

# Measurements on 8” Novati Wafer

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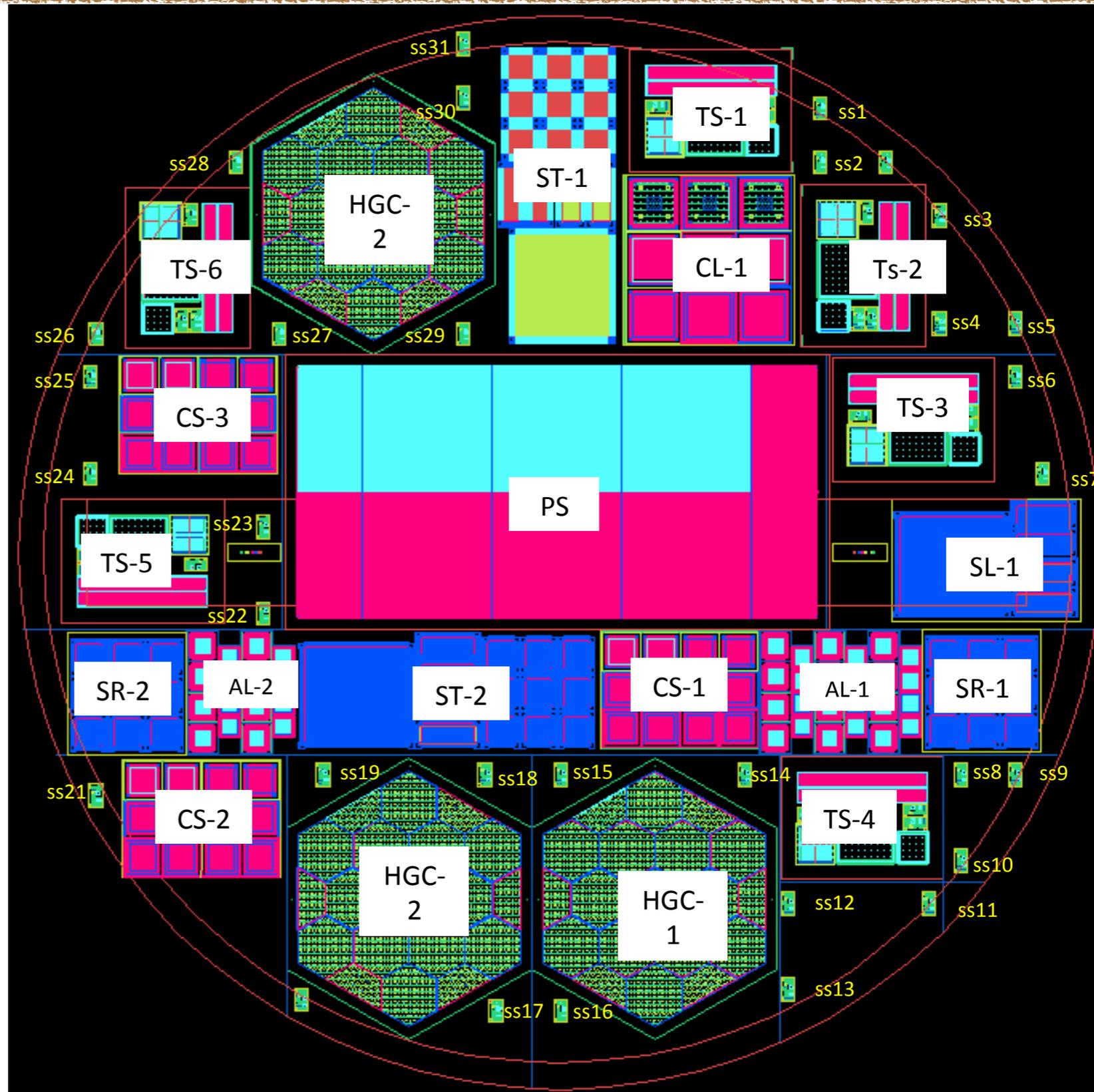
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## **USCMS Outer Tracker Workshop**

Brown University, Providence, RI, USA

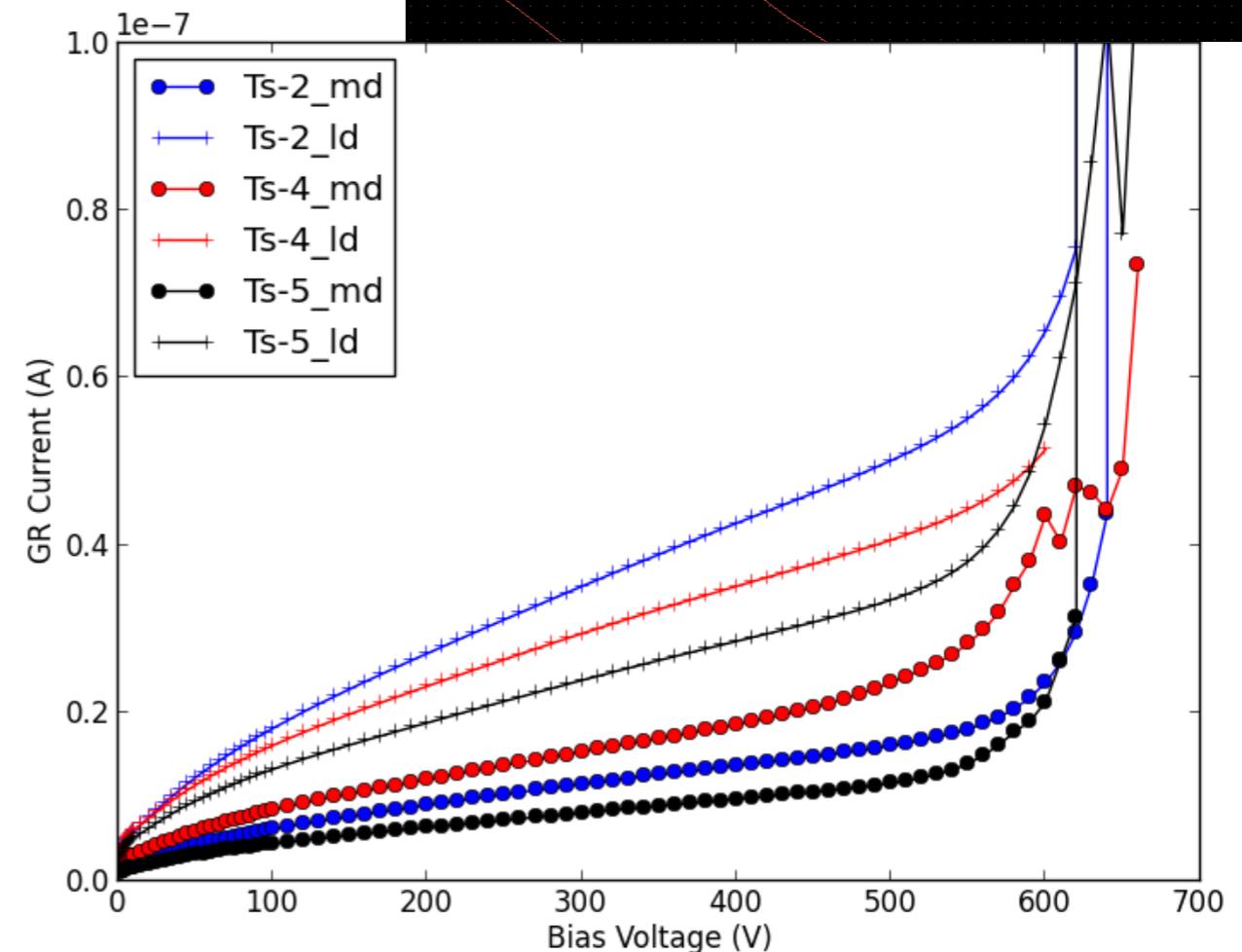
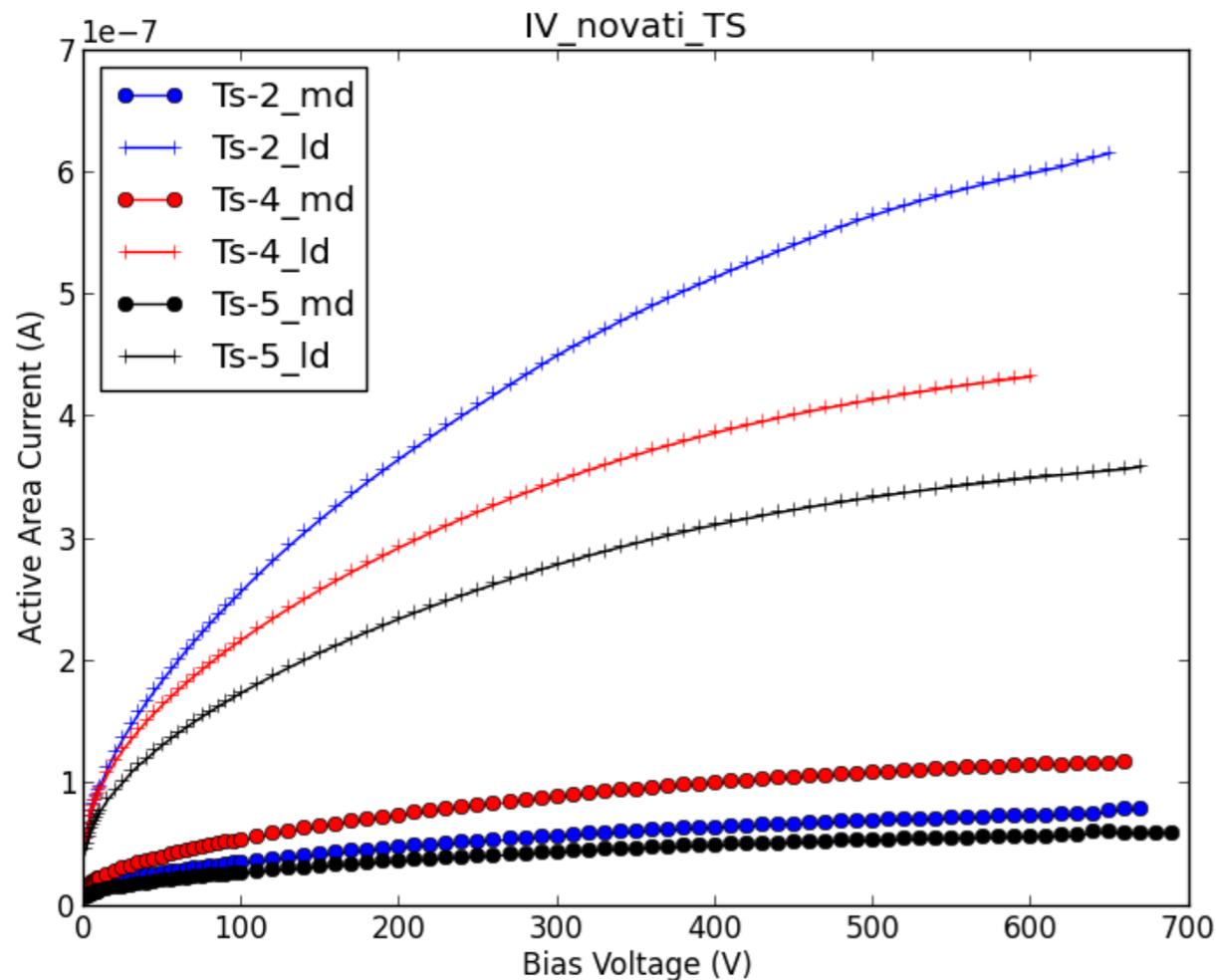
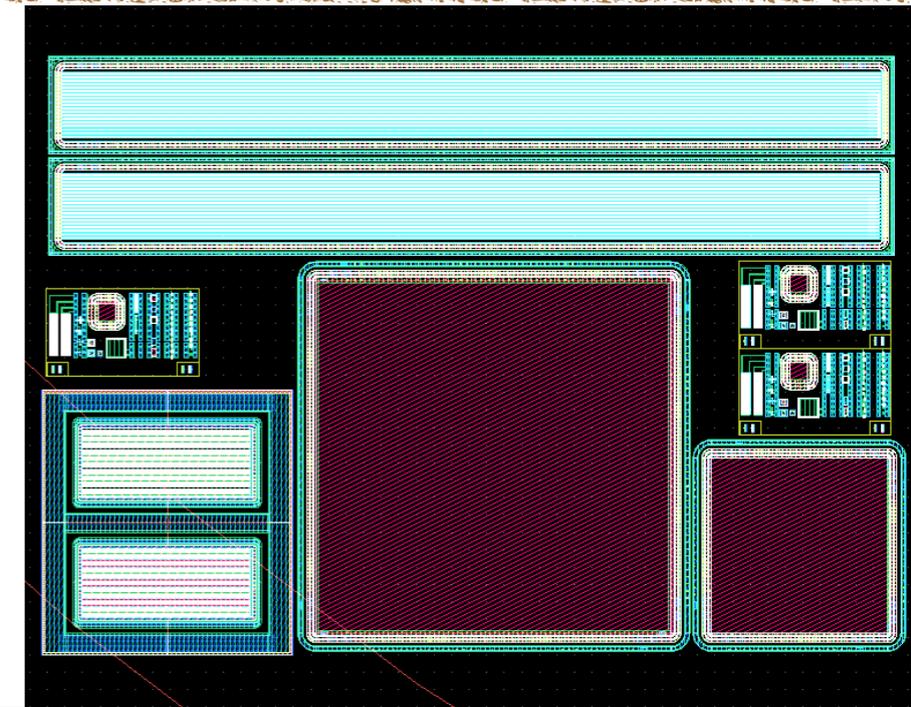
# Full Wafer Design

- 8" wafer
- Float Zone material
- n<sup>++</sup>-on-p
- Thickness:
  - 725um
  - 500um → diced TS
- Structures we've looked at:
  - SS
    - small diode
  - TS
    - medium and large diode
    - Twenty strips AC and DC
  - CL
  - HGC
  - SL
  - PS



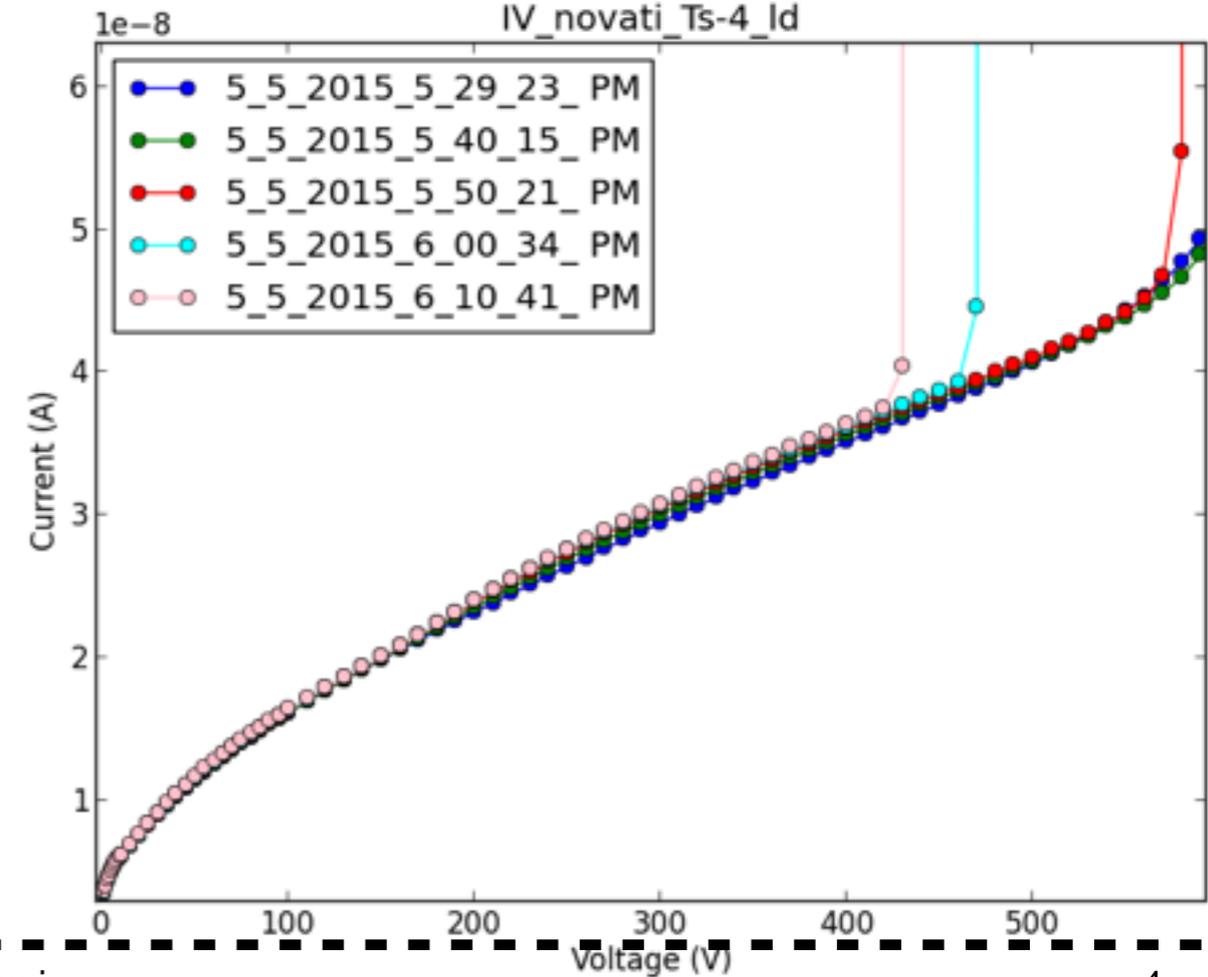
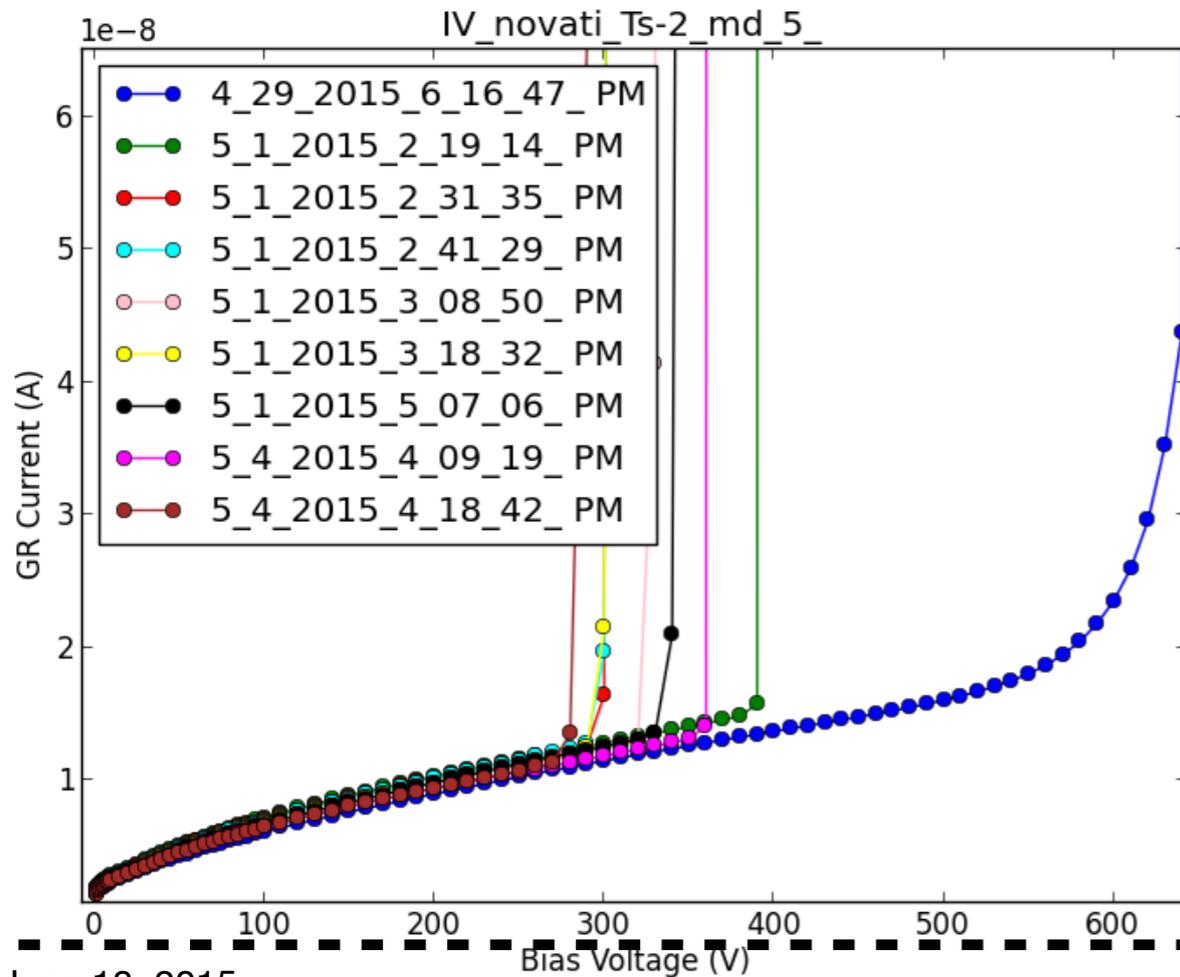
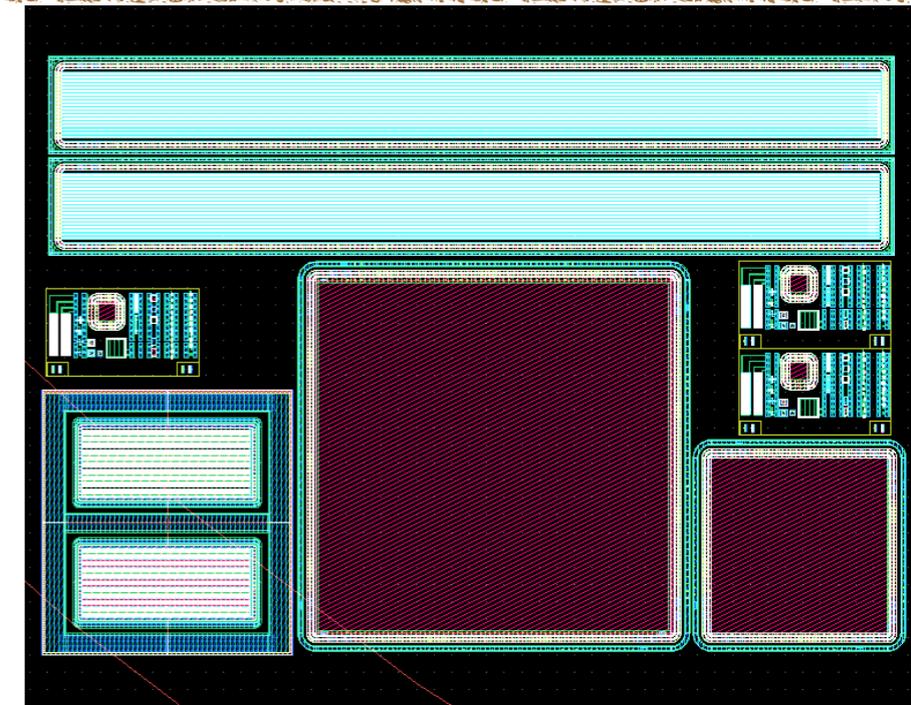
# Diode IV Characteristics

- Measurements on LD and MD in different TS structures
- Comparison of results from very first measurements
- GR breaks down around 600V
- Uniform across different structures



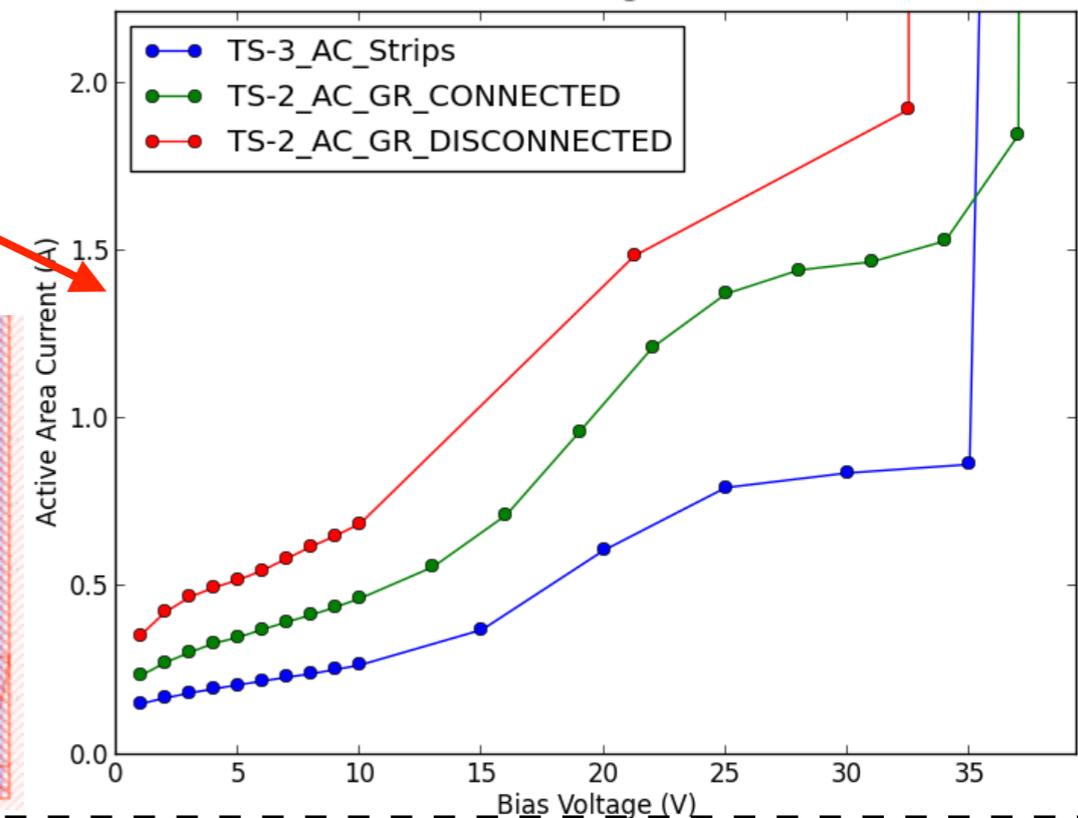
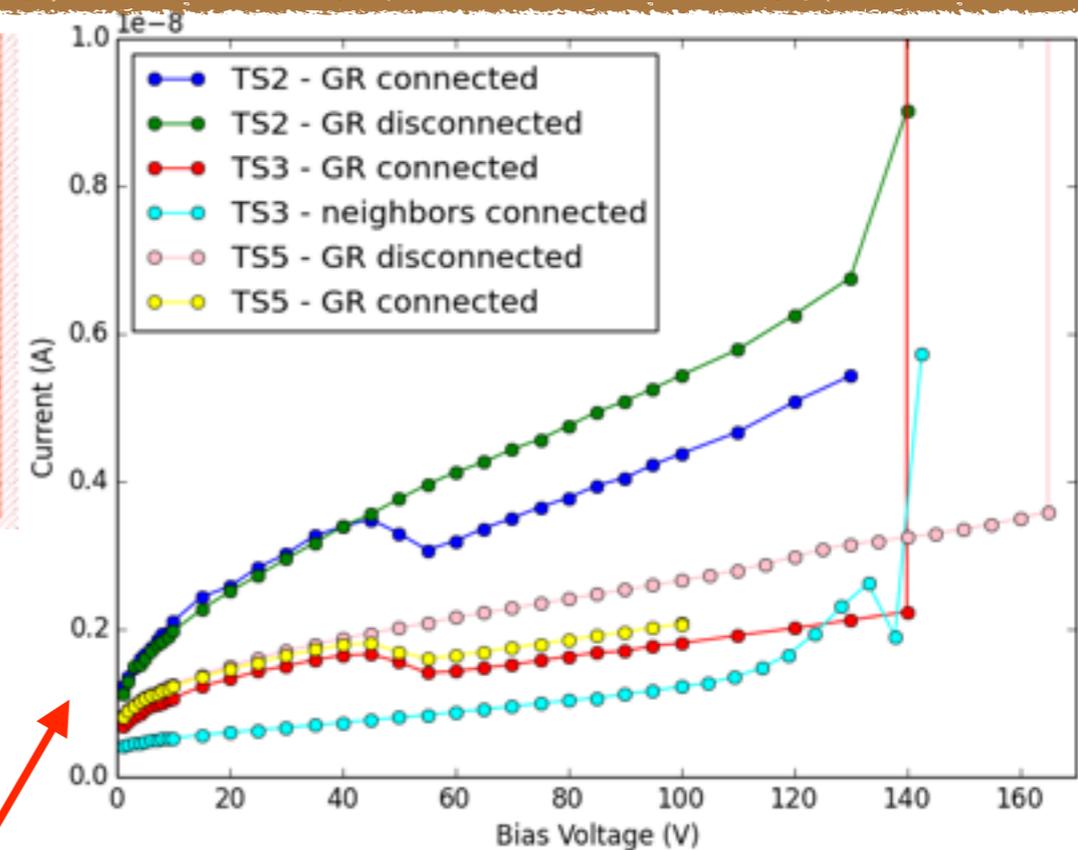
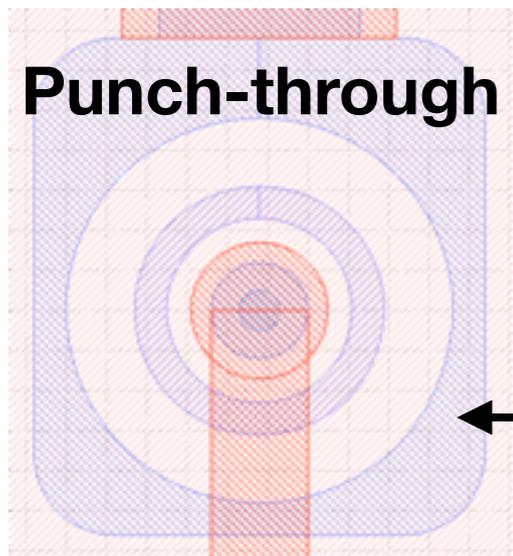
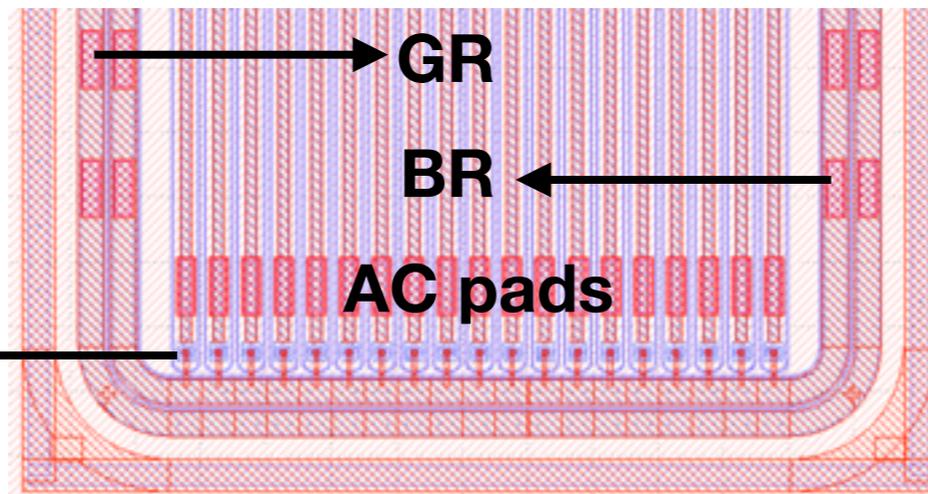
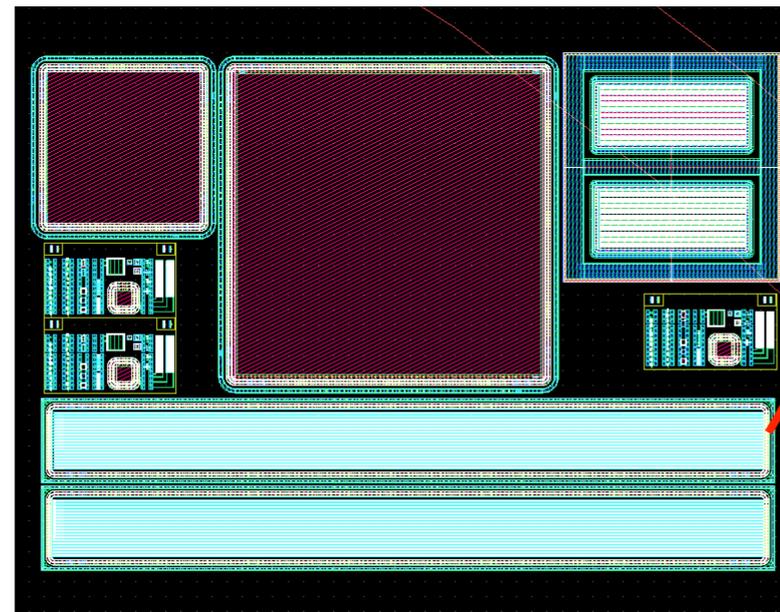
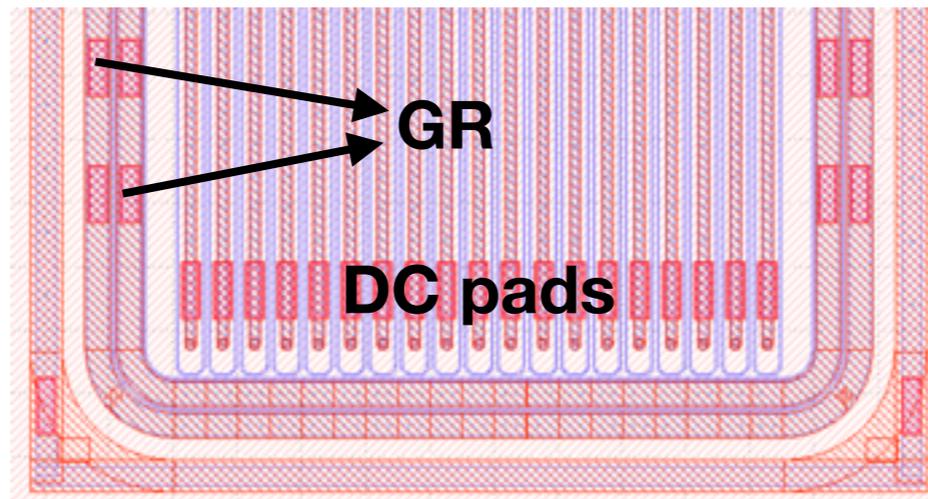
# Diode IV Characteristics

- Repeating the same measurements results in lower break down voltages
- How much the b-d voltage drops seems to depend on how high the current gets in the previous measurement



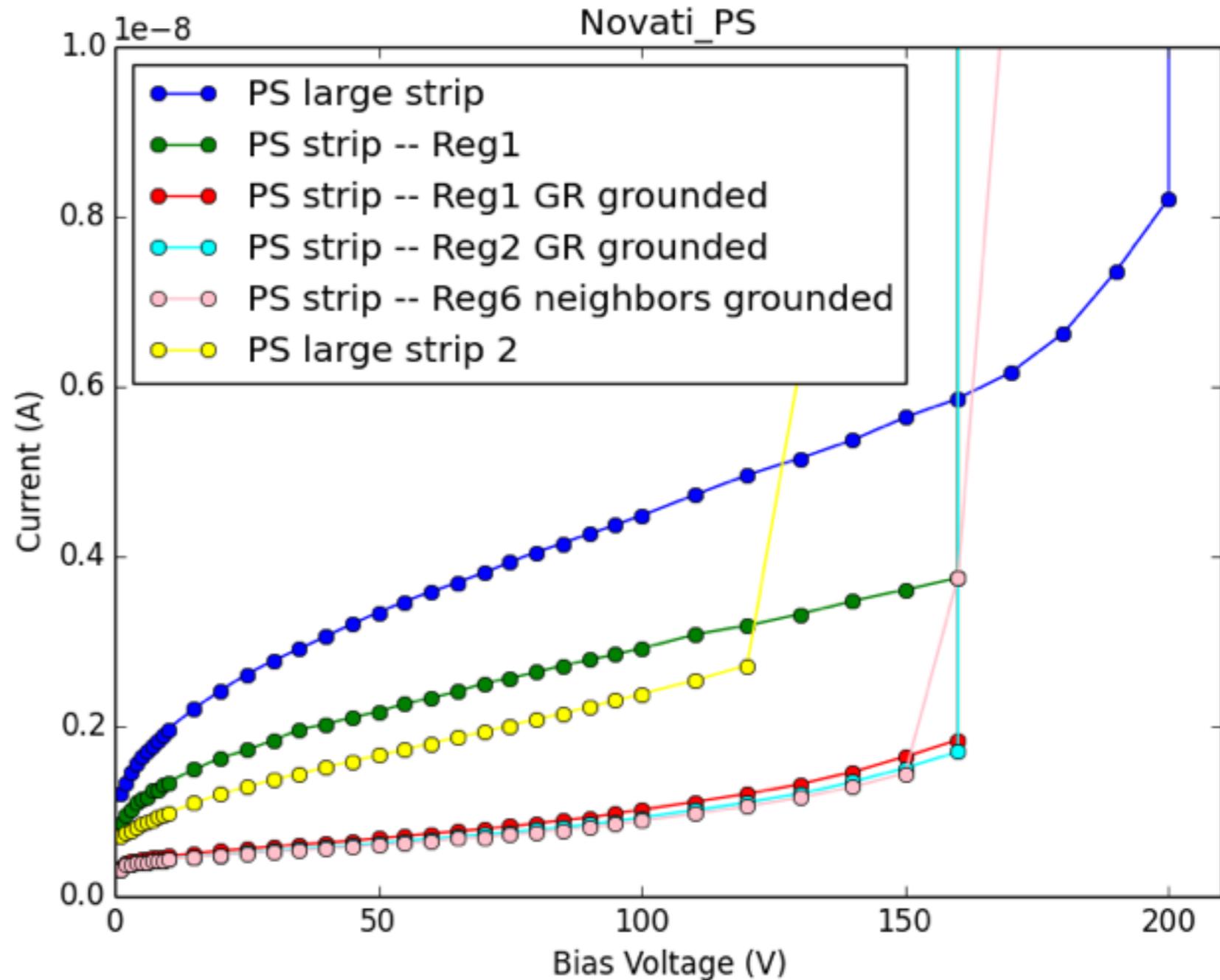
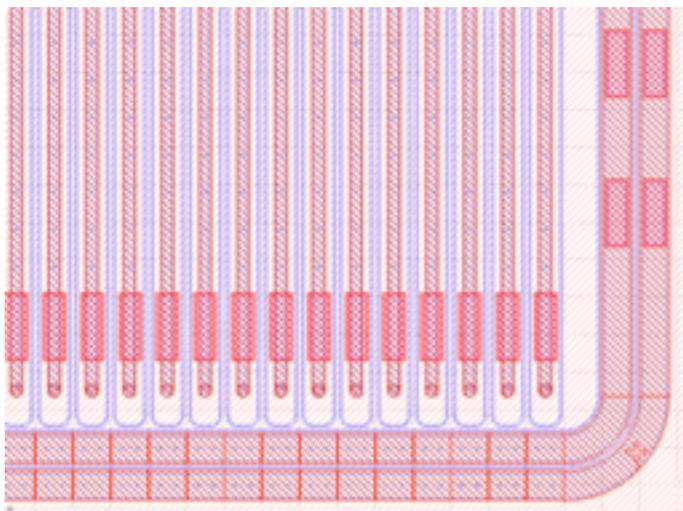
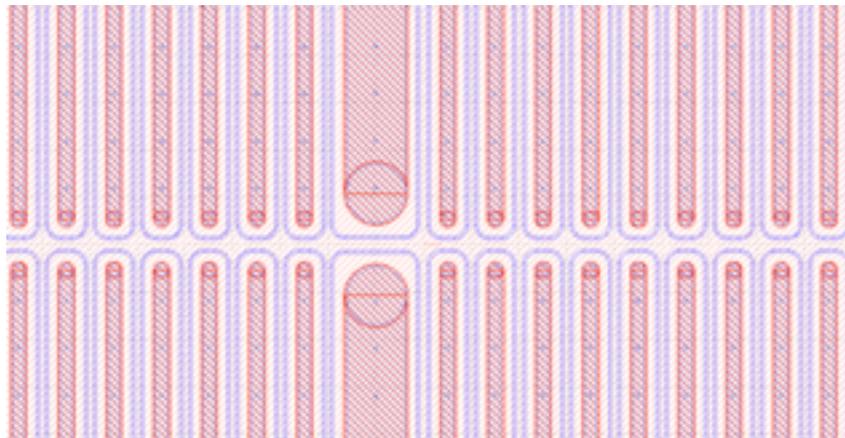
# Twenty Strips in Test Structure

- Single strip leakage current from DC coupled twenty strips
- AC coupled strips measured from bias ring
- Significantly lower B-D compared to diodes
- Lower b-d for AC coupled strips



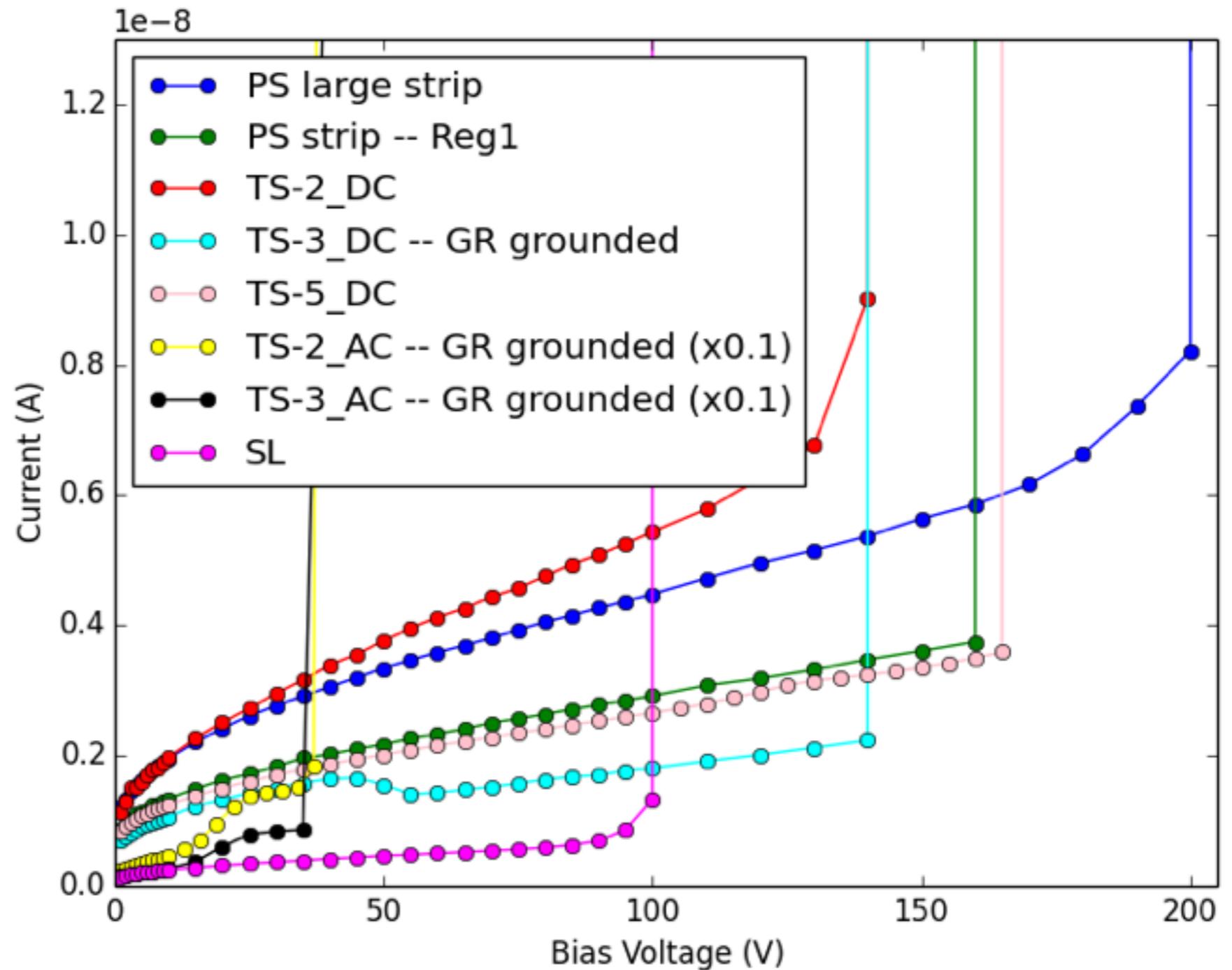
# PS Sensor Measurements

- First measurements compared
- B-D voltage drops 20-50V in the next measurements
- Uniform across different strips

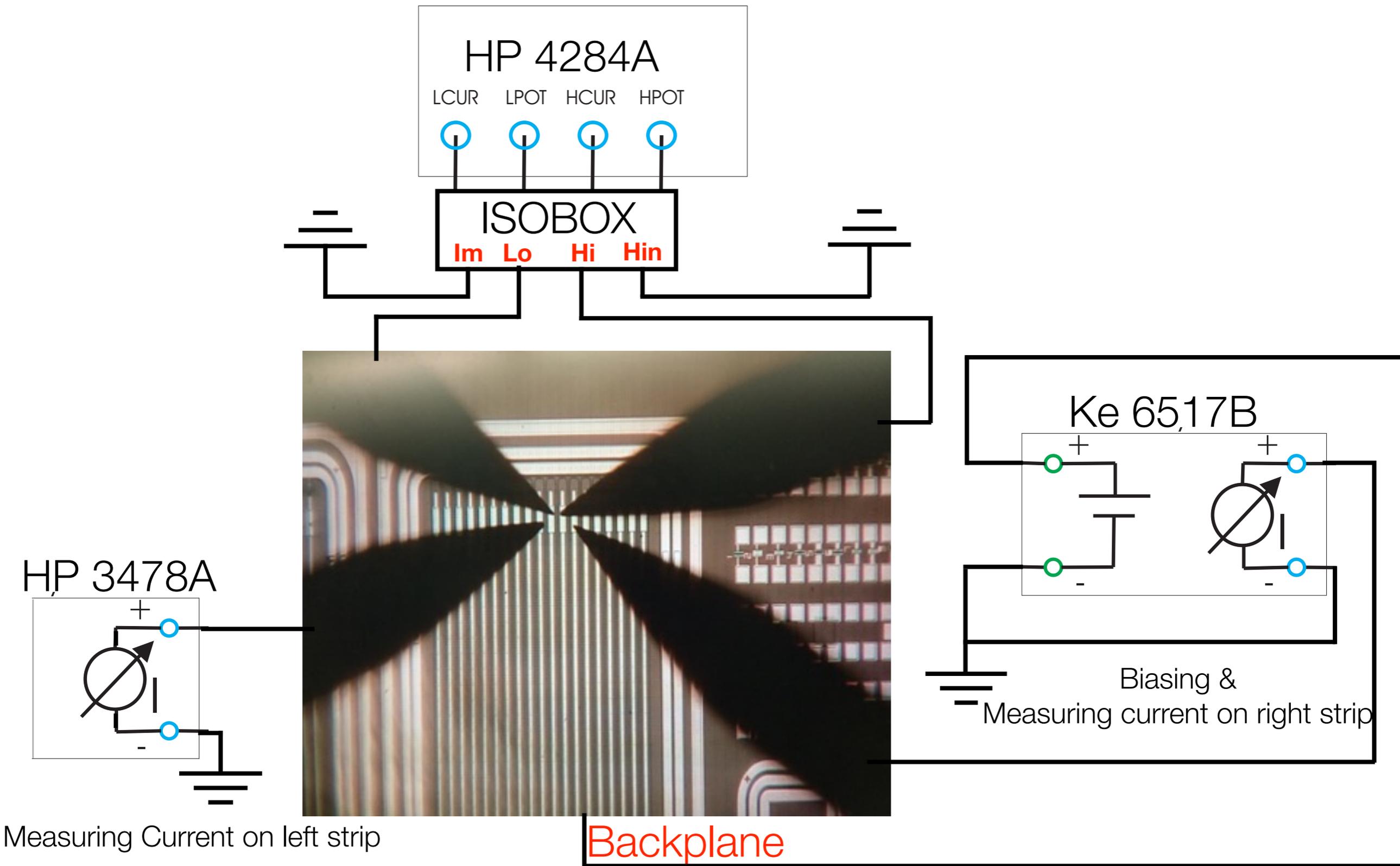


# Comparison of Strip Leakage Current Measurements

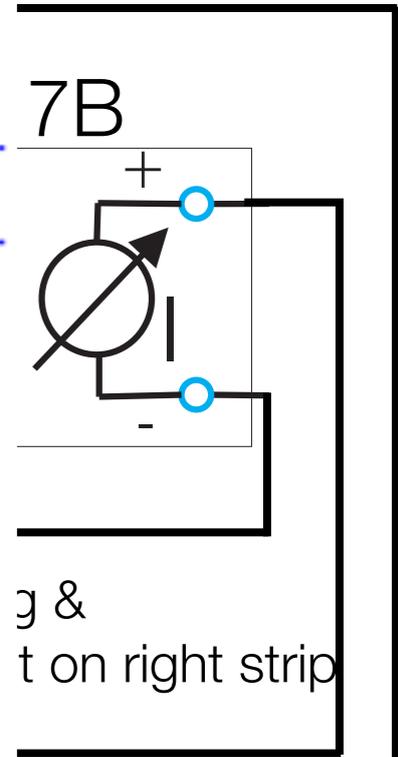
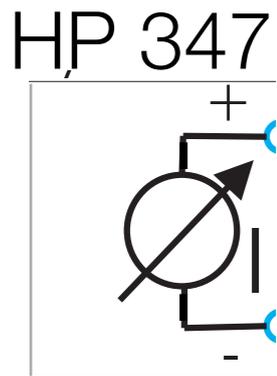
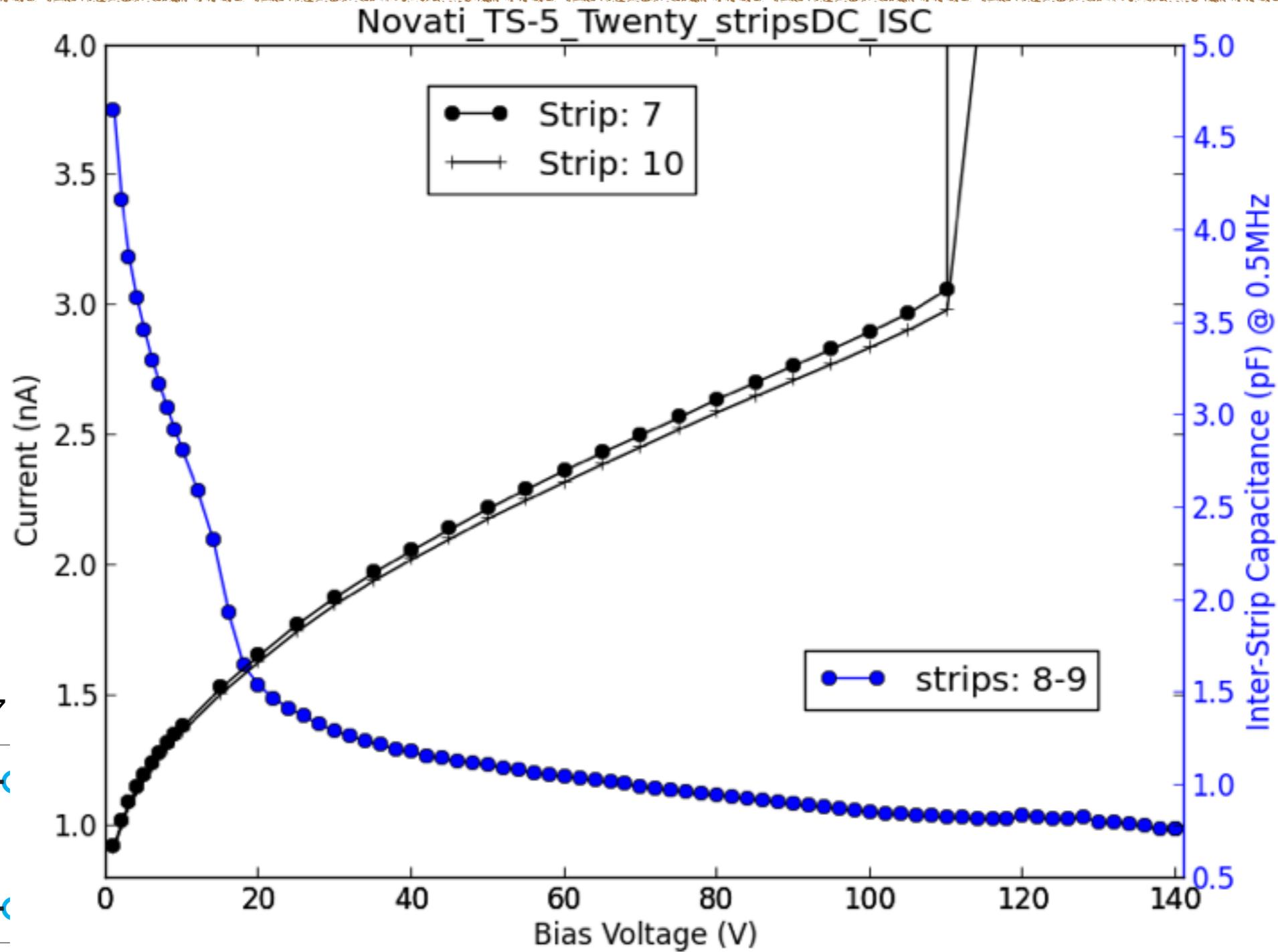
- Compare measurements from different structures with strips
- Sensor behavior is approximately uniform across different structures



# Inter-Strip Capacitance: DC Coupled Twenty Strips



# Inter-Strip Capacitance: DC Coupled Twenty Strips

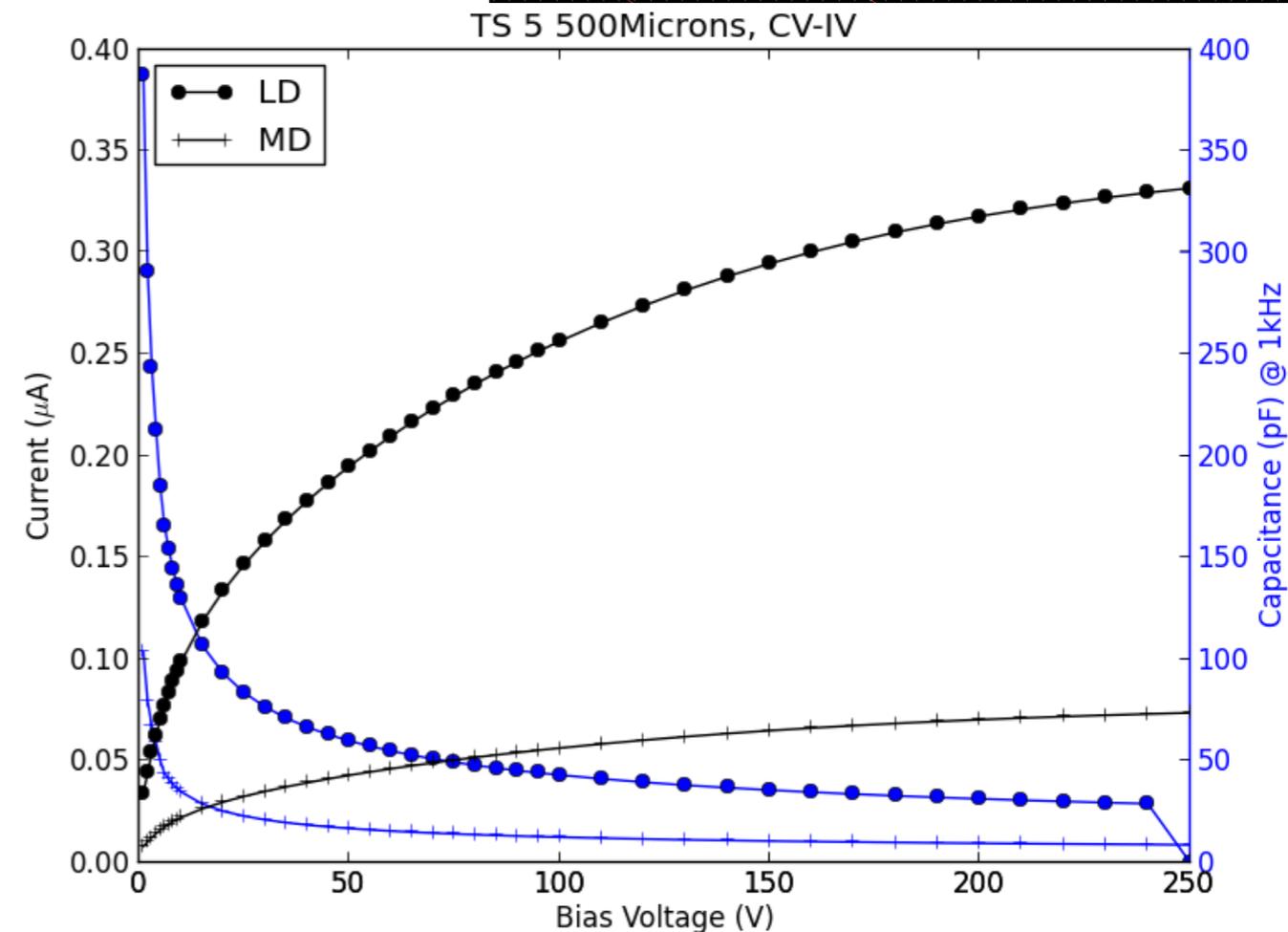
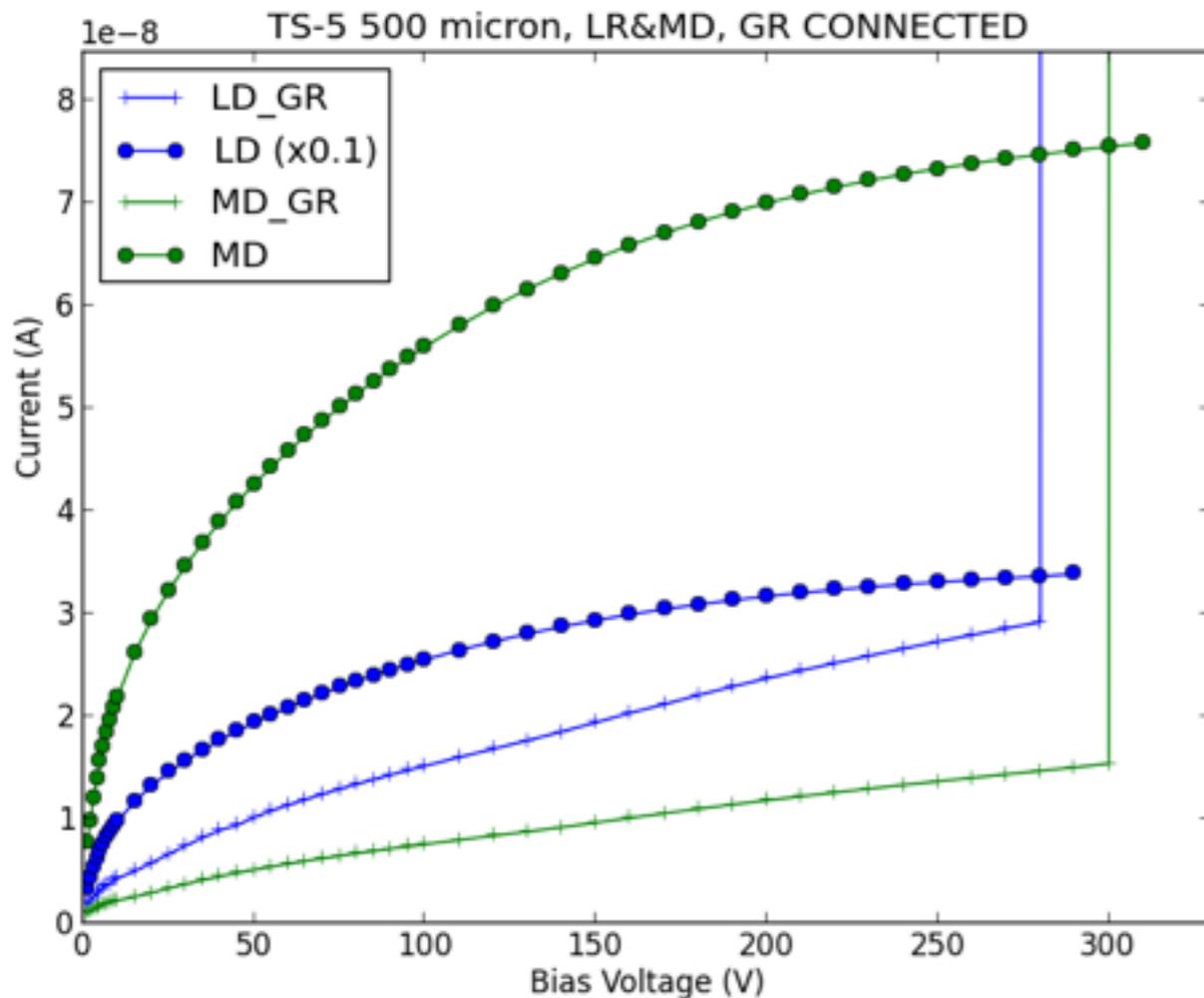
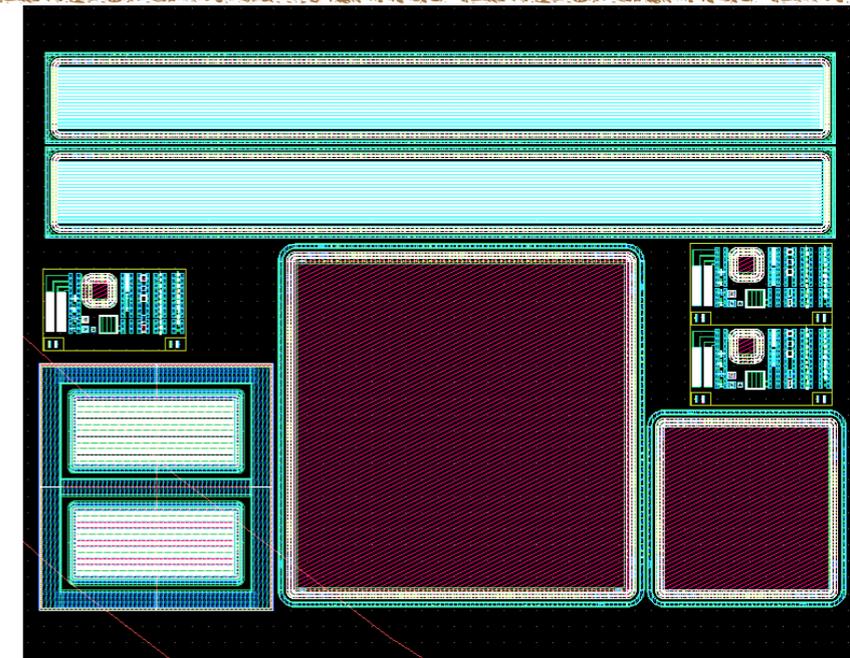


Measuring Current on left strip

Backplane

# Measurements on Diodes: TS5-500um

- Measurements on TS-5 thinned to 500um
- Structure diced from the wafer
- B-D voltage is significantly lower
- Diodes could not be depleted



# Measurements on Diodes: TS3-500um

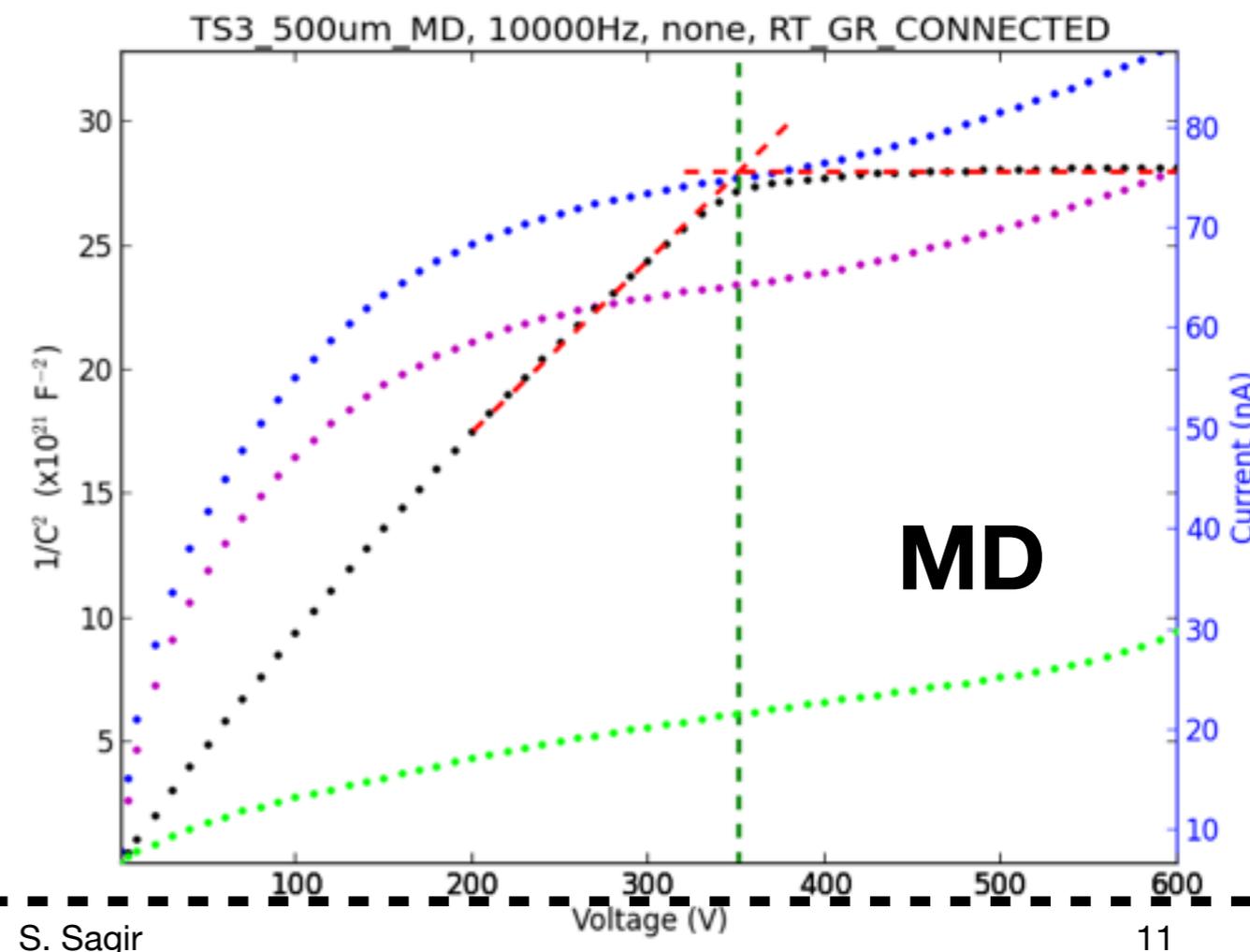
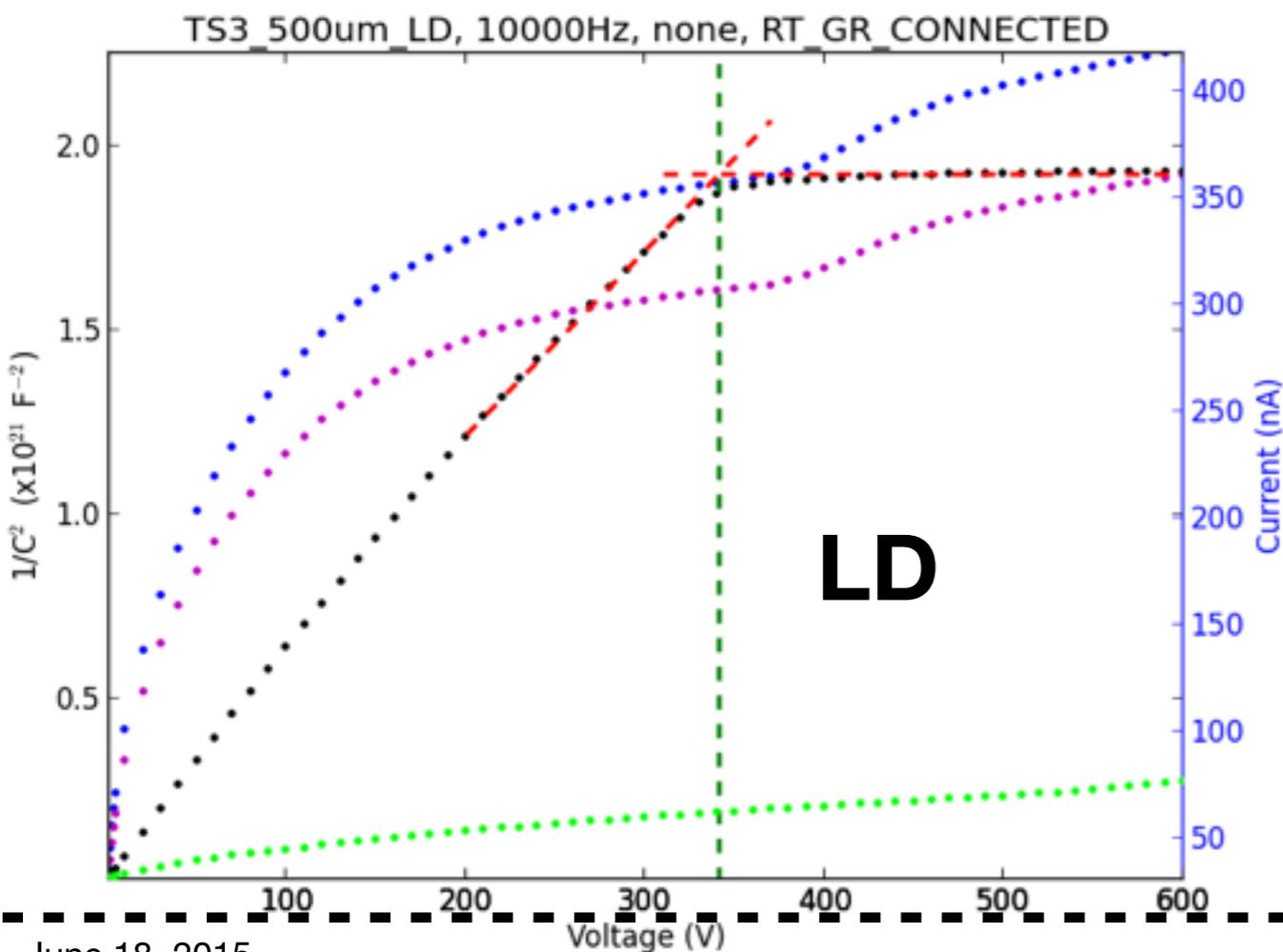
|  | MD        | LD        |
|--|-----------|-----------|
| Depletion Voltage (V)                                      | 351       | 341       |
| Leakage Current (nA) @20C                                  | 64        | 306       |
| End Capacitance (pF)                                       | 6         | 23        |
| Thickness ( $\mu\text{m}$ )                                | 441       | 462       |
| Effective Doping Concentration ( $10^{11}\text{cm}^{-3}$ ) | 24        | 21        |
| Resistivity ( $\text{k}\Omega\text{cm}$ )                  | 5.7 (7.4) | 6.5 (7.6) |

$$d = \frac{\epsilon\epsilon_0 A}{C_{end}}$$

$$|N_{eff}| = \frac{2\epsilon\epsilon_0 V_{dep}}{e d^2}$$

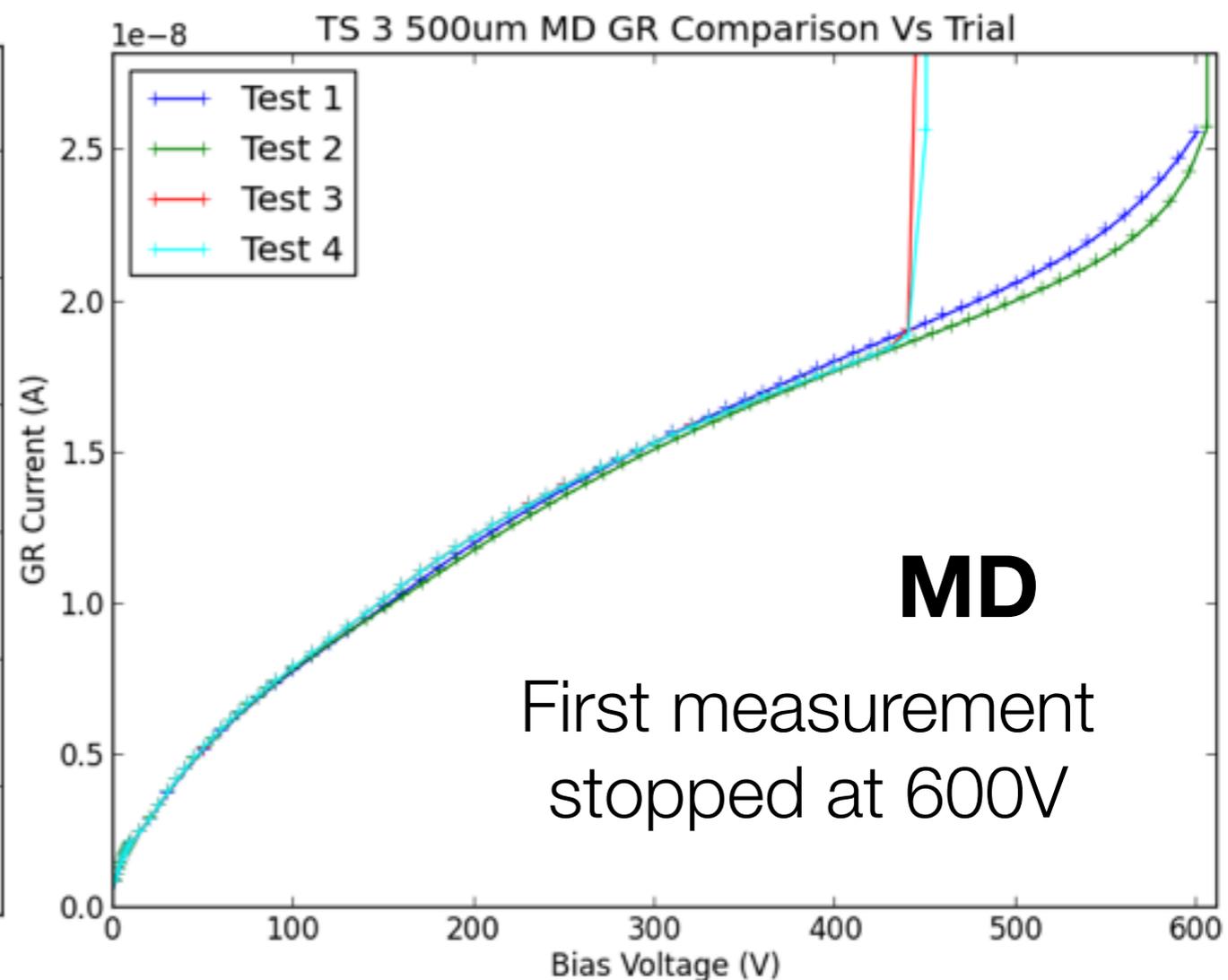
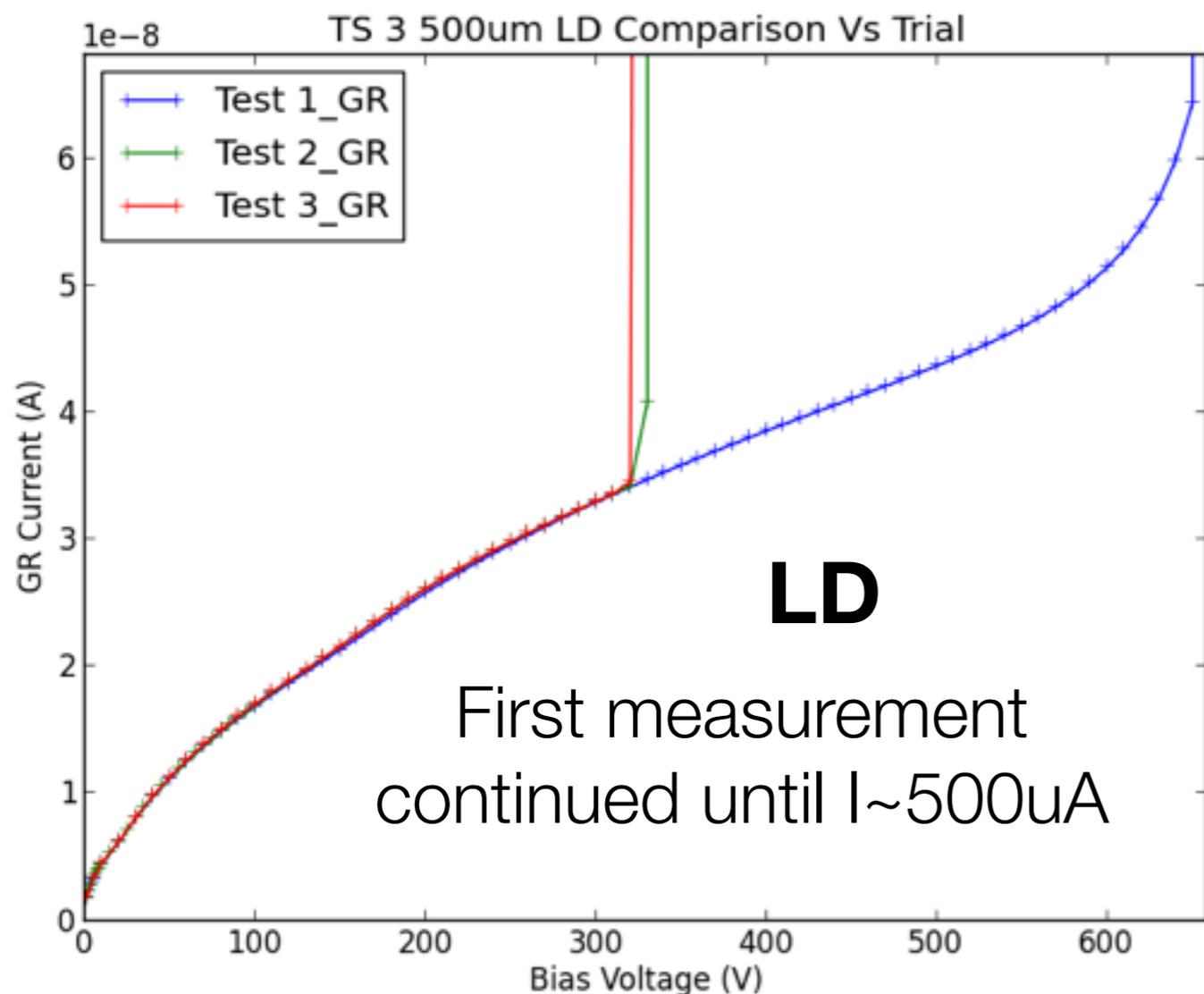
$$\rho = \frac{1}{e\mu_{e,h} |N_{eff}|}$$

(thickness fixed to 500 $\mu\text{m}$ )



# Measurements on Diodes: TS3-500um

- We repeat the IV measurements on TS-3 structure
- After the first measurement, b-d voltage drops down to  $\sim 300\text{V}$  (LD) and  $\sim 400\text{V}$  (MD) and diodes can no longer be depleted



# Summary

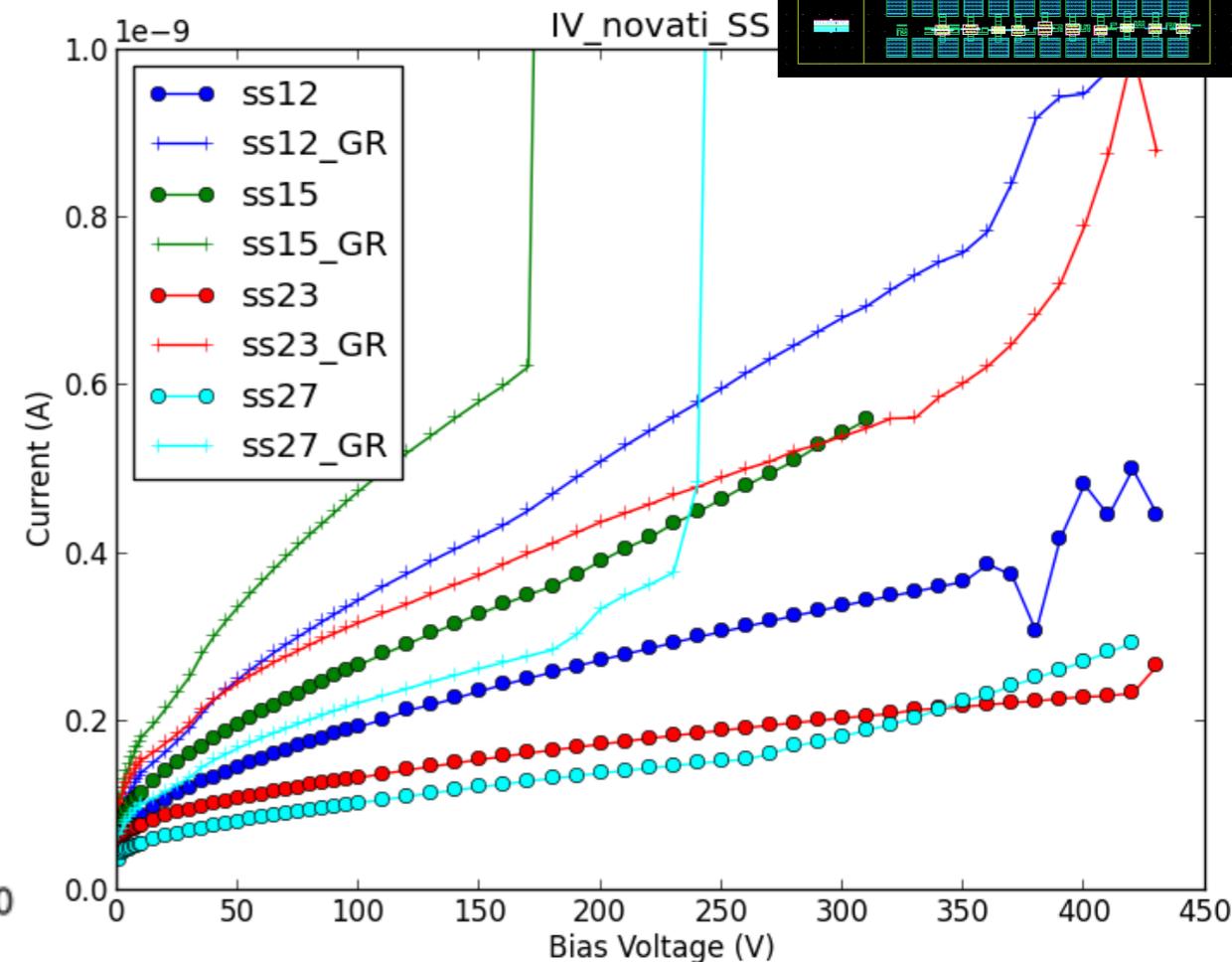
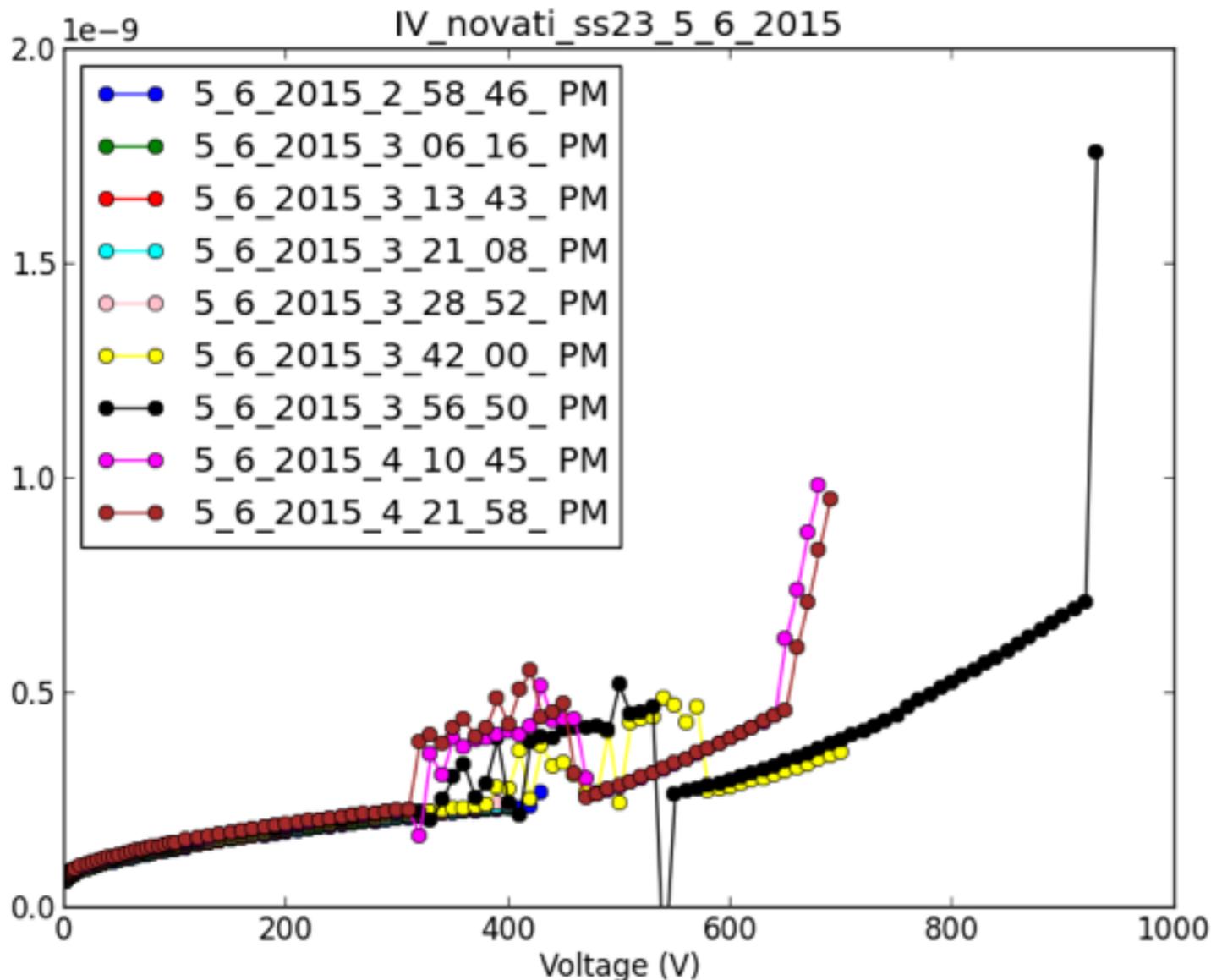
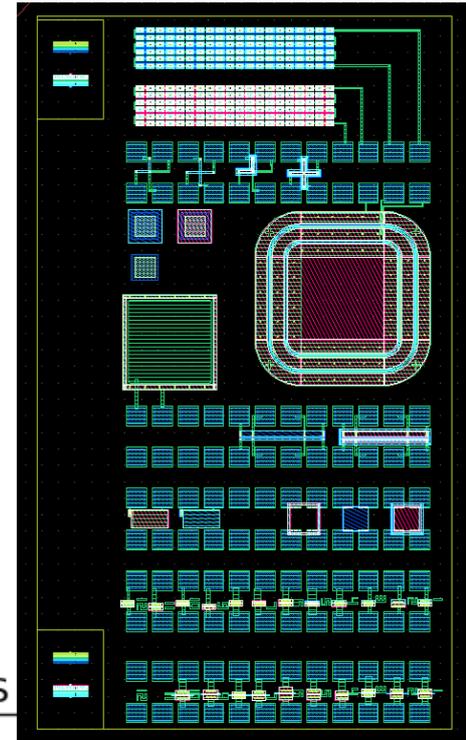
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- Studied several structures on Novati wafer; SS, TS, PS, CL, SL, HGC
- Diodes work well for the first measurement— depletion achieved with thinned sensors to 500  $\mu\text{m}$
- Lowering of b-d voltage as the measurements repeated
  - Break-down happens very suddenly, resulting in very high current
  - Drop in b-d voltage is dependent on high current in previous measurements
- Strips break-down very early:  $\sim 100\text{V}$  —depletion won't be possible even after thinning
- Strips behave approximately the same across different structures
- Inter-strip capacitance is within acceptable range  $\sim 1\text{ pF}$

**BACKUP**

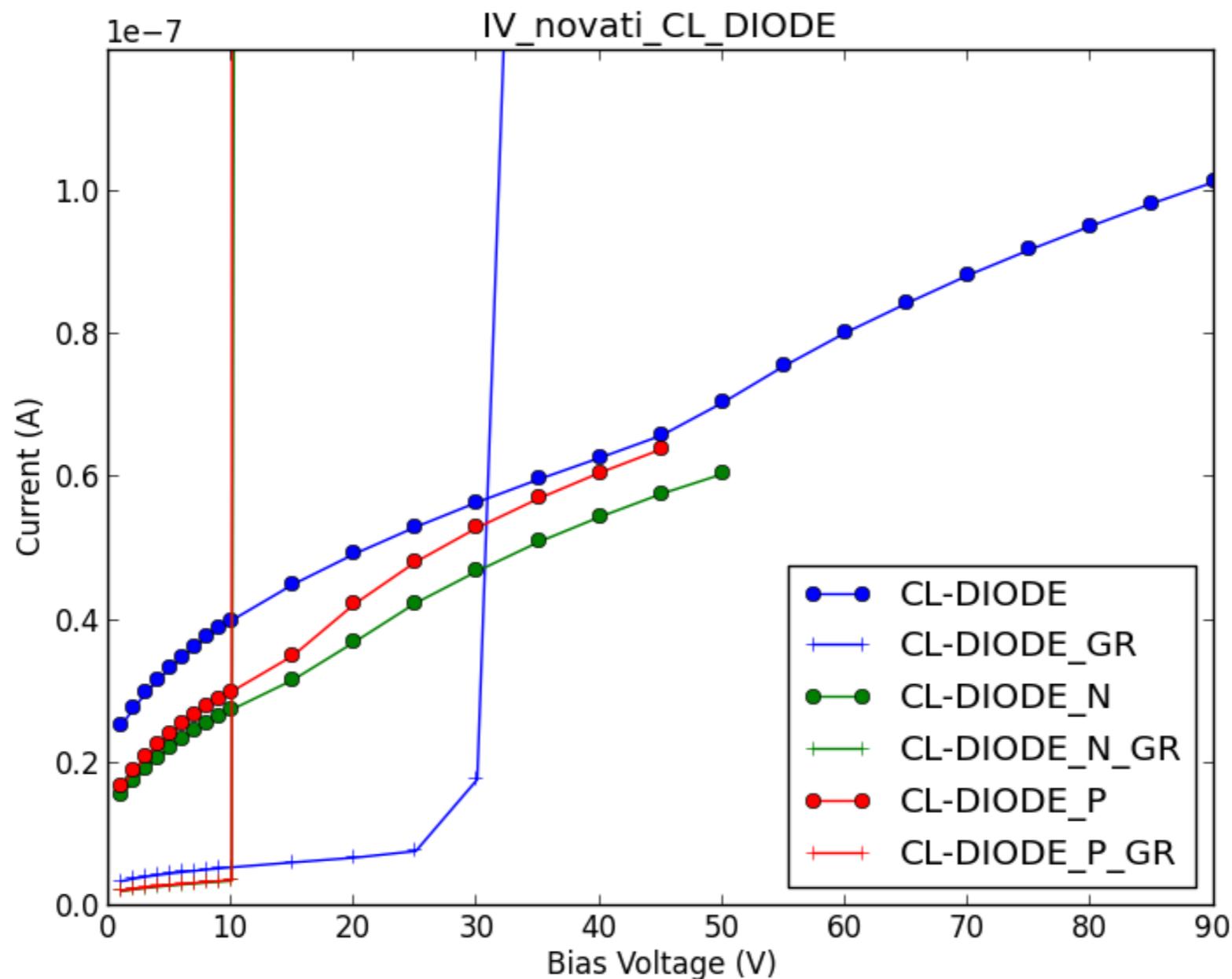
# Diode IV Characteristics: SS

- Diode in small test structure
- Current becomes rough around 300V and smooths out again until break-down
- Break-down voltage drops as the measurements repeated

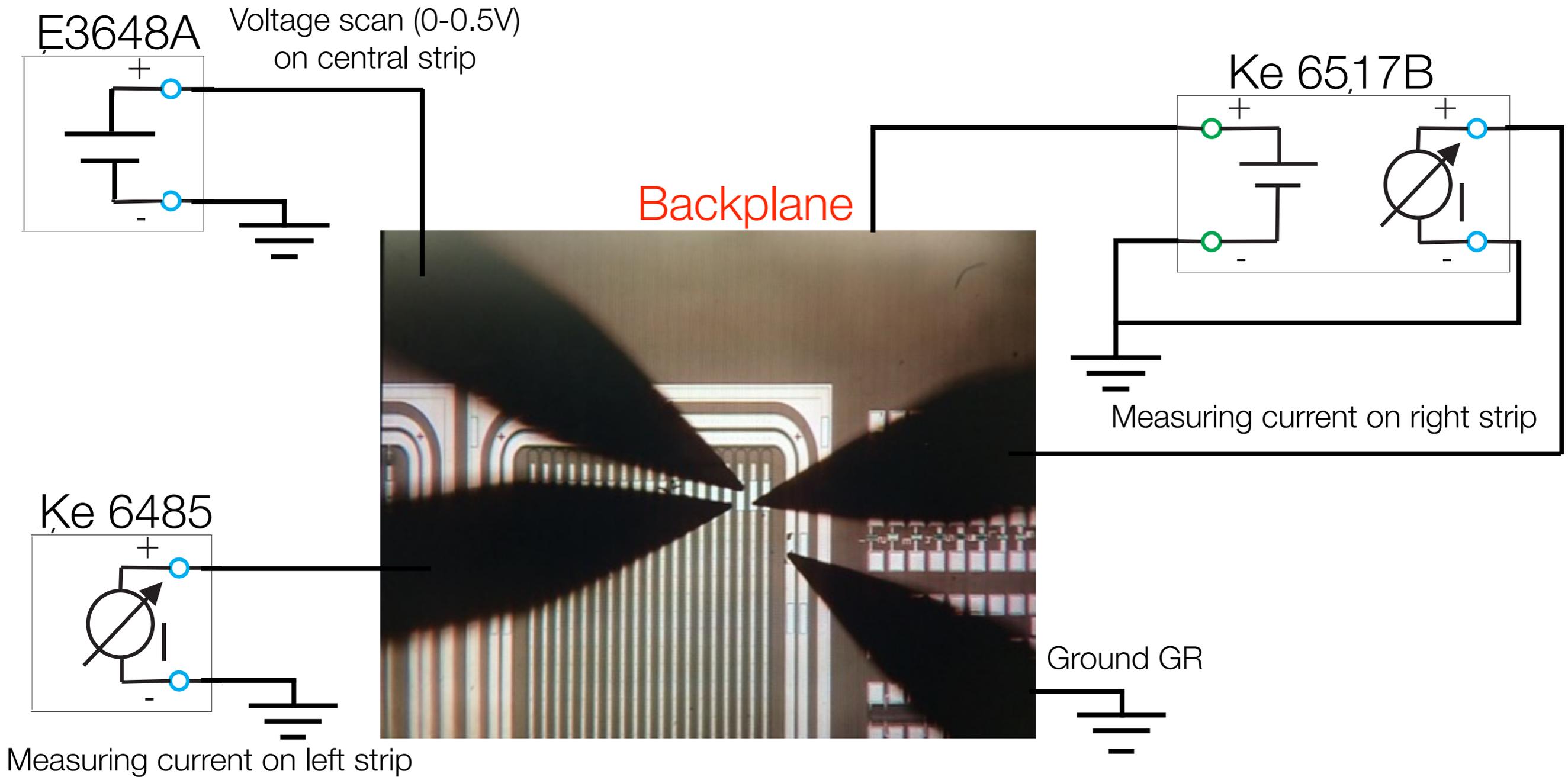


# Diode IV Characteristics: CL

- Diodes in CL Structure
- GR breaks-down around 10V and 30V

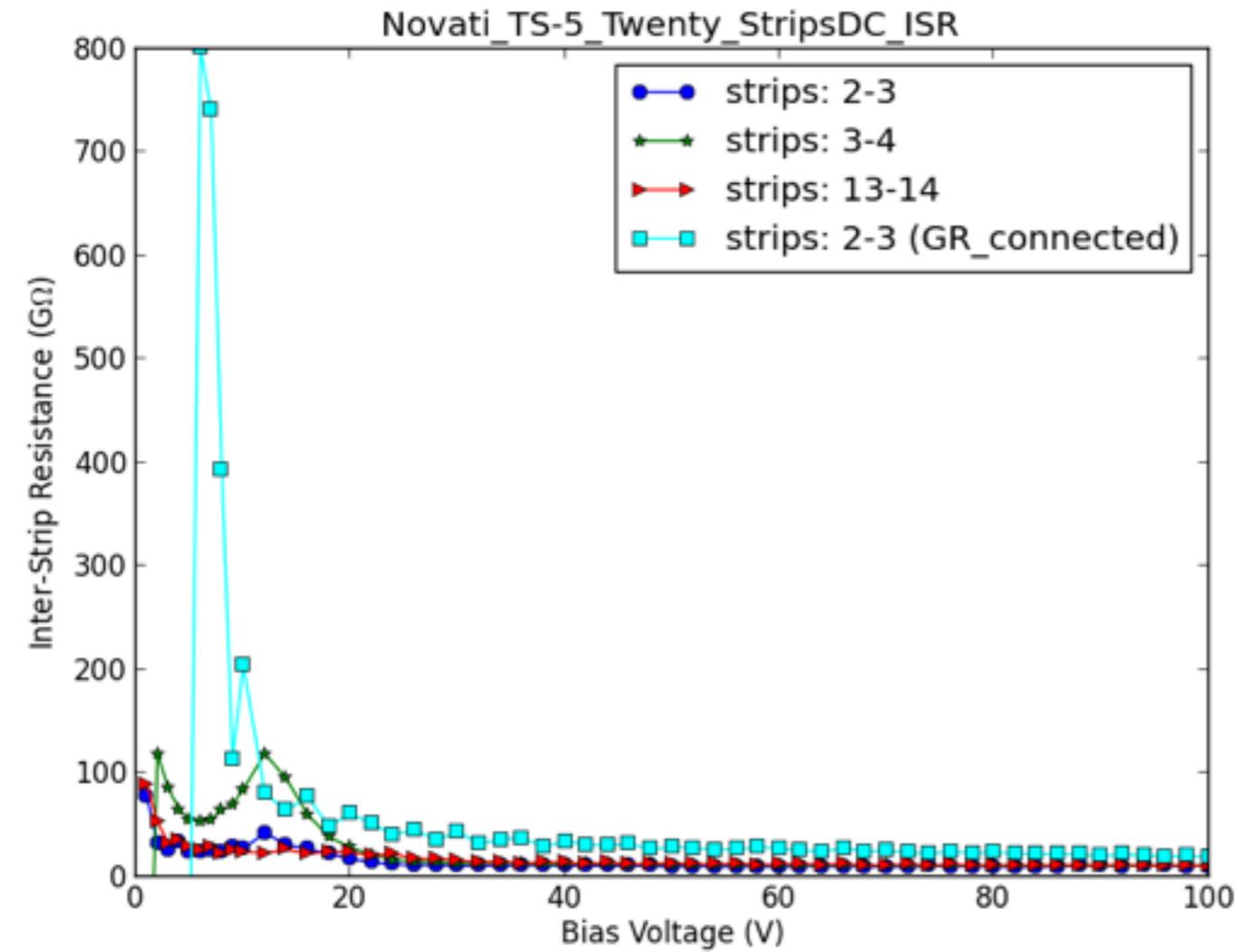


# Inter-Strip Resistance Measurement Schematic

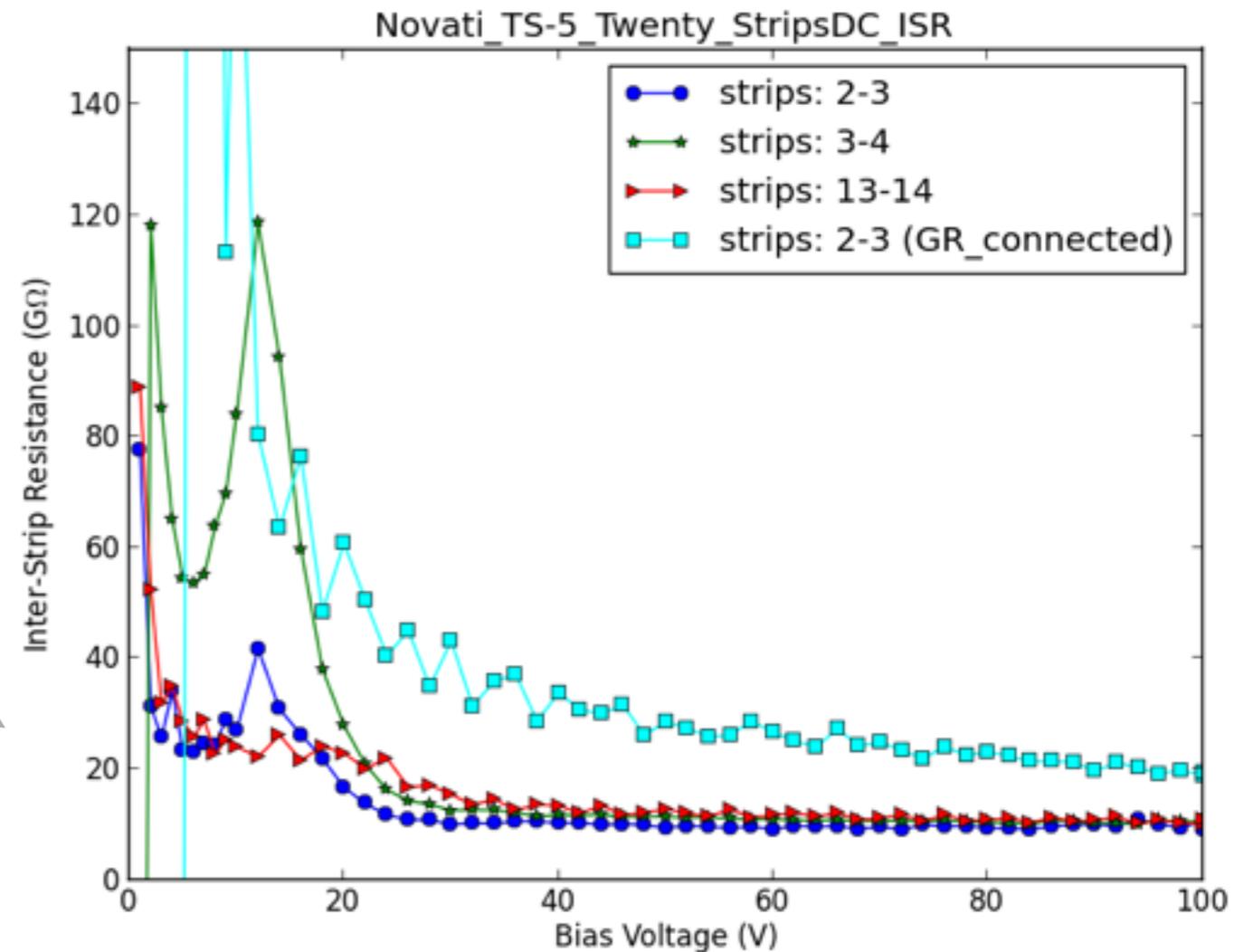


# Inter-Strip Resistance: TS-5/Twenty Strips DC

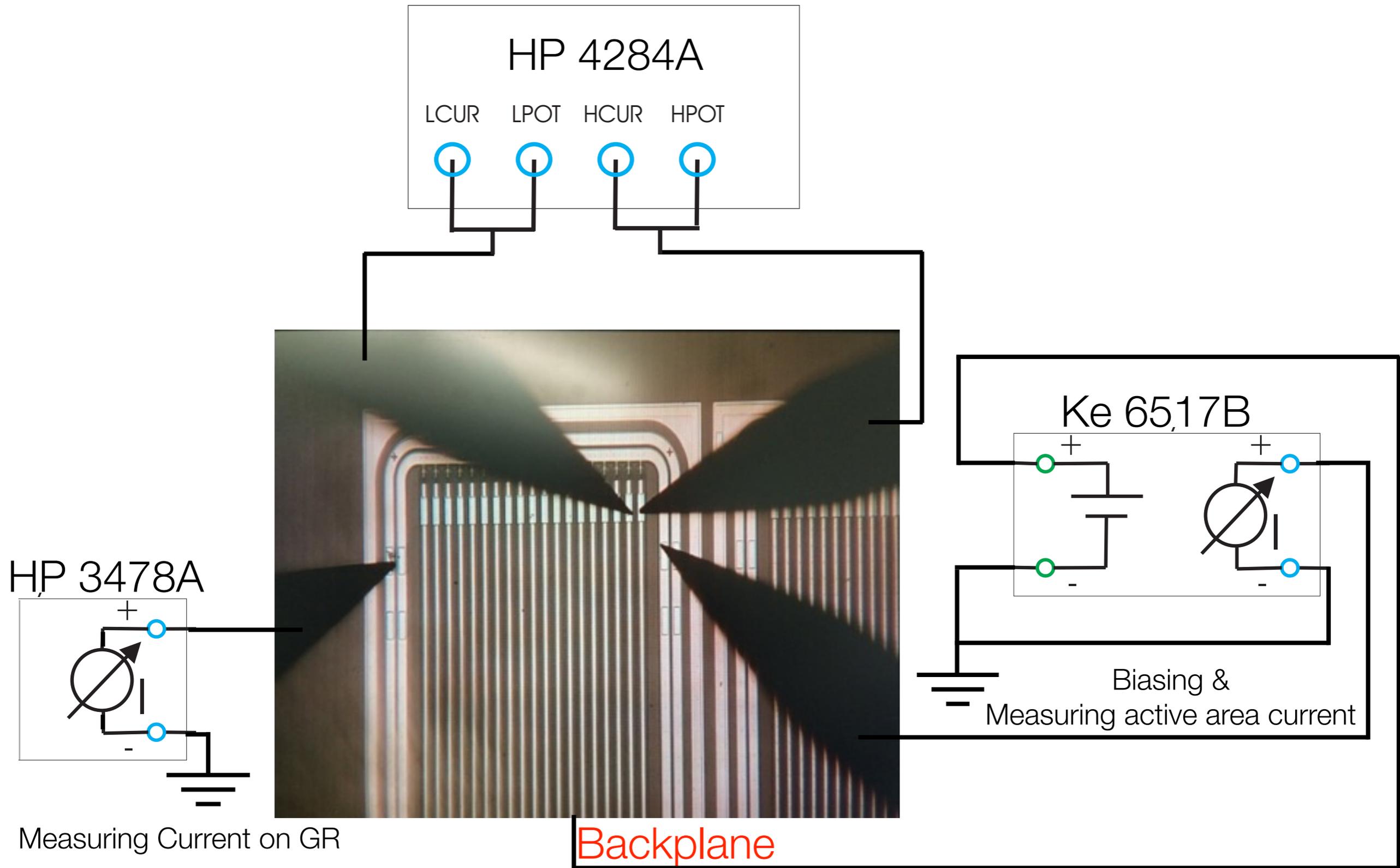
$$R_{int} = \left( \frac{d_I}{d_V} \right)^{-1}$$



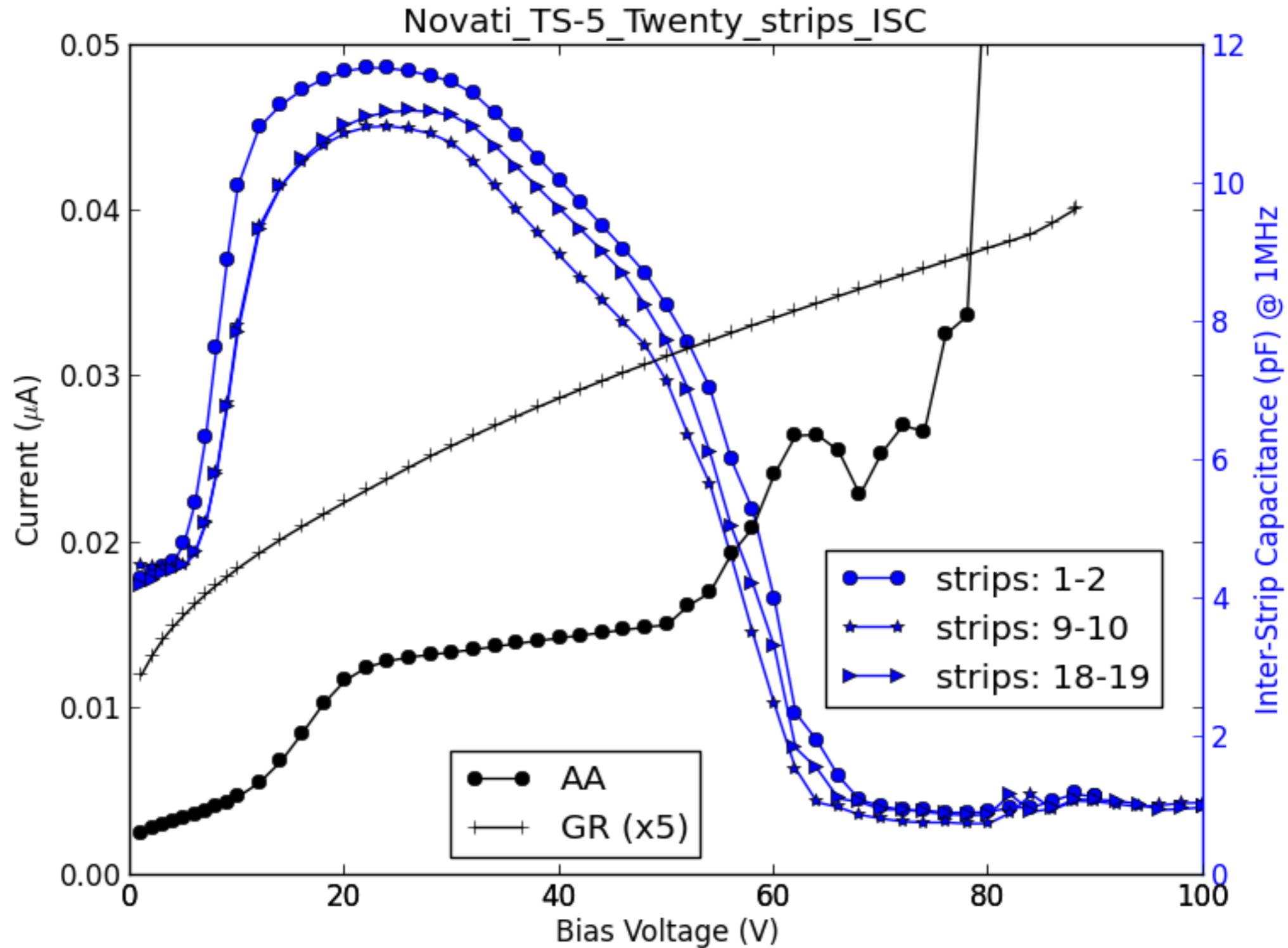
Zoom-in



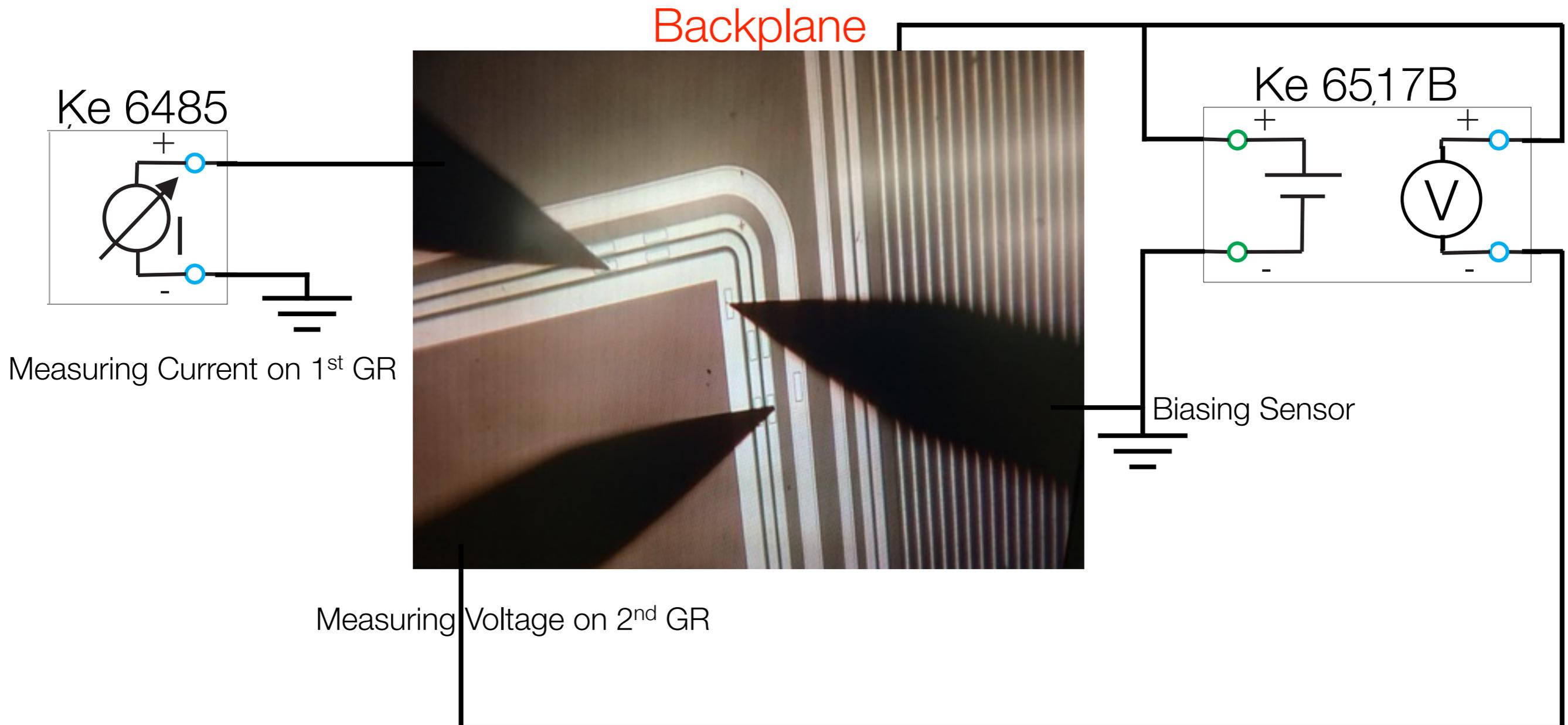
# Inter-Strip Capacitance Measurement w/ Bias Ring (AC)



# Inter-Strip Capacitance Measurement w/ Bias Ring



# Potential Measurement on the 2nd GR



# Potential Measurement on the 2nd GR

