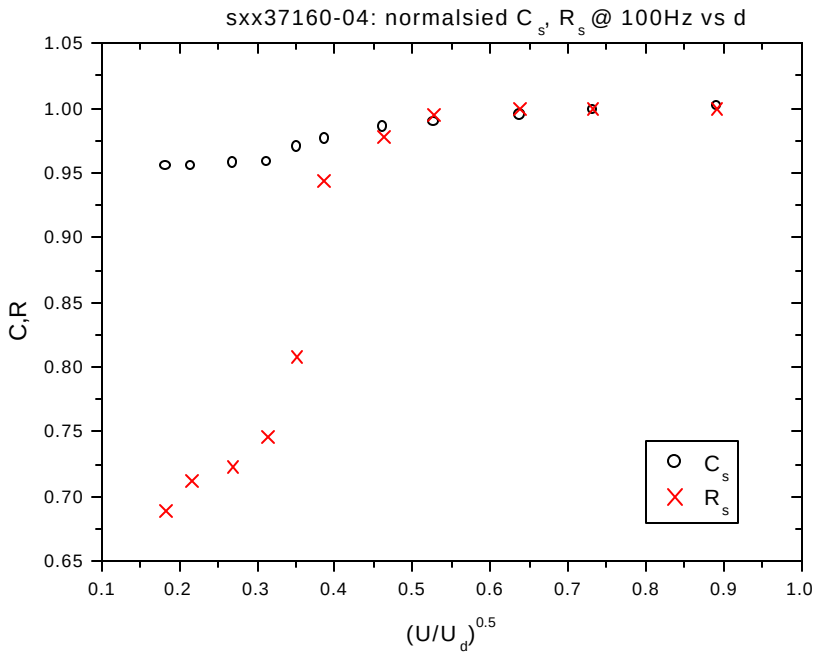
The detector in the fixture may be not as flat and parallel to the chuck surface as the bare detector put directly on the chuck. To minimise the chuck lift and to preserve good contact over all detector area the lift height for each strip is found individually based on the quality of the capacitance measurement.

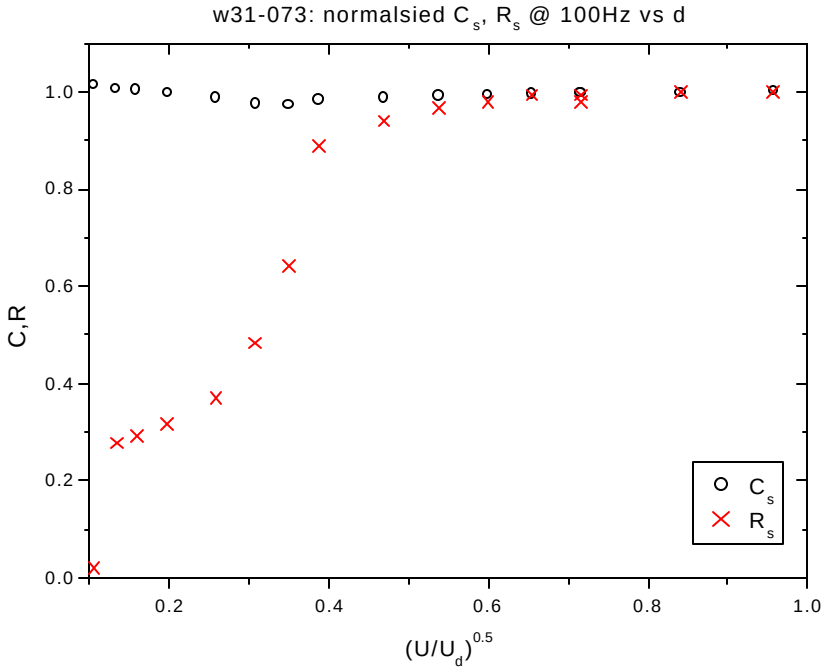


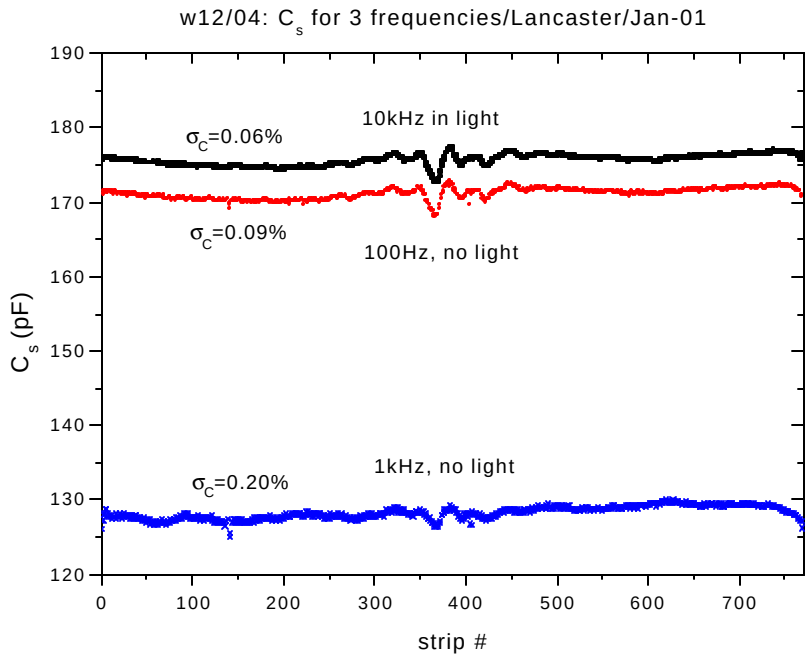
SCHEMATIC DIAGRAM OF TEST SET-UP

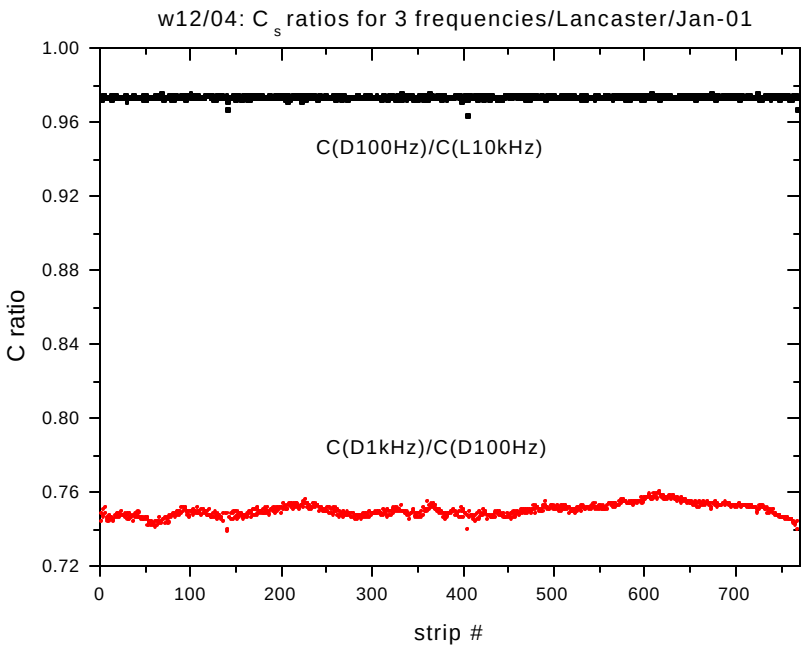

Frequency dependence of C s in light and in darkness
C/C dark (100Hz)
f (Hz)
w12/4 in light
w12/4 in dark
w31/73 in light
w31/73 in dark
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10 2
10 3
10 4
10 5

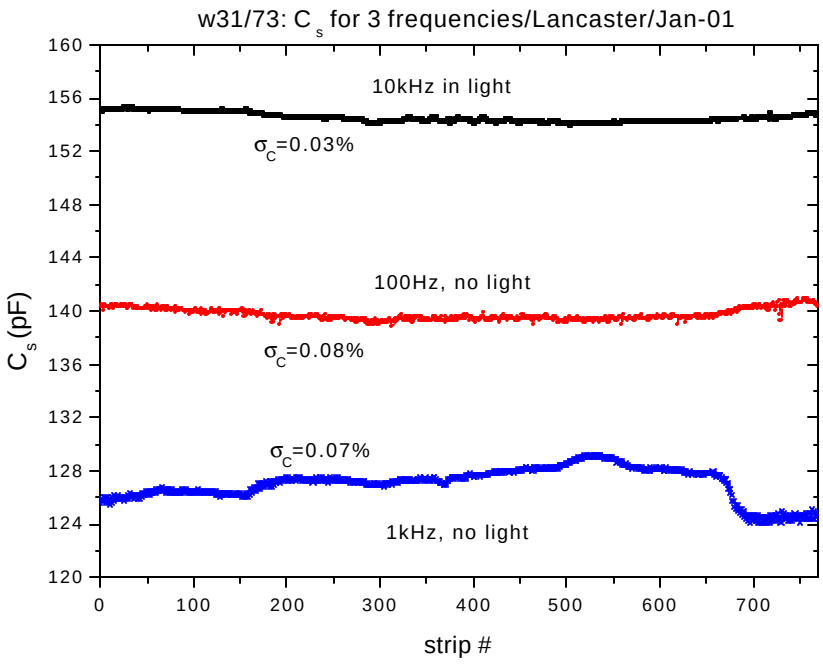

Frequency dependence of R s in darkness
R/R dark (100Hz)
f (Hz)
w12/4
w31/73
1.2
1.0
0.8
0.6
0.4
0.2
0.0
100
1000
10000
100000

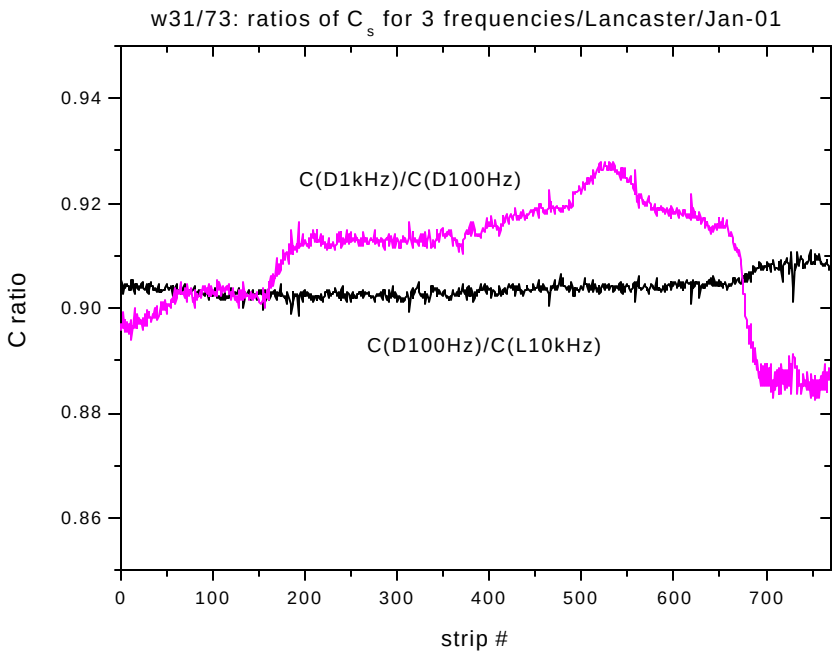

sxx37160-04: normalsied C s, R s @ 100Hz vs d
C,R
(U/U d) 0.5
C s
R s
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

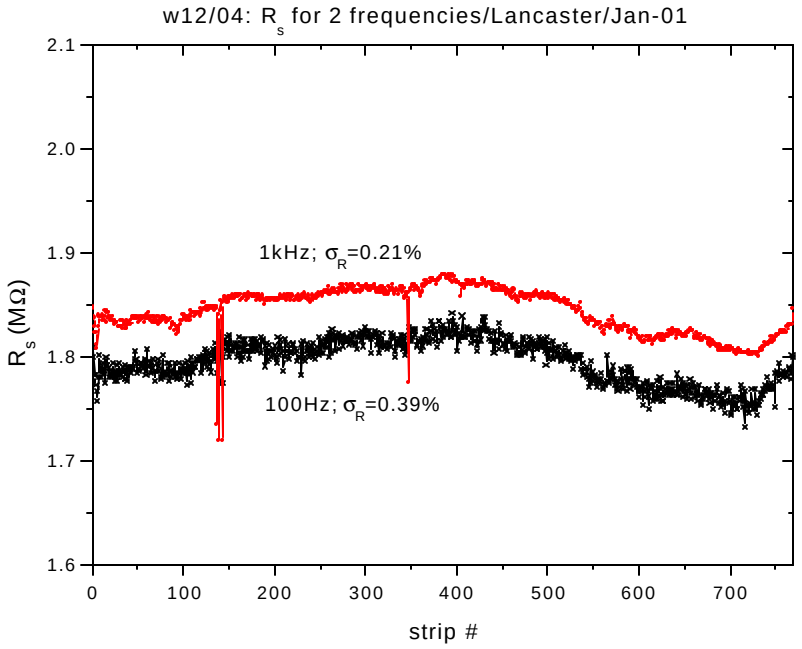

w31-073: normalsied C s, R s @ 100Hz vs d
C,R
(U/U d) 0.5
C s
R s
1.0
0.8
0.6
0.4
0.2
0.0
0.2
0.4
0.6
0.8
1.0

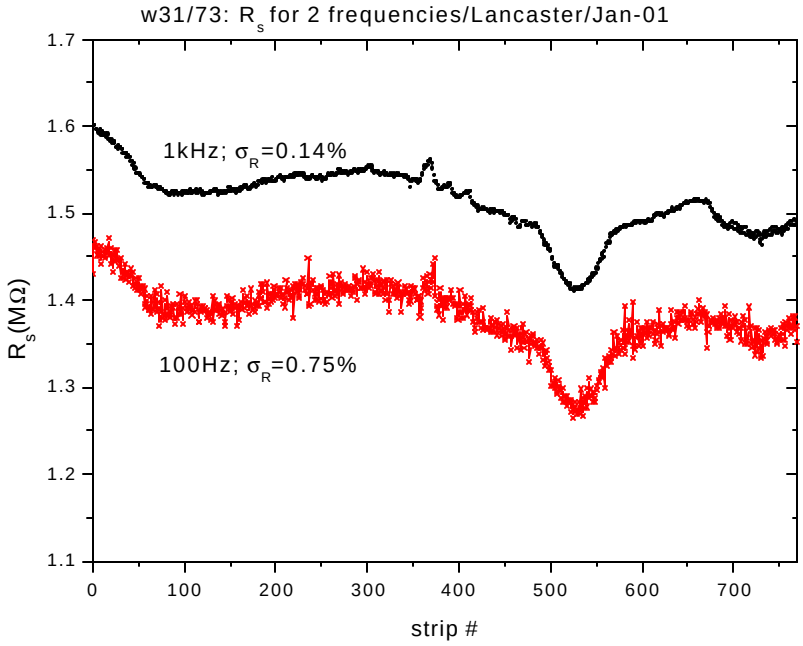

w12/04: C s for 3 frequencies/Lancaster/Jan-01
10kHz in light
σC=0.06%
σC=0.09%
100Hz, no light
1kHz, no light
σC=0.20%
C s (pF)
strip #

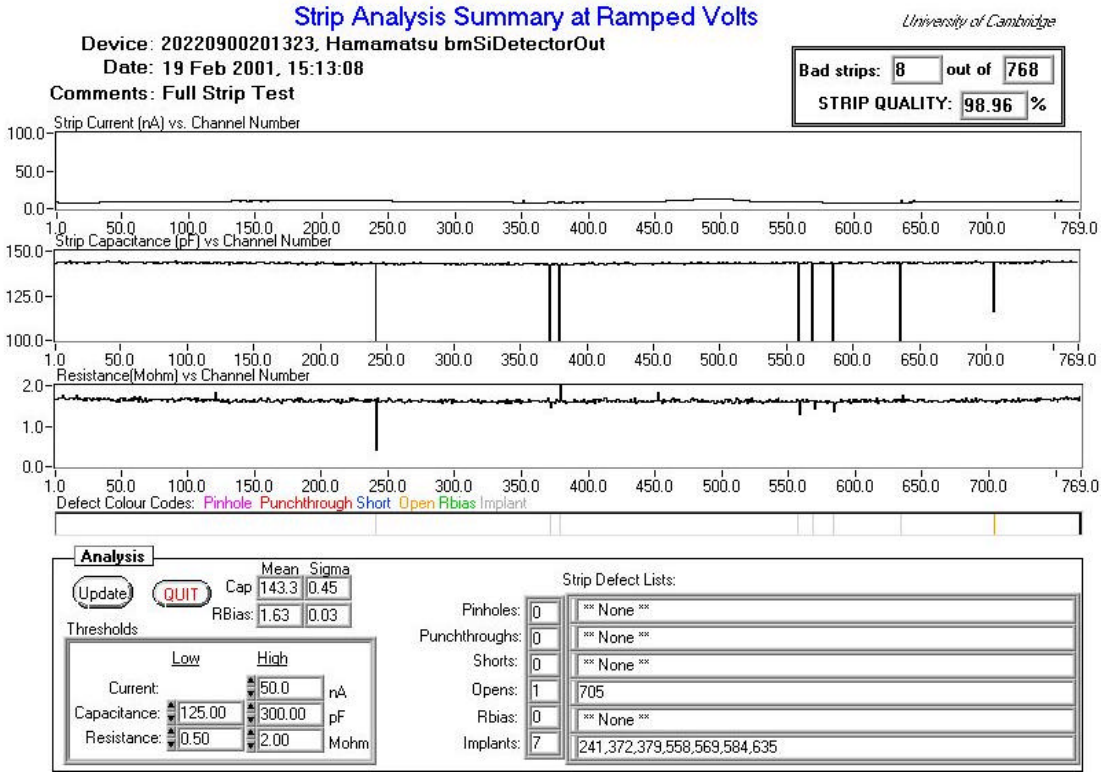

w12/04: C s ratios for 3 frequencies/Lancaster/Jan-01
C(D100Hz)/C(L10kHz)
C(D1kHz)/C(D100Hz)
C ratio
strip #

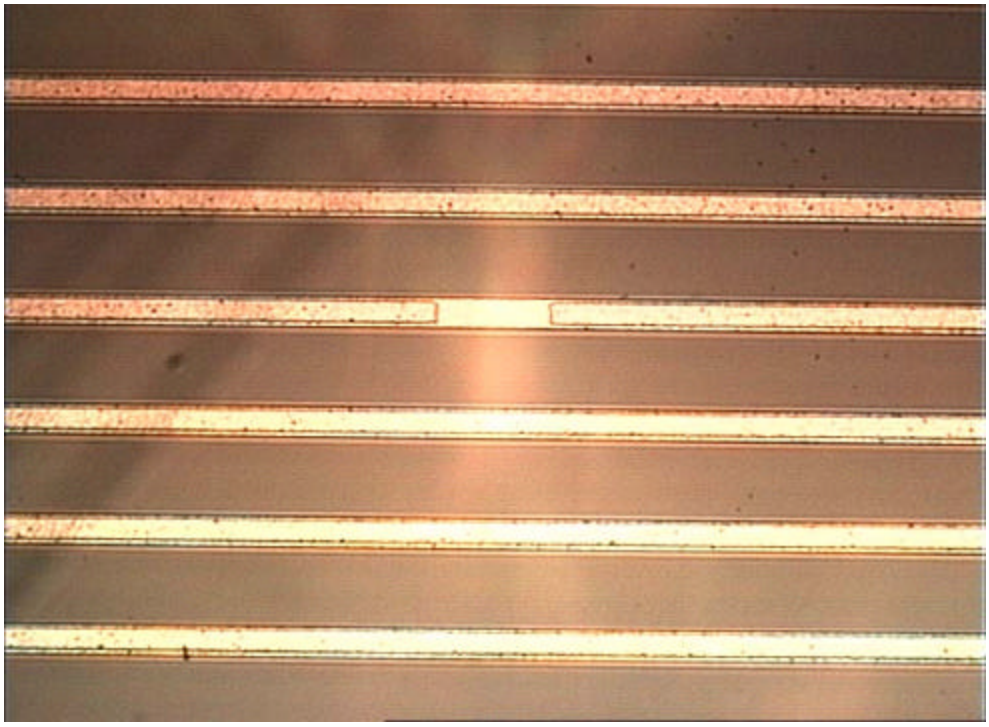

w31/73: C s for 3 frequencies/Lancaster/Jan-01
10kHz in light
σC=0.03%
100Hz, no light
σC=0.08%
σC=0.07%
1kHz, no light
Cs (pF)
strip #


w31/73: ratios of C s for 3 frequencies/Lancaster/Jan-01
C(D1kHz)/C(D100Hz)
C(D100Hz)/C(L10kHz)
C ratio
strip #

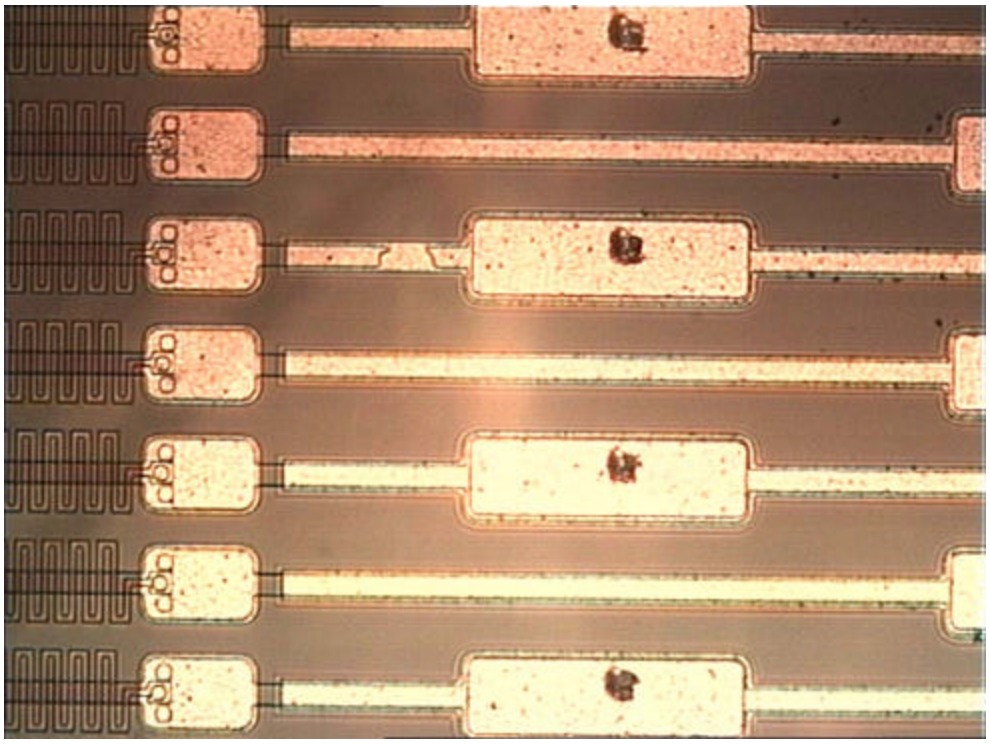

w12/04: R_s for 2 frequencies/Lancaster/Jan-01
2.1
2.0
1.9
1.8
1.7
1.6
R_s (MΩ)
1kHz; σ_R=0.21%
100Hz; σ_R=0.39%
0
100
200
300
400
500
600
700
strip #


w31/73: R_s for 2 frequencies/Lancaster/Jan-01
1.7
1.6
1.5
1.4
1.3
1.2
1.1
R_s(MΩ)
1kHz; σ_R=0.14%
100Hz; σ_R=0.75%
0
100
200
300
400
500
600
700
strip #


Strip Analysis Summary at Ramped Volts
University of Cambridge
Device: 20220900201323, Hamamatsu bmSiDetectorOut
Date: 19 Feb 2001, 15:13:08
Comments: Full Strip Test
Bad strips: 8 out of 768
STRIP QUALITY: 98.96 %
Strip Current (nA) vs. Channel Number
Strip Capacitance (pF) vs Channel Number
Resistance(Mohm) vs Channel Number
Defect Colour Codes: Pinhole Punchthrough Short Open Rbias Implant
Analysis
Update
QUIT
Mean Sigma
Cap 143.3 0.45
RBias: 1.63 0.03
Thresholds
Low High
Current: 50.0 nA
Capacitance: 125.00 300.00 pF
Resistance: 0.50 2.00 Mohm
Strip Defect Lists:
Pinholes: 0 ** None **
Punchthroughs: 0 ** None **
Shorts: 0 ** None **
Opens: 1 705
Rbias: 0 ** None **
Implants: 7 241,372,379,558,569,584,635



Strip 372



Strip 379

Strip Analysis Summary at Ramped Volts

University of Cambridge

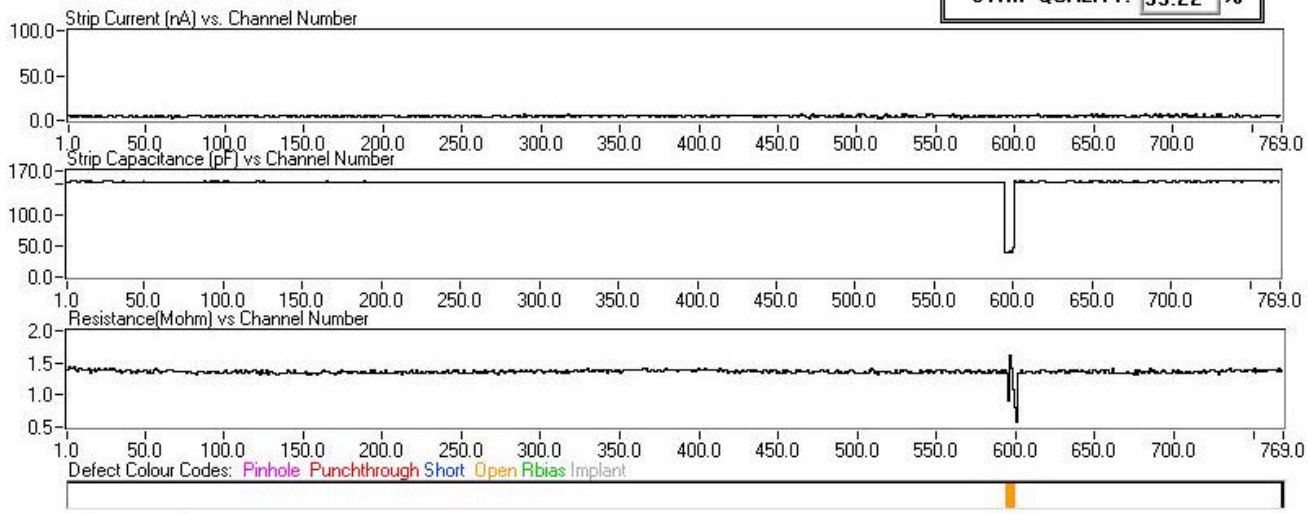
Device: STN39229-00149, Hamamatsu bmSiDetectorOut

Date: 09 Aug 2000, 15:54:06

Comments: Full Strip Test

Bad strips: 6 out of 768

STRIP QUALITY: 99.22 %



Analysis

Update QUIT

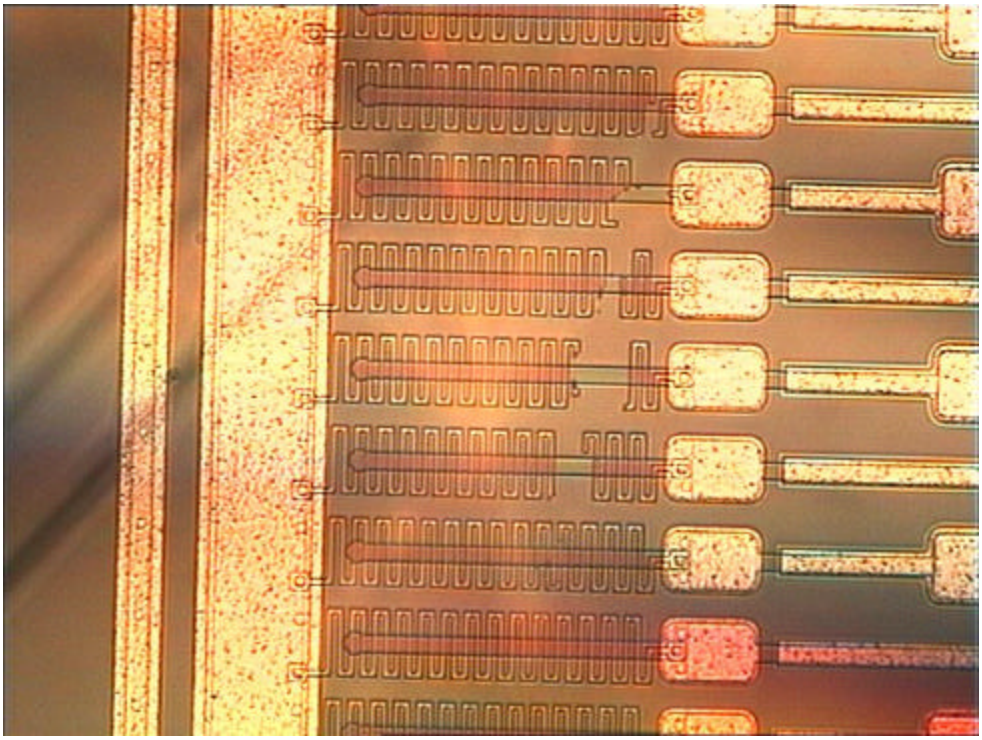
	Mean	Sigma
Cap	152.6	0.42
RBias:	1.37	0.02

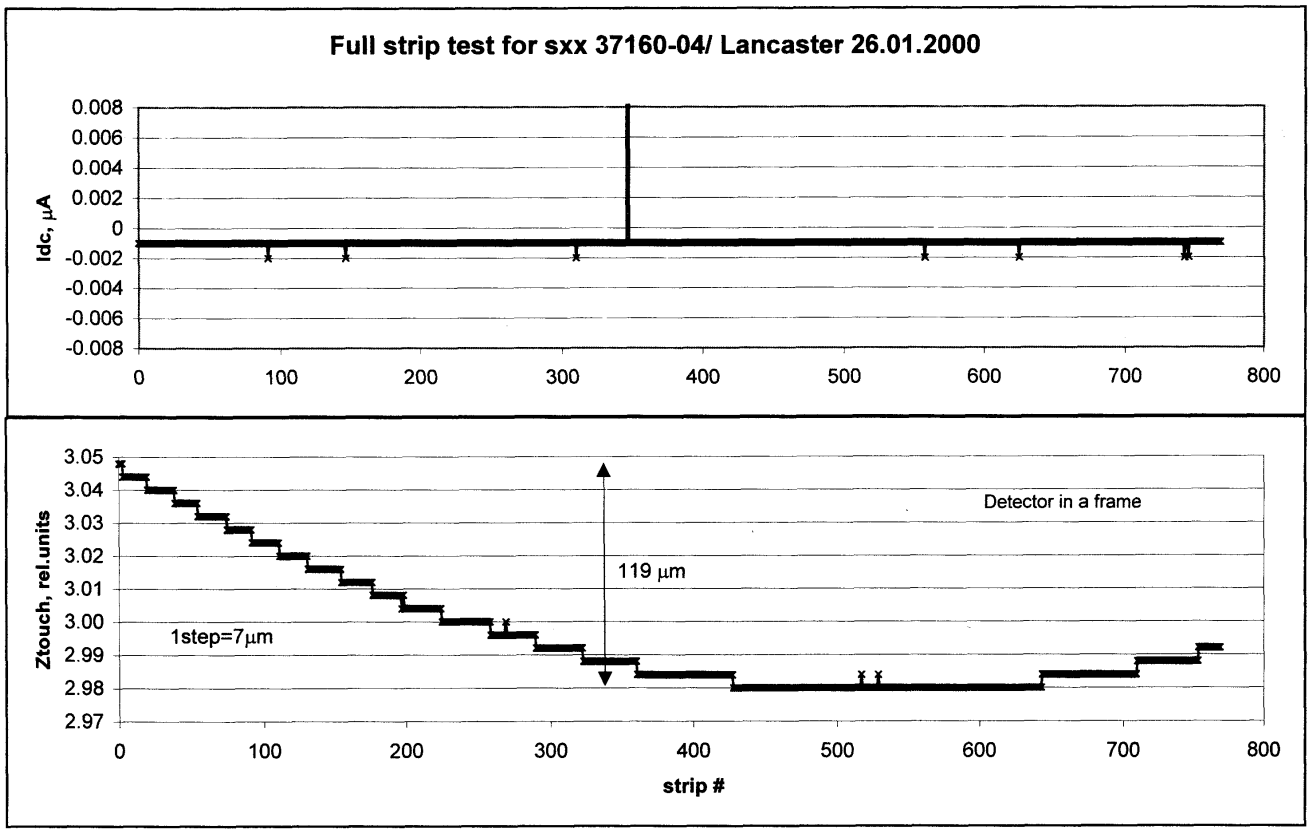
Thresholds

	Low	High	
Current:		50.0	nA
Capacitance:	100.00	300.00	pF
Resistance:	0.50	2.00	Mohm

Strip Defect Lists:

Pinholes:	0	*** None ***
Punchthroughs:	0	*** None ***
Opens:	6	595, 596, 597, 598, 599, 600
Shorts:	0	*** None ***
Rbias:	0	*** None **
Implants:	0	*** None ***




Full strip test for sxx 37160-04/ Lancaster 26.01.2000
Idc, μA
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
0
100
200
300
400
500
600
700
800
Ztouch, rel.units
3.05
3.04
3.03
3.02
3.01
3.00
2.99
2.98
2.97
Detector in a frame
119 μm
1step=7μm
strip #

4. Conclusions

1. The strip quality tests used by ATLAS SCT measure the values and check the electric strength of the coupling capacitors, measure the values of the polysilicon bias resistors and reveal the defects in the readout strips, implant strips and bias resistors.

2. The Simple Strip Test can be done in light with a bare unbiased detector put directly on the chuck of a Probe Station. It is however insensitive to the defects in the strip implants and the bias resistors.

3. The Full Strip Test is performed in darkness with the detector put in a fixture allowing its biasing. It is more informative but technically more difficult than the Simple Test.

4. A lift-search procedure developed at Lancaster University allows corrections for the distortions of the detector flatness induced by the test fixture.