‘Hamamatsu Outer Layer Sensors Fermilab Probe Results’

Dzero RunIIb SMT Meeting
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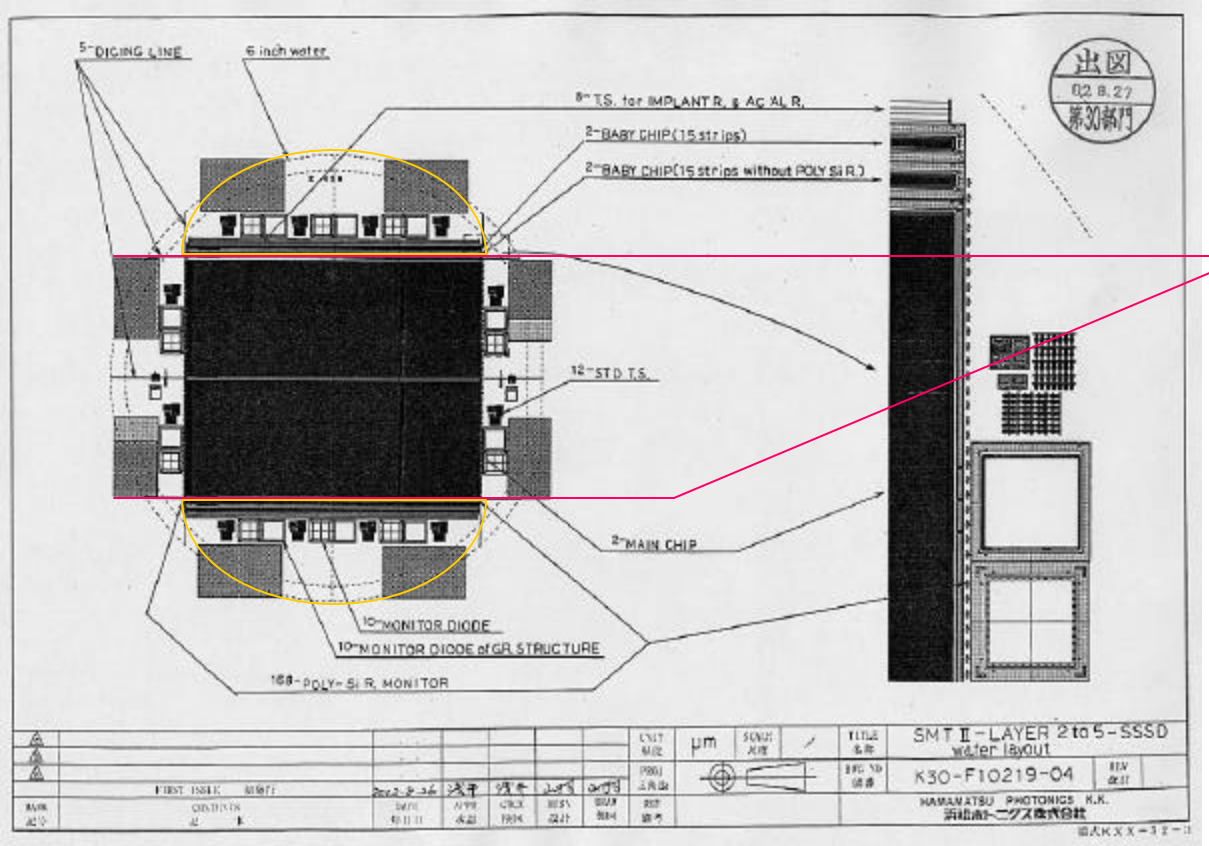
Fermilab

Hamamatsu Wafer Layout

- Hamamatsu 6” wafer layout for outer layer sensors
  - Two silicon sensors
  - Four test structures; labeled with serial numbers of adjacent sensors
    - » Fermilab receives only two ‘half-moon’ structures

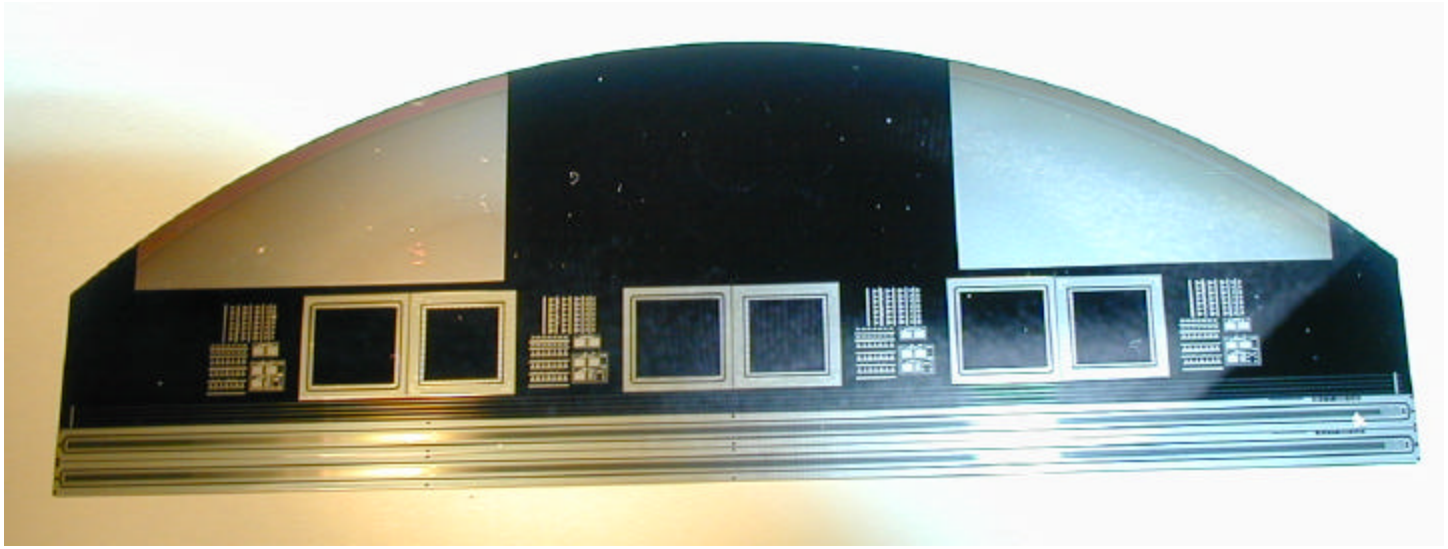


Sensor Specifications

Depletion voltage	V < 300V
Biasing scheme :	polyresistors on both ends
Poly resistor values:	0.8 ± 0.3 MΩ
Implant strip width:	8 mm
Metal strips:	Al, AC-coupled over the p-implant
Al strip width:	2 - 3 mm metal overhang on each side
Al strip thickness:	> 1 mm
Al strip resistivity:	< 20 Ω/cm
Coupling capacitance:	> 12 pF/cm
Junction breakdown:	> 350 V
Micro-discharge breakdown:	> 350 V
Coupling capacitor breakdown:	> 100 V
Total detector current:	< 100 nA/cm^2 (at RT, full depletion voltage+10%V)
Total detector current at 350V:	< 16 μA
Interstrip resistance (DC):	> 2 GΩ
Total interstrip capacitance:	< 1.2 pF/cm

Test Structure

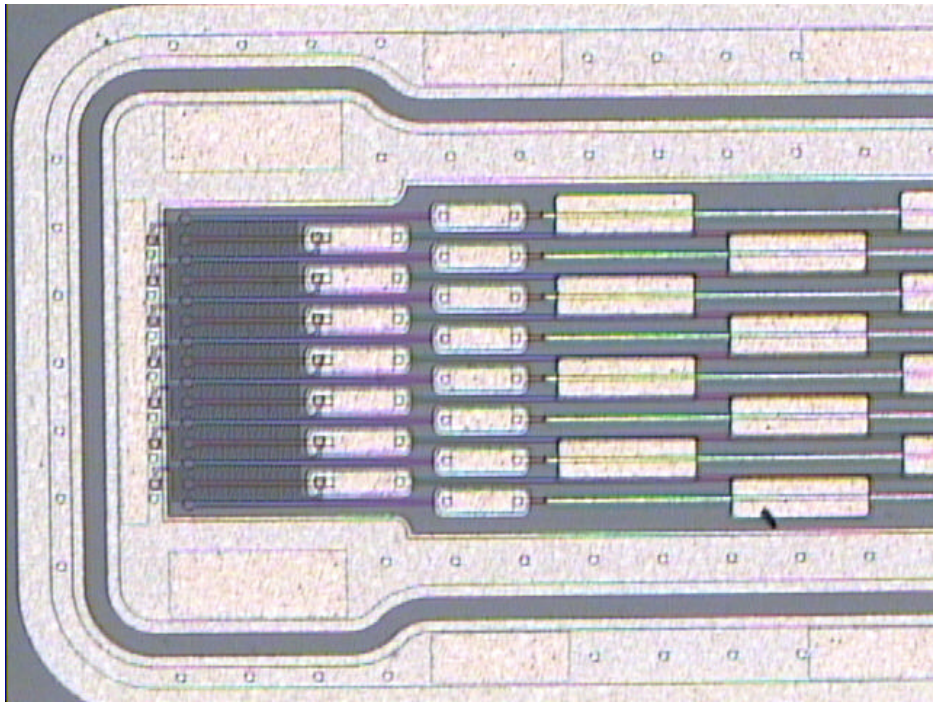
- Four discrete elements on test structure

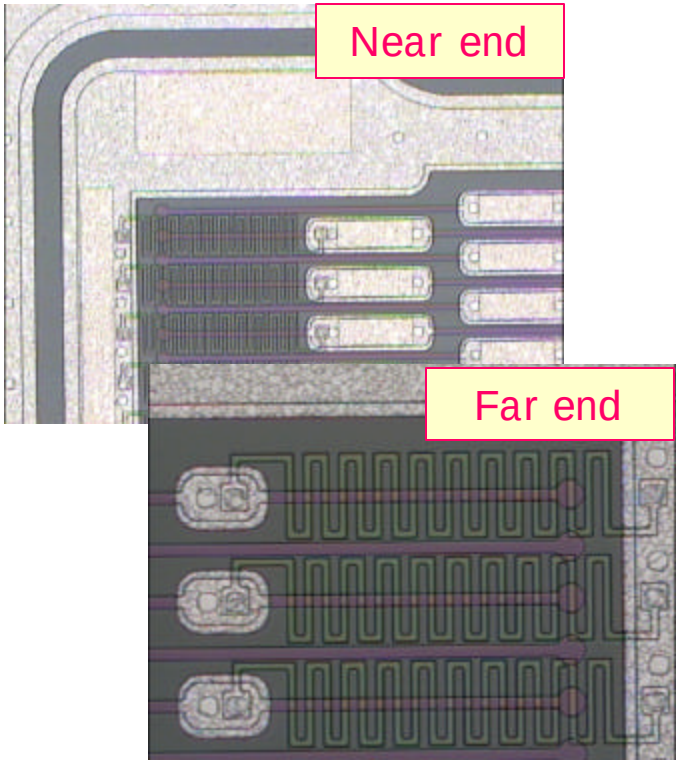


  - baby sensors with and without polysilicon resistors
  - strip implants and aluminum strips
  - diodes with and without guard structure
  - Three separate series of various elements on sensors

Test Structure: Baby Sensors

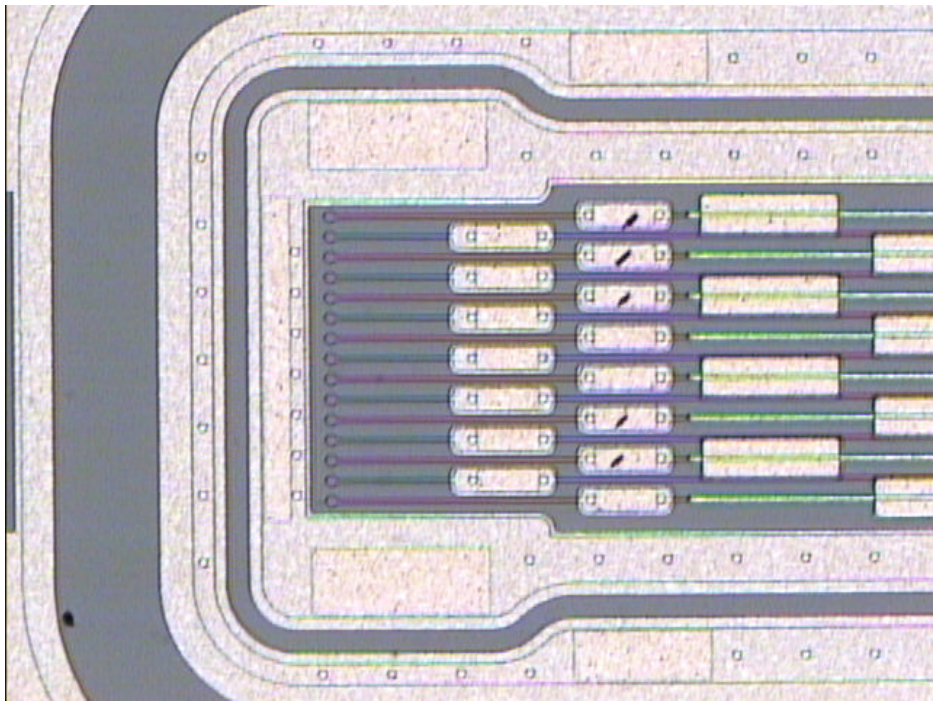
- Baby sensor with 8 strips and intermediate strips with poly-Si resistors

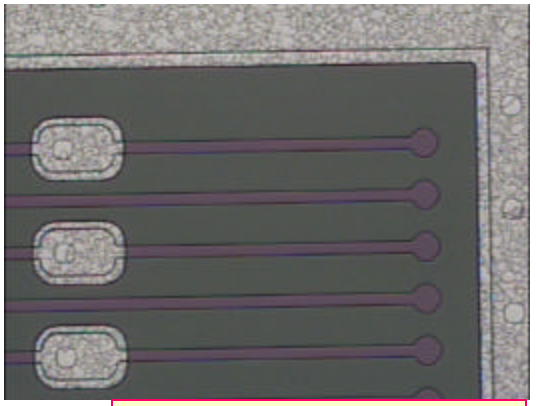




Test Structure: Baby Sensors

- Baby sensor with 8 strips and intermediate strips without poly-Si resistors

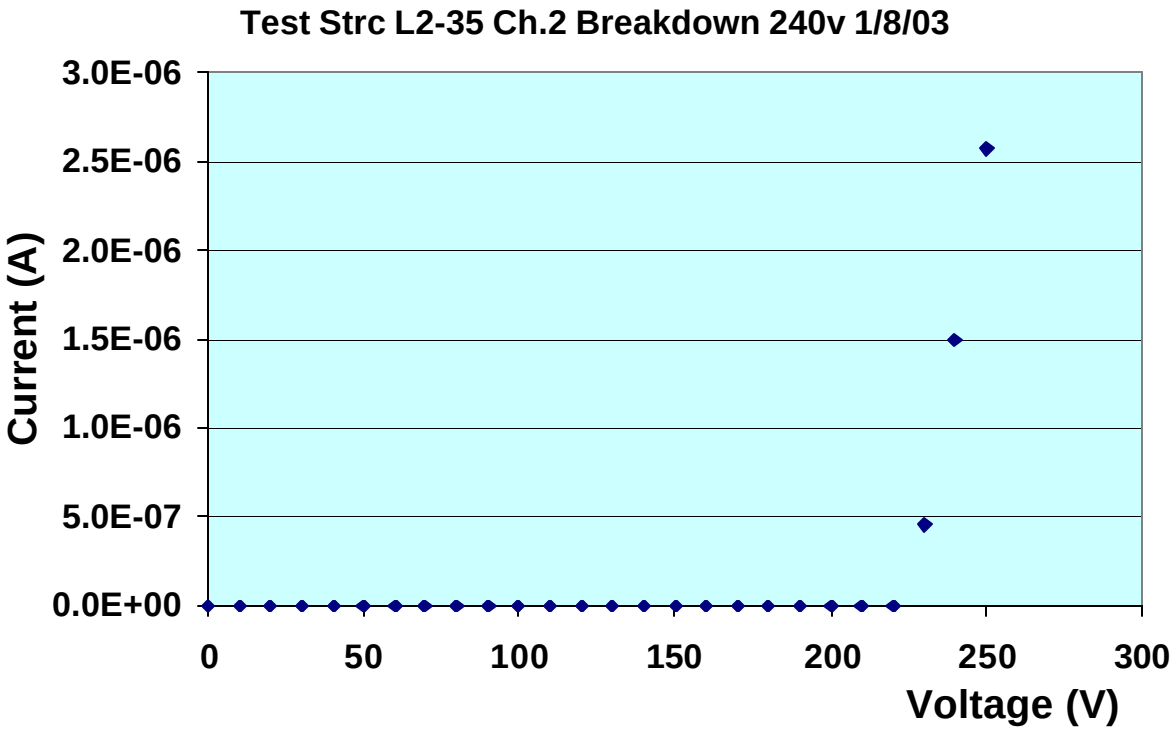




Far and Near End

Test Structure: C_c Breakdown

- Test Structure 35/36
  - Measure AC coupling capacitor breakdown on strips of test structure, between DC and AC pad

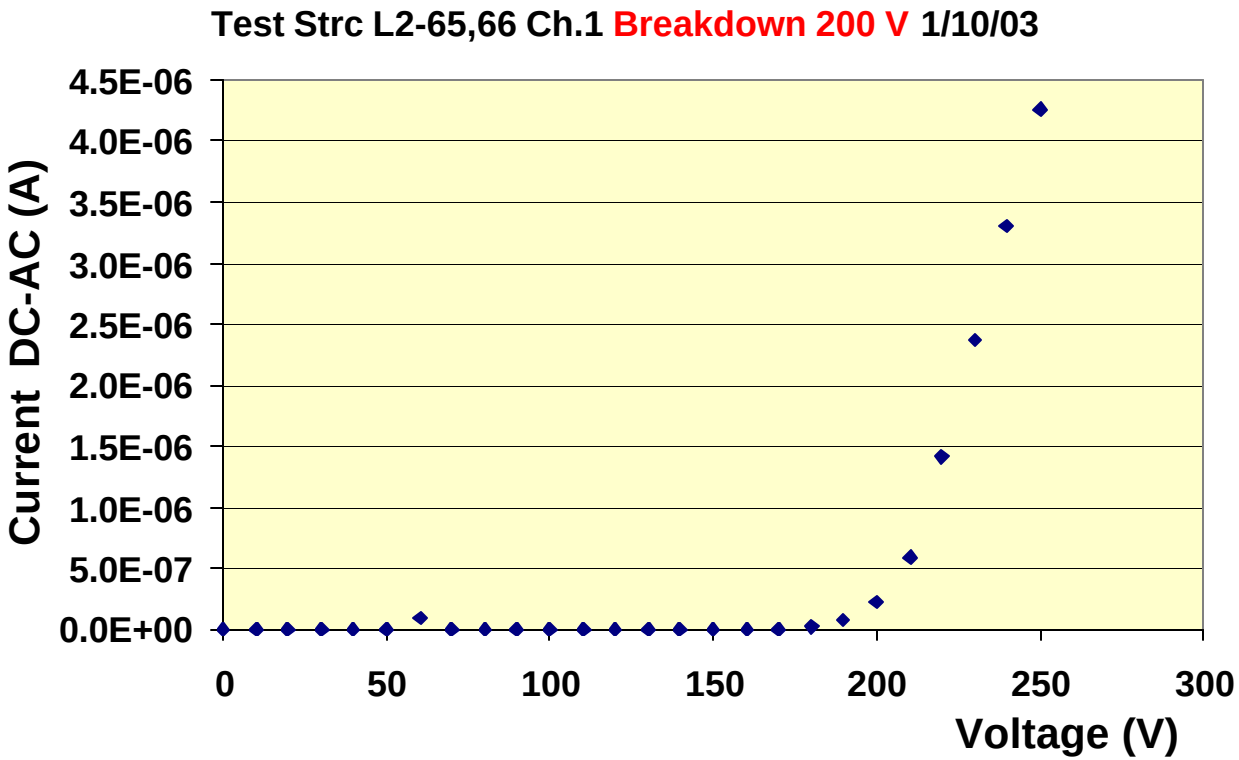


» Ch. 2: V_{bd} = 230 V; Ch. 3: V_{bd} = 230 V;

» Ch. 5: V_{bd} = 230 V; Ch. 8: V_{bd} = 230 V;

Test Structure: C_c Breakdown

- Test structure 65/66

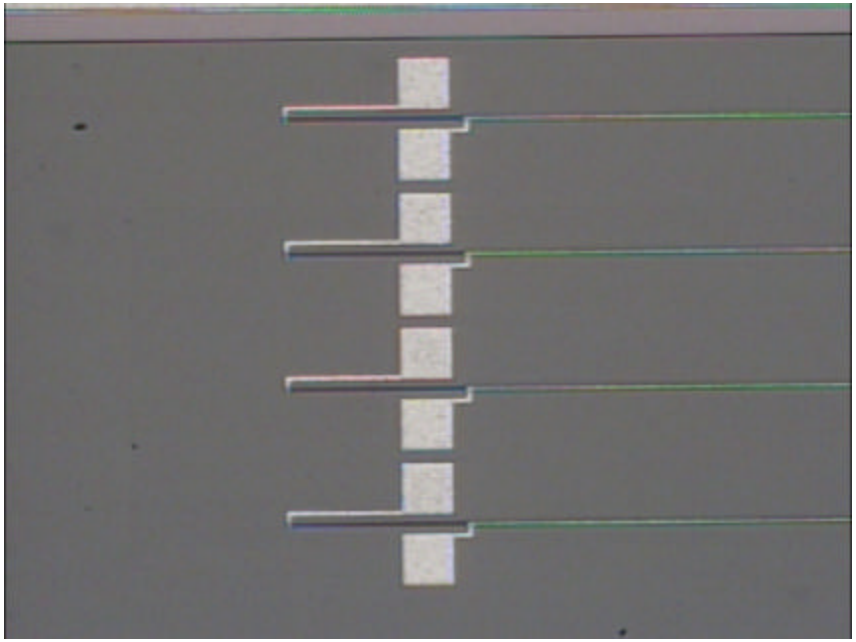


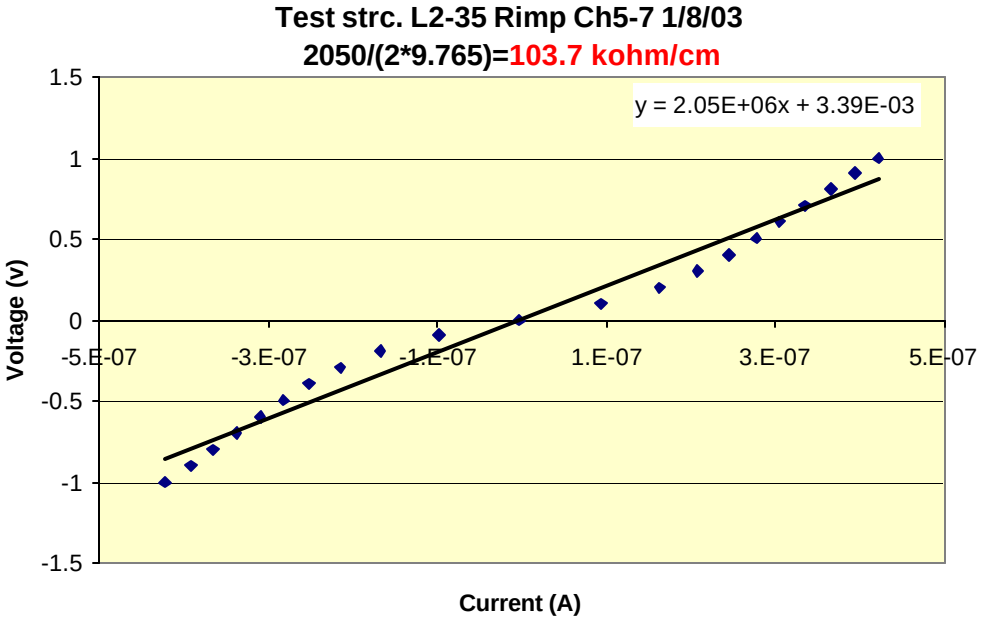
» Ch. 1: V_{bd} = 200 V; Ch. 2: V_{bd} = 200 V;

» Ch. 3: V_{bd} = 200 V; Ch. 6: V_{bd} = 200 V; Ch. 7: V_{bd} = 200 V;

Test Structure: Implant Resitance

- Measure of p-implant resistance and Al strip resistance
  - Separate pads for implant and Al
  - Wirebond two pads on TS 35/36
  - Measure two sets of strips

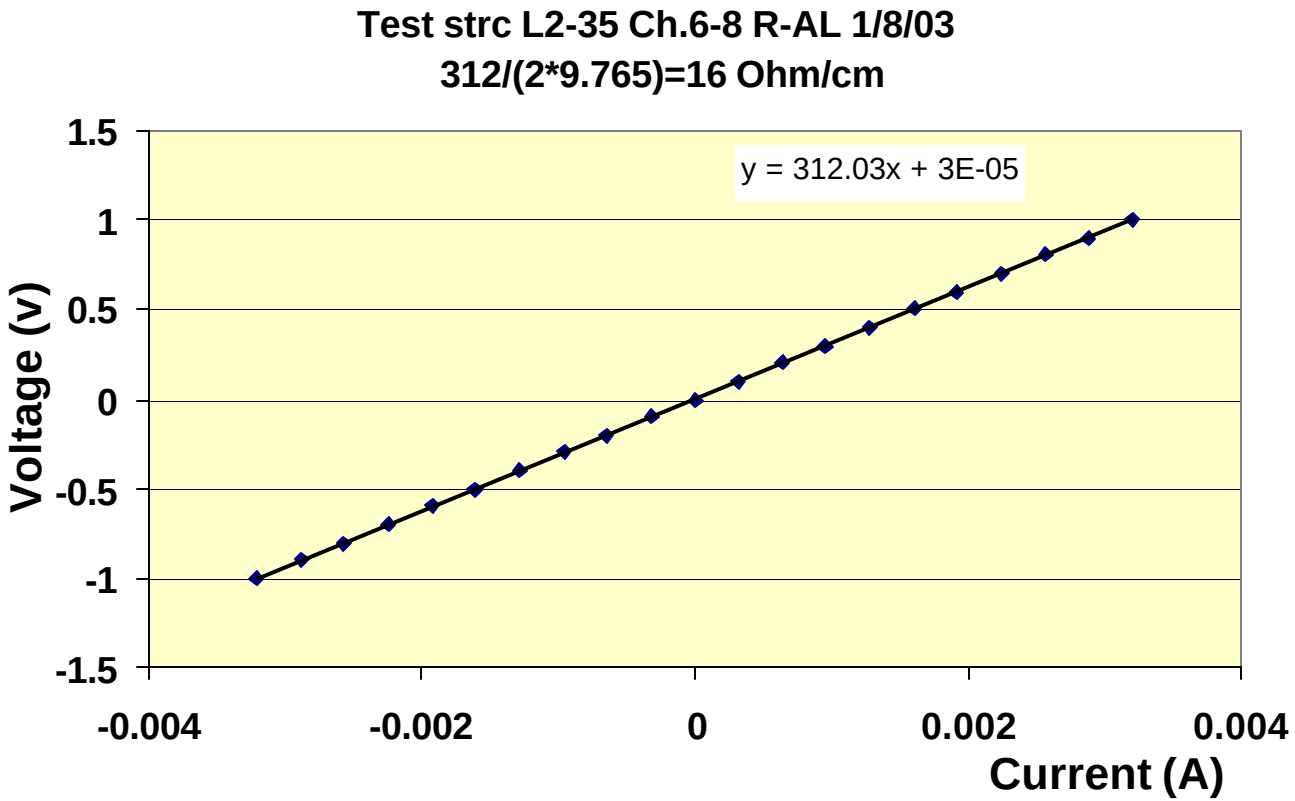




» R_{imp} = 104 kΩ/cm
» No spec. on sheet resistance

Test Structure: Al Strip Resistance

- Al strip resistance TS 35/36



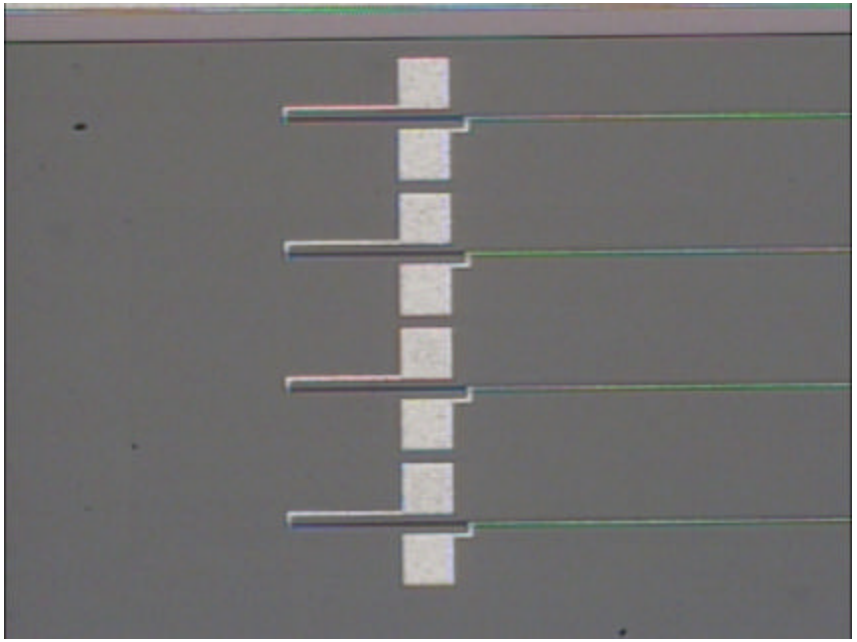
- R_{Al} = 16 Ω/cm for the two sets of strips

Test Structure: C_c

- Measure C_c from test structure implant

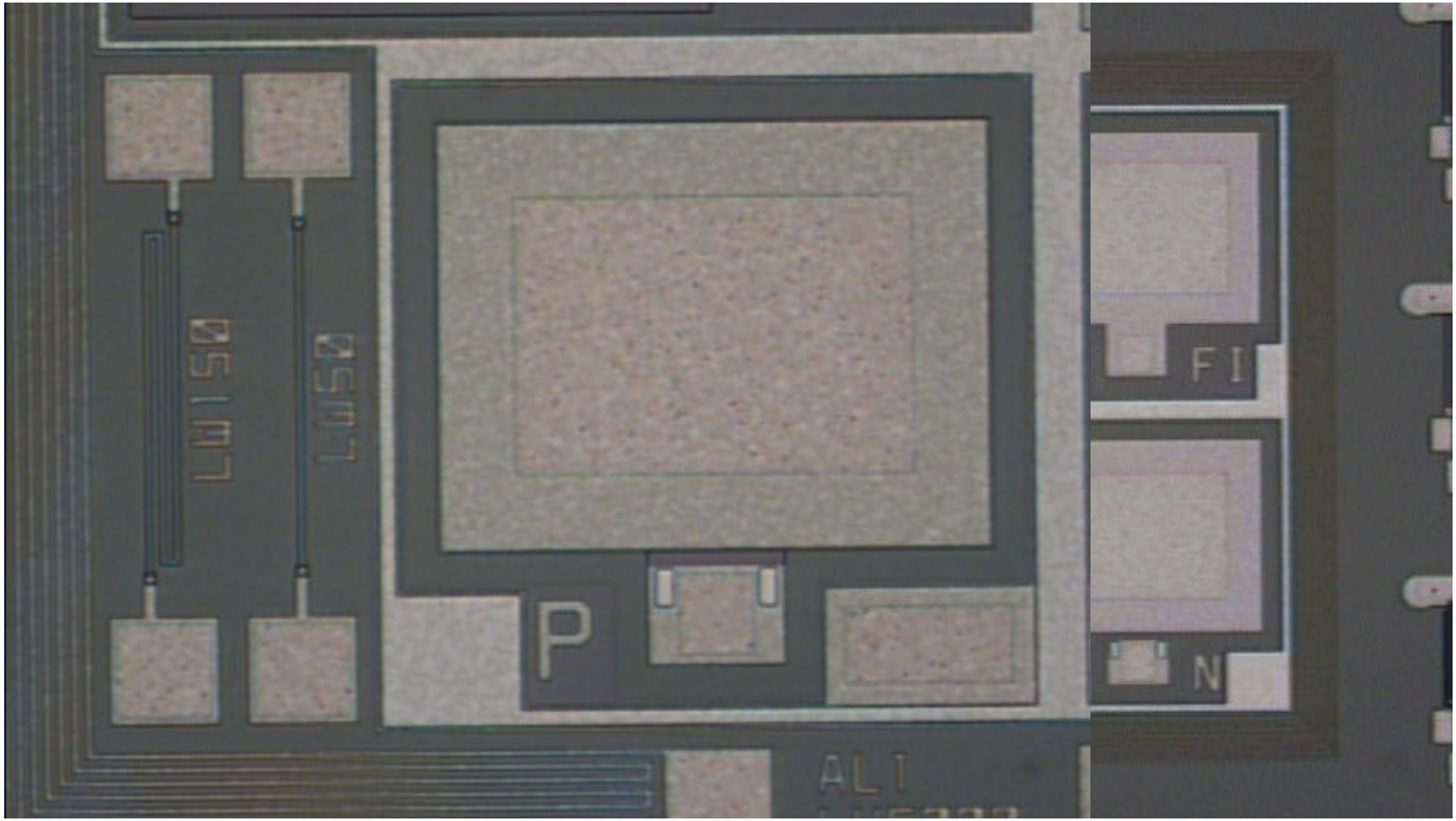
DC - AC	Cc
Ch.1 - 2	~92 pF
Ch.3 - 4	91-93 pF
Ch.5 - 6	~93 pF
Ch.7 - 8	~93 pF

  - Length of implant is 9.76cm
  - Expected value should be ~120 pF



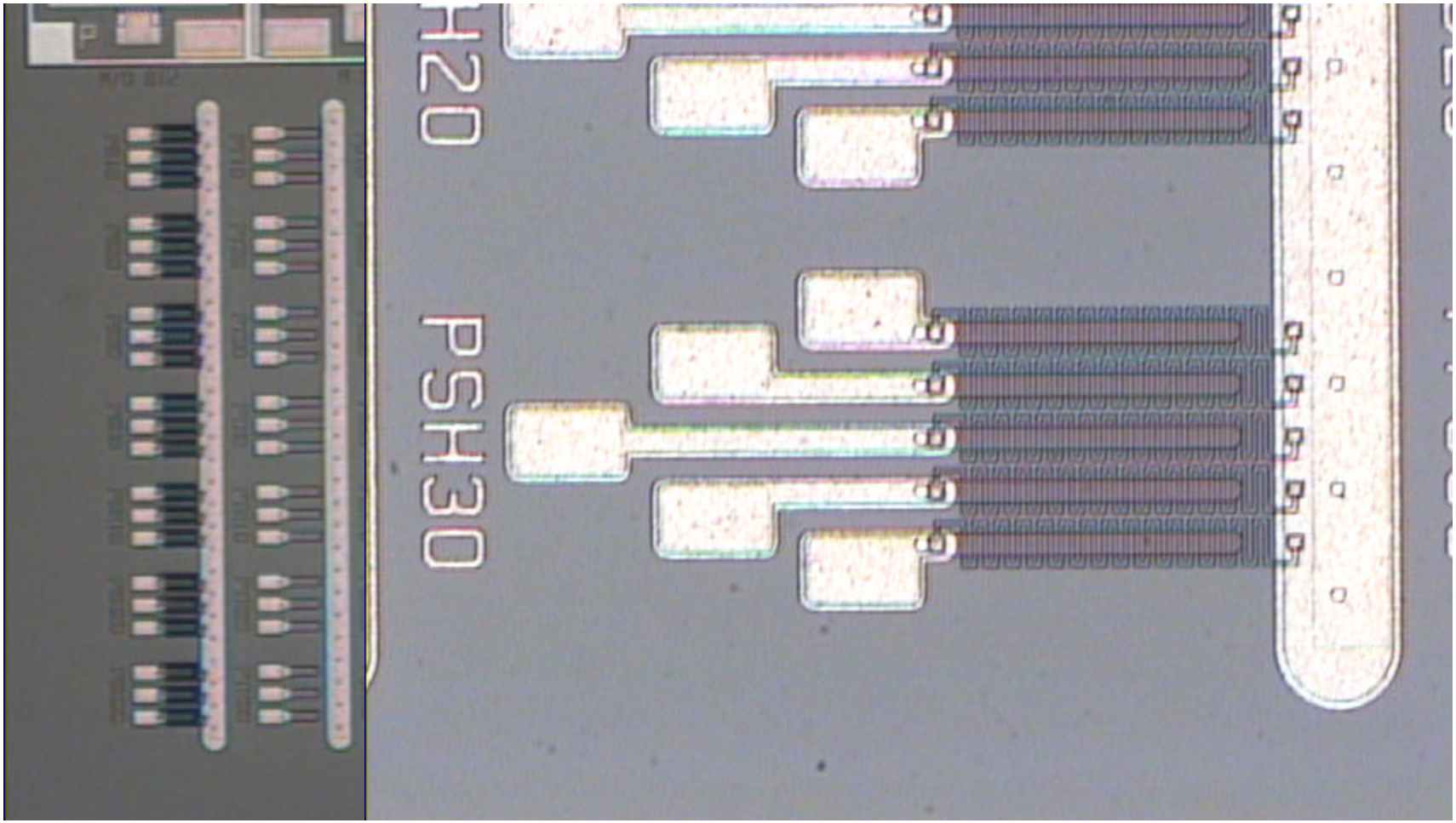
Test Structure: various elements

- Other structures



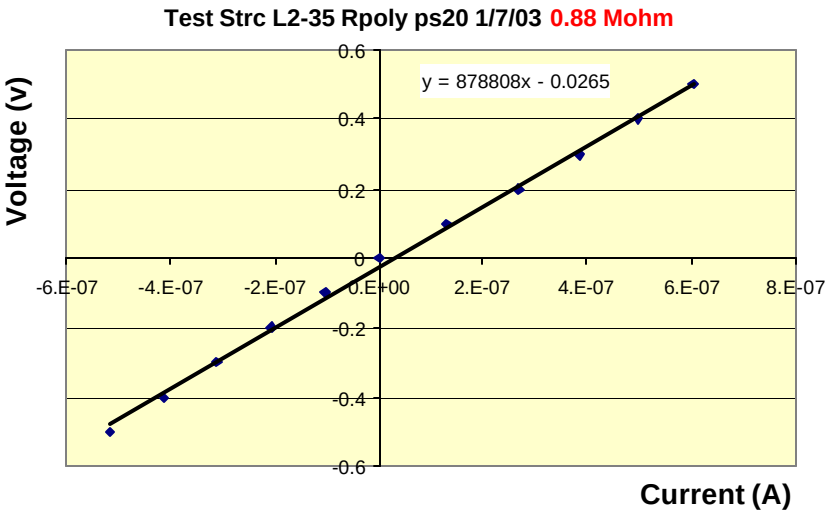
Test Structure: various elements

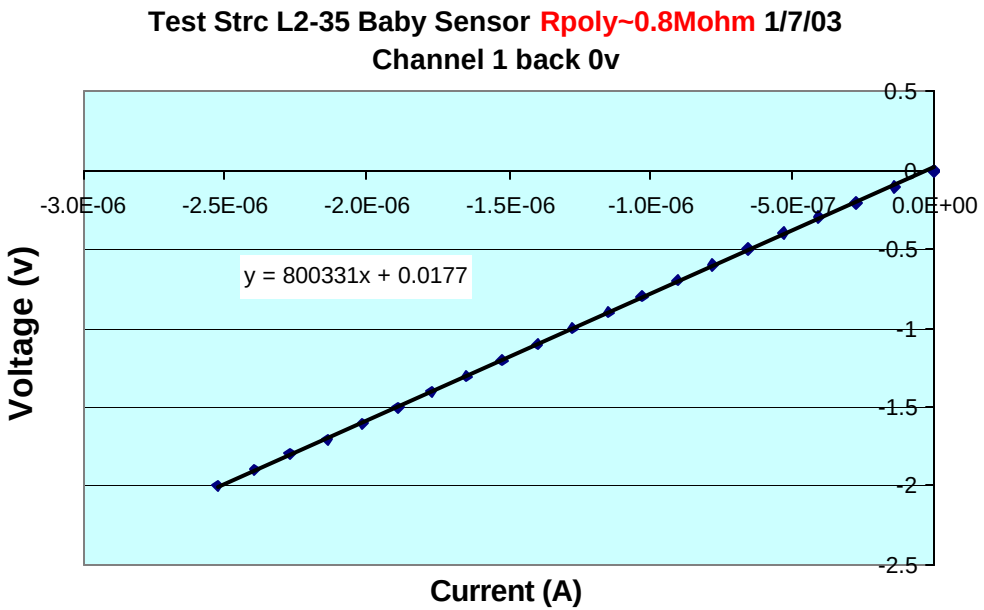
- Sets of Poly-silicon Resistors



Test Structure: R_{poly}

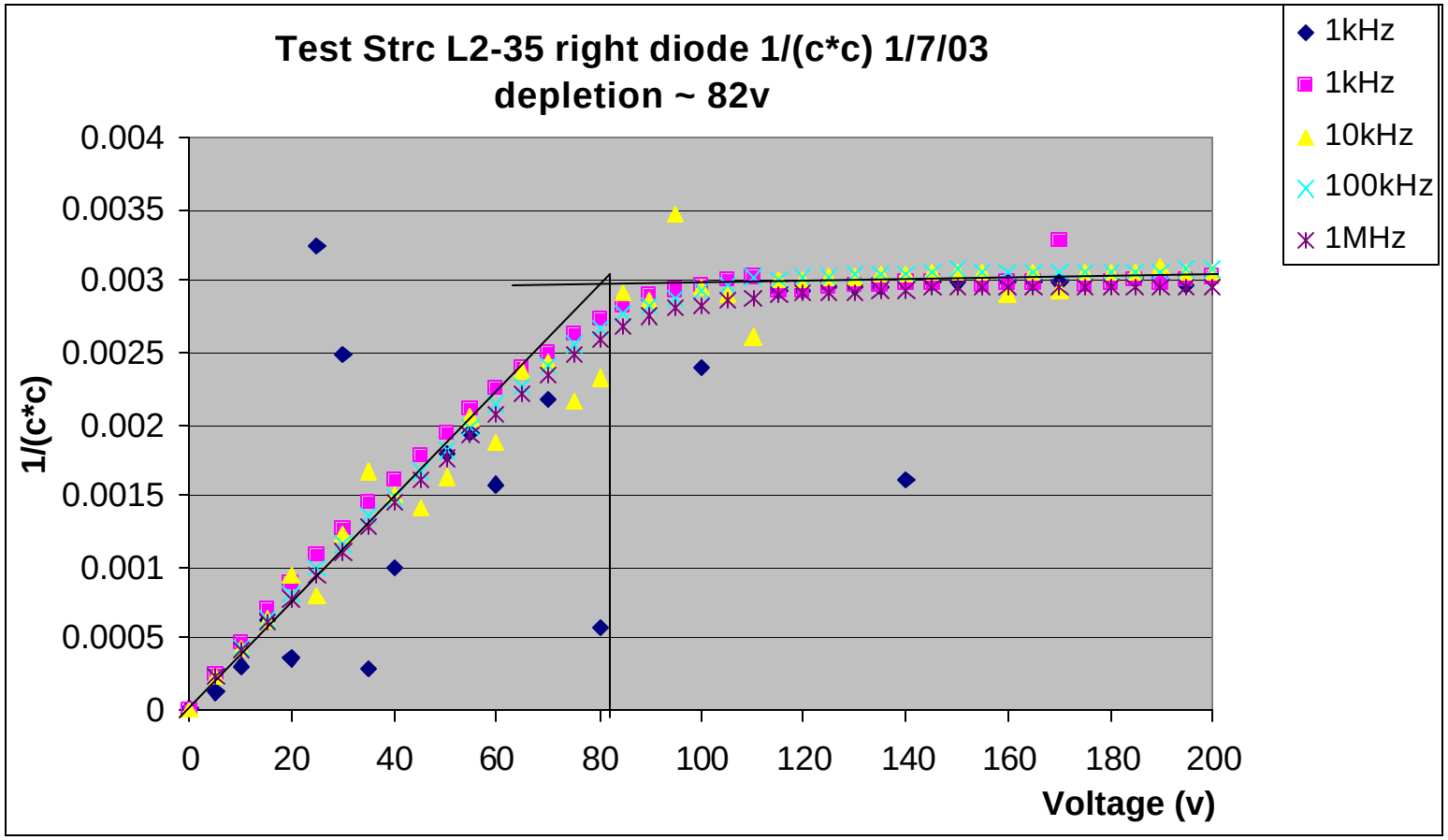
- Measure TS 35/36 'ps20':
  R_{poly} = 0.8 MΩ
- Measure TS 35/36 baby sensor:
  R_{poly} = 0.8 MΩ





Test Structure: Diode

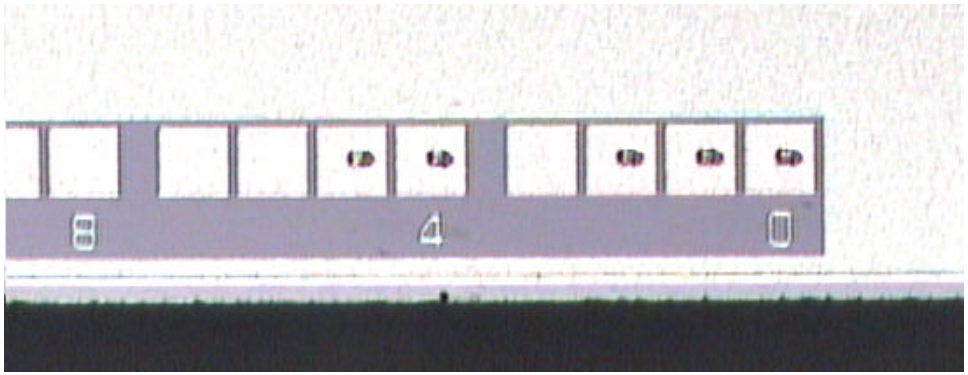
- Measured C-V curve of diode on test structure



Sensor Measurements

- So far measured sensors: 28, 29, 33, 47, 48, 51, 19, 20, 21
  - Probe station was setup incorrectly for first three sensors
    - » Voltage limited to 150V; So no correct I-V curve (yet) for those sensors

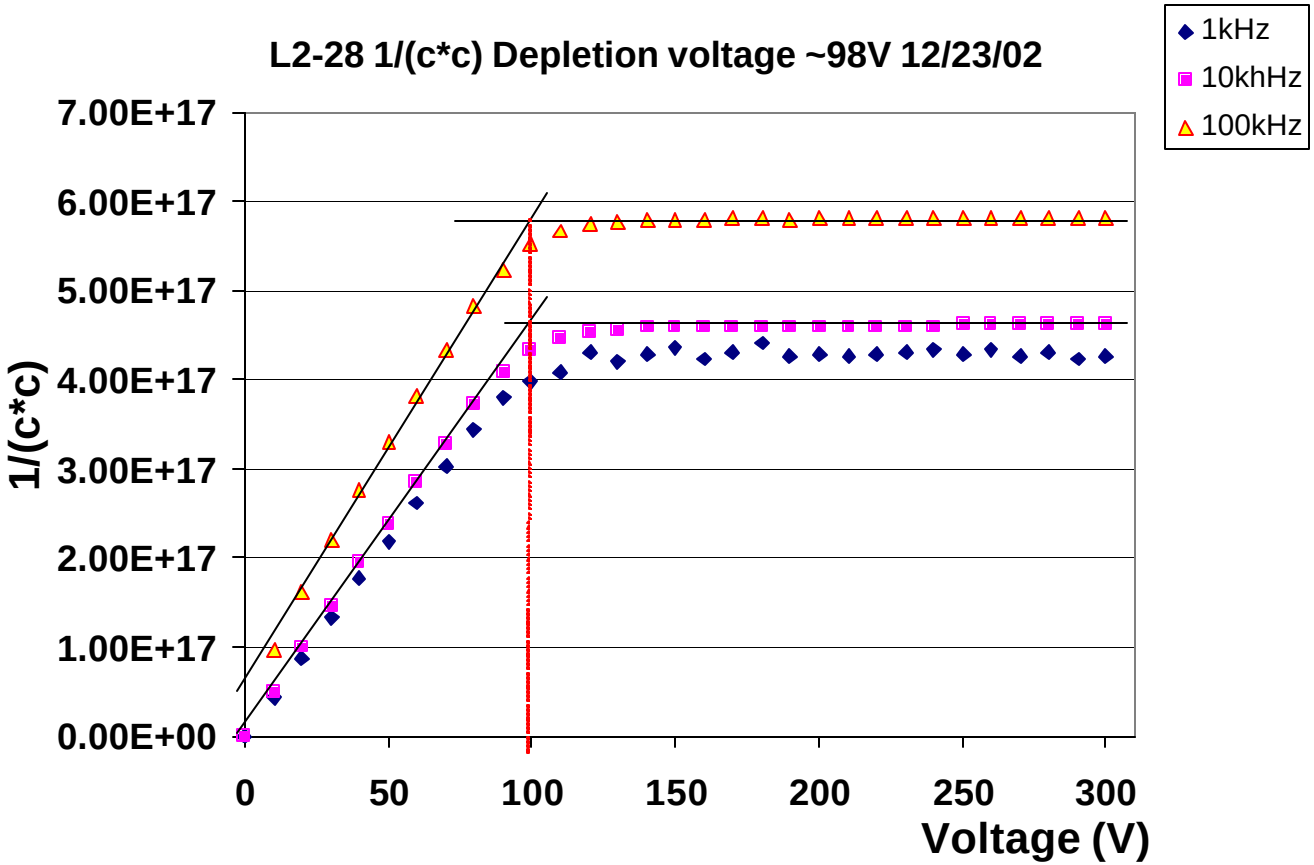
- Sensor has scratch pad for sensor serial number
  - Question: what's the serial number of this sensor?



  - Answer: 55 (0011 0111) Wrong !
  - Correct answer is 37 !
    - » HPK interprets each set of 4 scratch pads as 1 digit. Why ??

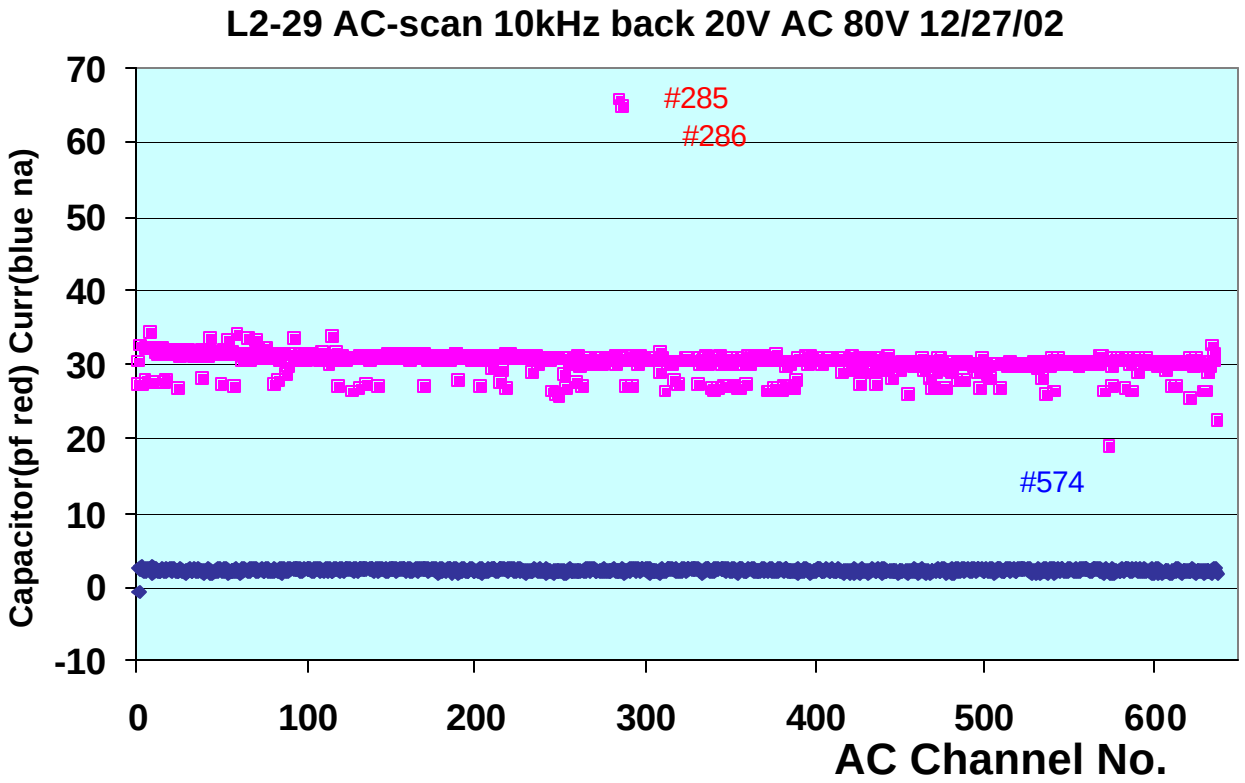
C-V Scan

- C-V scan #28



AC-Scan

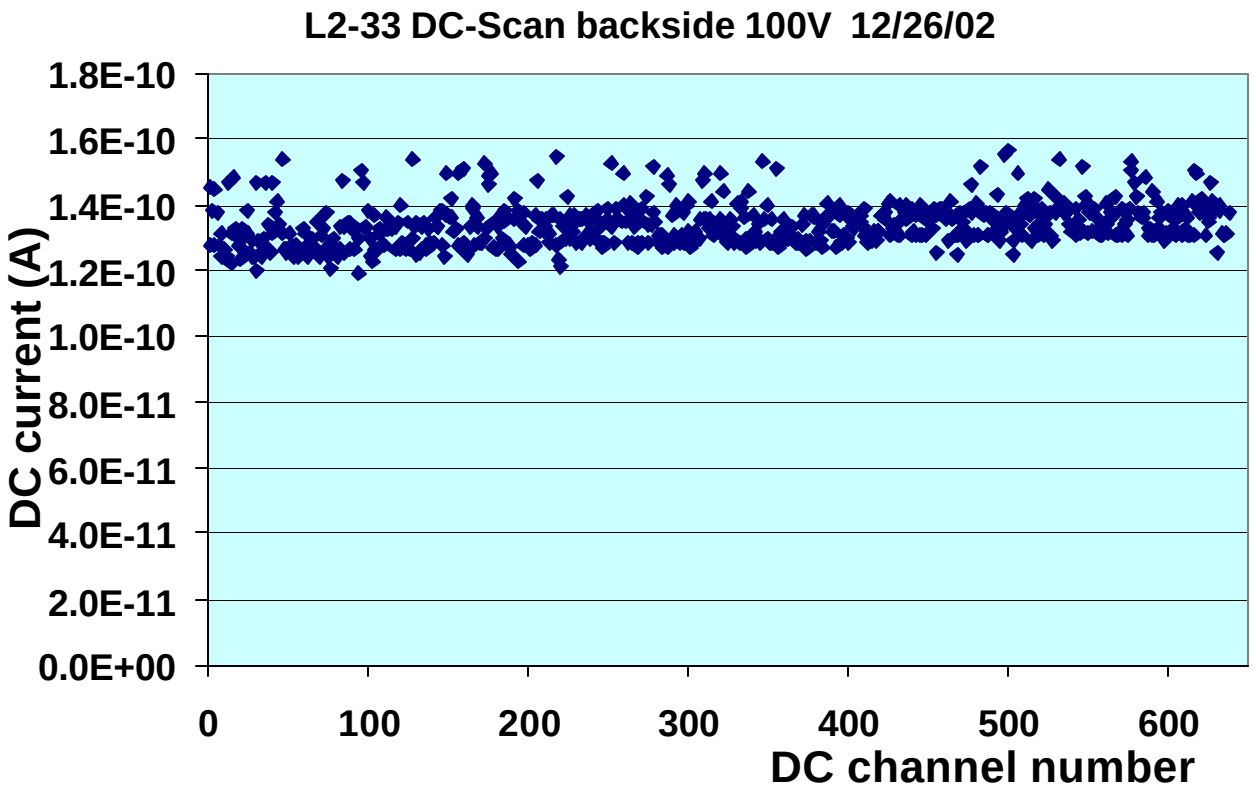
- AC-scan #29



- Channels 285 and 286 shorted, as verified by visual scan

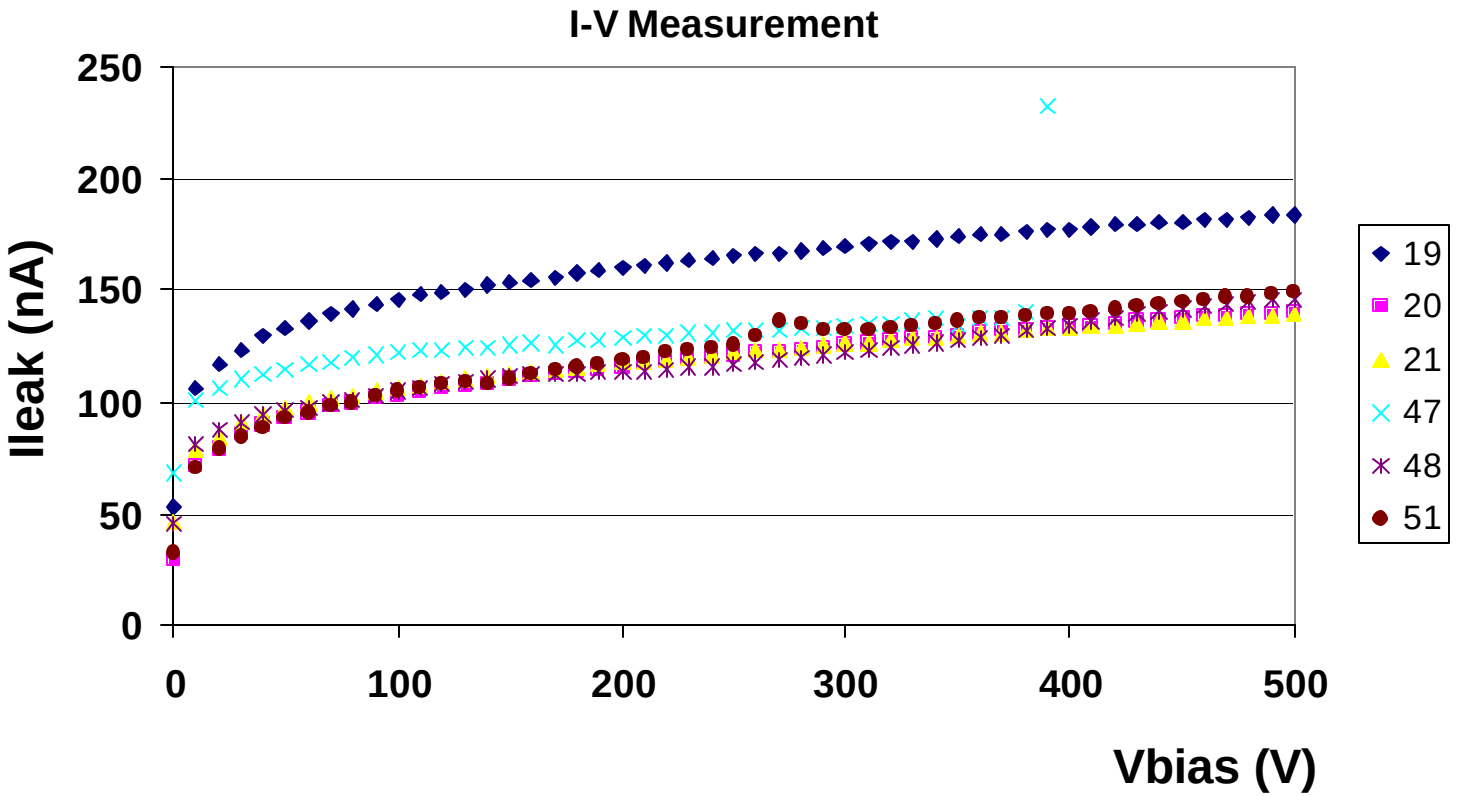
DC-Scan

- DC scan of sensor #33

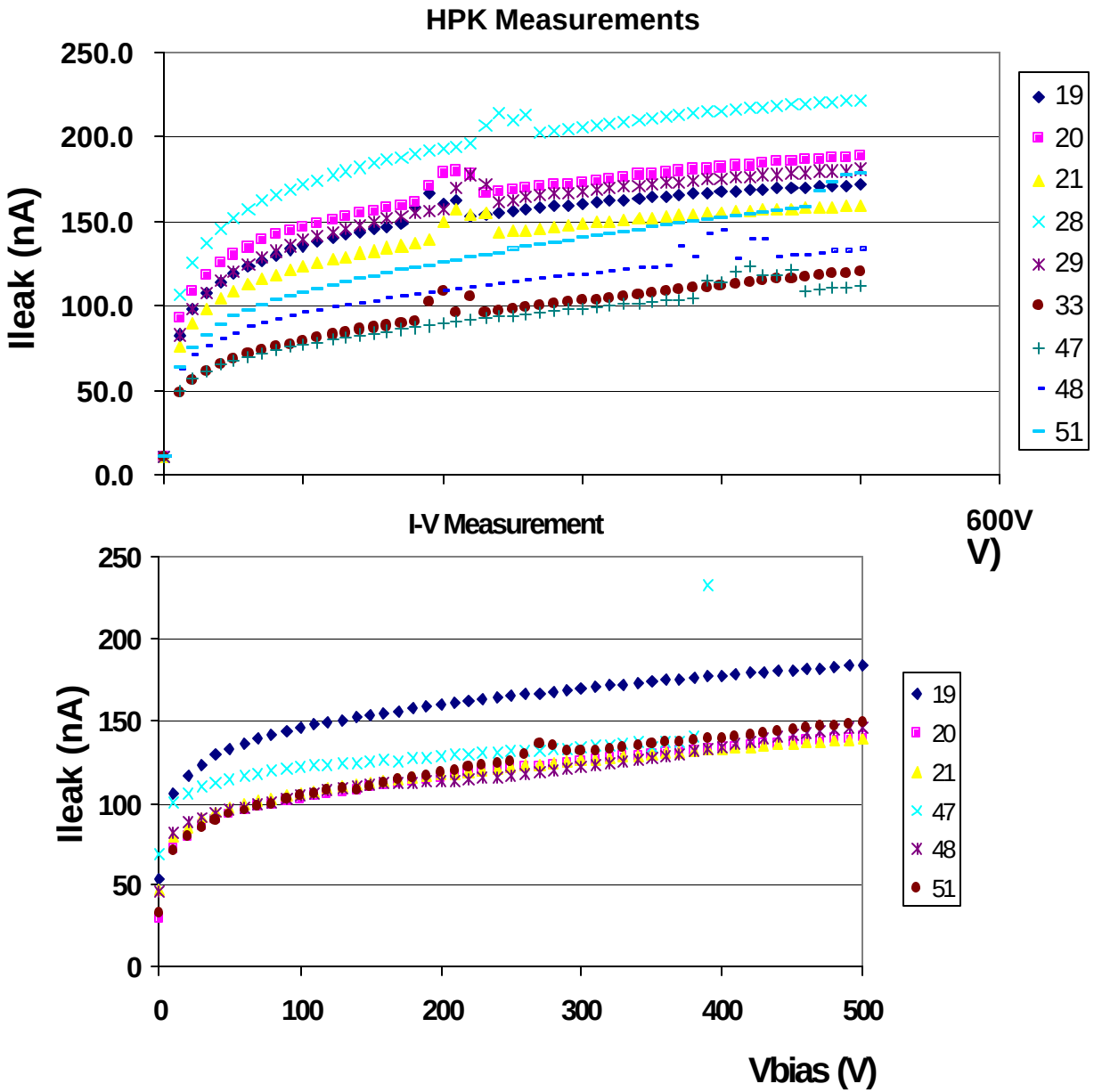


I-V Scan

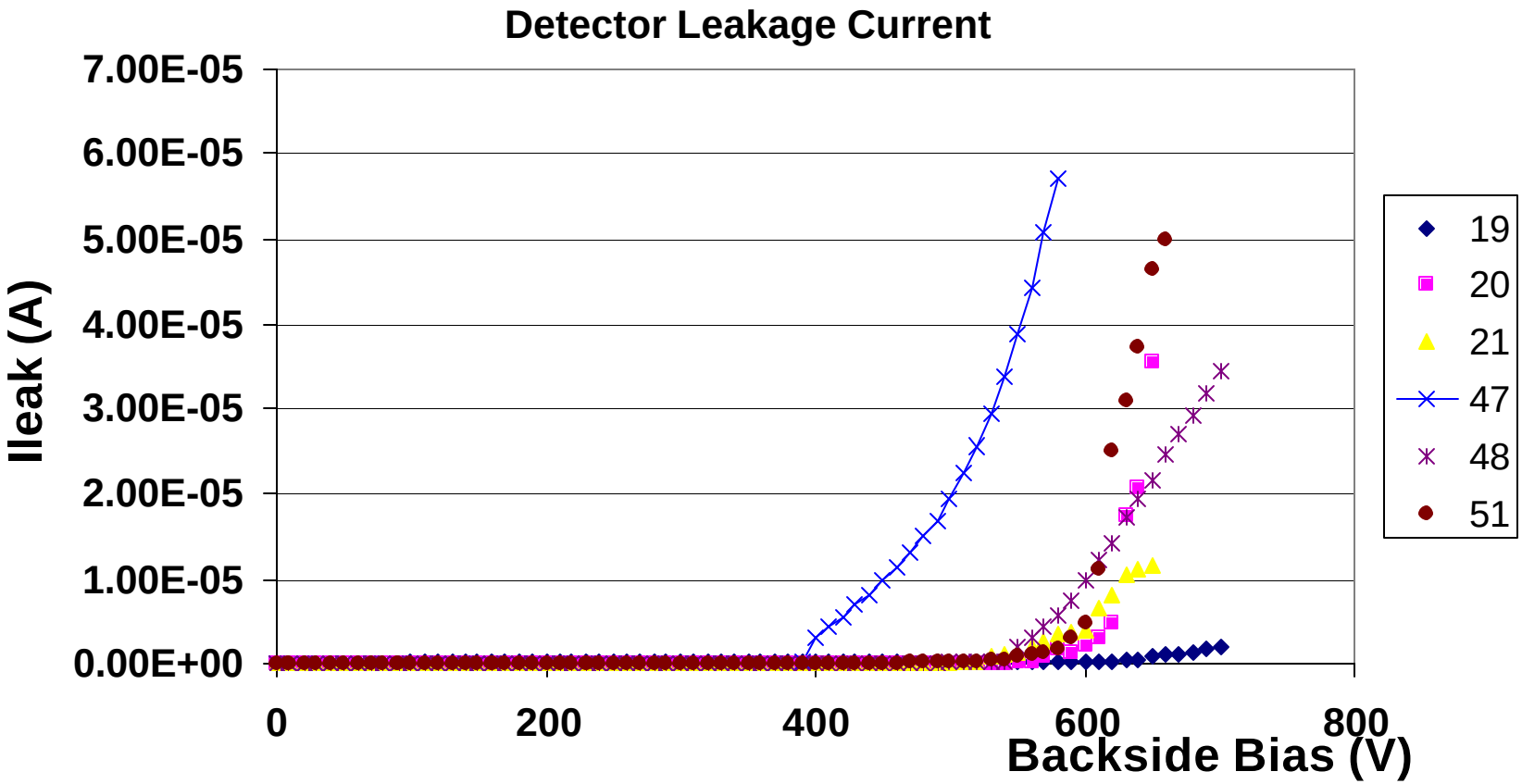
- Measurement of I_{leak} of detector before breakdown



I-V Scan Comparison HPK



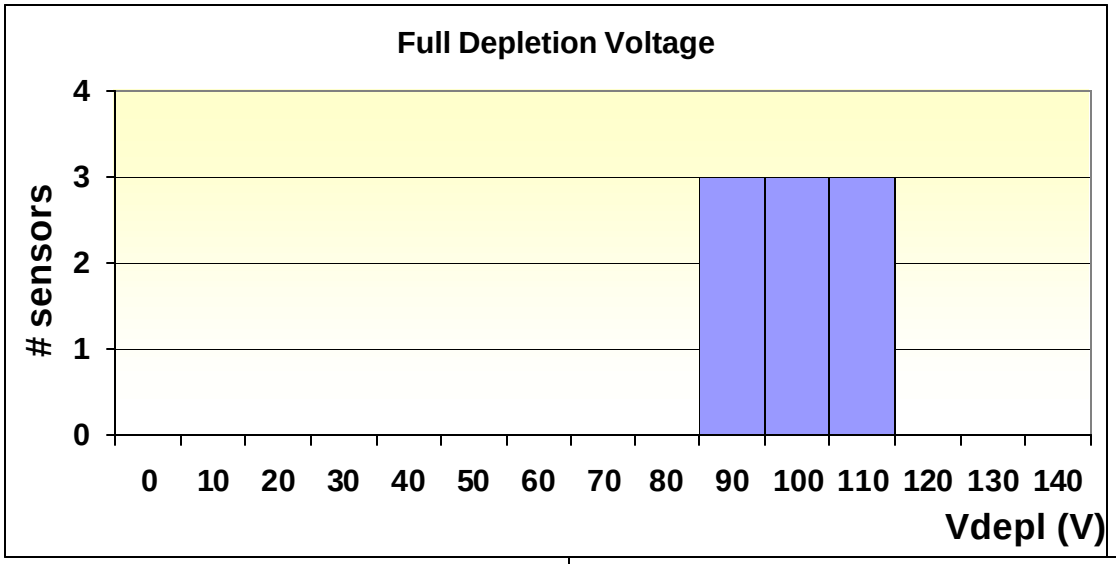
I-V Scan

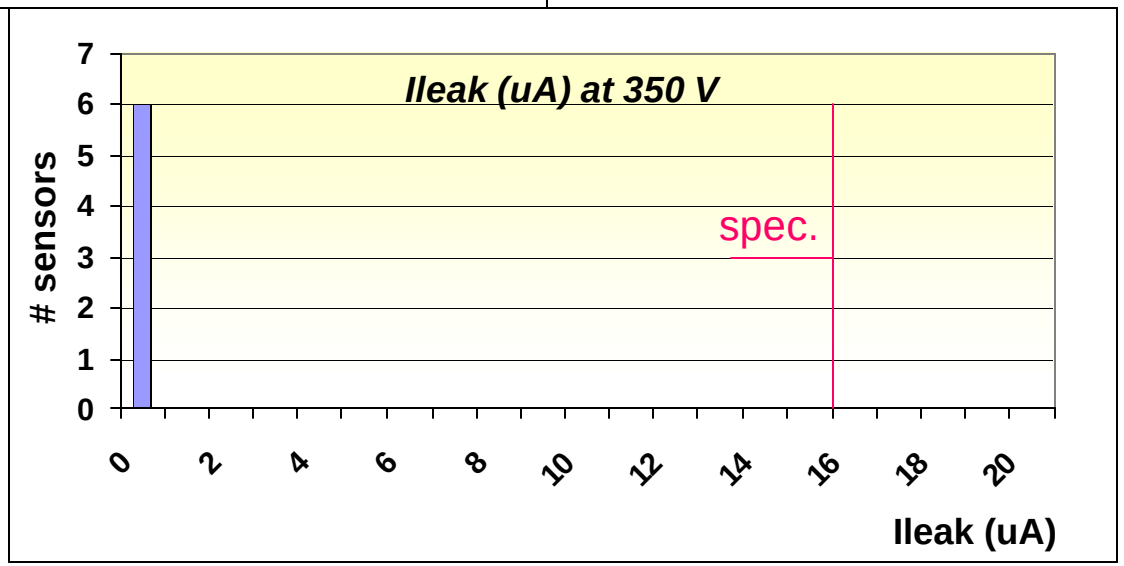


- Sensor 47 was measured more than once. Measurement shown is last measurement.

V_{depl} and I_{leak} at V_{bias} of 350 V

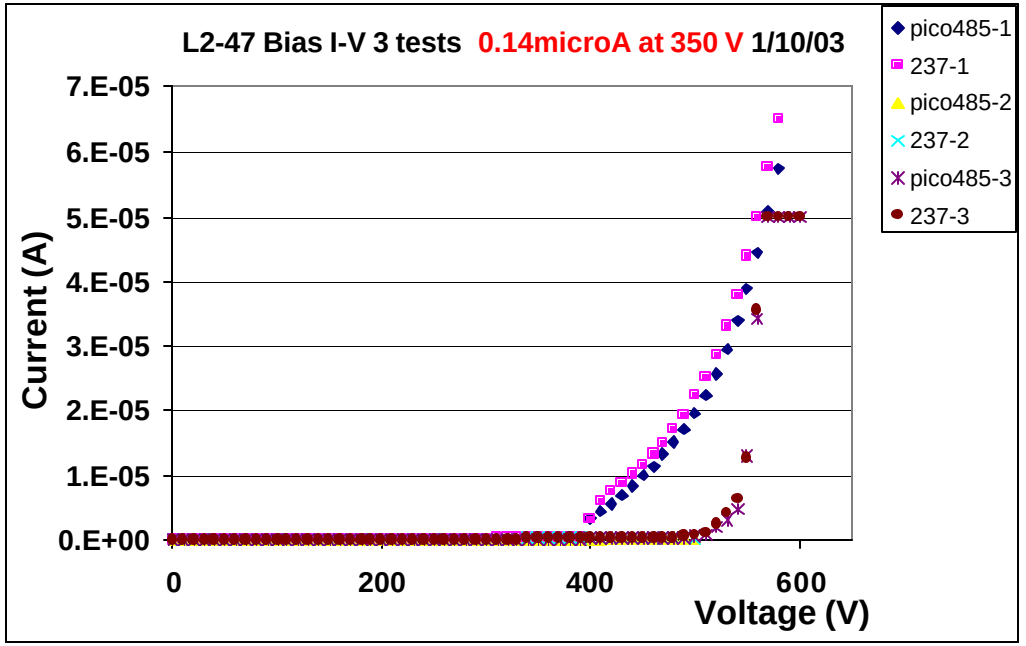
- Full depletion voltages of all 9 sensors measured so far from CV-scan

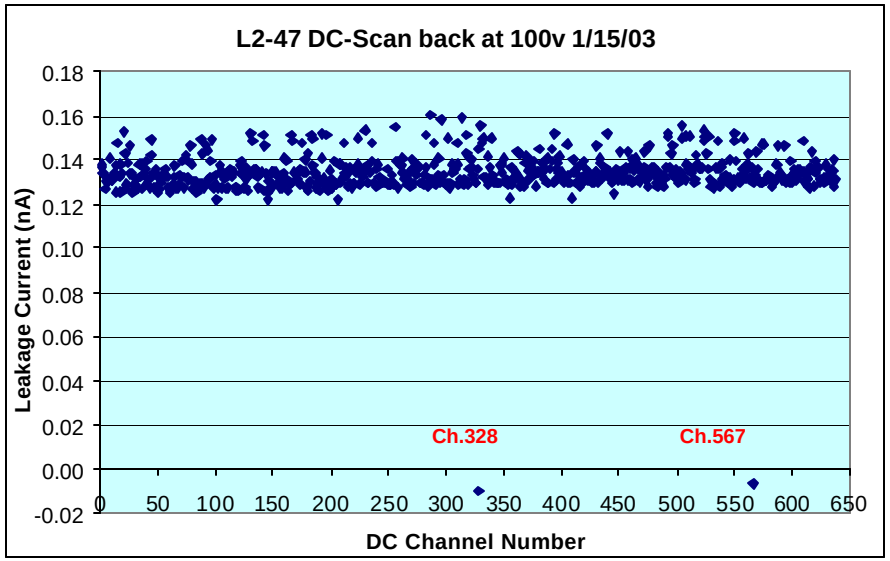




Sensor # 47

- I-V curve of sensor 47
- Regular DC scan of sensor 47

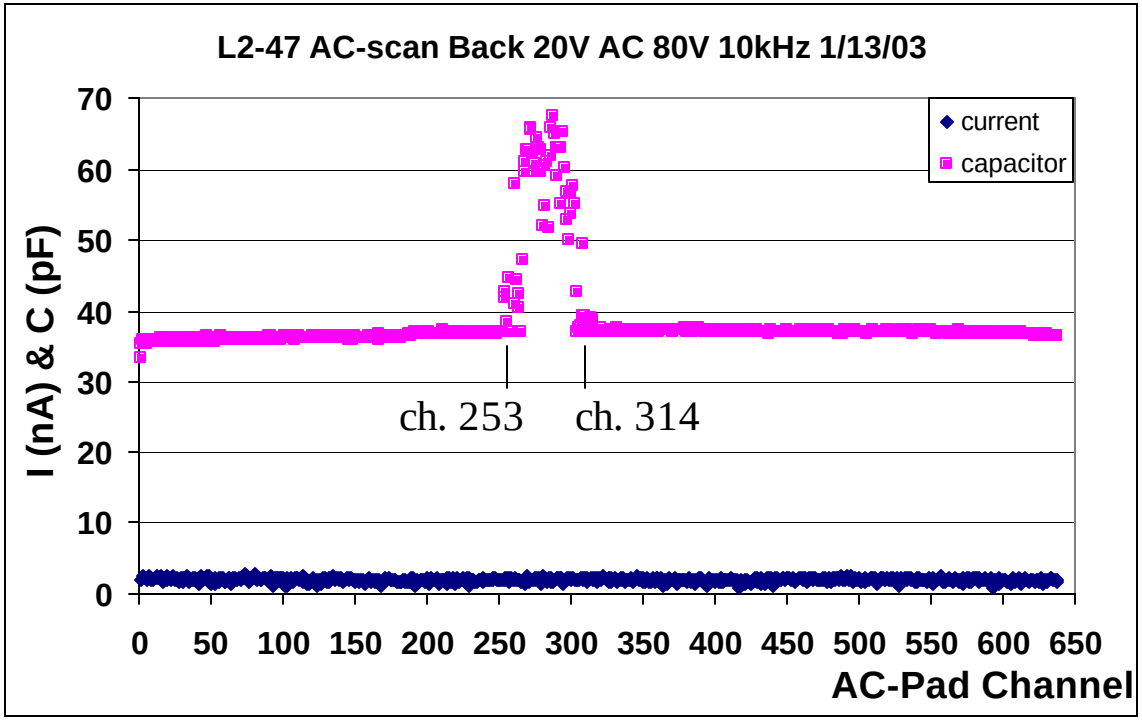




no good pad contact for low channels

Sensor # 47

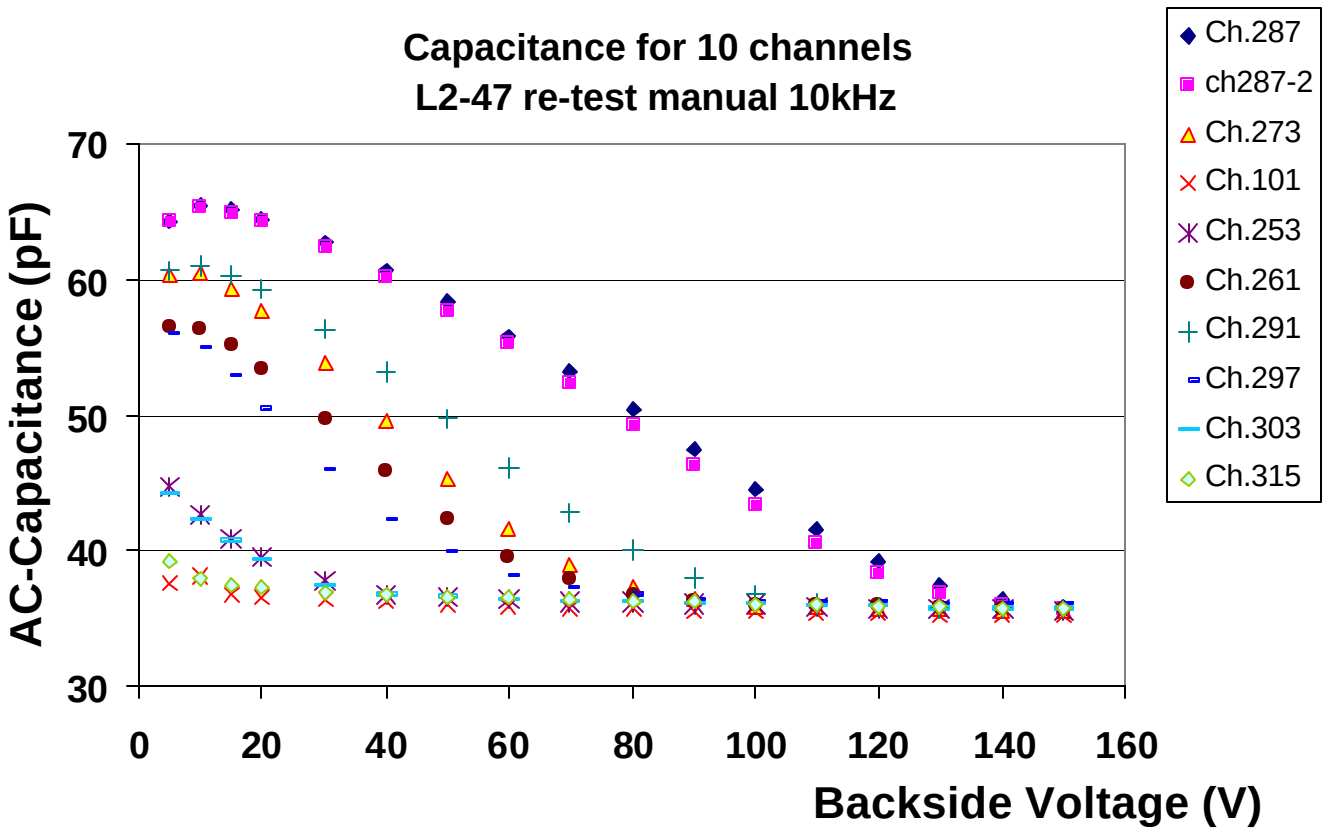
- AC scan



- Channels 253 – 314 unusually high capacitance
- Measurement done with backside bias at 20V

Sensor # 47

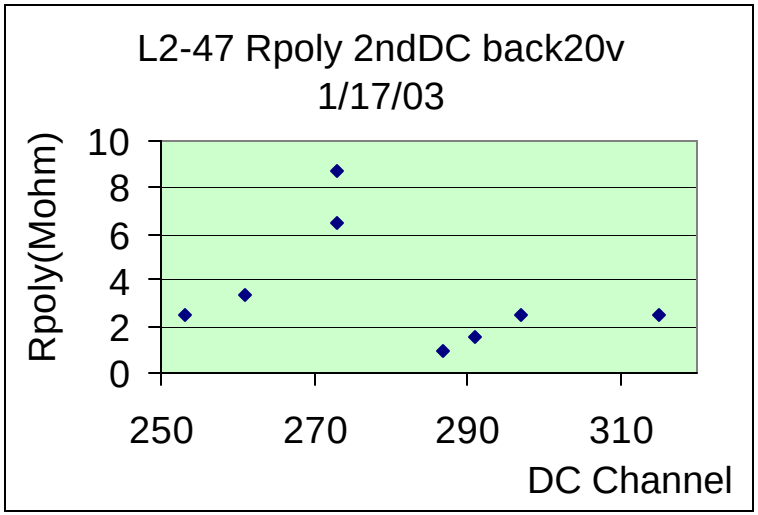
- Measure C_c as function of backside voltage for strips in region of interest (V_{depl} for this sensor is 87 V)



- channels with slowest decrease are in the middle of the bad region

Sensor # 47

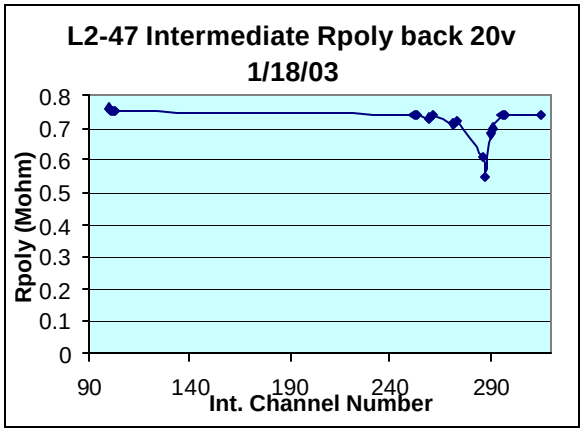
- Measure R_{poly} for affected channels at the DC-pad



  - Note: there is no R_{poly} at the end where the pad is probed
  - Measurement is the combined resistance of strip and R_{poly}

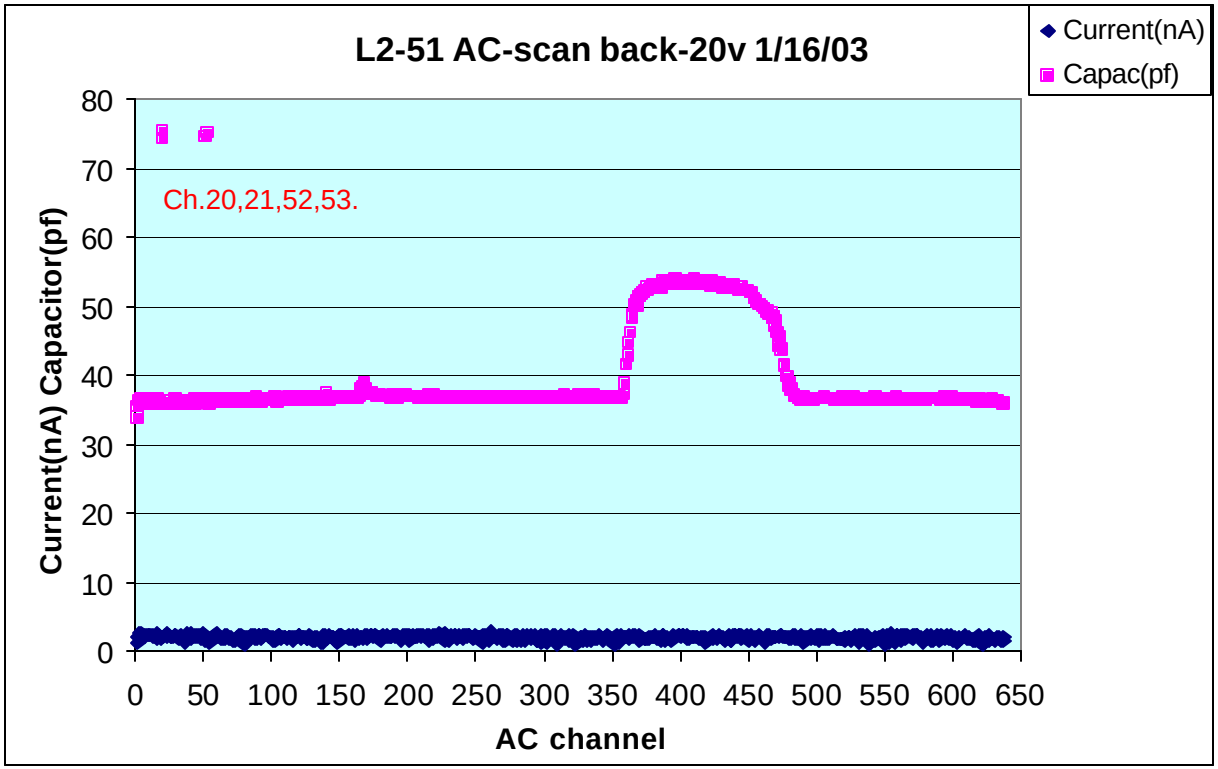
- Measure $R_{poly\ on}$ on DC pad for the adjacent intermediate strip, which has R_{poly}

  - Measure directly R_{poly} , plus possible higher order effects
  - Are intermediate strips shorted ?



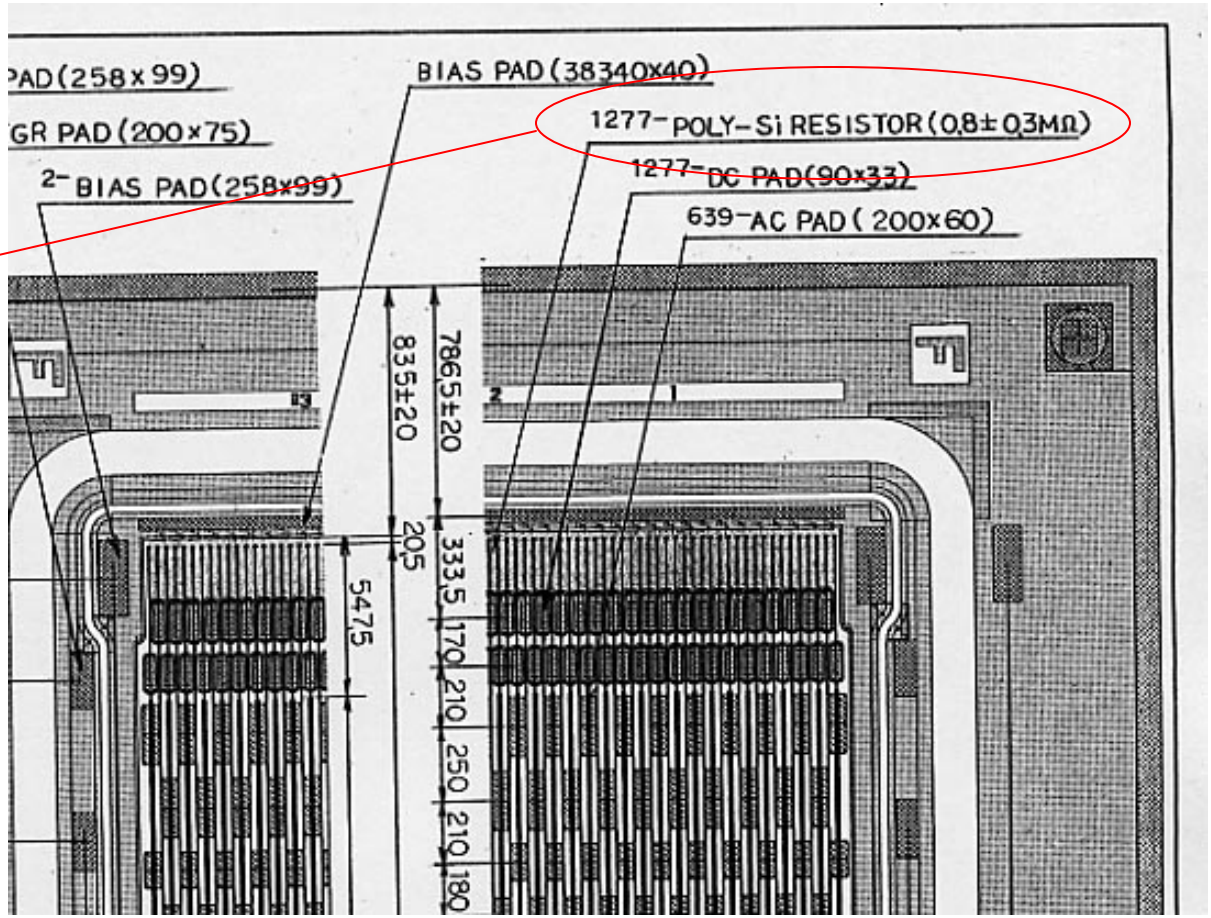
Sensor # 51

- AC scan



Comment

- Official HPK drawing for sensor layout:



This is not the layout of the sensor

Conclusions

- Measurements indicate that sensor quality is very good
- But, there are some puzzles …