US Production Report

CMS Tracker Steering Committee

4 September 2003

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Santa Barbara

Outline

- Pilot Production Run in August
  - Motivation
  - Results
  - Lessons
- Current plans and status
  - Stereo
  - Hybrid completion
  - Rods
- Sensor Issues

US Production in August

- Philosophy:
  - Parts available to build 35 – 45 modules. Rather than build at some arbitrary pace, we decided to build all the modules in a continuous way, day-by-day, as a test of our capability to maintain continuous production. All production steps were followed (see slide 4)
- What was done:
  - FNAL:
    - 10 modules produced in several days using 1 or 2 plates per day (with 2 modules per plate).
  - UCSB:
    - 3 modules per day (one plate) for 5 days straight.
      - First 3 modules were dummies, all the rest were functional.
      - Cycled through all 4 production plates
    - 2 modules in one day (waiting for hybrids to arrive from FNAL)
    - 3 plates in one day with 3 modules each! (This is our expected average peak rate at each site.)

US Module Production Plan

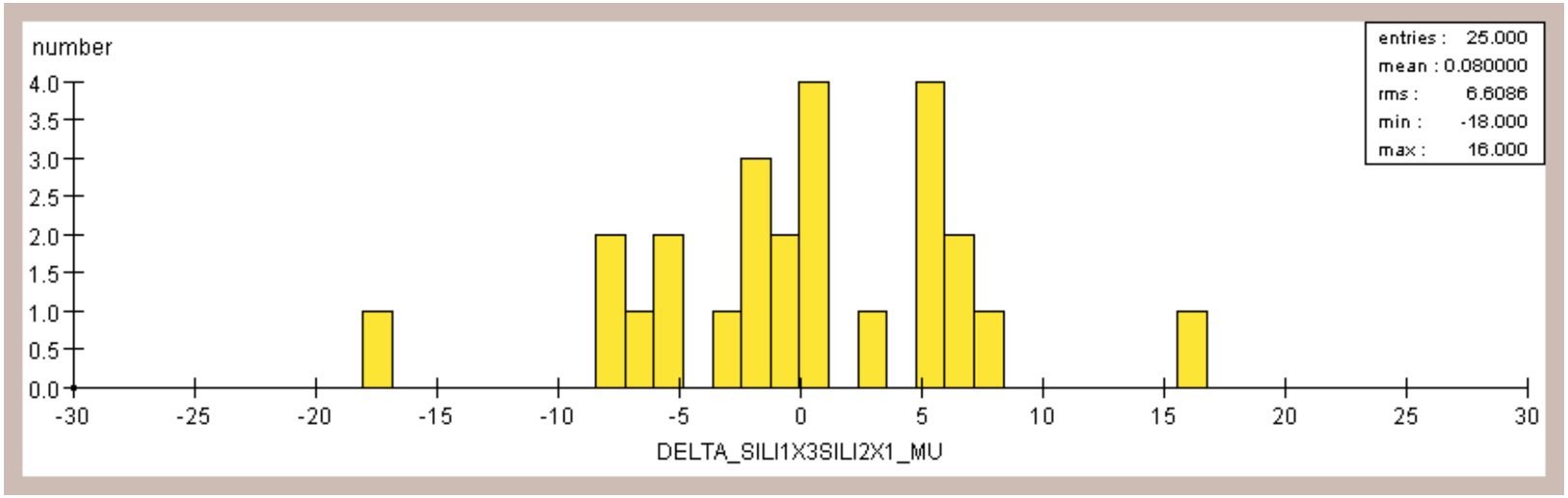
- Hybrids
  - New UCSB Task: Wirebond &Test:
    - Quick Test then Wirebond pa's
    - Thermal cycle with continuous ARC test and pitch adapter pulsing

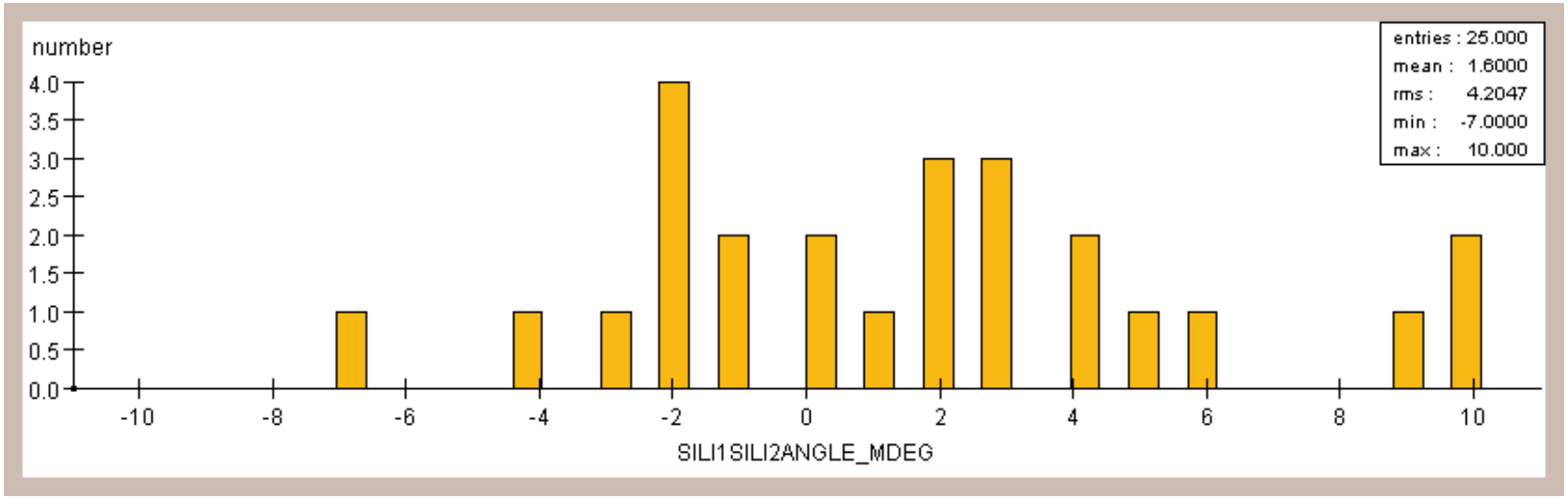
    Adds 3.3 Million bond wires
  - Ship half to FNAL
- Frames and sensors
  - Received by FNAL
  - Sample checks at Rochester
  - Ship half to UCSB
- Module production: FNAL & UCSB
  - Gantry fabrication of 12+ modules per day per site (average=9 at peak)
    - Overnight cure
    - Cross-check on OGP
  - Wirebond 12+ modules/day/site
    - Recent significant improvements
  - Fast test with ARC/LED
    - Simple repairs
  - Overnight temp cycling with readout in "Vienna box"
  - Full characterization with ARC/LED
    - Diagnostics and Repairs if Necessary
  - Store for installation in rods

Results for 35 functional modules

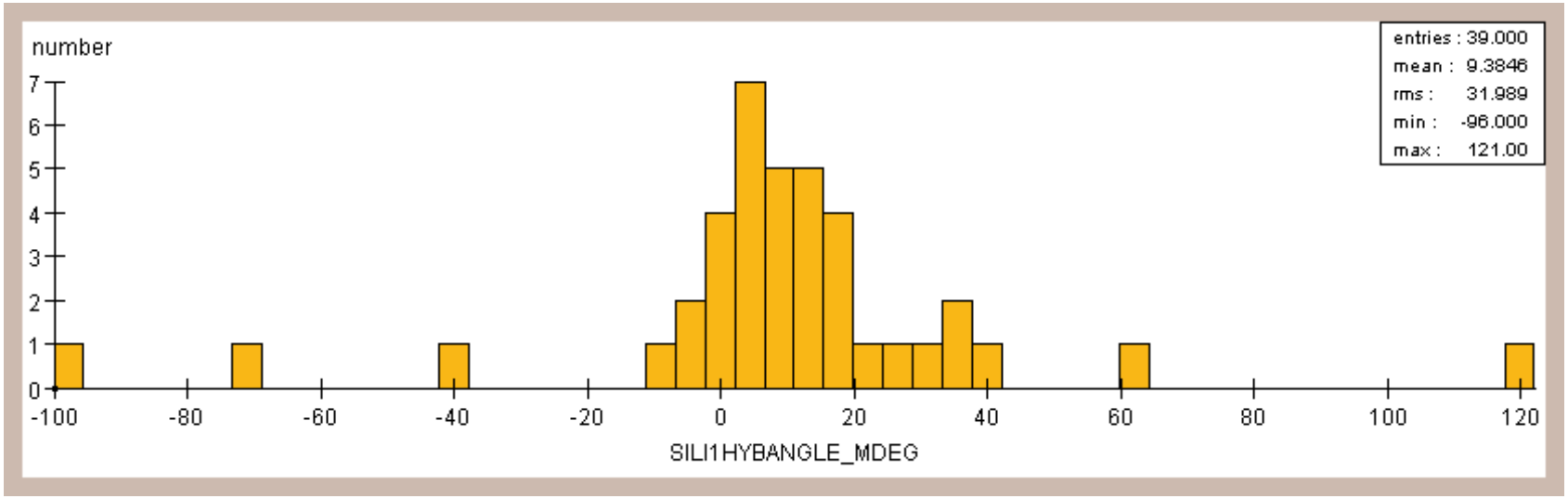
- Mechanical results very good
  - All modules in specs (see next slides)
  - Several improvements achieved
- Electronic Test Results
  - 22 (4) modules are Grade A (B)
  - Of the remaining 9 modules, 8 were expected to fail based on the choice of silicon (discussed later)
- Production sustainability (test of 3 plates in one day)
  - Gantry: Completed 3 plates by mid-afternoon
    - 4th plate would be possible without much difficulty
  - Wirebonding: Completed 9 modules in ~5 hours
    - Mainly limited by RMT pitch adaptor bonds
    - Aside: We recently learned to take full advantage of automated capabilities of the K&S 8090. With good pitch adaptors we find that we can now fully wirebond a TOB 4-chip module in 5 minutes.

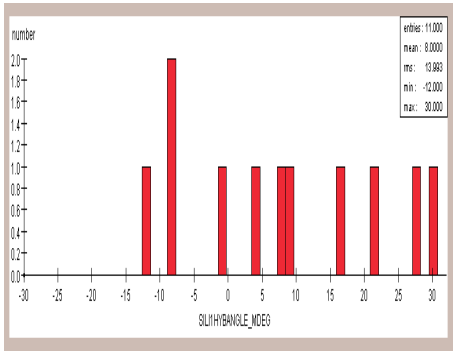
Gantry Results (UCSB) - 1





Gantry Results (UCSB) - 2



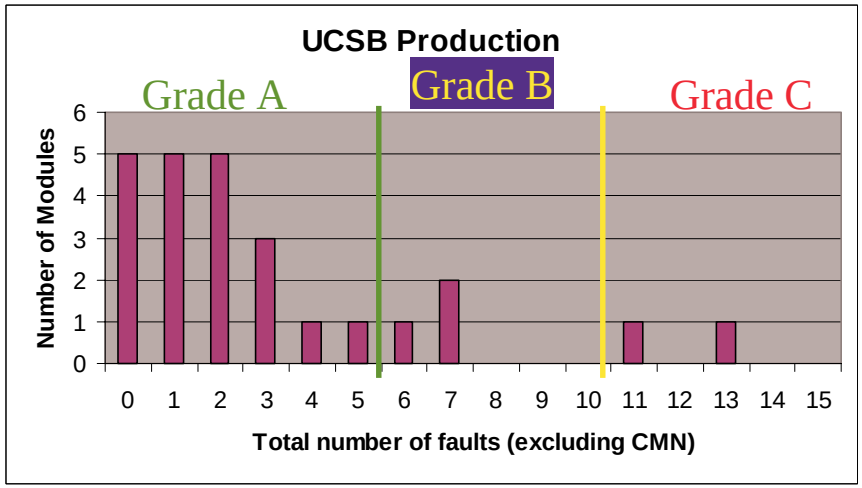


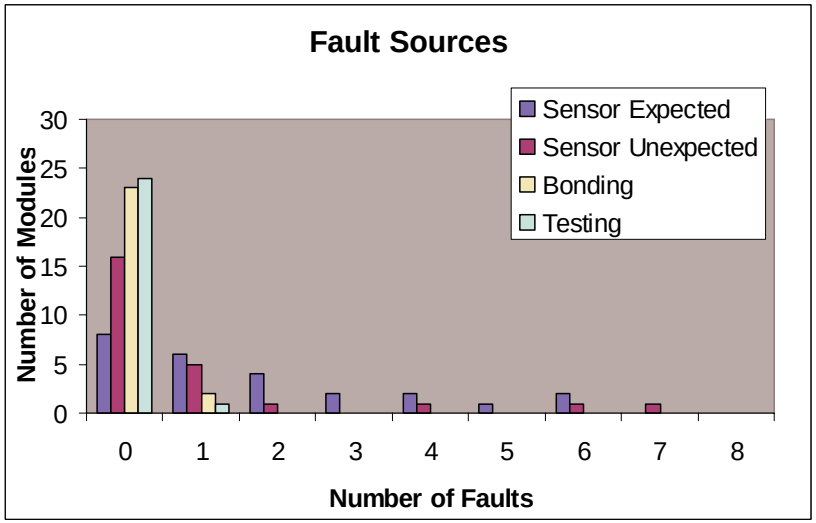
By slightly increasing the hybrid clamping we reduced the angular range of silicon-to-hybrid alignment by more than a factor of 5 (240 mdeg to 45 mdeg)

UCSB Module Testing

- 25 Modules Tested
  - 17 Grade A
    - 1 has Common Mode Noise (CMN) and increased I_{BIAS} *occasionally* (not understood)
  - 3 Grade A/F
    - 2 Broken Cables
    - 1 CMN and Broken Cable

    We are developing a tool for SAFE cable connections: Differential output lines are thin and vulnerable at edge of thicker backing on cable.
  - *2* Grade B
  - 1 Grade B/F
    - CMN
  - 2 Grade C/F
    - 2 CMN





FNAL Summary

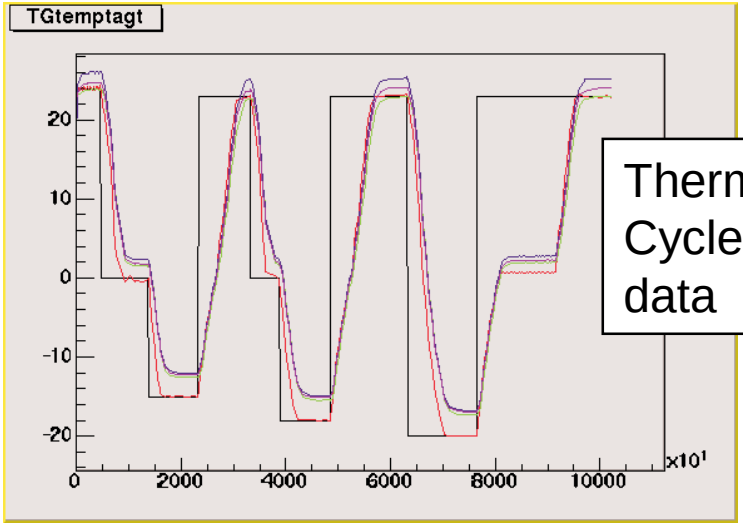
Module Number	689	690	691	692	693	694	695	696	697	698
Grade	B/C	F/C	A	F/C	F/C	A	B	A	B	A

In total, only six modules satisfy the requirements as stated in the Module Testing Procedure document.

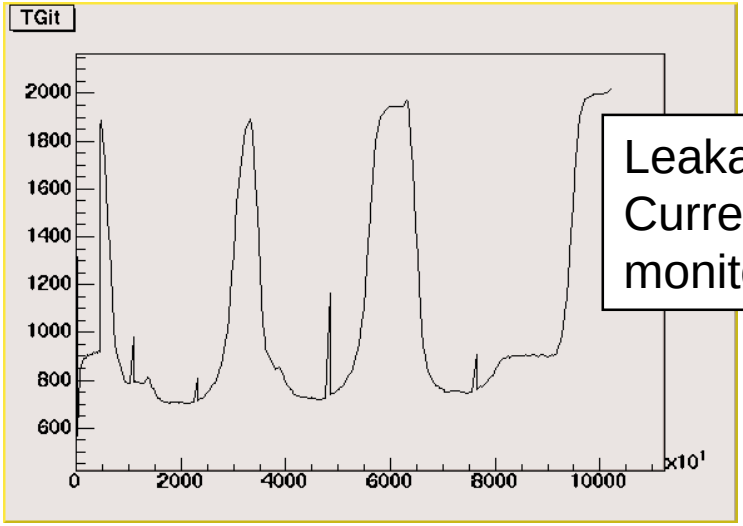
Saw same CMN as UCSB on 4 of the modules.

LT Test Results (UCSB)

- 21 modules had a weekday run of
  - 21 hours at 400 V
  - 3 cycles from 23C to -20C
- Subset of 4 modules had a weekend run of
  - 63 hours at 400 V
  - 9 cycles from 23C to -20C
- Subset of 5 modules had a weekend run of
  - 80 hours at 400V
  - 9 cycles from 23C to -20C
- Subset of 1 module had a weekday run + a weekday run of
  - 100 hours at 400V
  - 12 cycles from 23C to -20C
- No new bad channels found
- One channel w/slight increase in noise



Thermal Cycles data



Leakage Current monitoring

Other Items

- Stereo module production readiness
  - Stereo wirebond fixtures are completed
  - Stereo gantry plates now in machine shop
    - Ready for dry runs and dummy production week of Sep. 15th
    - Functional module production week of Sep. 21st if parts available
- Hybrid testing and wirebonding
  - We've completed the 4 hybrid test box. We're ready NOW to take over hybrid wirebonding/thermal testing/QA from Alan Honma's group.
- Rods
  - Can readout rods at UCSB
  - Rod test box nearly complete
  - Expecting rod from Duccio: Plan to assemble and test first rod this month (this is in fact a major milestone).
- Purchased new mini-gantry for controlled dispensation of sylgaard
  - This is for reinforcement of modules to avoid breakage in transport
- 1st (2nd) Rod burn-in stand completion in October (November)

Sensor Issues: Executive summary

- Re-probing
  - UCSB remade IV curves for 75 sensors
    - Wanted to determine whether high current strips were created prior to or during module assembly
    - Found ~10% of sensors had significantly different IV curves than indicated in DB – selected 5 of the worst cases for use in modules at UCSB.
- Module Production at UCSB
  - Found that IV curves did not change after module fabrication
  - Found that the 5 pre-selected high IV sensors resulted in 4 modules with high CMN
  - There is one module that has intermittent high CMN that was not anticipated.
- Module Production at FNAL
  - There was no pre-production IV probing
  - 4 of 10 modules showed higher IV than DB prior to strip bonding and all 4 have high CMN

Sensor probing (Summary)

Mini-production Sensors

- 25 from Perugia
  - Been used in previous module builds
    - Biased sample of sensors
- 4 had higher current in sensor IV probe
  - 3 used in modules
    - 1 caused chip common mode noise problem
    - 2 had mid-sensor opens (burns)
- Otherwise IV match well
  - RH% at QTC 30-35%
- 50 from Pisa
- 10 have higher currents in IV probing
  - 5 sensors have increased current large enough (>10μA) to cause a chip to have a large common mode noise
  - Consistent with rate seen in previous production
- 10 have much lower (>2 times less) currents
  - Pisa RH% during probing range from 10-50%
  - Most of these sensors probed at >40% RH

Summary of Production

- 25 Modules Produced
  - First sensor IV probed
  - Sensors sorted into three groups
    - Matching QTC measurements
    - Higher IV than QTC measurements
    - Lower IV than QTC measurements
  - Modules are assembled with sensors with matching or higher QTC measurements
    - First sensor bias bonded and IV measured
    - Second sensor bias bonded and IV measured
    - Module fully bonded, IV measured and module tested
- 20 modules produced with sensors with matching probe data
  - Only one in 20 (1038) had 7μA extra current(micro-discharge) and CMN on one chip after module bonding
    - Additional tests show both no extra current and no CMN, AND extra current and CMN
  - All other modules had no CMN problem and only small changes in current (<0.5μA)
- 5 modules produced with sensors with higher IV
  - 4 of 5 show micro-discharge large enough to cause a CMN on a chip as expected
  - 2 show burnt mid-sensor opens

Slide layout

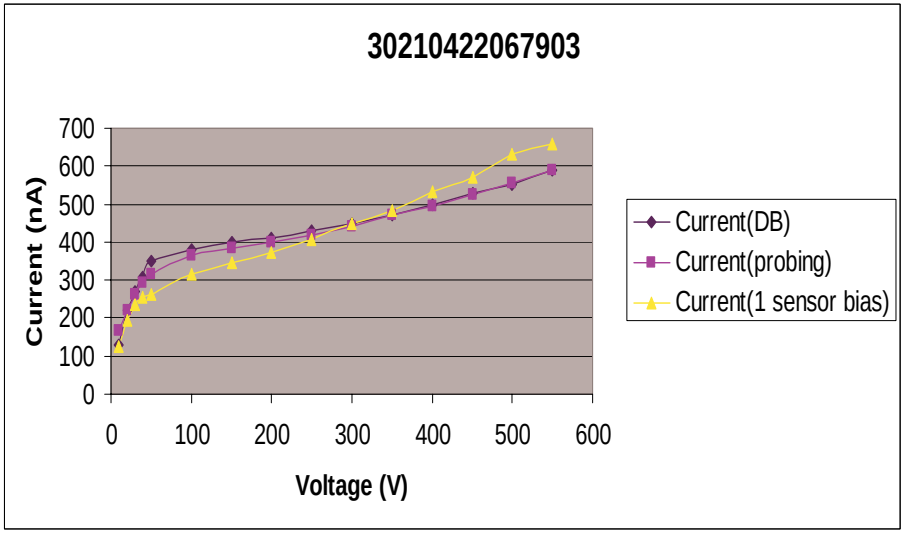
Following slides have following layout:

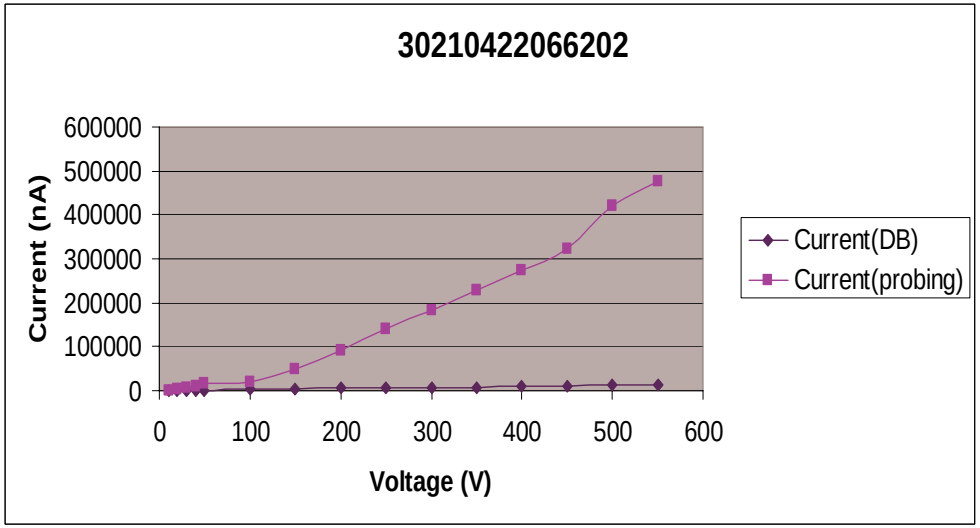
First (near) Sensor IV	Second (far) Sensor IV
Module IV	Results/Comments

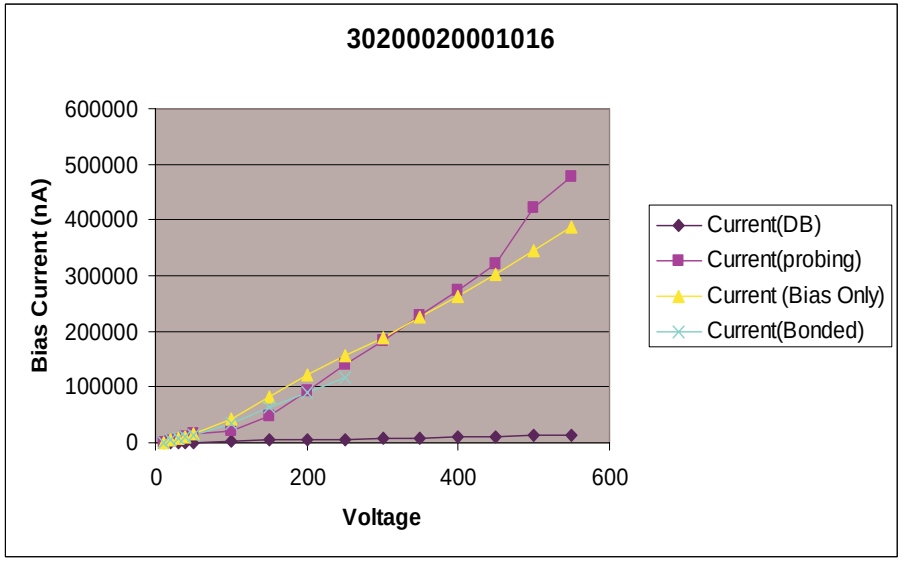
Tendency to CMN

Modules produced with higher IV measured at UCSB

30200020001016







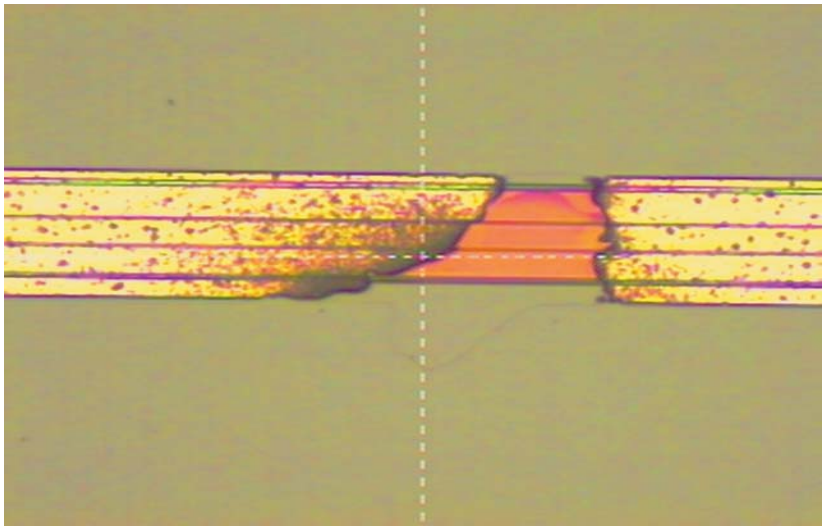
Mid-sensor open burn seen in sensor 30210422067903, channel 285.

CMN problem seen in chip 1 channel 38 due to sensor 30210422066202. CMN Noise problem begins at 90 V

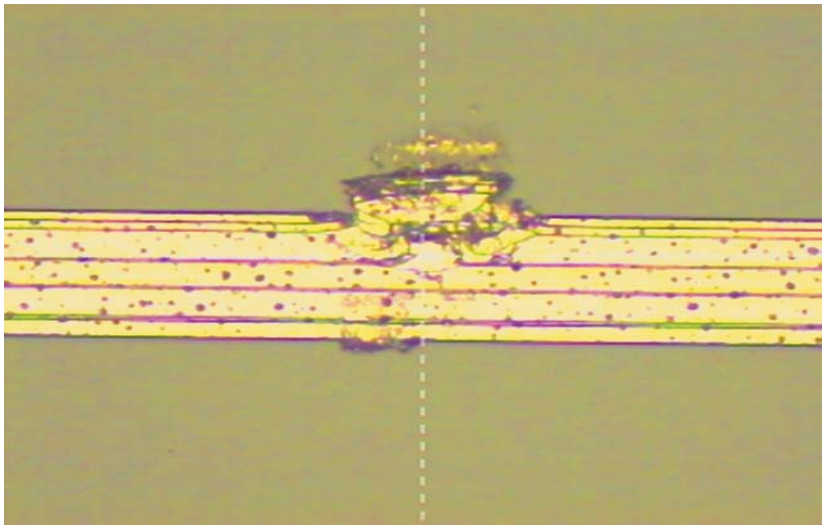
Note: the channels referenced above were found to be the noisy channels resulting in the high current found in IV probing.

Pictures of 30200020001016

- Picture of mid-sensor open “burn” seen in sensor 30210422067903, channel 285.

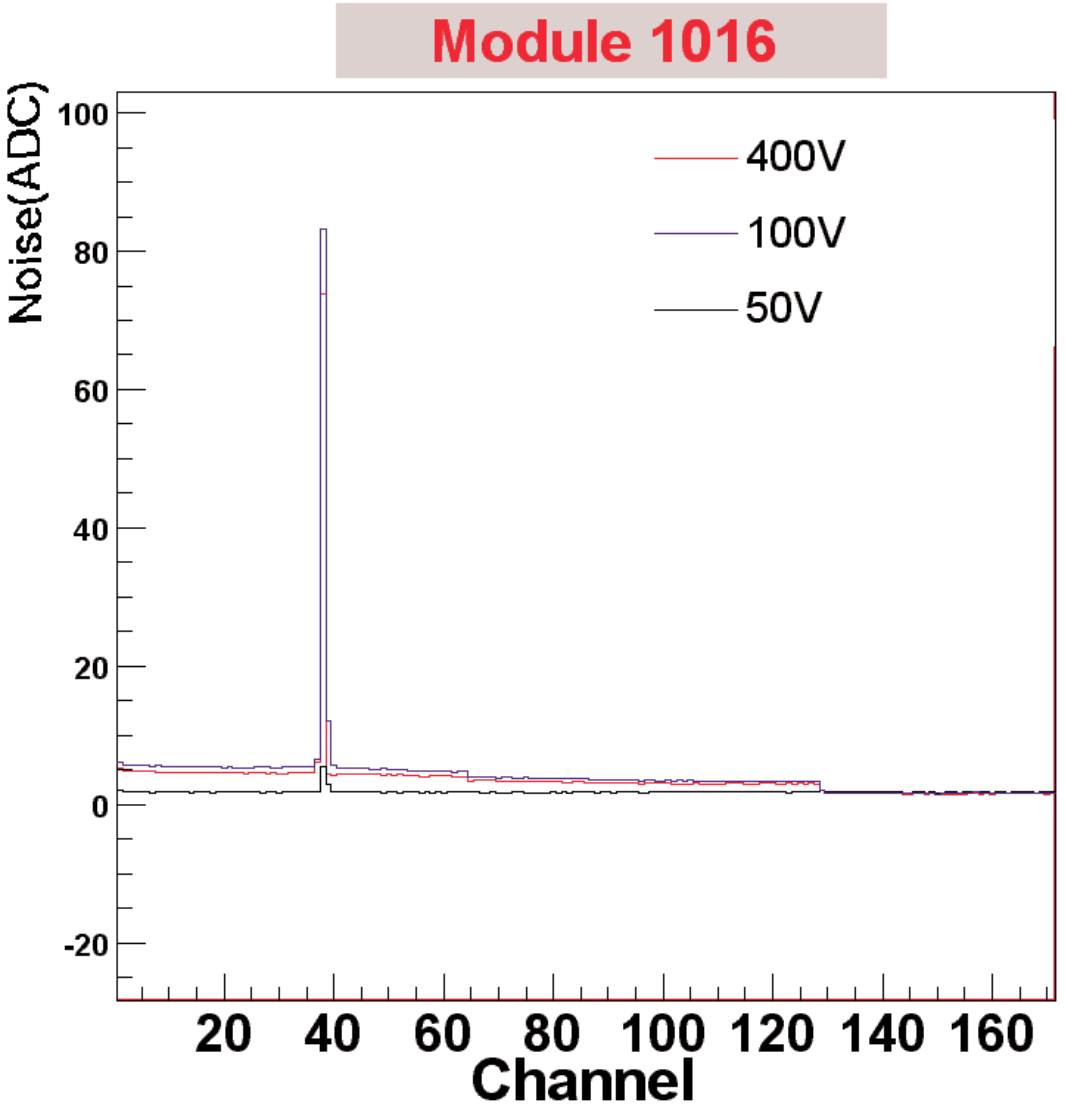


- Picture of channel 38, sensor 30210422066202. CMN noise problem begins at 90 V

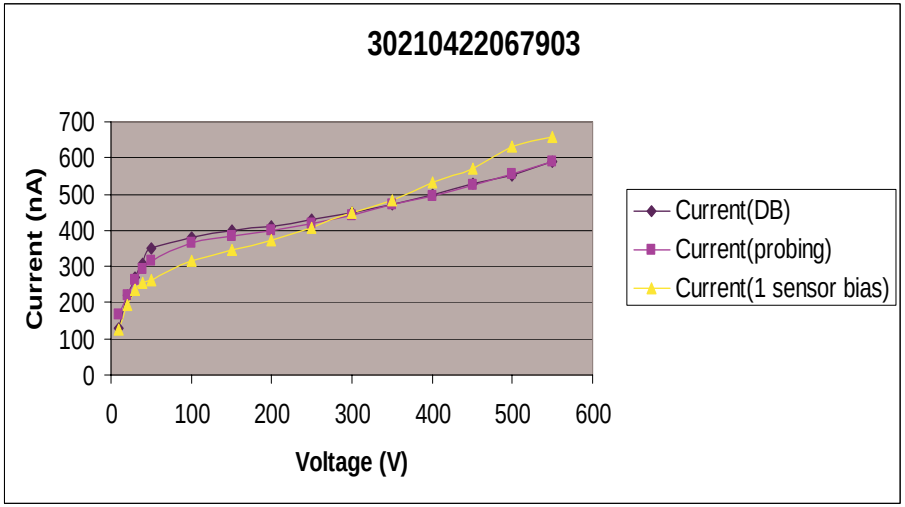


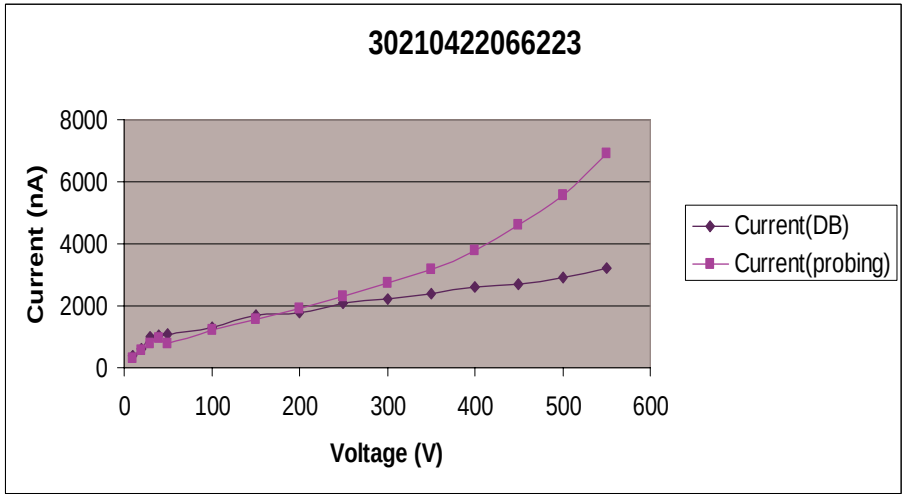
Noise of 30200020001016

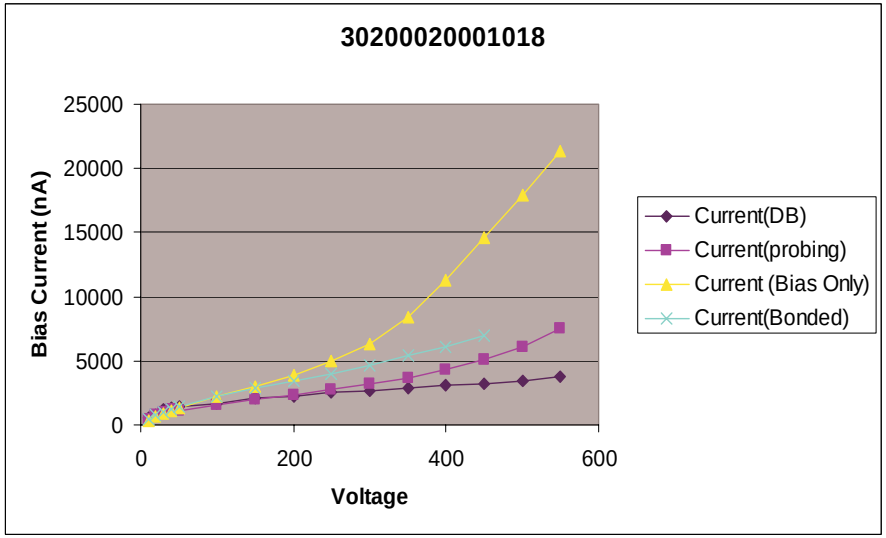
- Noise starts increasing on channel 38 with 10 V bias
  - Assume micro-discharge
- Noise on channel 38 reaches a plateau at 100 V bias and is large enough to cause 5 ADC common mode noise on chip 1.



30200020001018



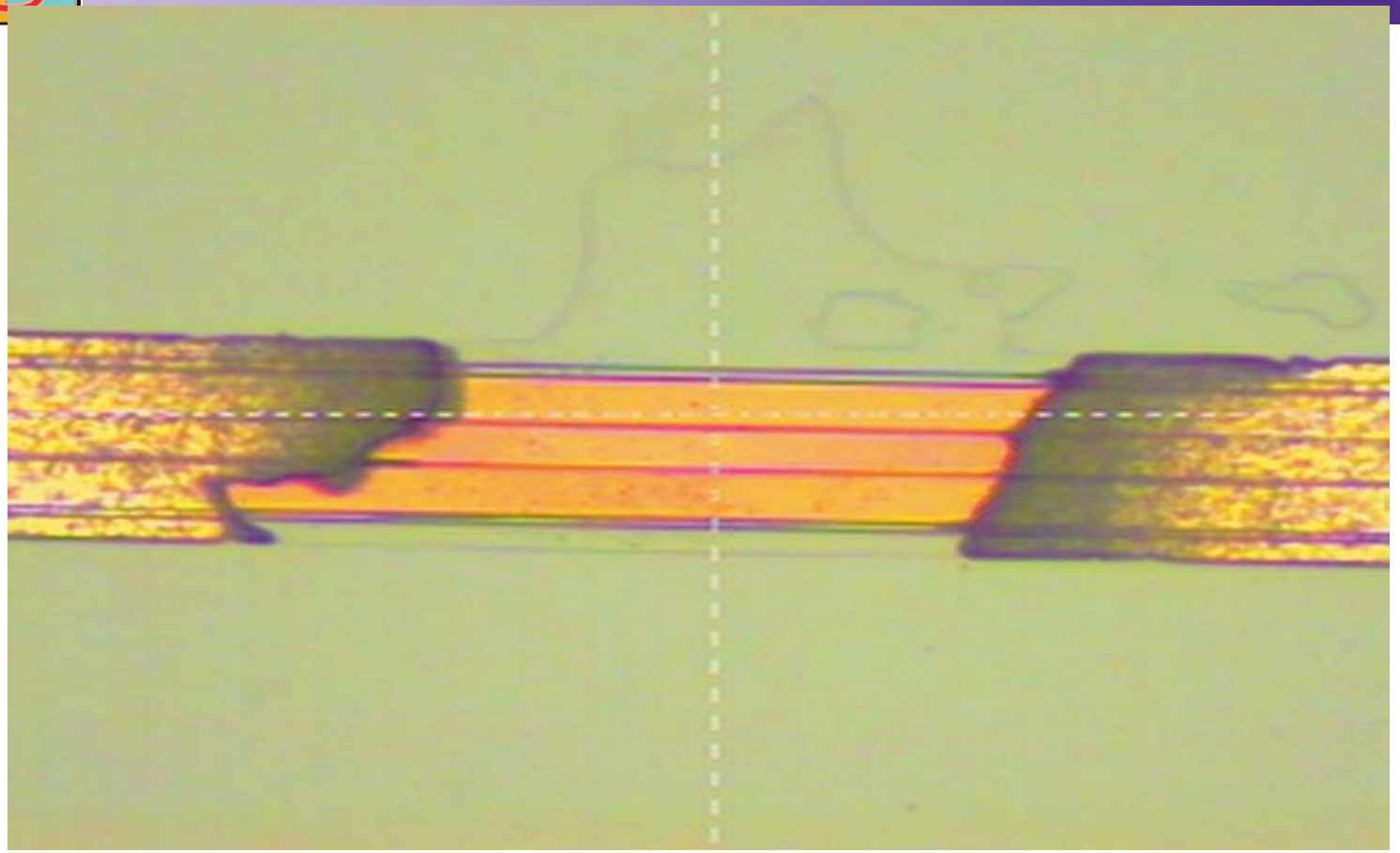




Mid-sensor open burn seen in sensor 3021042206623, channel 446. This may explain the increased current seen in UCSB IV probe and the decrease after module bonding.

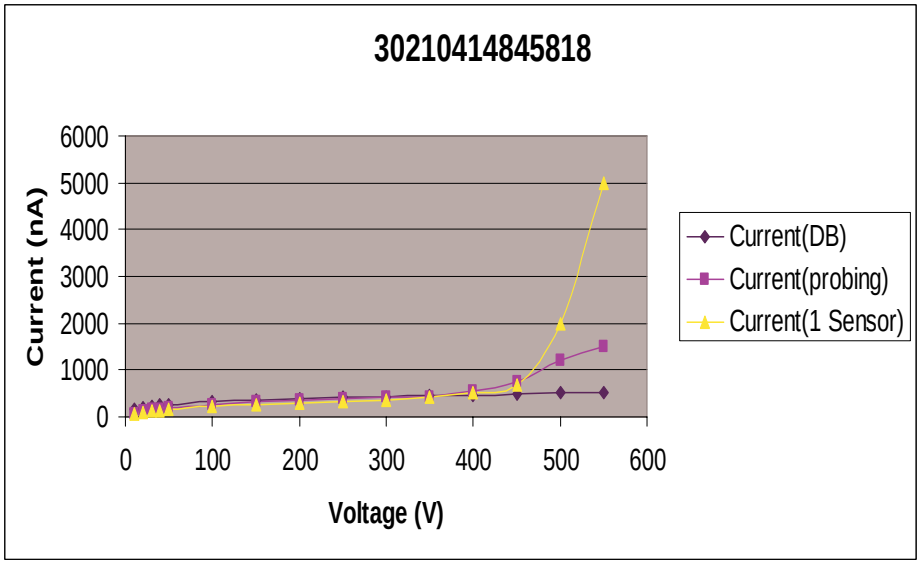
Channel has about half the average LED response.

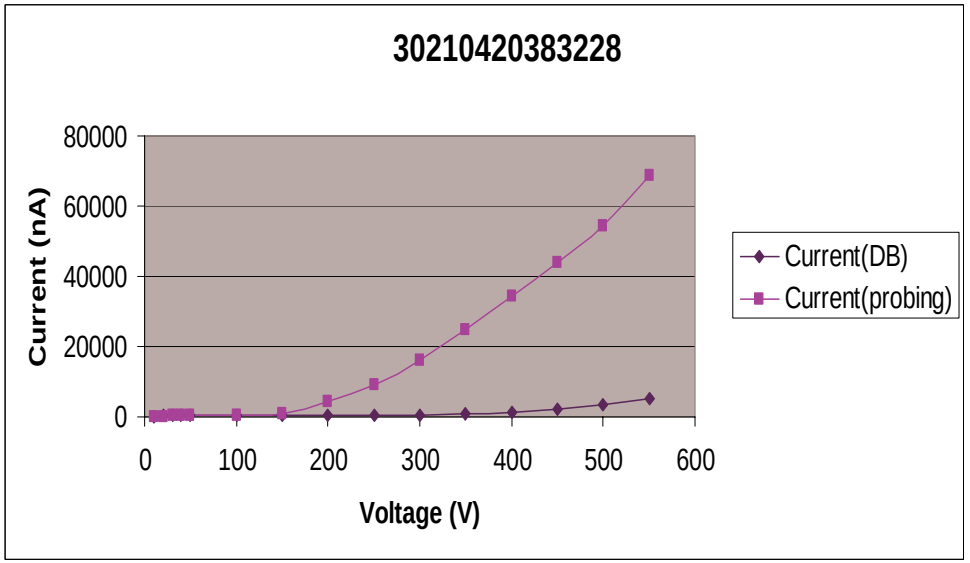
Picture of 30200020001018

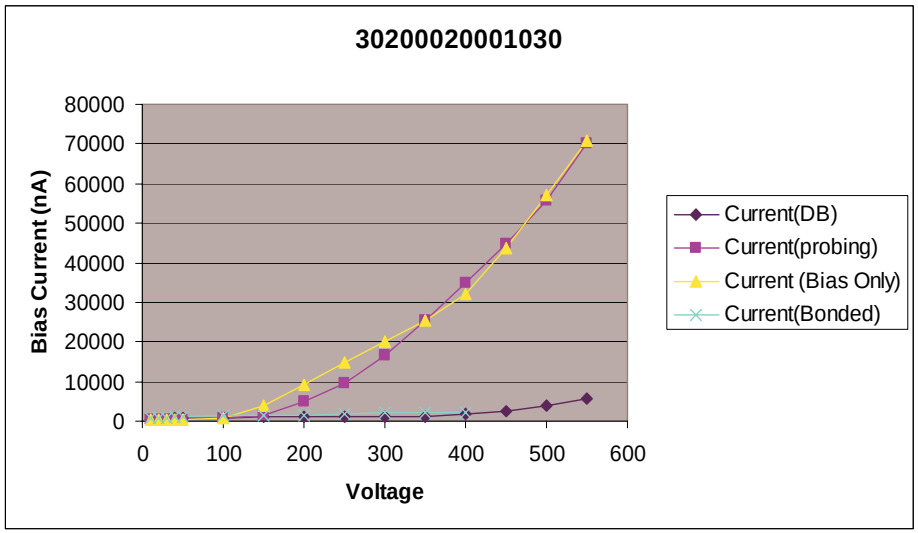


Sensor mid-sensor open due to “burn” on channel 446, sensor 30210422066223

30200020001030





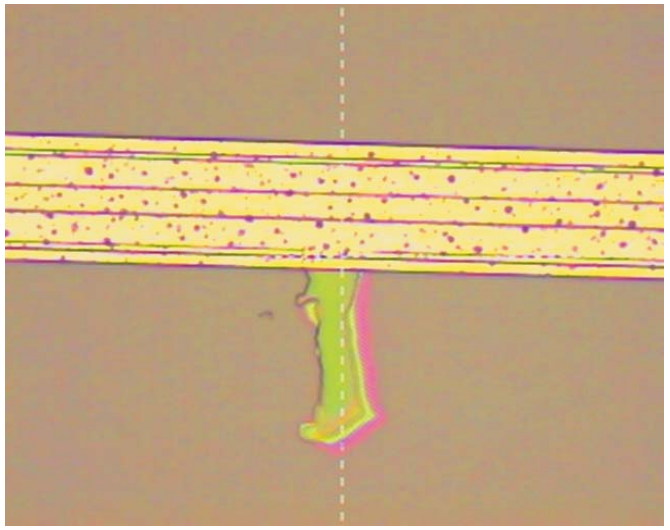


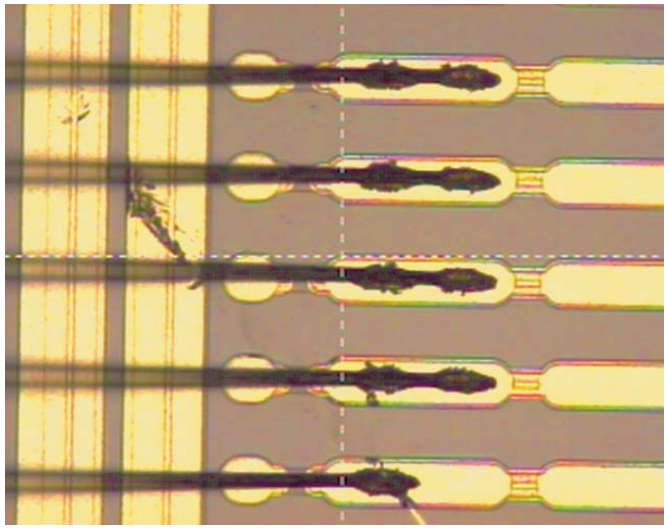
Sensor scratched due probing of hybrid. Bias and guard rings damaged but this results in LOWER current!

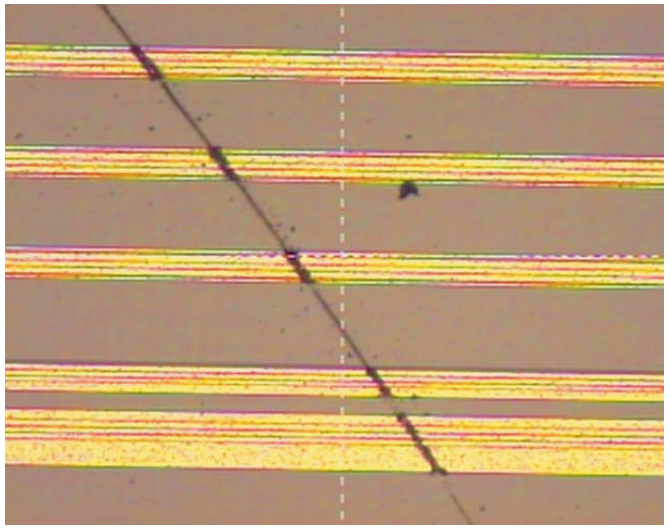
Upon initial power-up, the bias current is high and CMN problem seen in chip 3, due to channel 308 in sensor 30210420383228. As running persists, noise decreases and CMN problem stops!

Pictures of 30200020001030

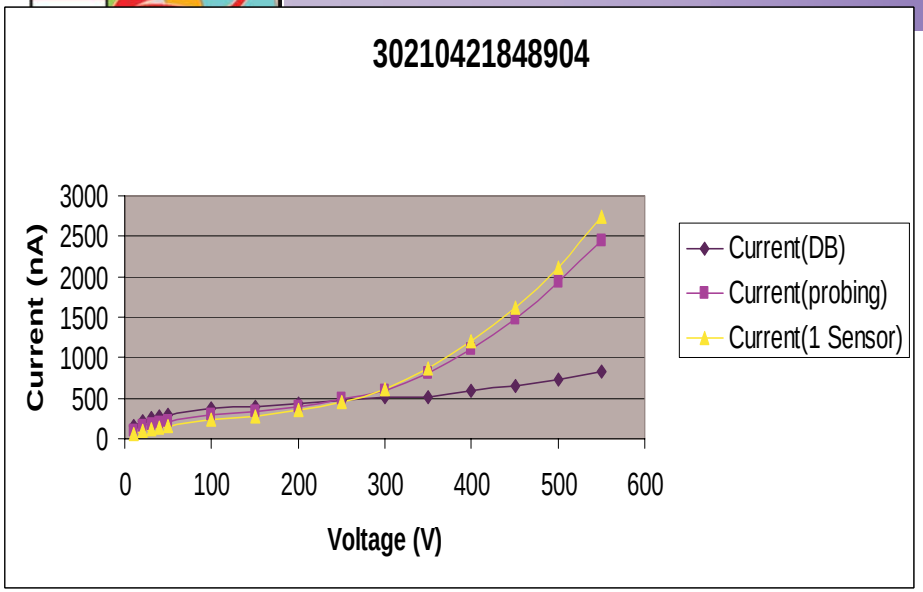
- Picture of channel 308, sensor 30210420383228 which causes CMN problem on chip 3.
- Accidentally scratched sensor while probing a hybrid problem.

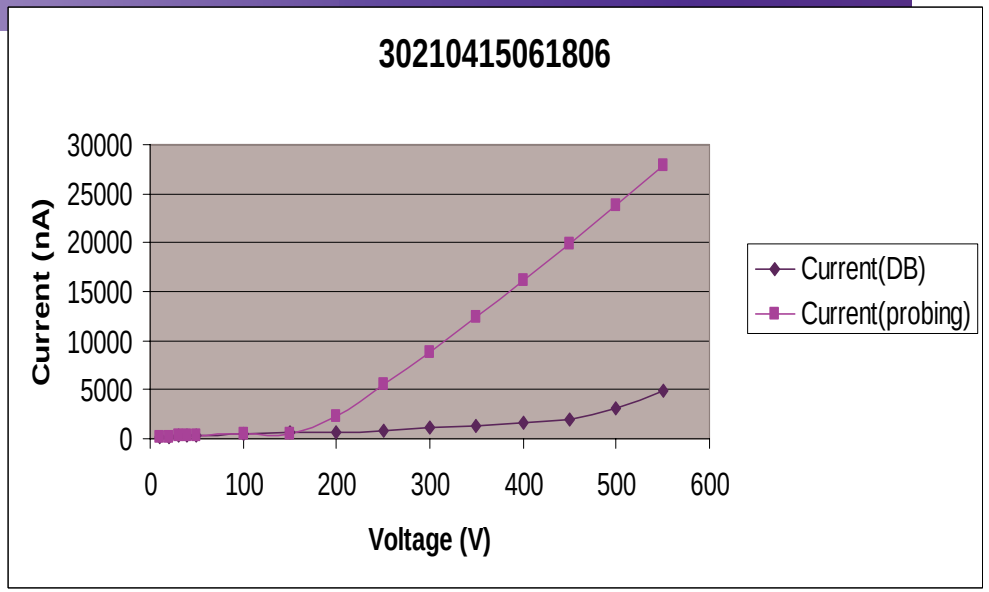


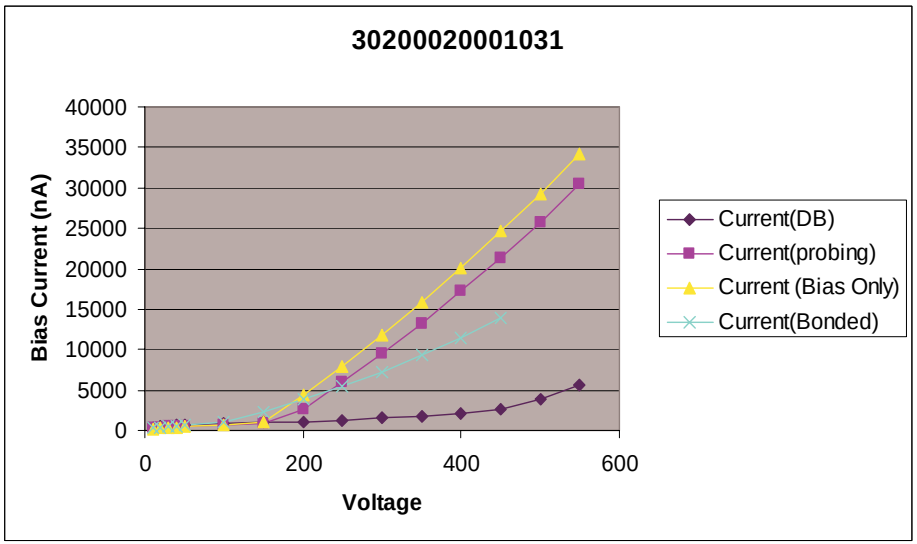




30200020001031



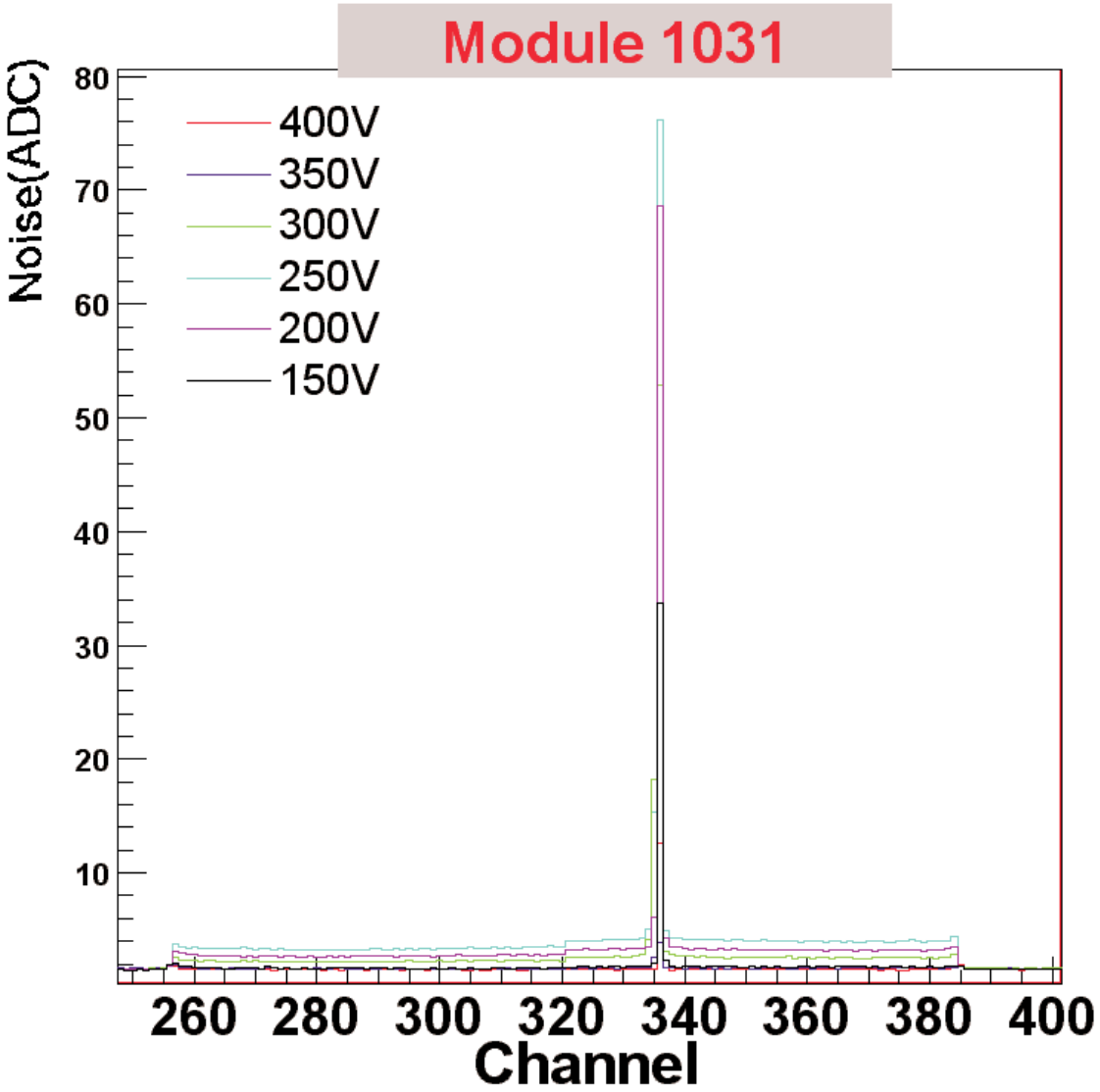




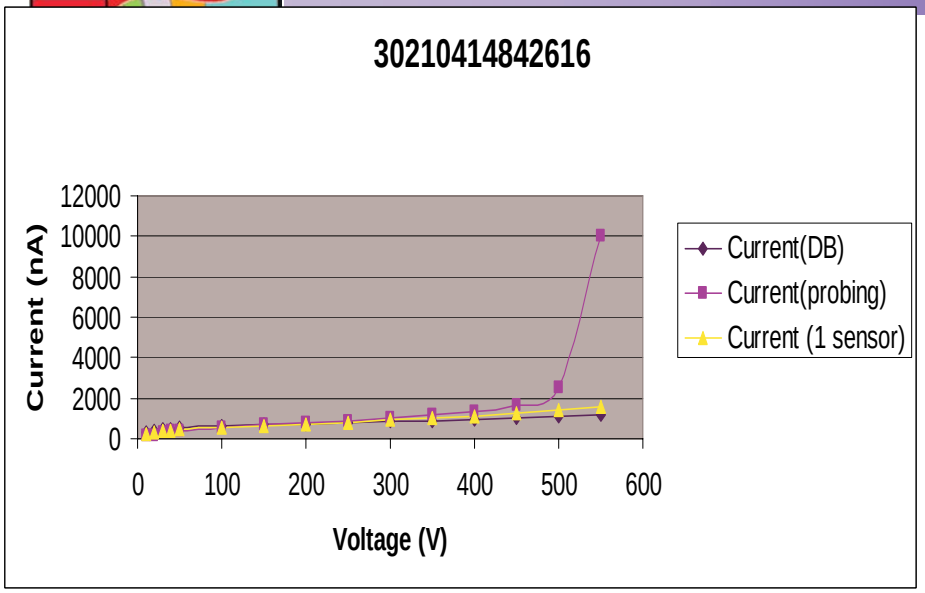
CMN problem seen in chip 3, due to channel 336 of sensor 30210422066202. Noise is a maximum at 240 V, and then *decreases* at higher bias voltage below the threshold level required to cause a serious CMN problem.

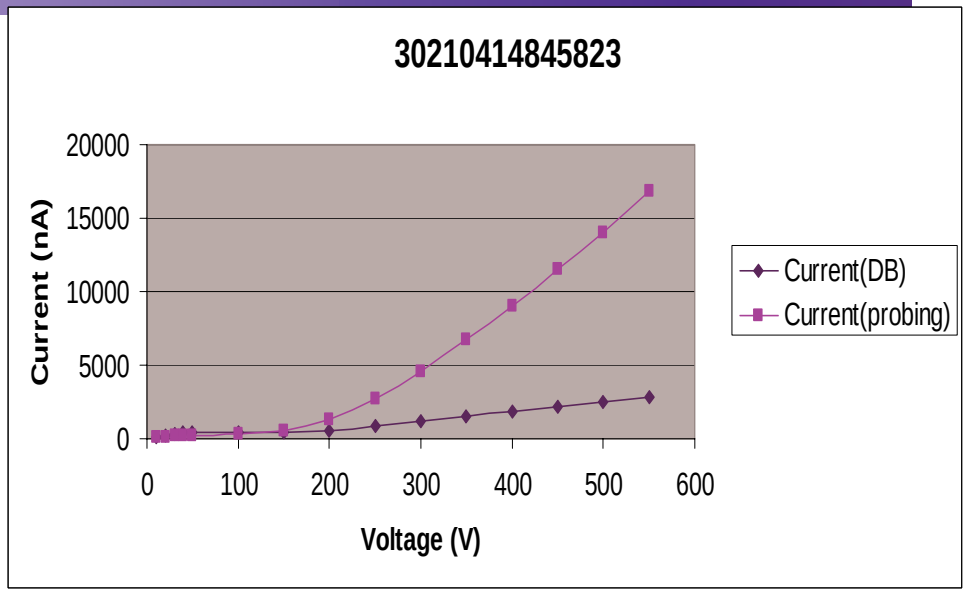
Noise of 30200020001031

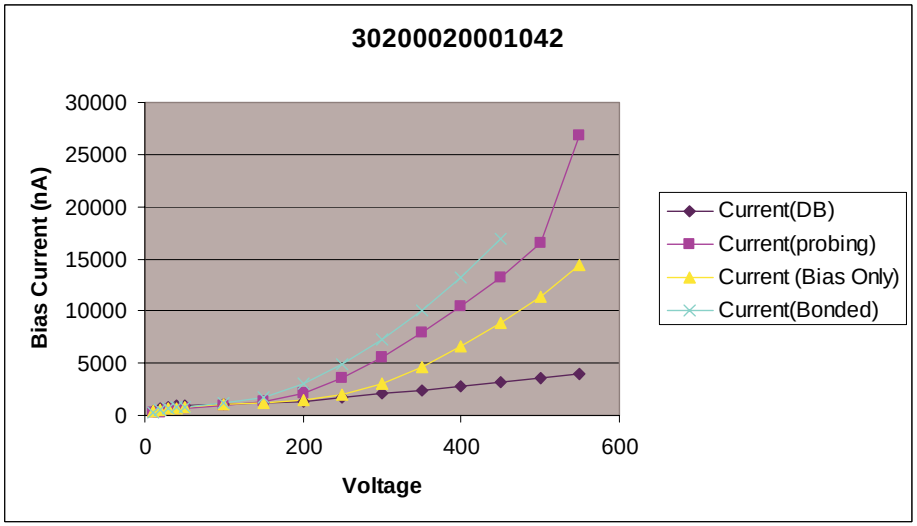
- Channel 336 shows initially increasing noise with voltage
- CMN on chip 3 reaches maximum at 250 V.
- CMN decreases as voltage increase beyond 250 V.
- At 400 V, CMN is gone. Noise on channel 336 is only 12 ADC counts.



30200020001042



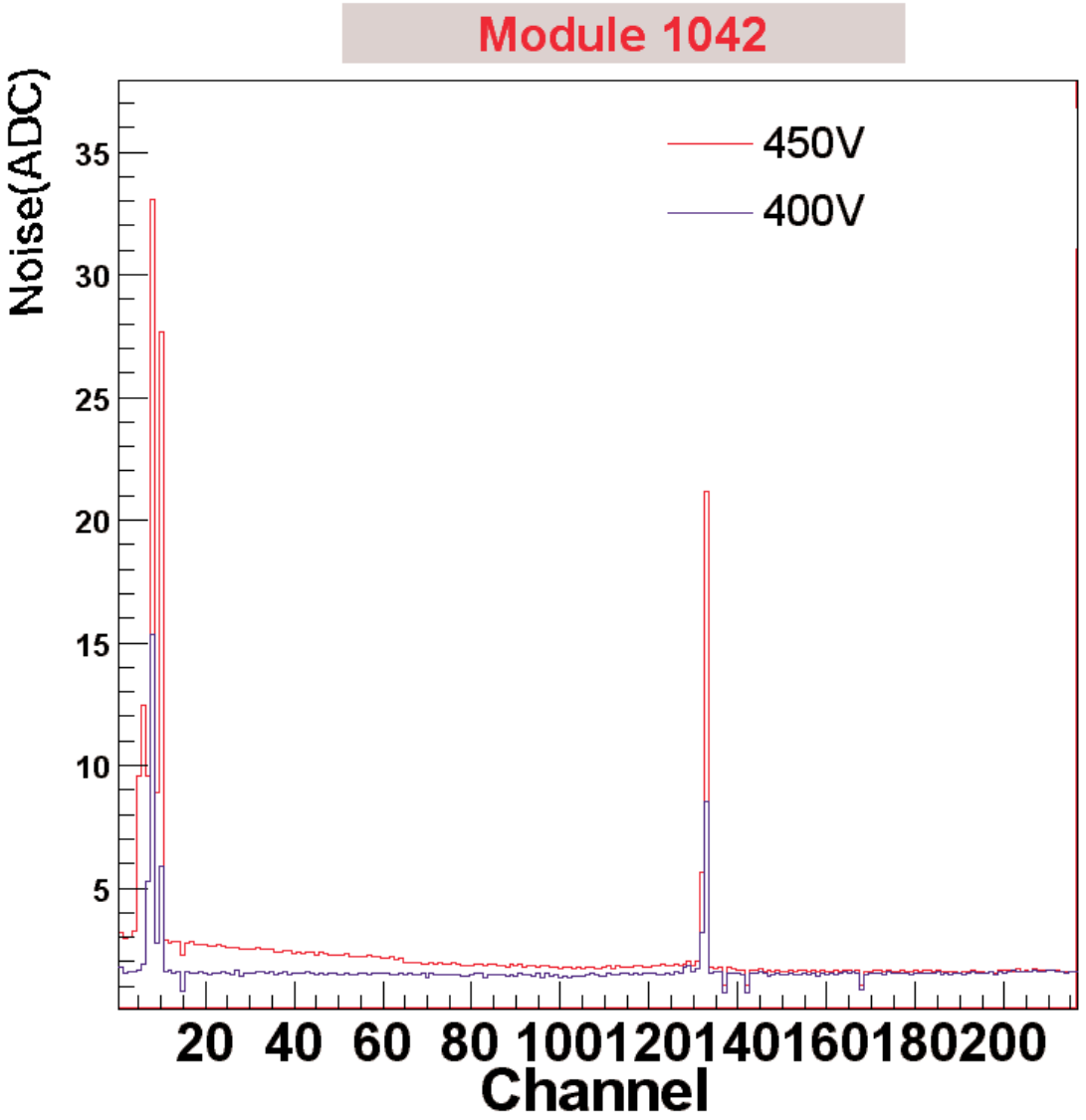




Micro-discharge problem seen in chip 1, channel 7-10 of sensor 302104845823. CMN on chip 1 starts at 450V but increased noise is seen at lower bias voltages on channels 7-10

Noise of 30200020001042

- Channels 7-10 show increased noise at 400 V.
- At 450V, chip 1 begins to show common mode noise



Sensor Issues: Our Conclusions

- Significant differences from QTC sensor probing have been found
  - ~10% of sensors have current increases >20 μA from QTC prior to module assembly
    - Roughly consistent with the rate of occurrence of the CMN problem (aka micro-discharge) observed at various production sites
  - Many sensors have much lower IV now
    - We assume that relative humidity was higher at QTC
- Of the 20 modules produced with sensors whose IV curves in the QTC database matched those obtained in UCSB re-probing, only one showed any change in current
  - This Module showed regular current in some tests afterwards so the problem appears to be intermittent
- Of the 5 modules produced with sensors whose IV curves in the QTC database were very different from those obtained in UCSB re-probing, 4 had serious CMN problems!
  - Pre-screening sensors thus decreases significantly the number of bad modules made due to sensor issues.
  - Testing time would also be very much reduced because much more time is spent in diagnostics for modules with CMN problems.

Summary & Concerns

- Demonstrated capability for high rate production of modules in the US production lines.
  - UCSB Capacity 10 modules per day (limited by the Wien box)
    - With weekend Wien box operation, we have capacity of 12 modules/day
  - FNAL capacity is 6 modules per day (limited by Wien box)
- Stereo module production will be available in less than 3 weeks!
- Rod assembly ready to start this month.
- Issue of noisy strips inducing serious CMN problems is real but early (low statistics) indications are that it can be mostly eliminated with IV checks of sensors.
  - *We're comfortable going into production like this, but we'd be happier if this phenomenon were better understood…*