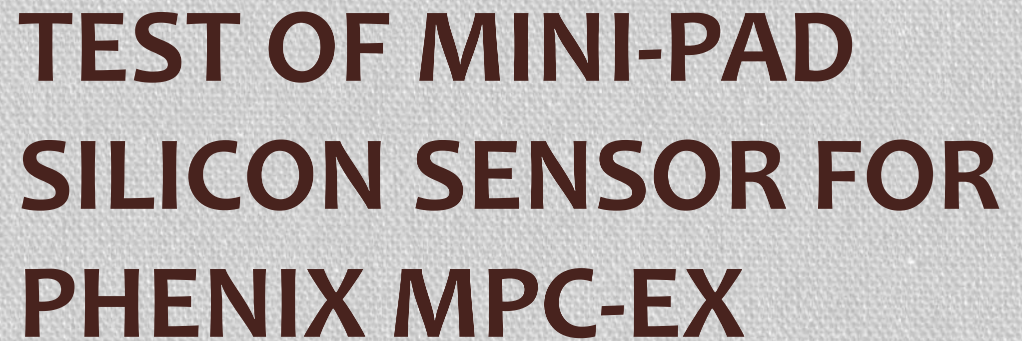


TEST OF MINI-PAD SILICON SENSOR FOR PHENIX MPC-EX

Dahee Kim

(Ewha womans university)

for MPC-EX collaboration

Contents

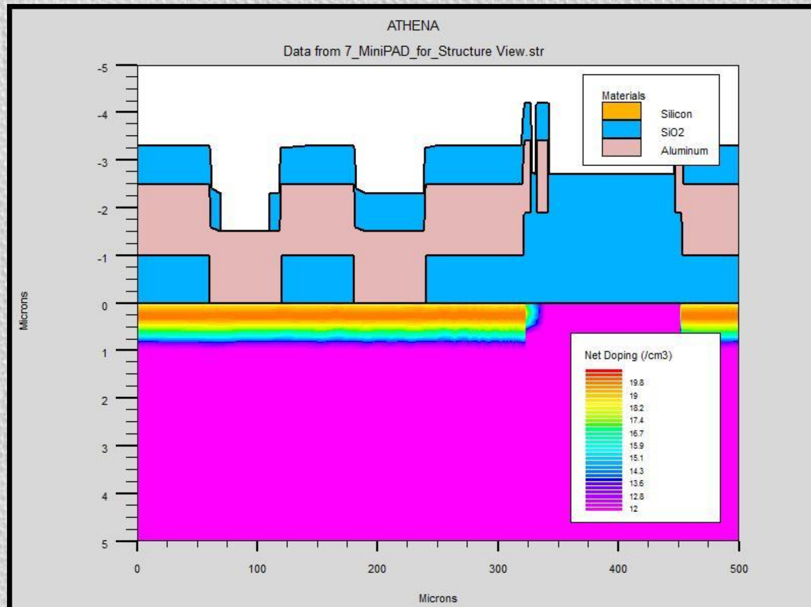
- We report test results of prototype silicon sensors for PHENIX MPC-EX. We describe basic theory and suggest key tests for silicon sensor.

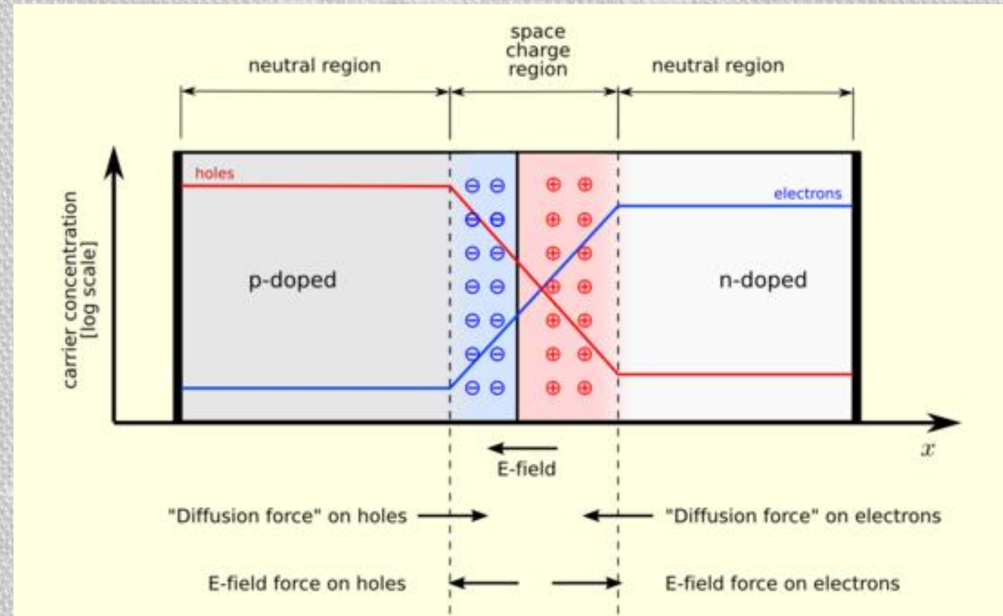
  Suggested and reported key tests are

  - CV characteristics
  - IV characteristics
  - & Electric circuitry test

Basic theory

- Operation of PIN sensor.
- Electron-hole generation & depletion region.



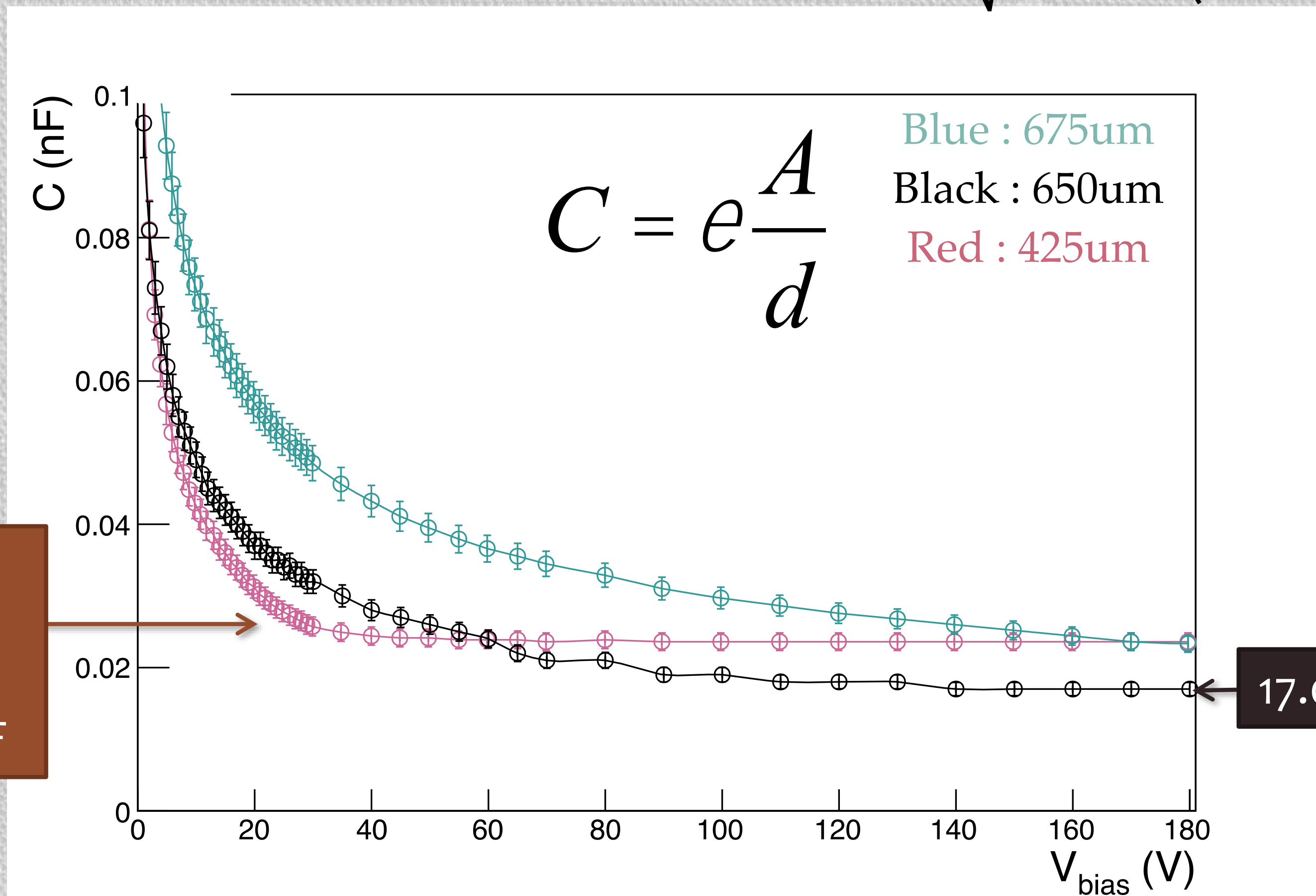


$$d = \sqrt{2\, rme\left(V + V_{bi}\right)}$$

Capacitance

- Relation to depletion thickness.

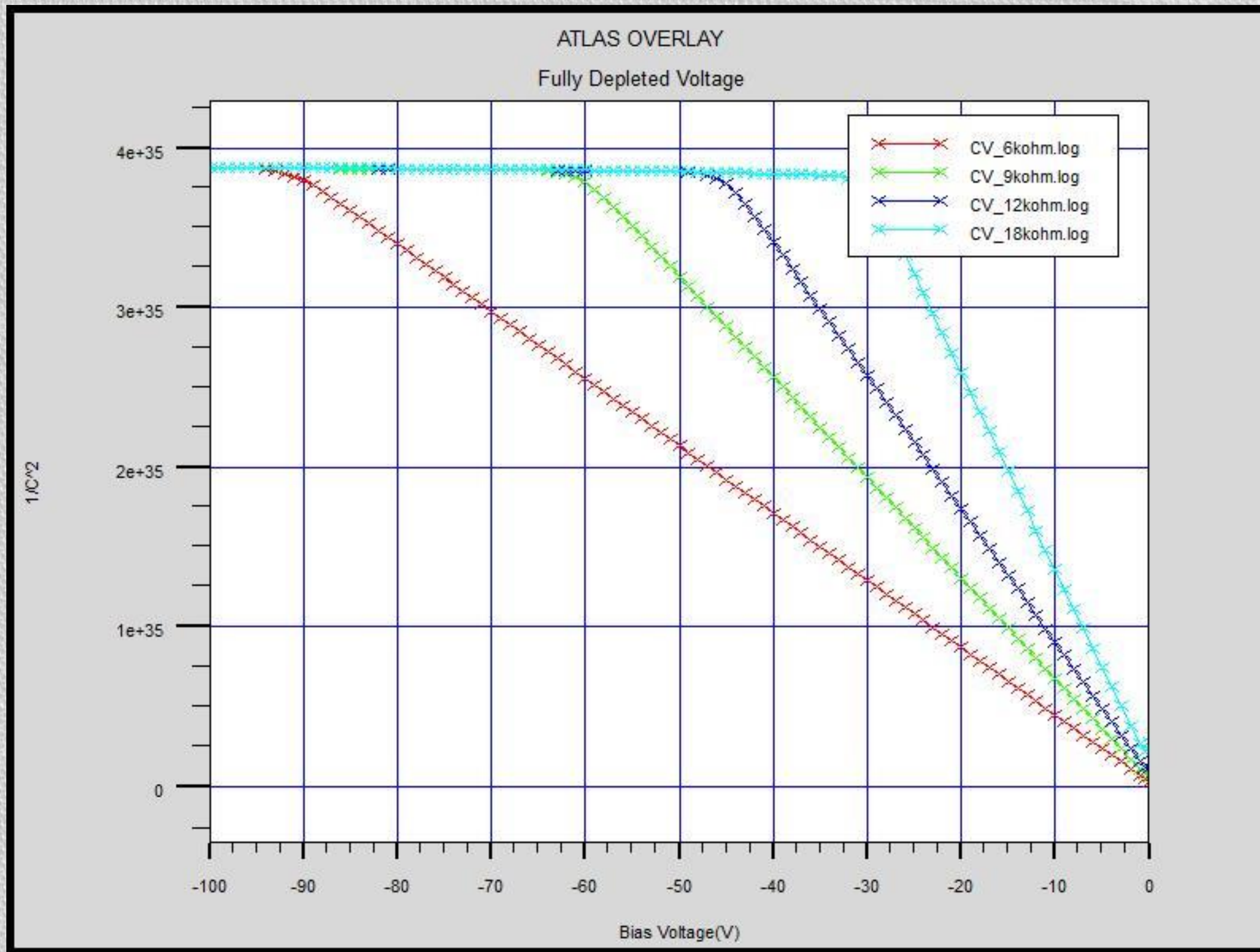
$$d = \sqrt{2 r m e \left(V + V_{bi}\right)}$$



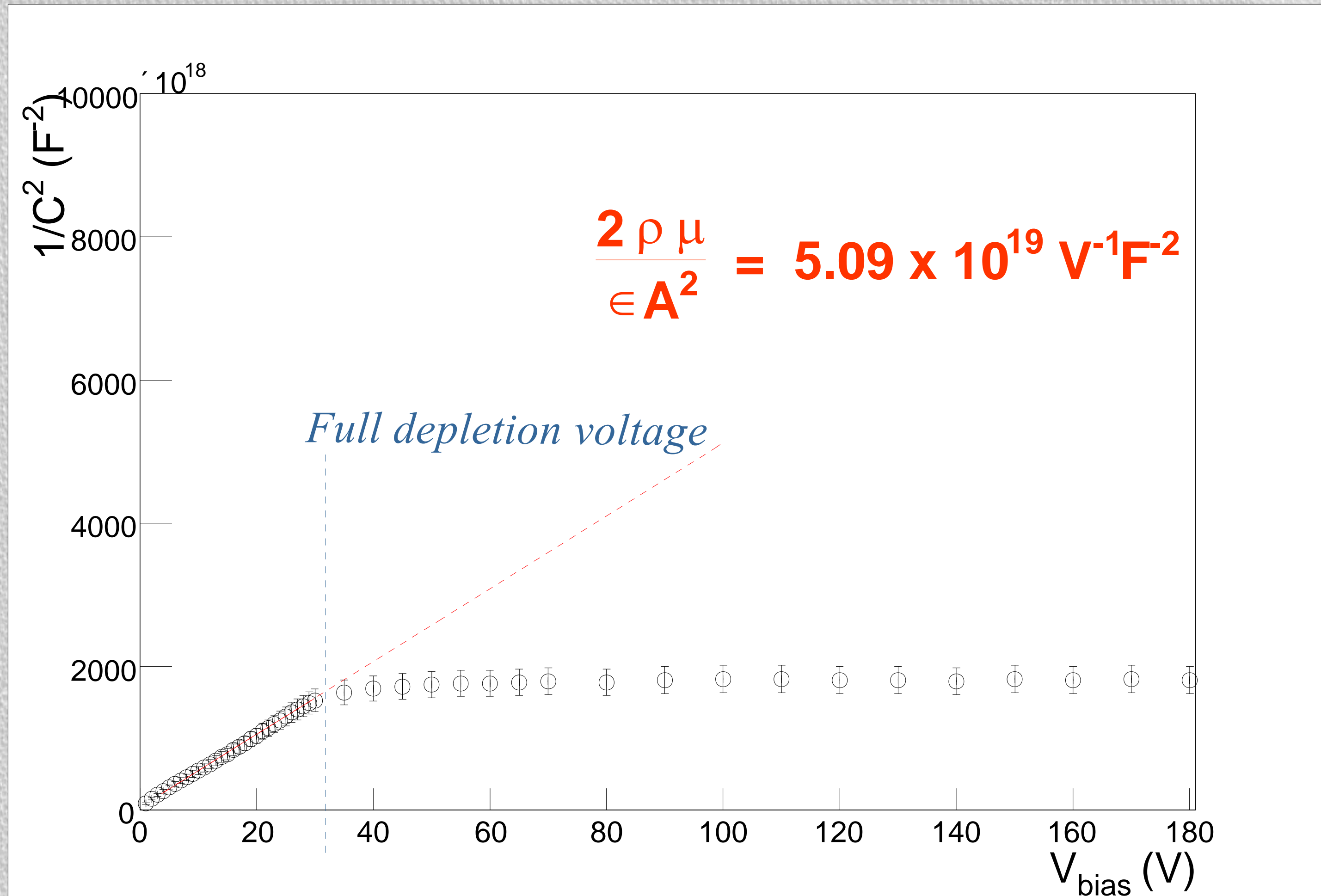
Full depletion region is about 23.5pF

17.0pF

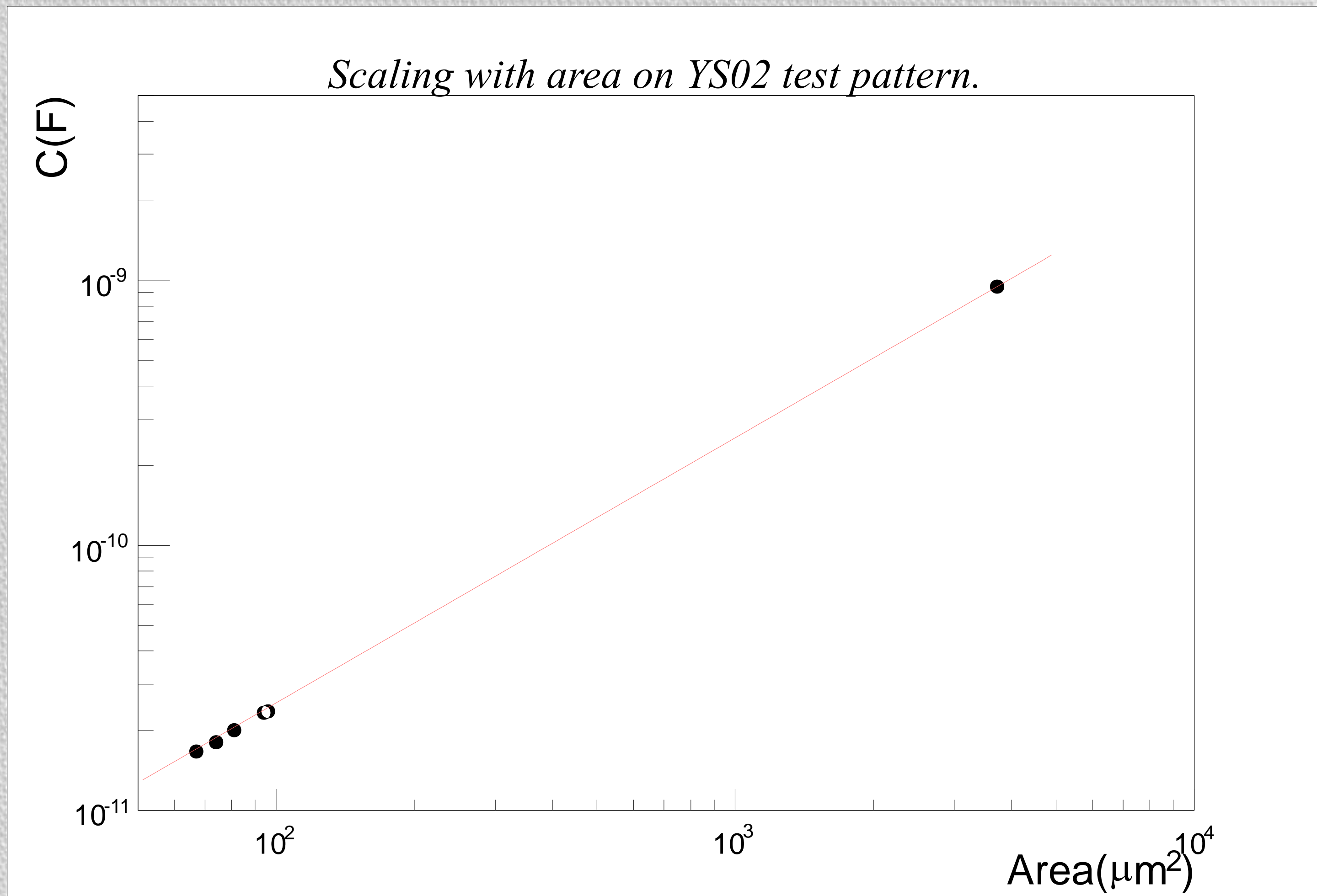
Simulation about CV characteristic



Capacitance



- Scaling with area on test pattern.

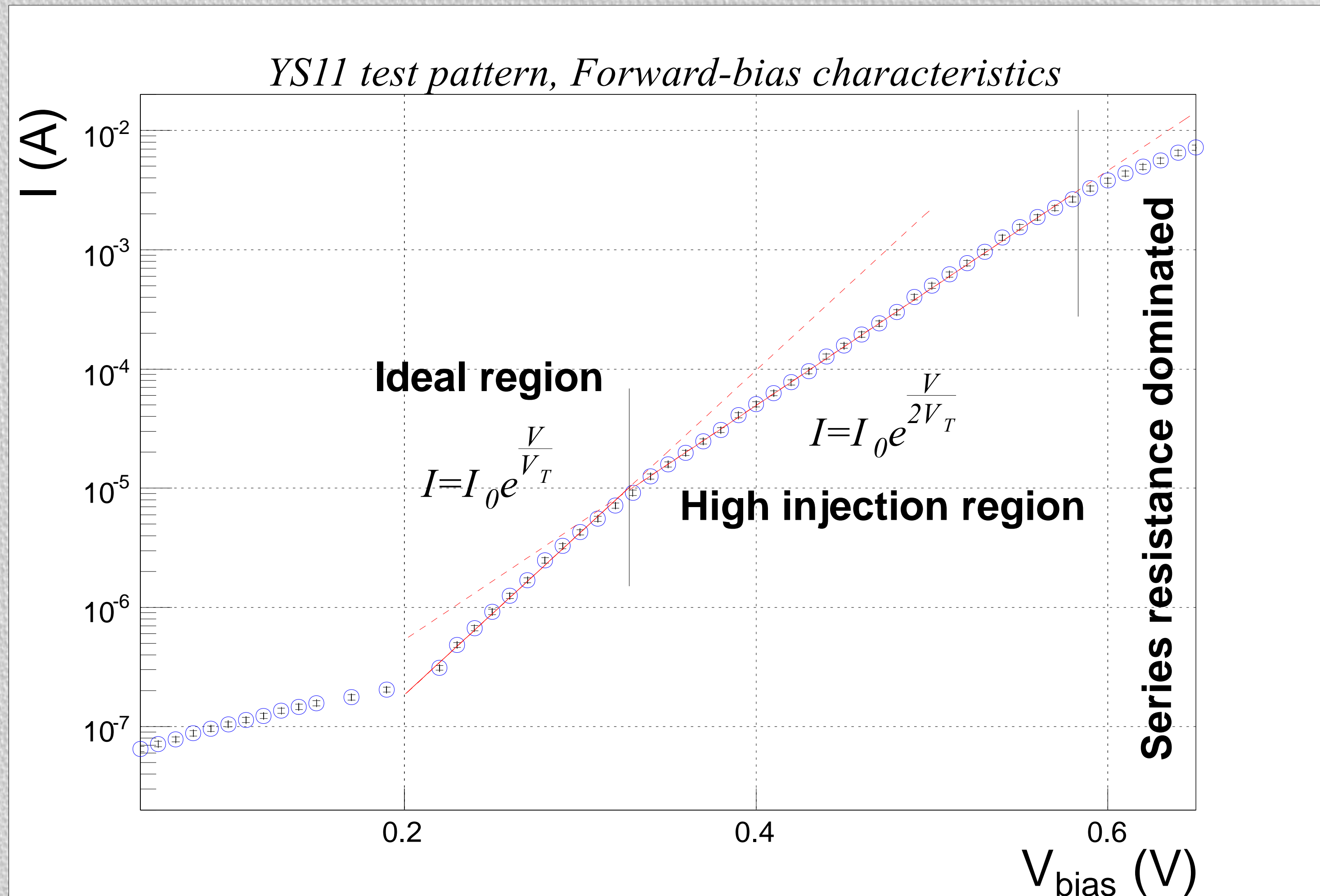


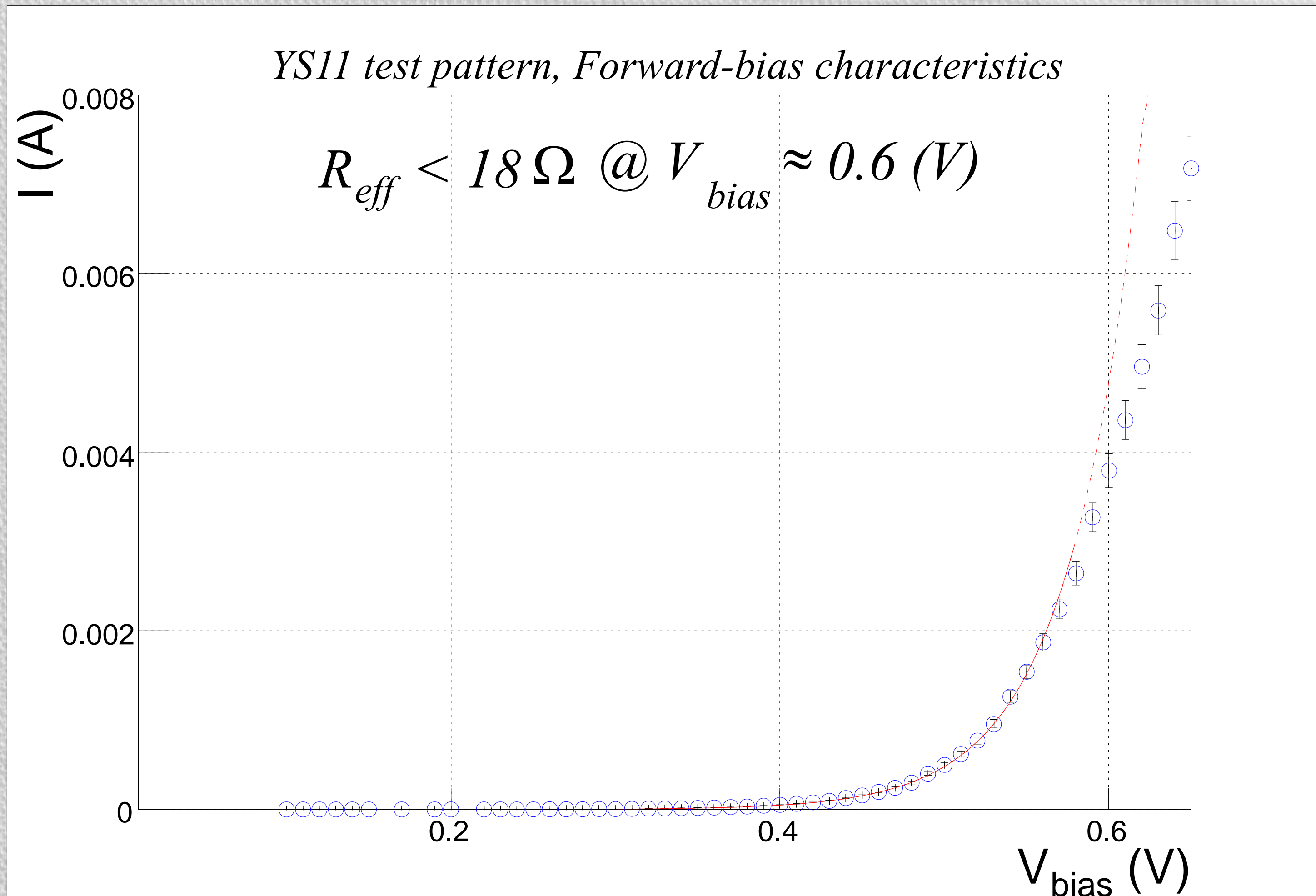
Current

- Shockley diode equation(Ideal case)
- $I = I_0(e^{\frac{V}{V_T}} - 1)$ $V_T = \frac{kT}{q} = 26mV$ at 300K

  $V > 4V_T = 0.1(V) \rightarrow I \approx I_0 e^{\frac{V}{V_T}}$
- Simplifying idealization (drift, diffusion, thermal recombination-generation).
- Not considered
  : Surface leakage current, high injection, defect etc.
- With high injection(large I), $I = I_0 e^{\frac{V}{V_T}} \rightarrow I_0 e^{\frac{V}{2V_T}}$

Forward bias current



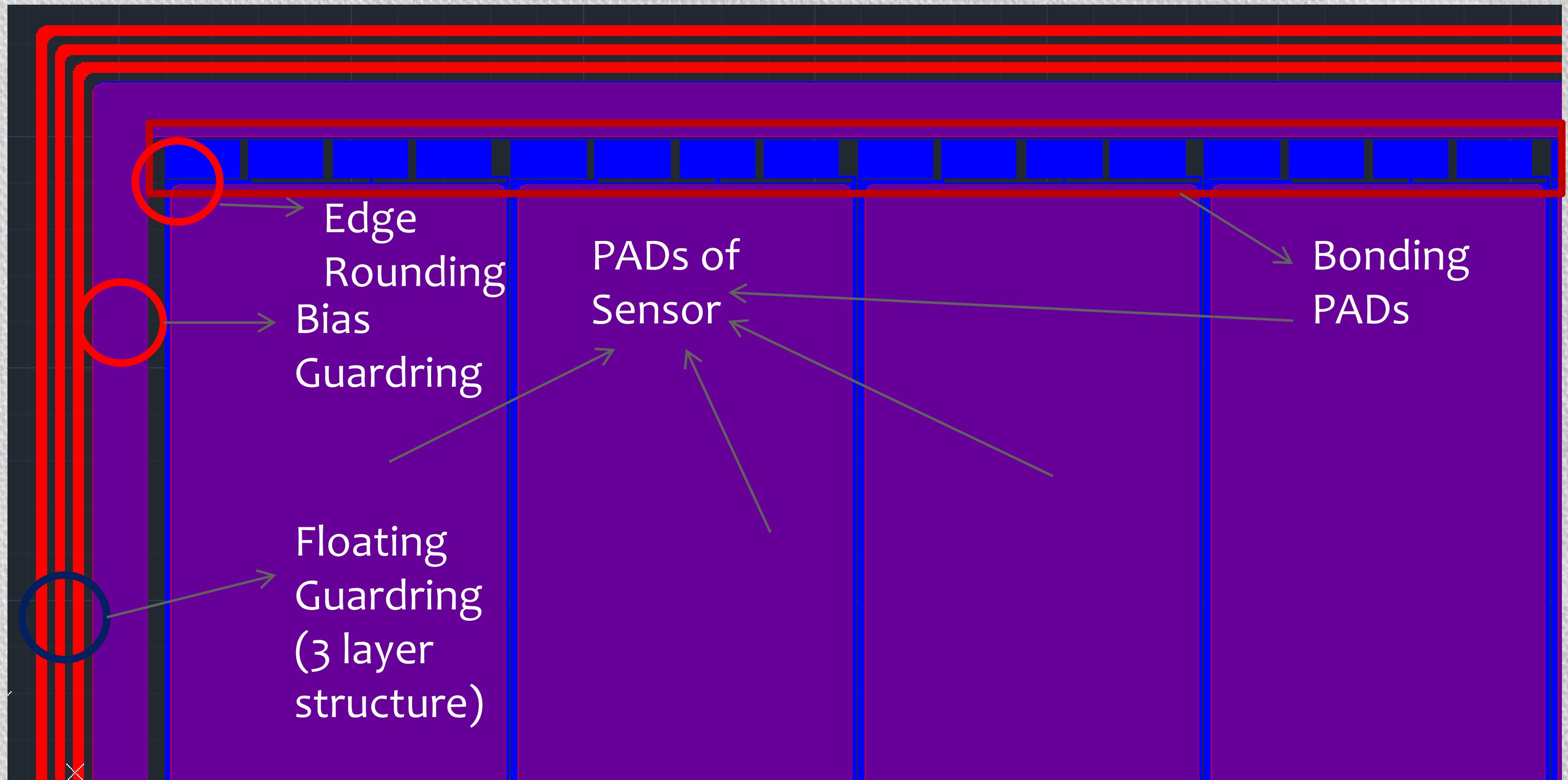


$$\frac{dV}{dI} = R = R_{diode} + R_{ext} = \frac{2V_T}{I} + R_{ext} \rightarrow R_{ext} \quad (V \rightarrow \infty)$$

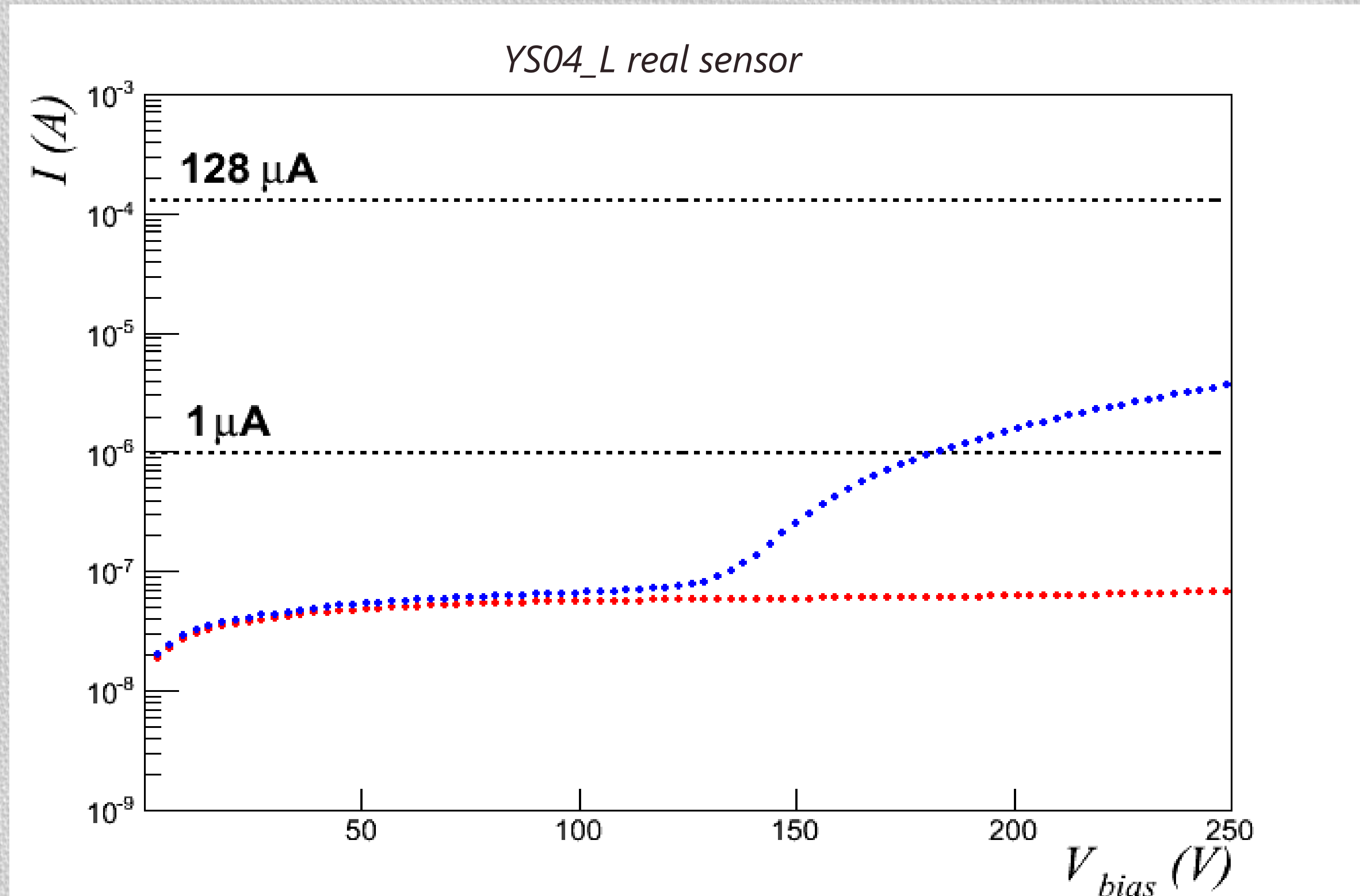
Reverse bias current(Leakage current)

- Source of leakage current
  - Volume term
    - Thermal recombination-generation leakage current
    - Defect
  - Surface leakage current
  - Radiation(include light and cosmic ray etc..)

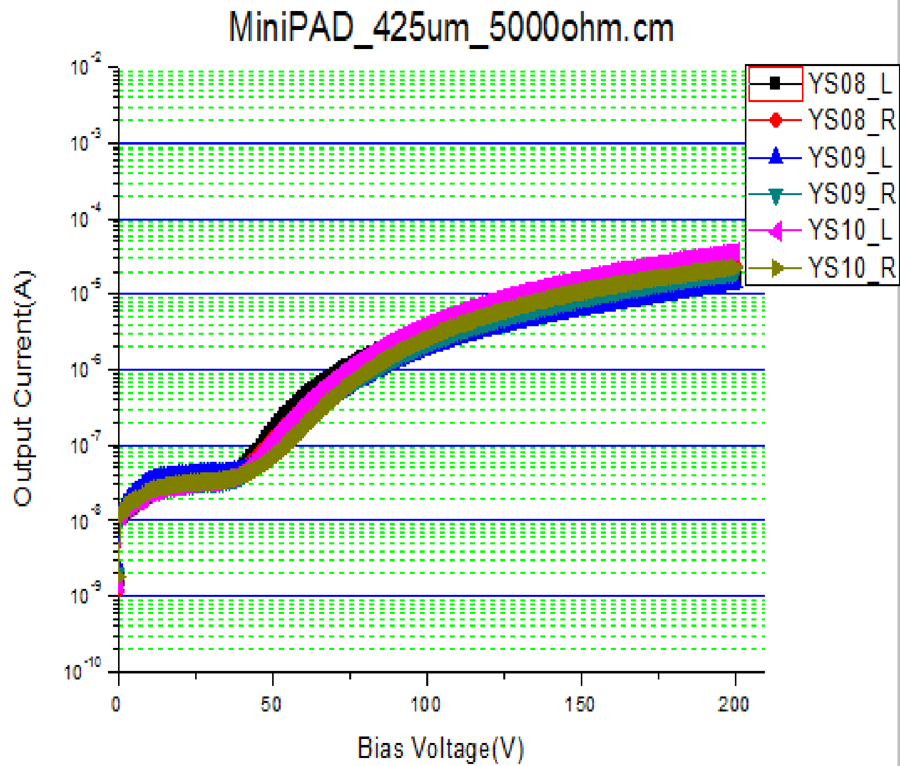
Guard ring structure

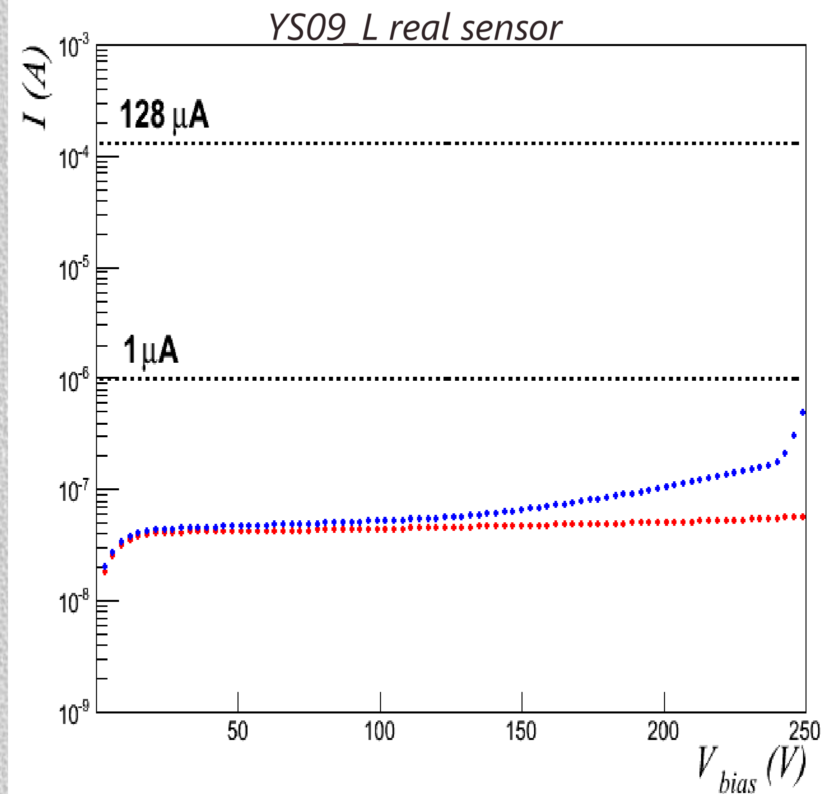


Effect of Bias Guard Ring



Effect of Dicing



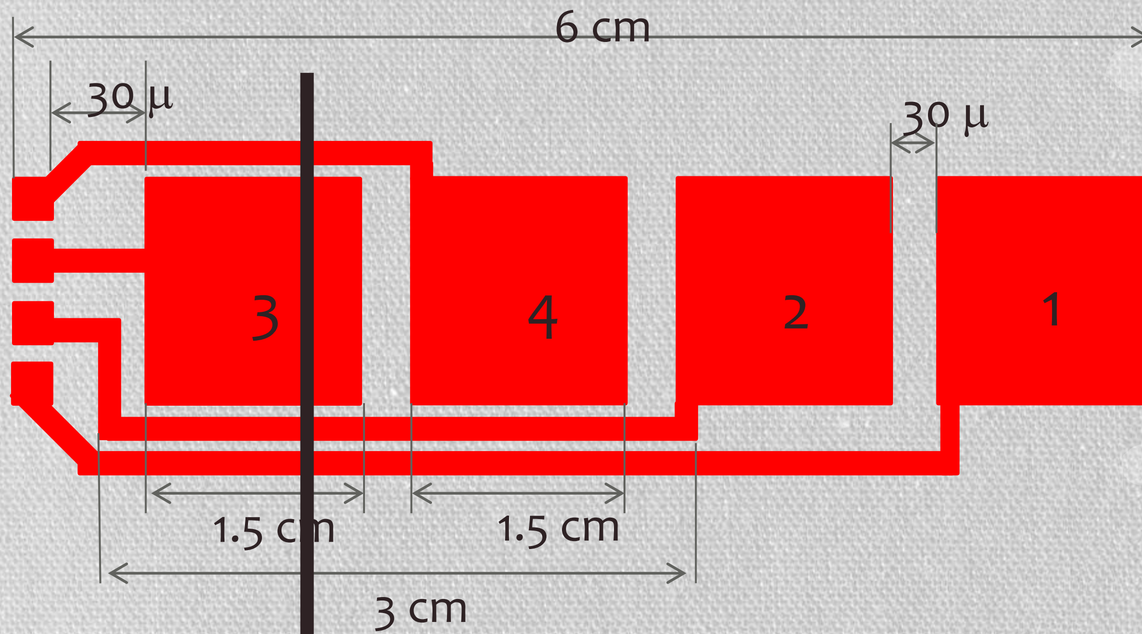


Before dicing
Floating Guard Ring

After dicing

Electric circuit test

- We measured resistance between neighboring channels. Small fraction of them had short. Current yield ~ 30%. Statistics suggest the short is between metal traces. Stringent metal etching process is expected to cure the problem.



Electric short happens between neighboring channels.

The short frequency is proportional to trace overlap.

Summary

- We measured full depletion voltage for 425μm wafer to be 35V which corresponds to resistivity ~15,000 Ωcm.
- No breakdown is observed until the reverse bias voltage of 250V.
- We observed low leakage current less than 1μA for the whole sensor of 6 x 6 cm.
- We identified a small number of shorts between neighboring channels and attribute the problem to close metal traces. We propose further etching process for metal layer and/or increased space between metal traces.