Quality Assurance for L0

Purpose: monitor sensors from HPK

make sure we can build L0 detector

Documentation:

Run IIb Quality Assurance Document

D0note 4120, draft 4.0

Testing sites: HPK, Fermilab, Stony Brook

Irradiation: Kansas State University

Overview

The sensors received from HPK for RunIIb were excellent.

Based on that experience, only a small fraction of the sensors will be selected for detailed mechanical and electrical tests by us. This fraction (currently 10%) could change depending upon what we find.

Tasks at Fermilab

- initial registration upon receipt from HPK
- visual inspection of each sensor
- mechanical measurements (on 10%)
- electrical measurements on each sensor
  - I-V and C-V measurements
- stability - I(time)
- special measurements as appropriate
  - on sensors, diodes, and test structures

Visual Inspection

Verify defects found at HPK

Check using a probe station with video camera for selected sensors (about 10%, or if flagged by HPK):

- edge chipping (< 50 μm)
- processing abnormality
- breaks in bias resistors
- alignment of metallization with implant (>2microns on each side)

Mechanical Measurements

Using an optical metrology system:

wafer thickness $320 \pm 20 \mu m$

wafer warp, best effort $< \pm 50 \mu m$

cutting lines

accuracy $\pm 10 \mu m$

parallelism $\pm 5 \mu m$

Whole Detector Measurements

Measurement	Bad Detector
C-V	
measure capacitance versus voltage	
determine Full Depletion Voltage	FDV> 300 V
	FDV< 40 V
I-V	
measure current up to 800 V	Itot > 1 μA at 700V
Number of bad strips	>1%

Strip Measurements at SB

(during a scan under computer control)

Measurement		Bad Strip
Idiel		>10 nA (PINHOLE)
current through the coupling capacitance		
Cac	(at 100 Hz)	> 1.2*mean (OPEN)
coupling capacitance		< 0.8*mean (SHORT)
Istrip		> 10 nA (LEAKY)
leakage current to a strip		
Rpoly		> 1.1 MOhm or < 0.5 MOhm
polysilicon resistance		
Rint	(even pairs only)	< 2 GOhm
interstrip resistance		
Cint	(even pairs only)	> 8.4 pF (0A)
interstrip capacitance	(at 100kHz)	> 14.4 pF (0B)

Testing Sites

Test	HPK	Fermi	SB
inspection		10%	
mechanical		10%	
I-V	100%	100%	10%
C-V	100%	100%	10%
Idiel	100%		10%
Cac	100%		10%
Istrip	TS	TS	10%, TS
Rpoly	TS	TS	10%, TS
Rint	TS	TS	10%, TS
Cint	TS	TS	10%, TS

TS=Test Structures

Additional TS Measurements as needed at Fermilab and Stony Brook

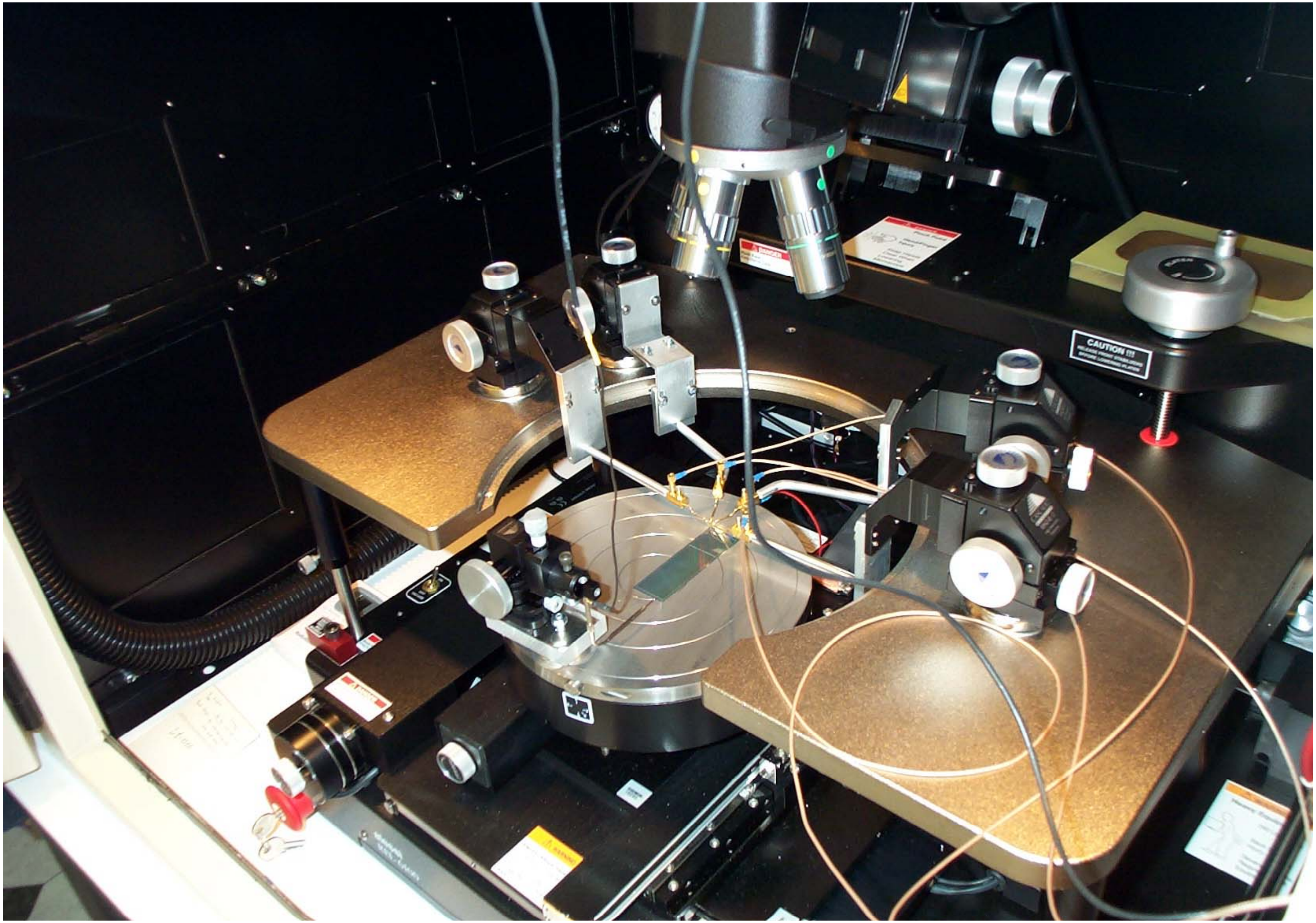
- total strip capacitance
- metal series resistance
- implant resistance
- flat band voltage
- coupling capacitor
- coupling capacitor breakdown voltage

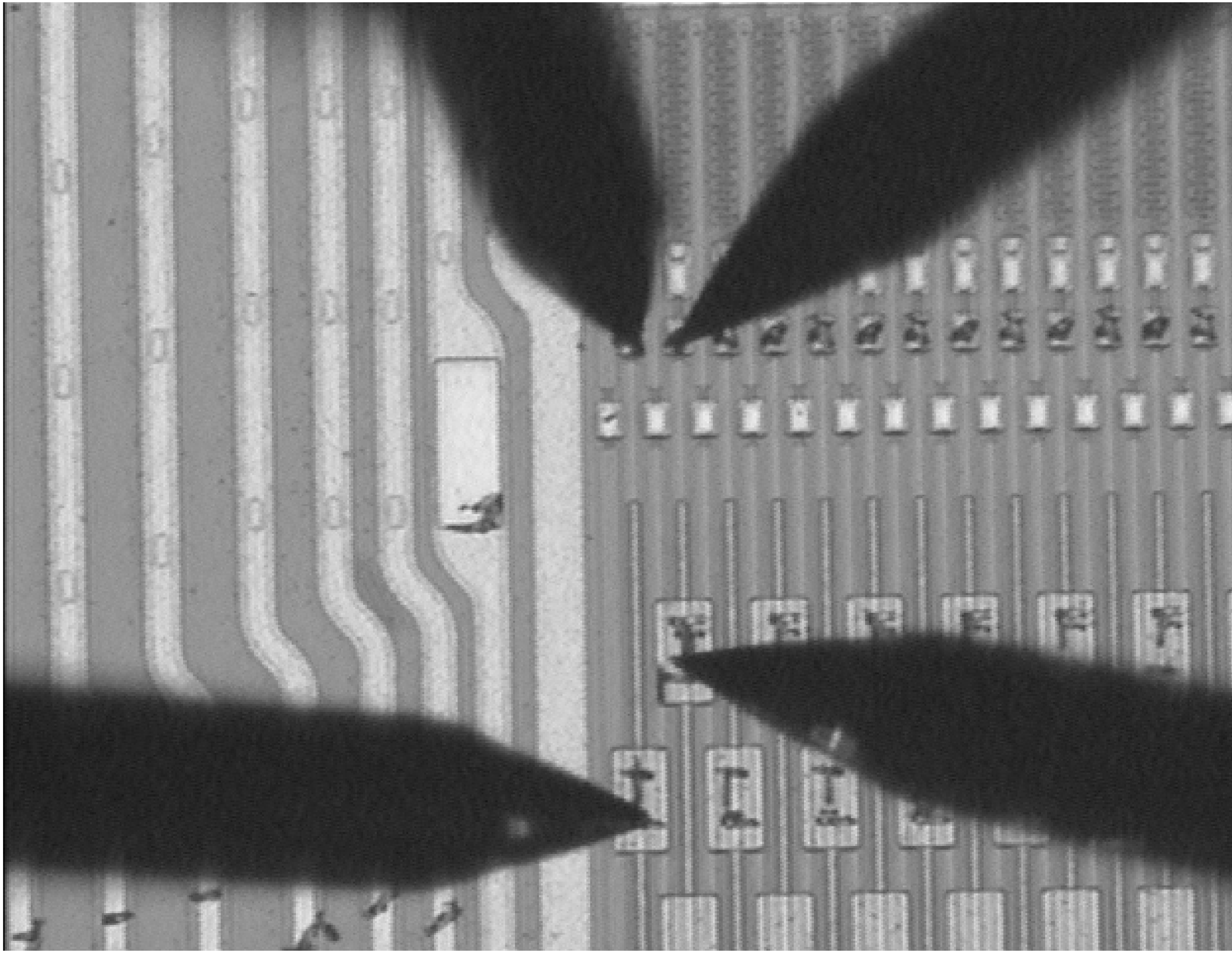
Equipment at Stony Brook

probe station	Alessi 6100
strip probes	4
bias line probe (rides chuck)	1
Source Measure Unit (voltage source with picoammeter)	Keithley 237
voltage source	Keithley 487
picoammeter	Keithley 487
LCR meter	Agilent4263B
4 X 8 Matrix Switch	HP34904A

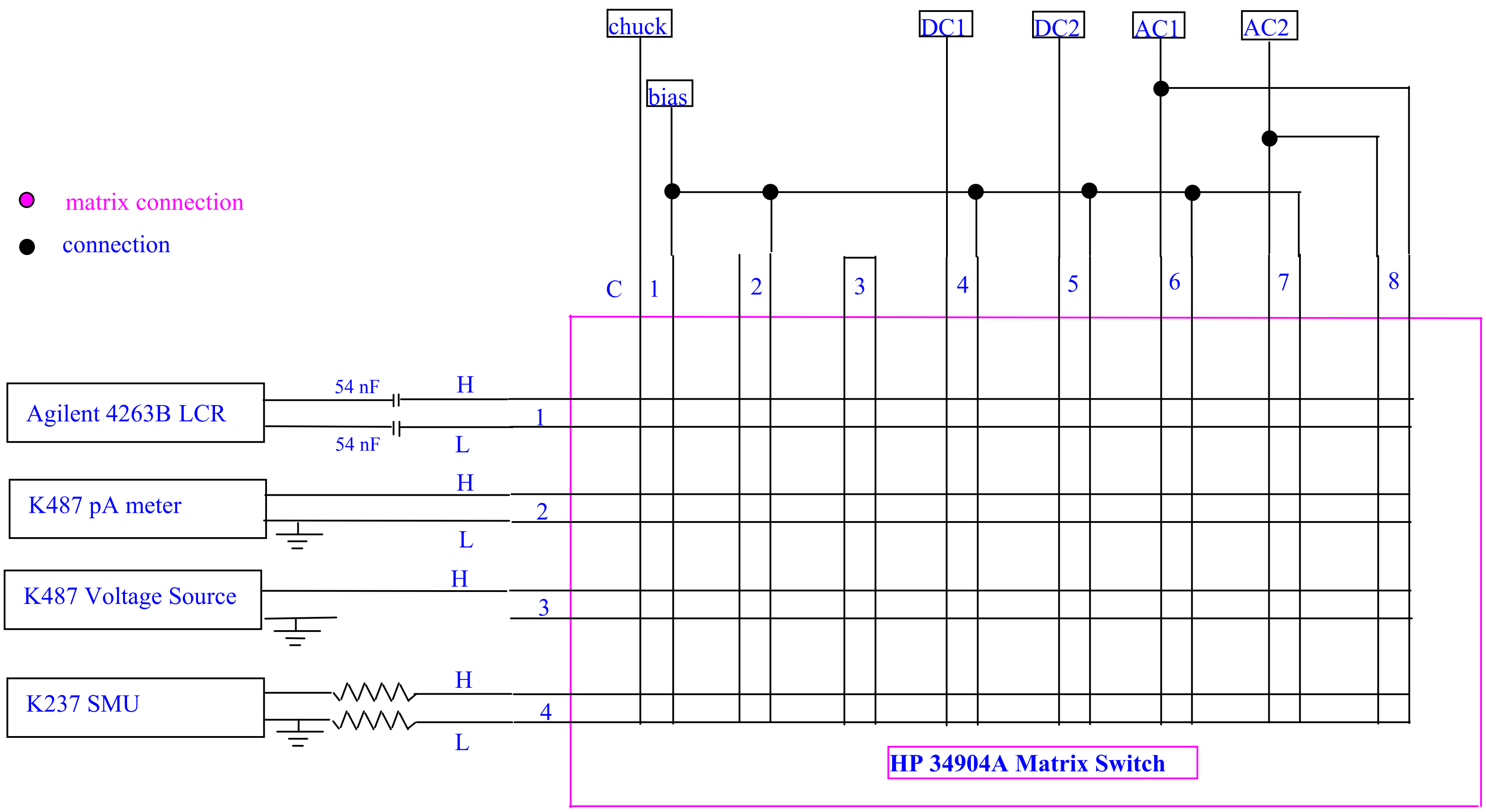
We use the matrix to perform multiple tests while only touching each pad once. We touch AC and DC pads of neighboring strips and complete the scan in pairs. One probe always even, one always odd. This enables interstrip measurements at the same time.

SB





Stony Brook Plan for use of the Matrix



Measurement Techniques

bias voltage	All measurements at FDV+20V.
Idiel	put 80V on AC pad and measure current out of SMU to bias line at ground.
Cac	measure capacitance between the AC pad and the bias line at f=100Hz
Istrip	measure current to the DC pad at ground with the K487
Rpoly	apply a voltage to the DC pad with the SMU and measure current from the SMU to the bias line at ground
Cint	measure capacitance between the two AC pads
Condint	Apply a voltage with the SMU to one DC pad and measure current to a neighbor at ground with the K487

Measurement Procedures

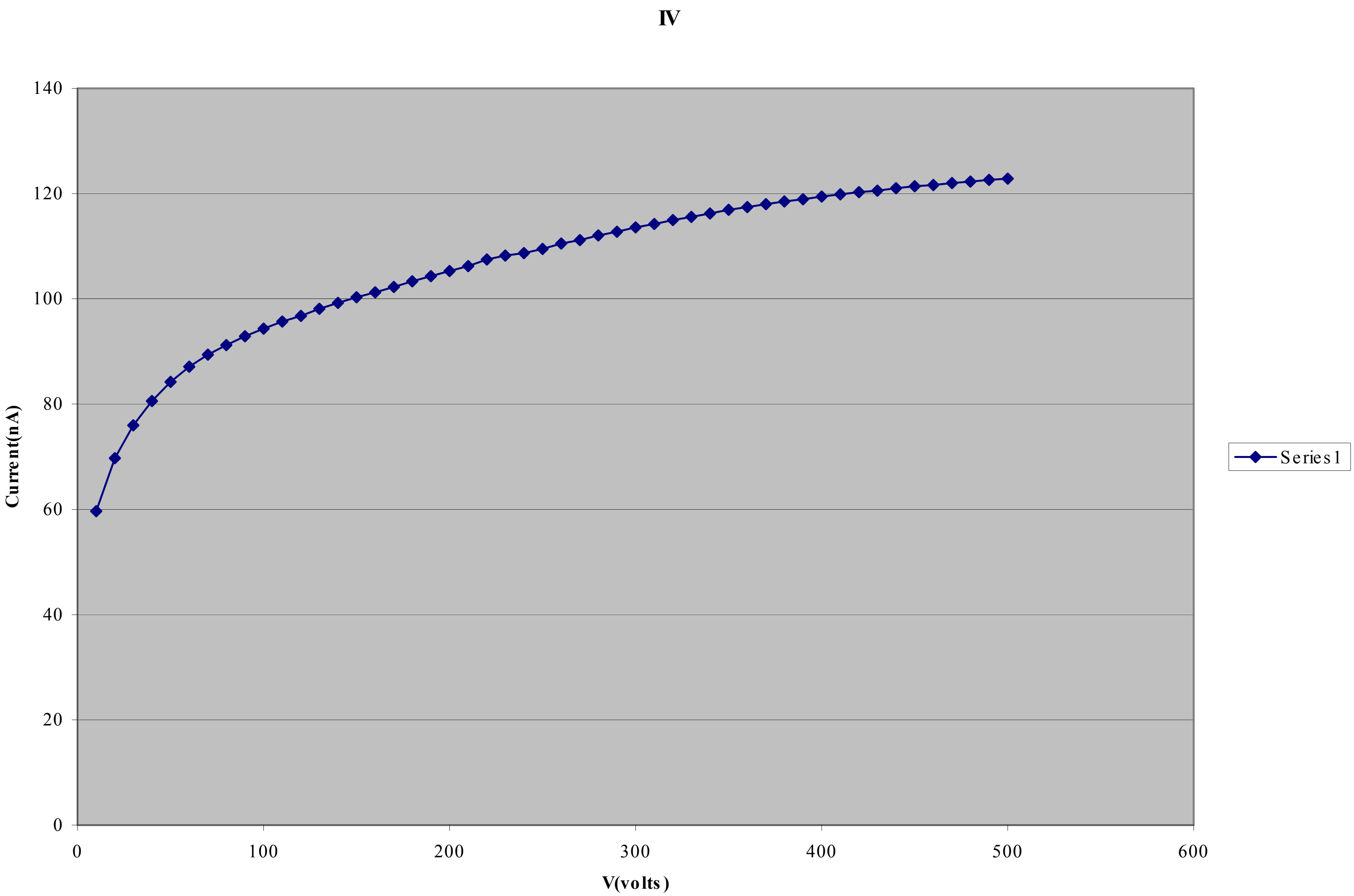
- Repeat obviously bad measurements:

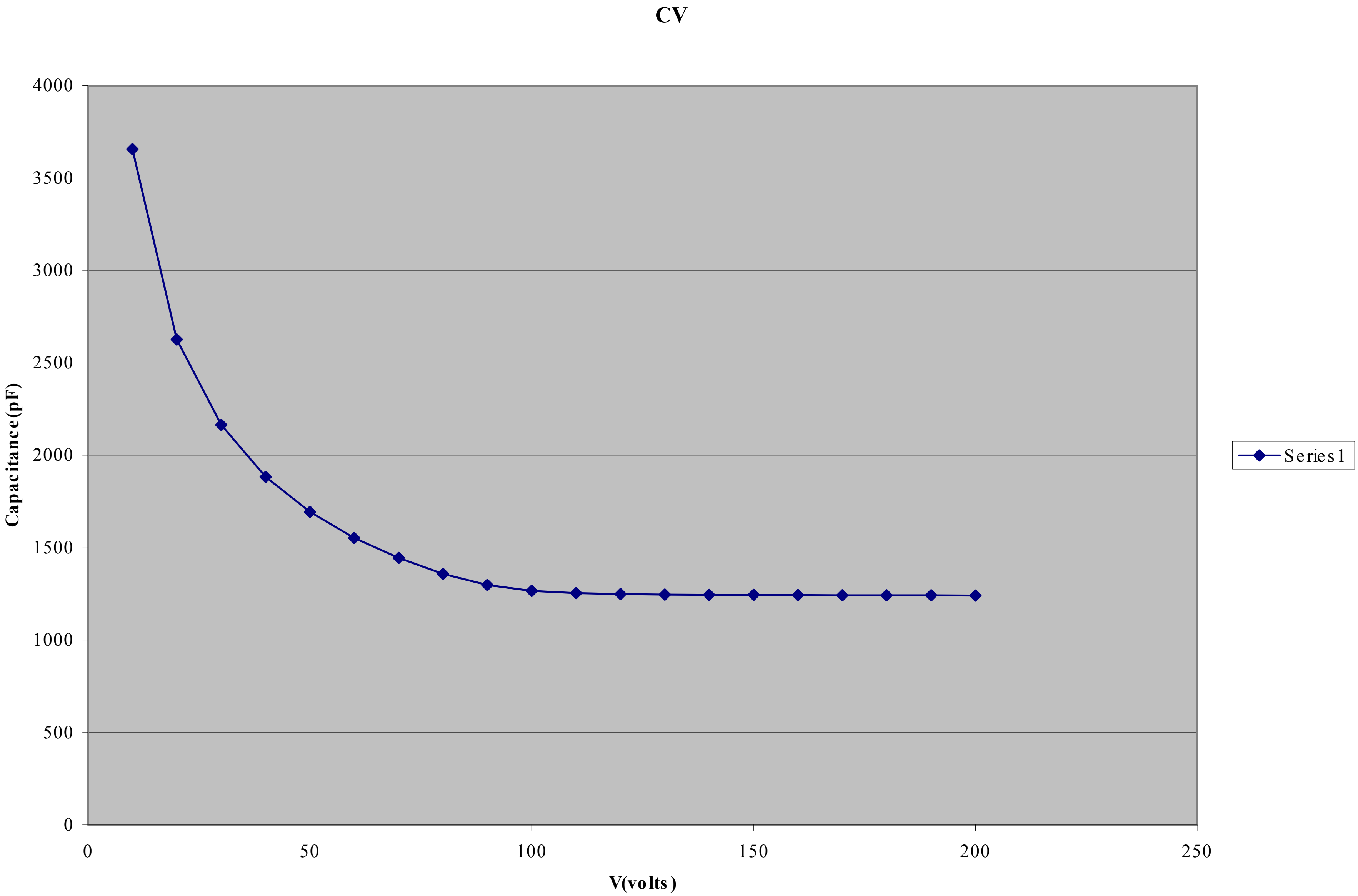
  The bias line loses contact: Strip currents approach the total leakage current.

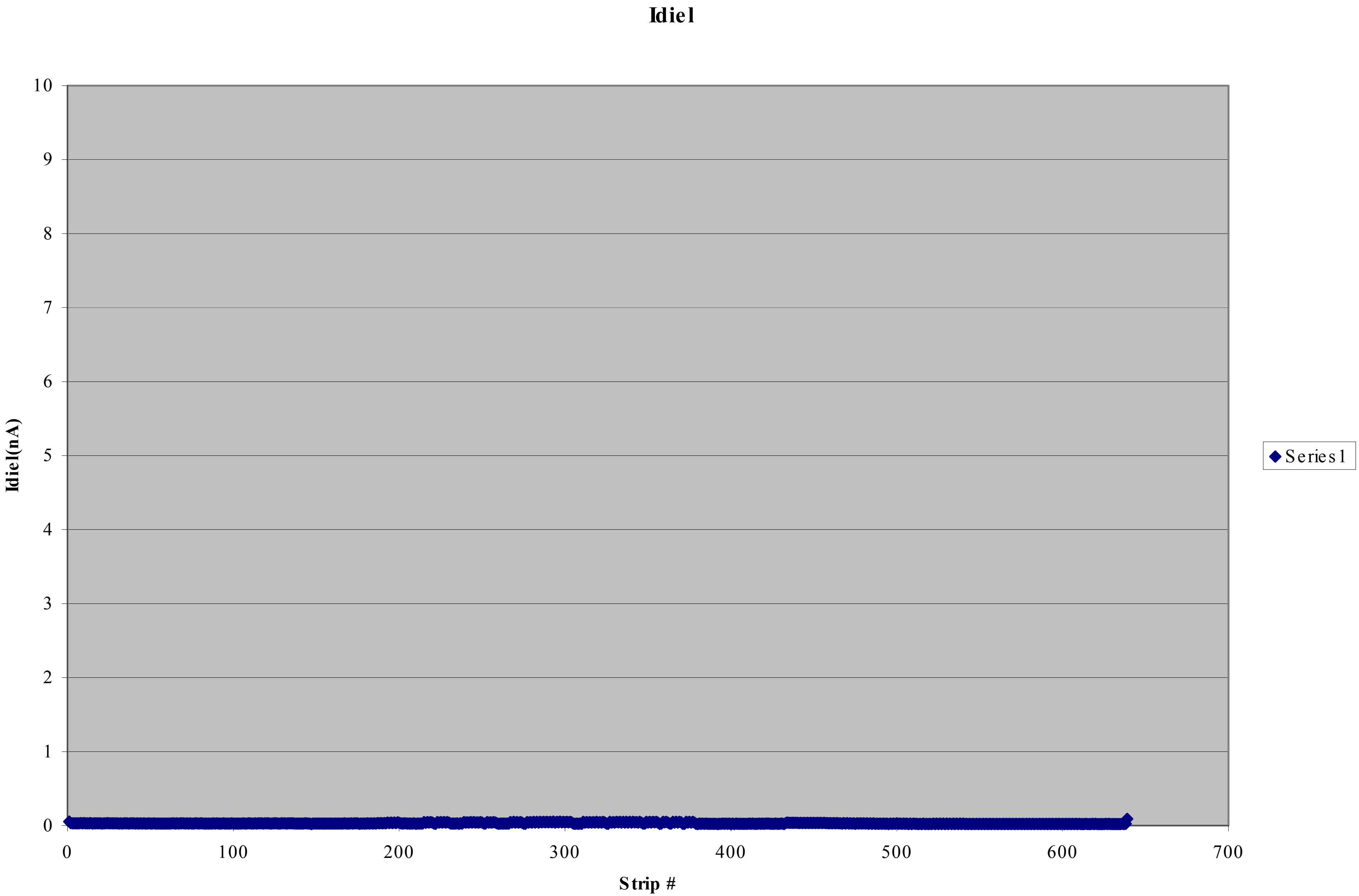
  SMU mode problem: Rpoly is infinite and Idiel is very small for all strips.

  [Neither of these has caused a problem recently.]
- Remeasure bad strips, to see if the problem is a result of bad contact.

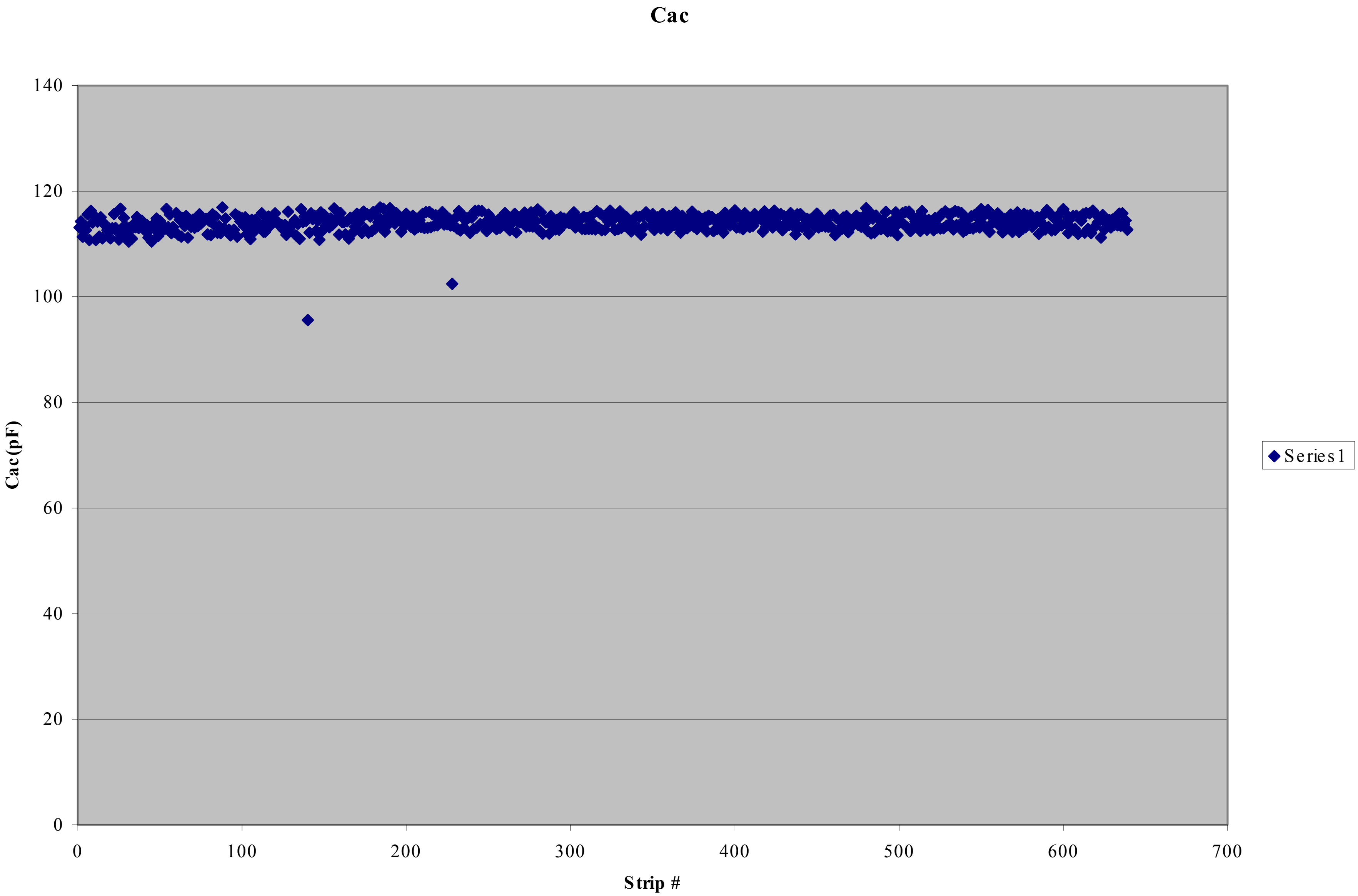
  If the bad measurement value repeats once, the strip is called bad.
- At the end of the scan lift both probes to measure the background and do a two-strip scan. The background values of Idiel, Cac, Istrip, Cint, and Condint are then subtracted from corresponding values for all strips. (We should subtract conductances in measuring Rpoly, but do not bother since the correction is very small.) The background values are generally a small fraction of the bad strip limit.

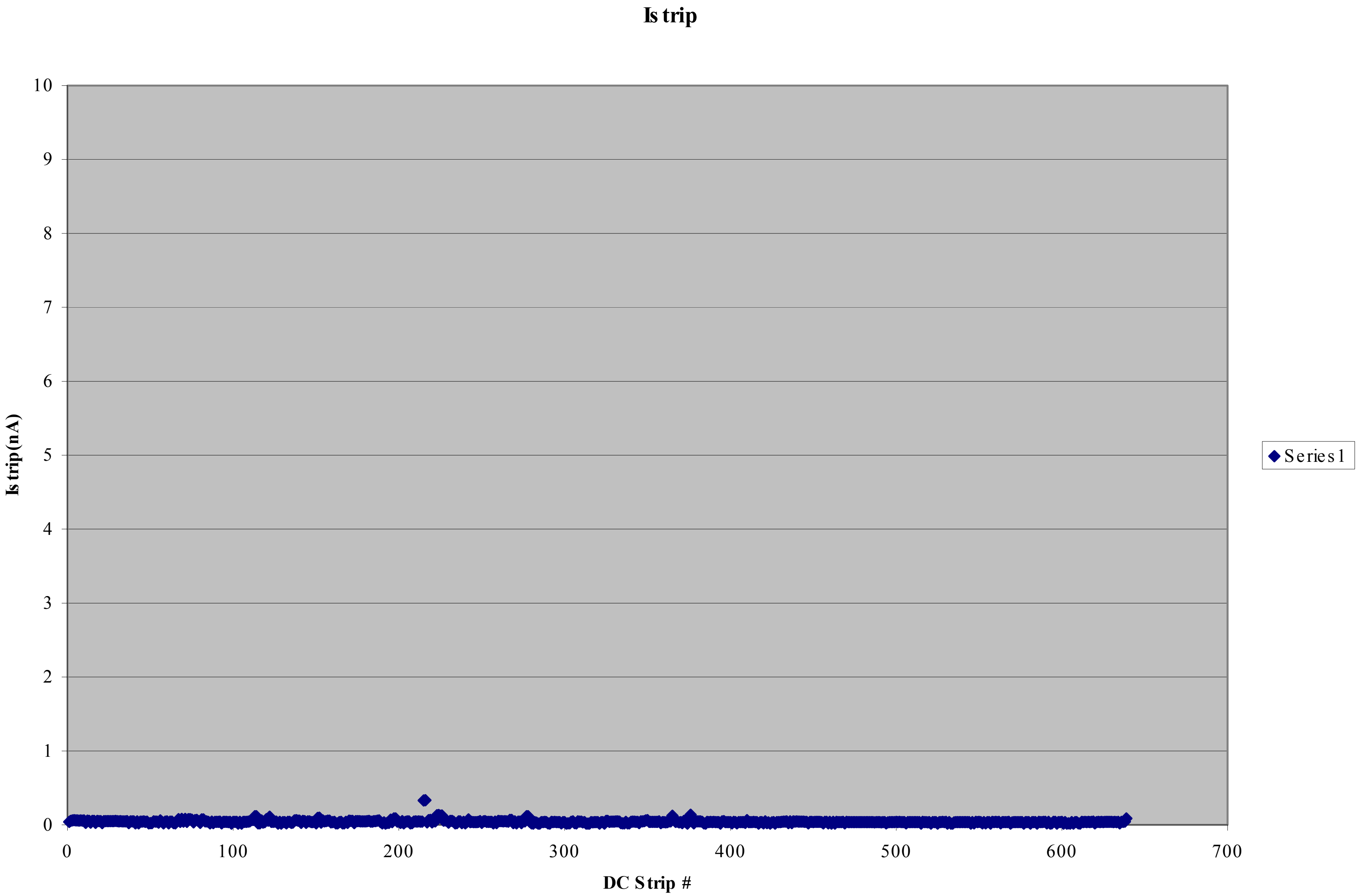

IV
Current(nA)
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
V(volts)
Series1

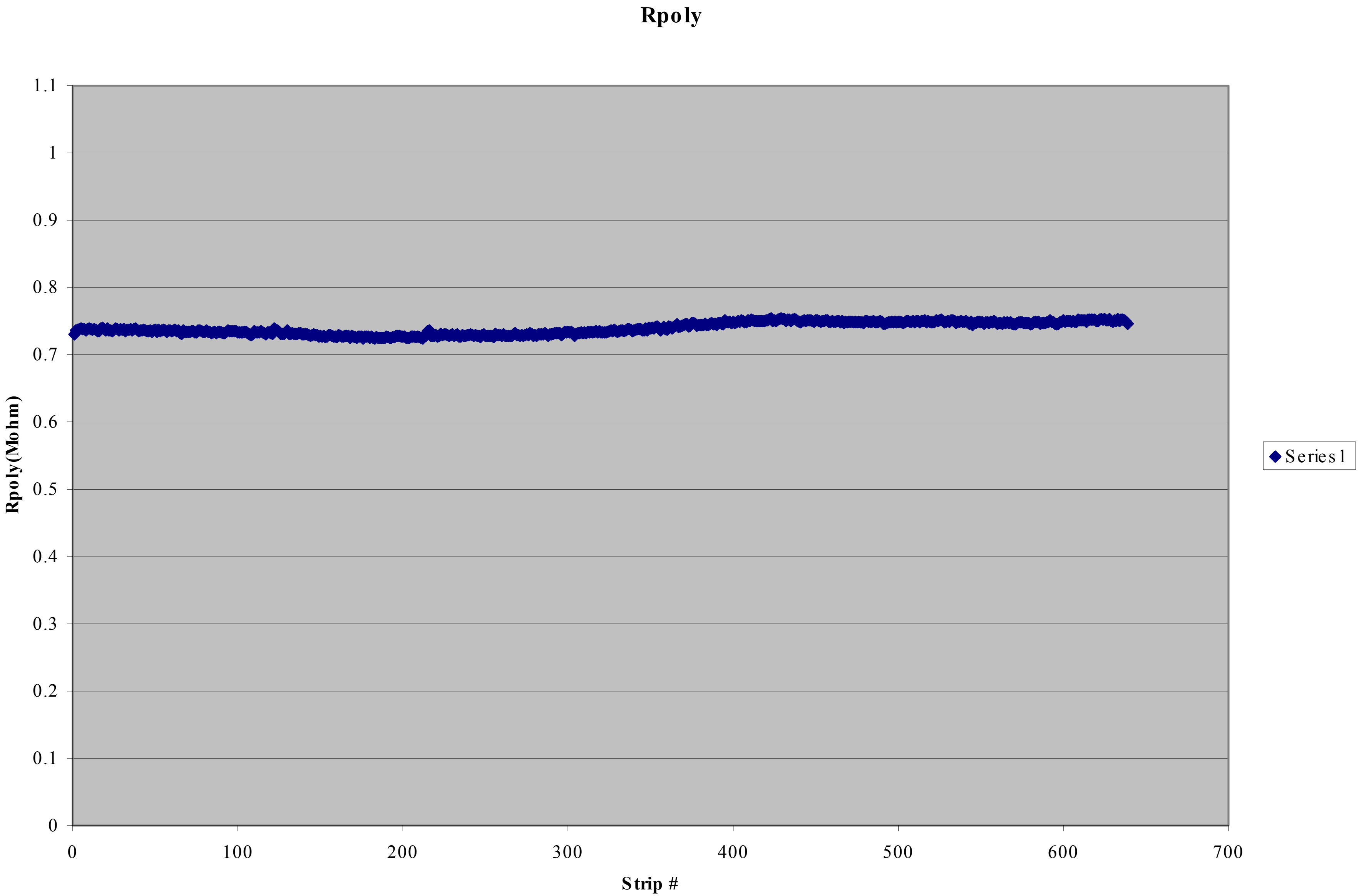

CV
Capacitance(pF)
4000
3500
3000
2500
2000
1500
1000
500
0
0
50
100
150
200
250
V(volts)
Series1

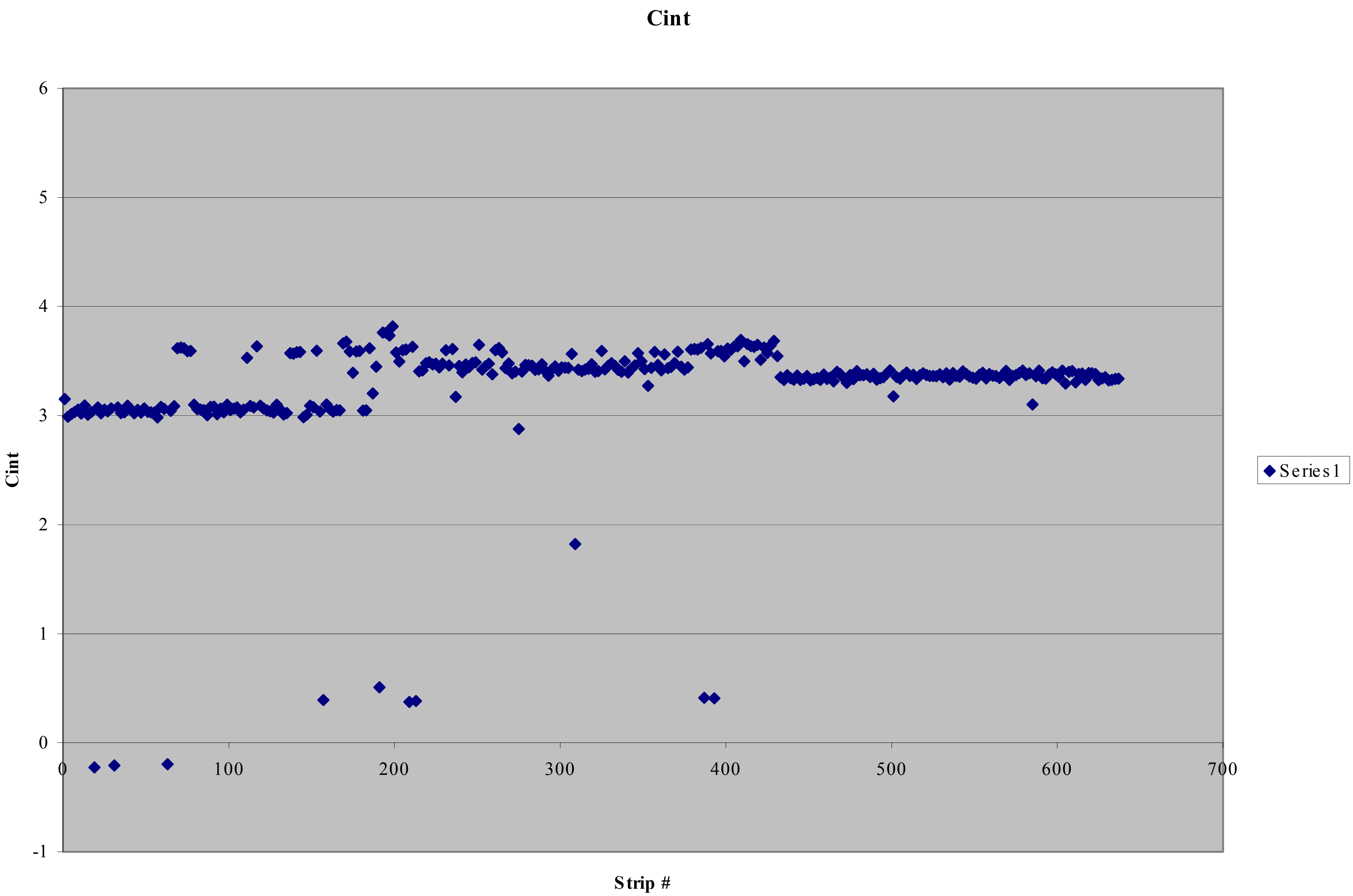


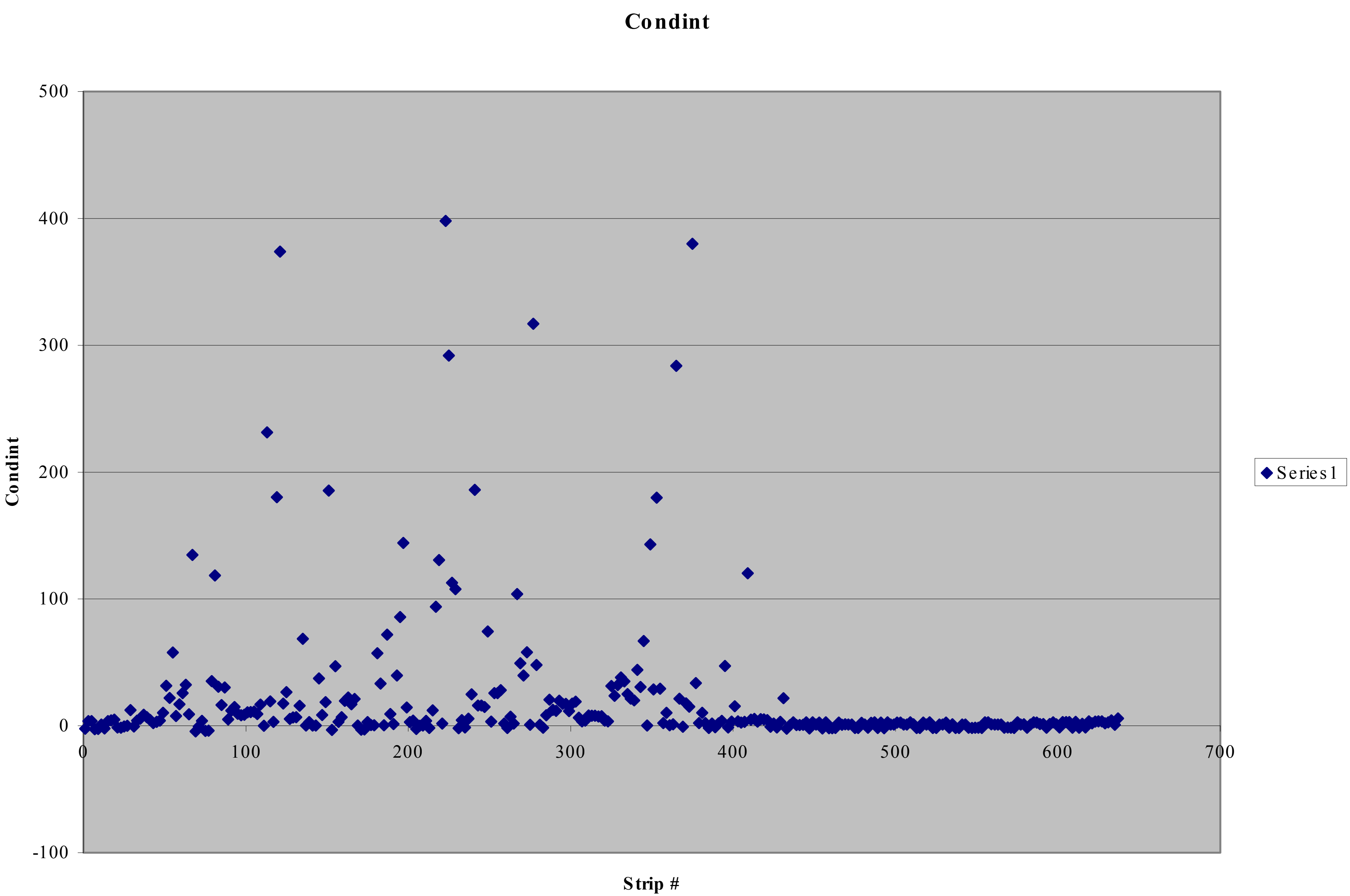
Idiel
Idiel(nA)
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
Strip #
Series1


Cac
140
120
100
80
60
40
20
0
Cac(pF)
0
100
200
300
400
500
600
700
Strip #
Series1


Is trip
Is trip (nA)
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
DC Strip #
Series1


Rpoly
Rpoly(Mohm)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
100
200
300
400
500
600
700
Strip #
Series1


Cint
6
5
4
3
2
1
0
-1
Cint
0
100
200
300
400
500
600
700
Strip #
Series1


Condint
500
400
300
200
100
0
-100
0
100
200
300
400
500
600
700
Condint
Strip #
Series1

Advantage of the matrix

make all the measurements at the same time

good diagnostics - problems are due to bad contact

contact	most sensitive measurement
bias line	Condint
AC pad	Cac
DC pad	Rpoly

History

We have done cross-calibration studies between HPK, Fermilab, KSU, and SB.

We know how to measure FDV, total currents, and strip properties.

At SB we have tested 24 L2 sensors.

The first 15 were perfect. Rate of bad strips less than 10^{-4}! Then selected problems and found 10 bad strips in remaining 9 sensors.

No sensor had >1% bad strips.

Irradiation

KSU will irradiate a few sensors and test structures to about 10^{13} neutrons/cm^2 (1 MeV equivalent)

These sensors and test structures will be tested at Stony Brook before and after irradiation.