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SiC PIN Update

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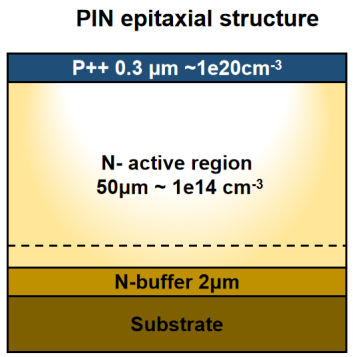
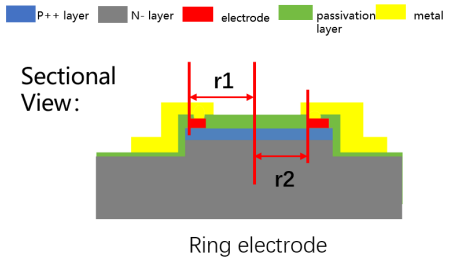
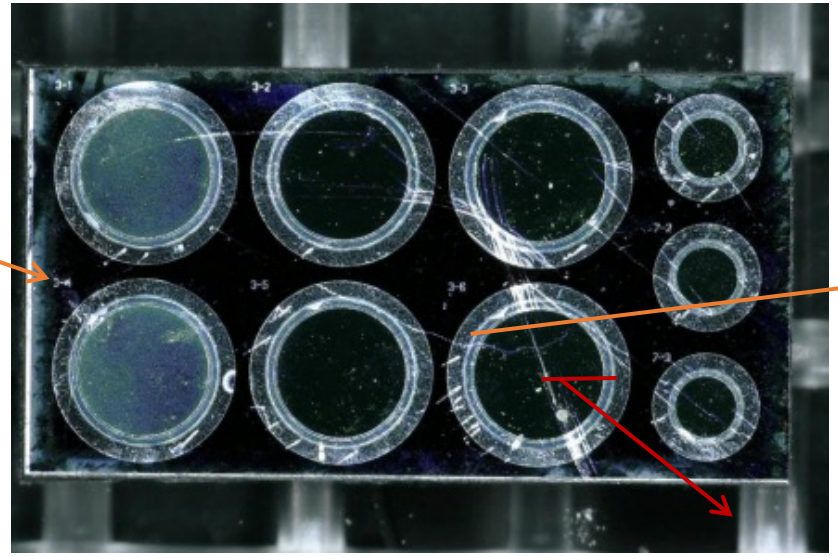
Discussion on the junction area

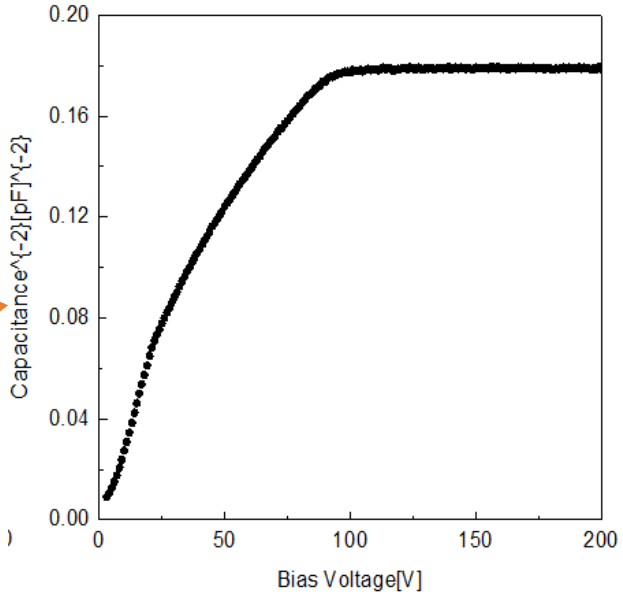




due to process limitation,the side is not steep



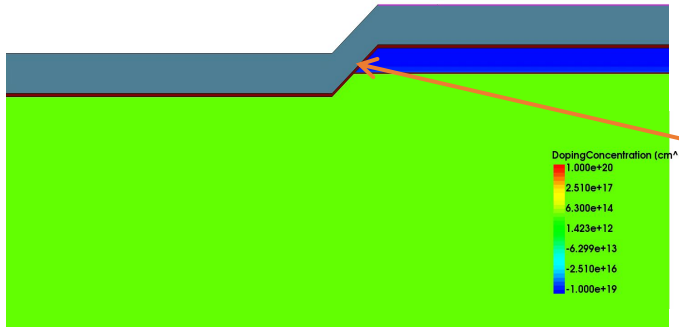
r = 490um



- 4H-SiC PIN Diodes: **Full epitaxy growth** including N_{buffer} & N- & P++
- Termination: **Etching**
- Full depletion voltage ~ 96V
- The doping concentration ~ 1.8e14 cm^{-3}
- The full depletion depth reaches ~ 27μm

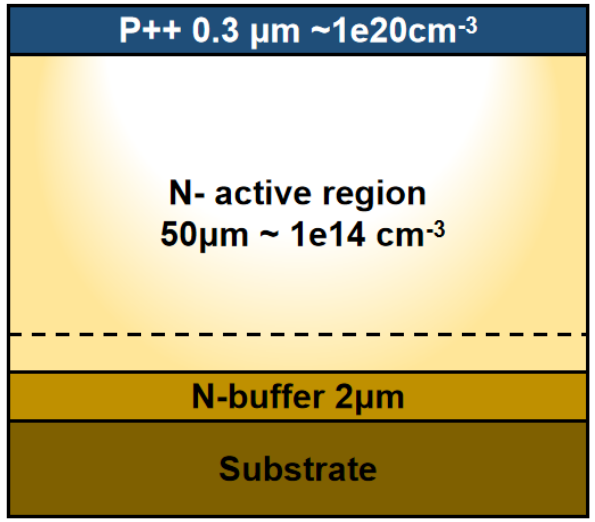
- The process of guard ring needs Ion implantation which was not considered
- Without a guard ring, lateral depletion is difficult to avoid.
- But how much is the lateral depletion?

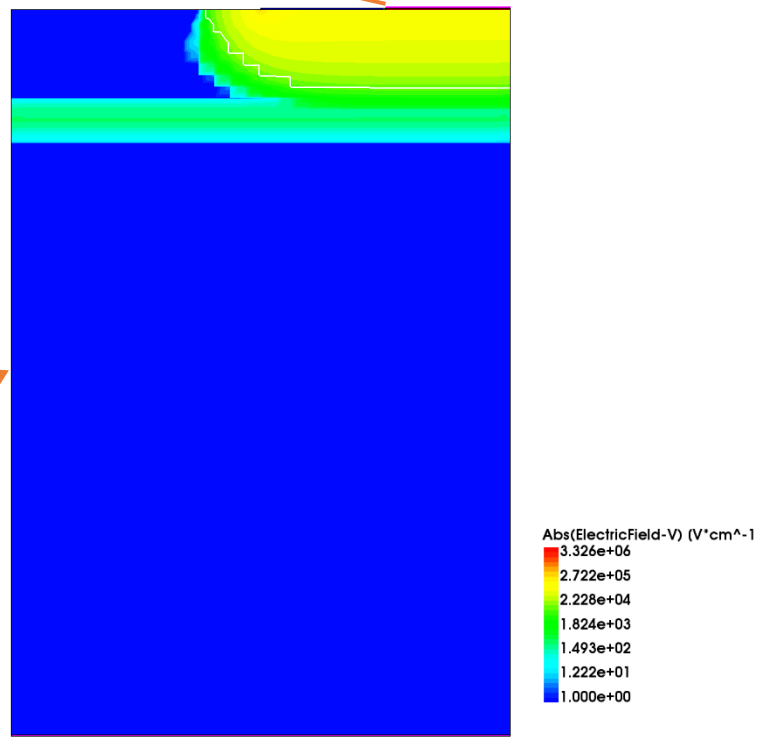
Simulation of lateral depletion

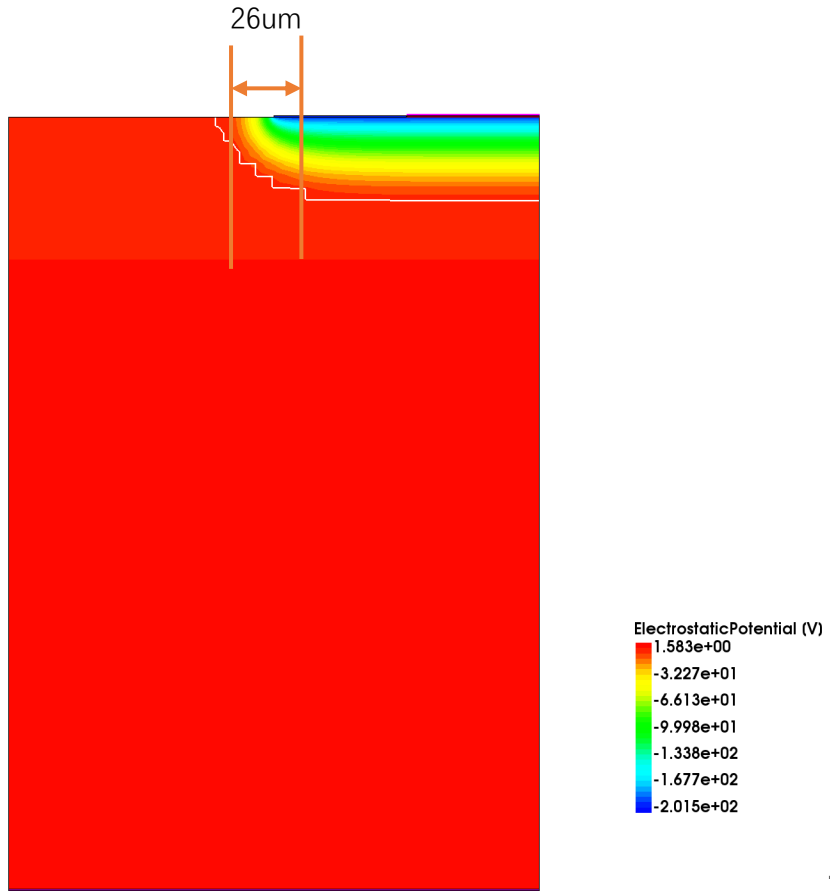


Etch(zoomed)

PIN epitaxial structure







Calibration of the junction area: Radius should be 490 + 26 = 516 um

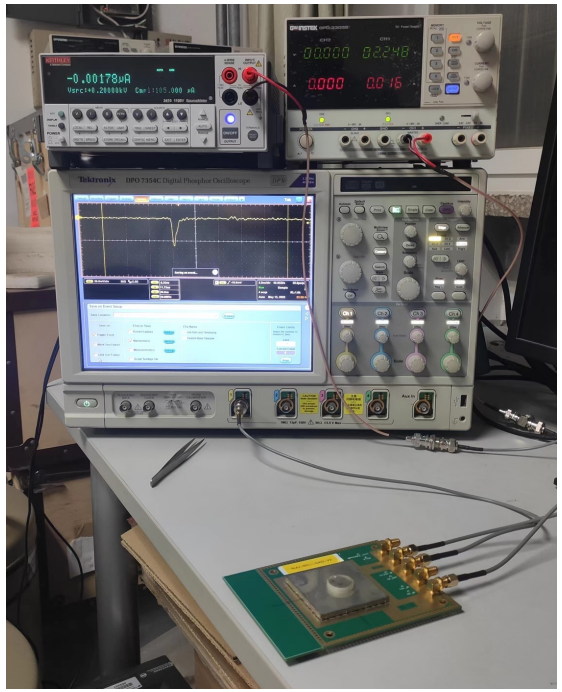
Calibration of doping concentration & depletion depth

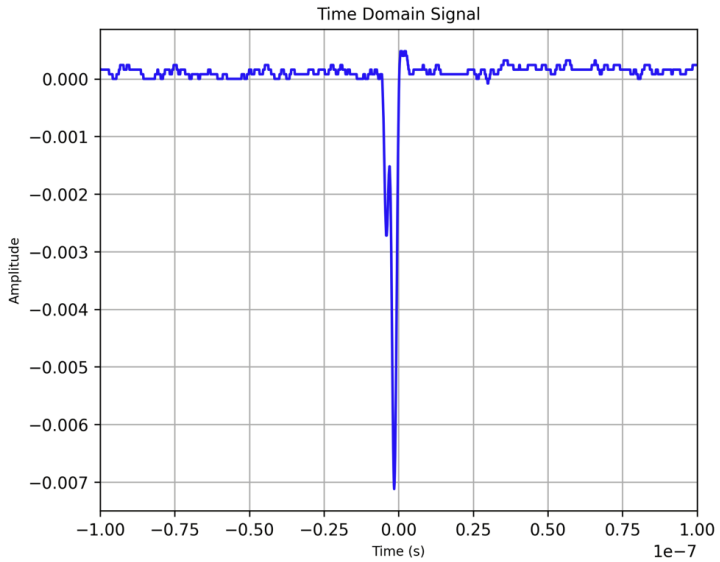
Comparison	Before Calibration	After Calibration
radius	490um	516um
junction area	7.5e-7m^2	8.4e-7m^2
doping concentration	1.8e+14cm^{-3}	1.46e+14cm^{-3}
depletion depth	27um	30um

The changes are very little after considering the lateral depletion

Background for R_f calibration

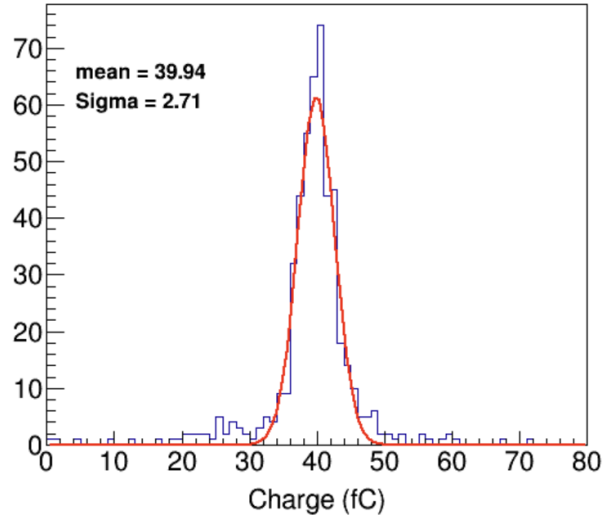
- Am-241 source
- Suffering from scattering in air
- sampling rate:100 ps/pt
- bandwidth:200 MHz
- No 2nd amplifier





$$Q = \frac{\int V(t)dt}{R_f}$$

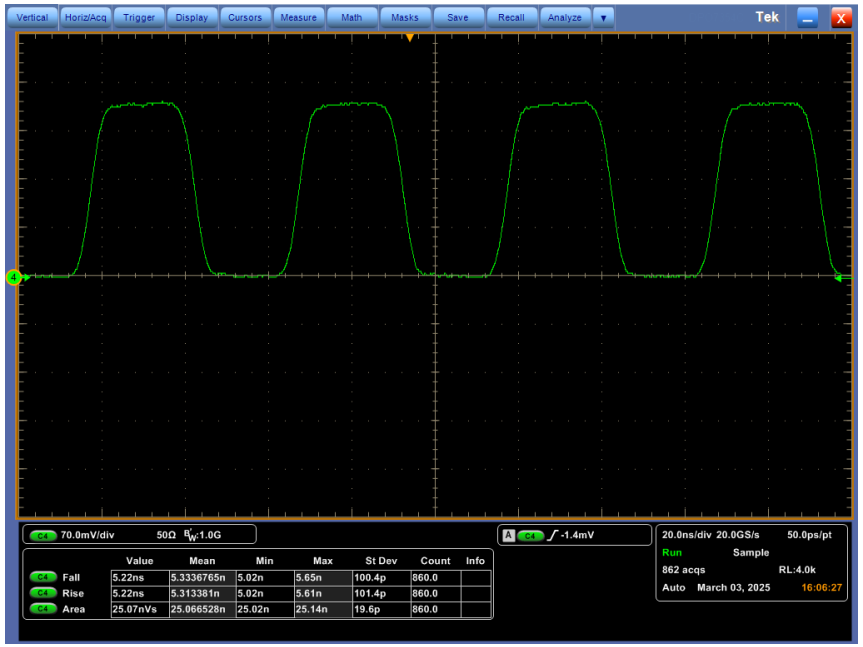
$$R_f = 500\Omega?$$



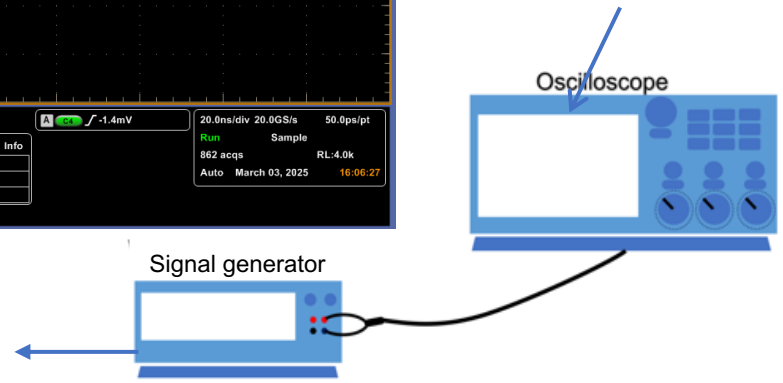
- Collected charge less than theoretical value $Q=\frac{E_{dep} \cdot e}{W} \approx 80fC$
- R_f not constant,depends on frequency

Refers to the last DRD3 report:
https://indico.cern.ch/event/1513609/

Calibration of the amplification factor

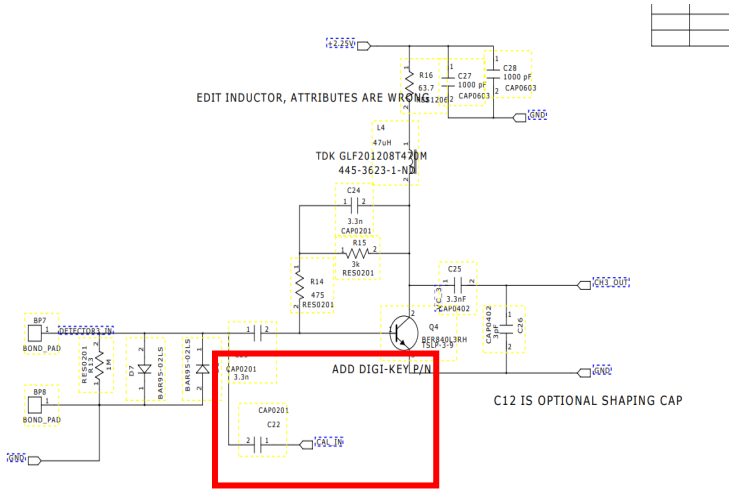


BW = 1GHz
Impedance = 50Ω



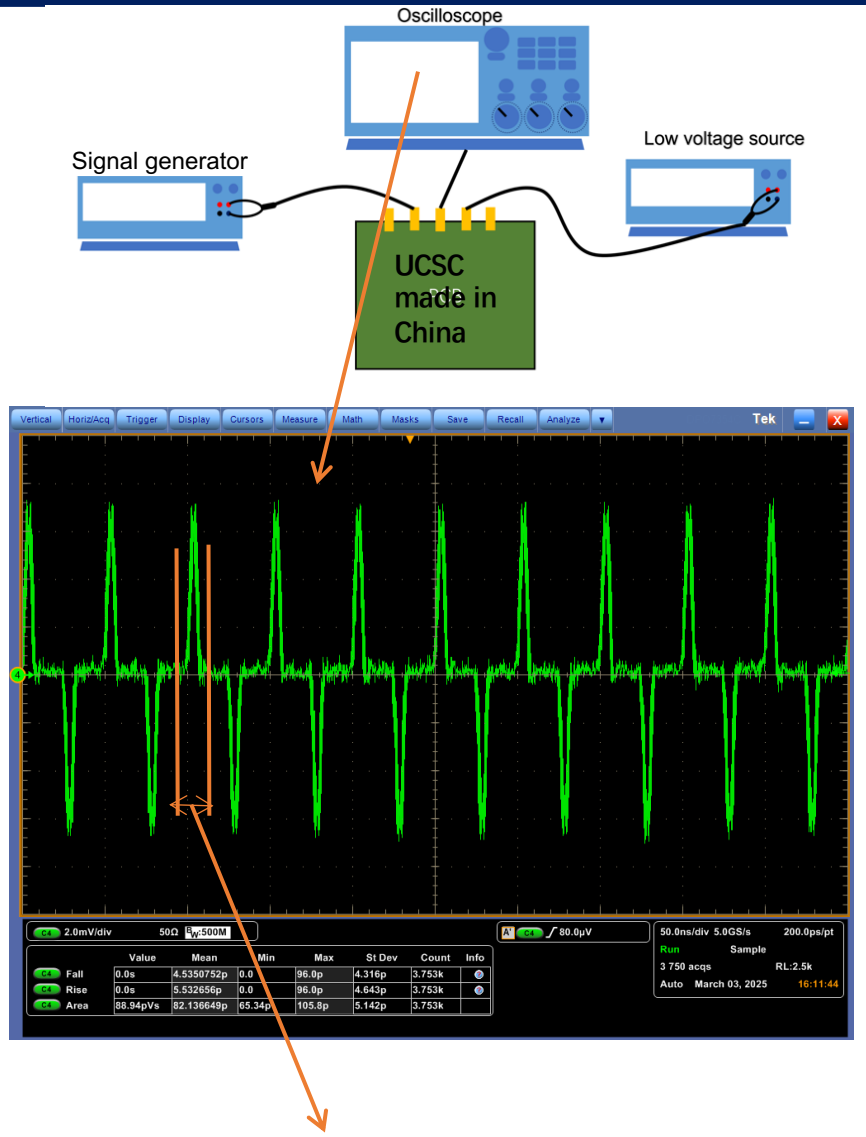
- 20 MHz pulse
- Rise time = 9 ns
- Average ΔV=0.247 V
- C_{22}=0.3 pF

Calibrate the amplifier from CAL IN



Input charge to UCSC board is $Q_{in} = C_{22} \times \Delta V = 75fC$

Testing of R_f



The integration range of the voltage signal

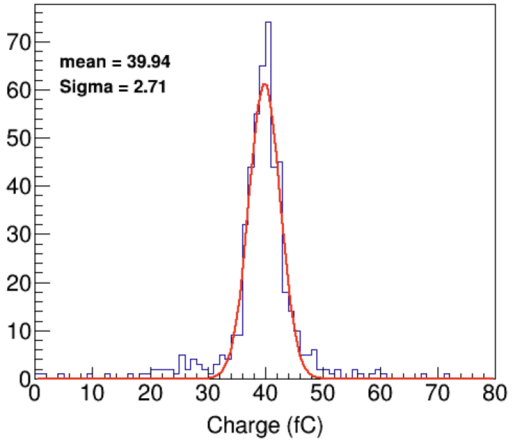
Output charge

$$Q_{out} = \frac{\int V(t)dt}{R_f} = Q_{in}$$

Calibrated R_f

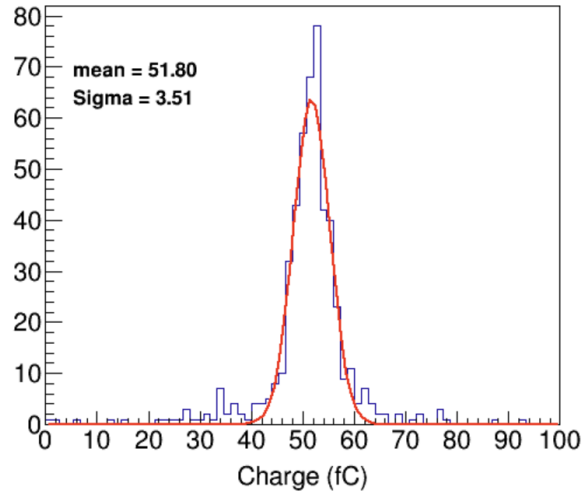
$$R_f = \frac{\int V(t)dt}{Q_{in}} = 385\Omega$$

Calibration Results



Before Calibration
R_f = 500Ω

After calibration with readout Board 1
R_f = 385Ω



- Charge collection of readout board1: 51.80fC
- Charge collection less than theoretical value 80fC:
  - The insulating layer has absorbed some of the charge carriers, but how much will it absorb?
  - high-frequency signals lost?
  - Impedance mismatch?

Summary and Plan

Summary

- Considering lateral depletion,the depletion depth($27um \rightarrow 30um$) still less than our expect
- Calibrating R_f (385Ω)

• Plan

- We plan to send readout boards along with our samples to UCSC and HEPHY next week
- Gamma Irradiation