

Plan

- TCT laser test (timing and depleted zone measurement)

- Yuzhen, Maosen ? Matt, Liejian ?, Suyu

- X ray Irradiation

- Yunyun, Suyu, Zhijun

- Sensor test

- (I-V , C-V , Breakdown ,doping profile measurement)

- 5x5 and 2x2 sensor I-V : Ryuta, Han Shuo ? Jingyi Liu
 - C-V for 5x5 and 2x2 : Baohua , Han Shuo ? Jingyi Liu ?, Yanping?
 - investigation of the channel switcher for 15x15 sensor : Ryuta, Maosen?
 - Setting up new probe station with cold chunk: Zhijun ,Baohua, ,Feng Lv ?
 - I-V and C-V for new NDL sensor: Liaoshan Baohua, Lianyou ?

- LGAD Design

- Baseline design (Field plane, doping) : Mei, Kewei, ,Yunyun
 - Irradiation hard design (Guard ring ...): Yunyun, Suyu, Mei

X ray Irradiation

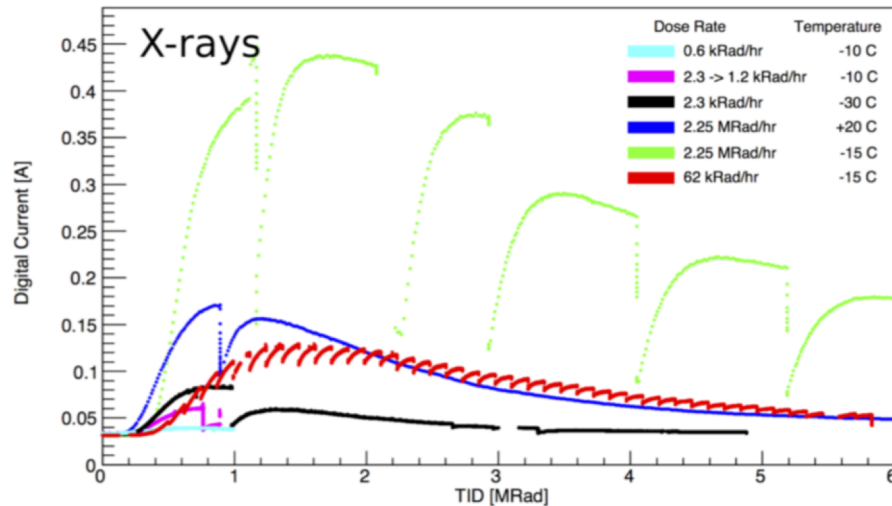
- Major concern from HGTD TDR:
 - There is no gamma irradiation study
- Comments from Philip Allport (Former upgrade coordinator)
 - Need to show that LGAD sensor and module can survive up to 4.7MGy

I think it should be a concern for this TDR that no comparable, module-level, studies of post-irradiation behaviour in test-beam are possible with the current state of maturity of the module prototyping. It is hard to believe that a Module PDR in a year's time, April 2020 (Table 13.4), which addresses this is really practical given the ITk experience.

As commented later, the authors correctly note (line 2265) “*the radiation hardness of the sensors available has not been established up to a fluence of to $5.1 \times 10^{15} n_{eq}/cm^2$* ”. Nor would I argue have they been shown to work after 4.7MGy.

X ray Irradiation

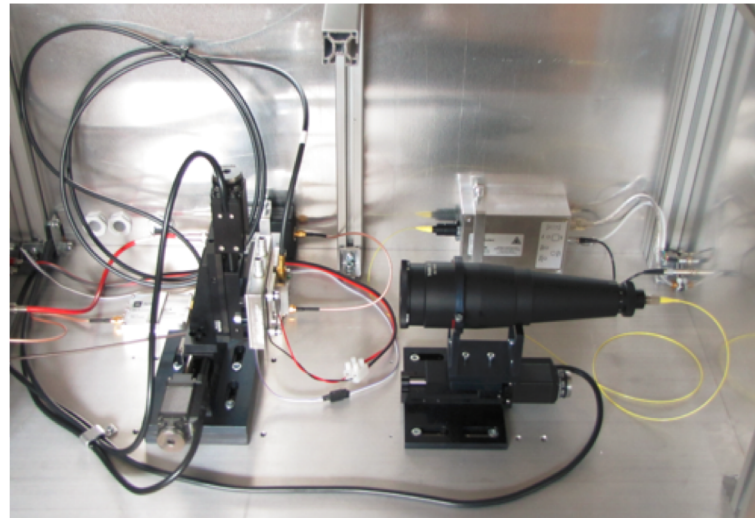
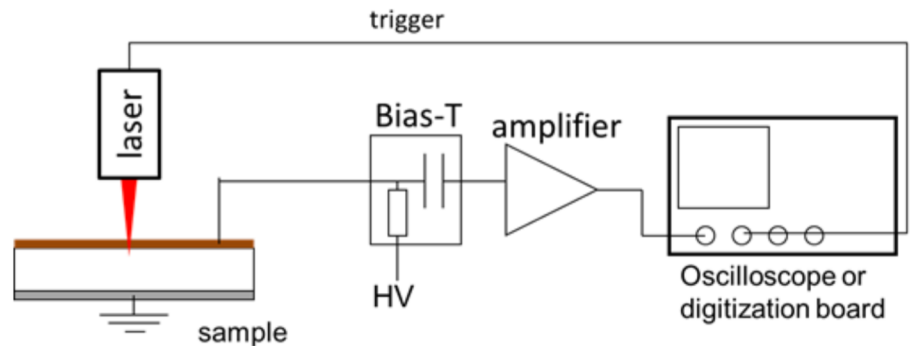
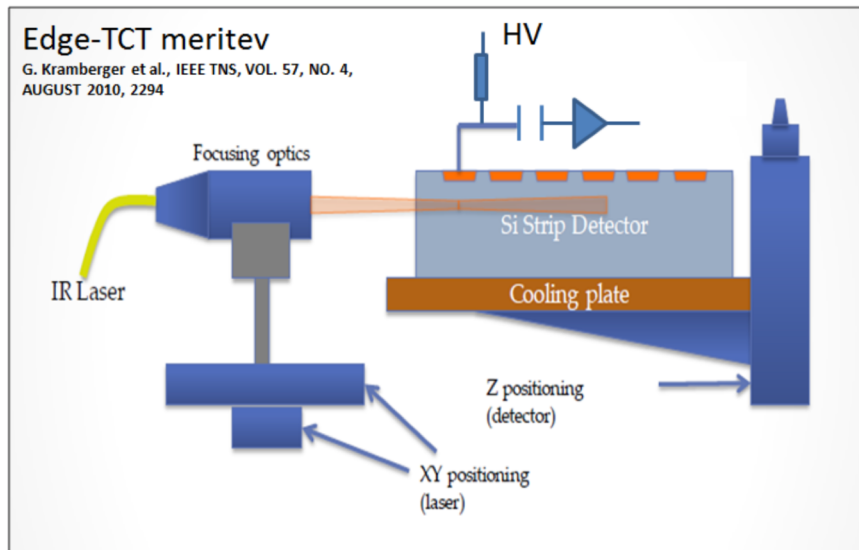
- Irradiate sensor to 1kGy, 10kGy, 100kGy, 1MGy, 10MGy
 - Measure the gain, timing resolution
 - interpad gap with laser
 - I-V and C-V , interpad resistance and capacitance
- Module
 - Data taking during irradiation



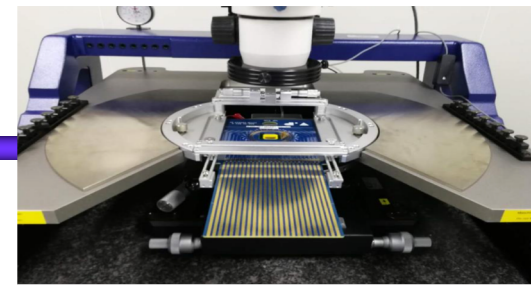
ABC130 digital currents Vs TID dose

TCT laser test

- Major question: whether LGAD can reach 30~50ps after irradiation
- Timing and depleted zone measurement
 - Try to understand the irradiation effect by measuring depleted zone
 - Shooting two lasers on two sensors to measure the timing resolution



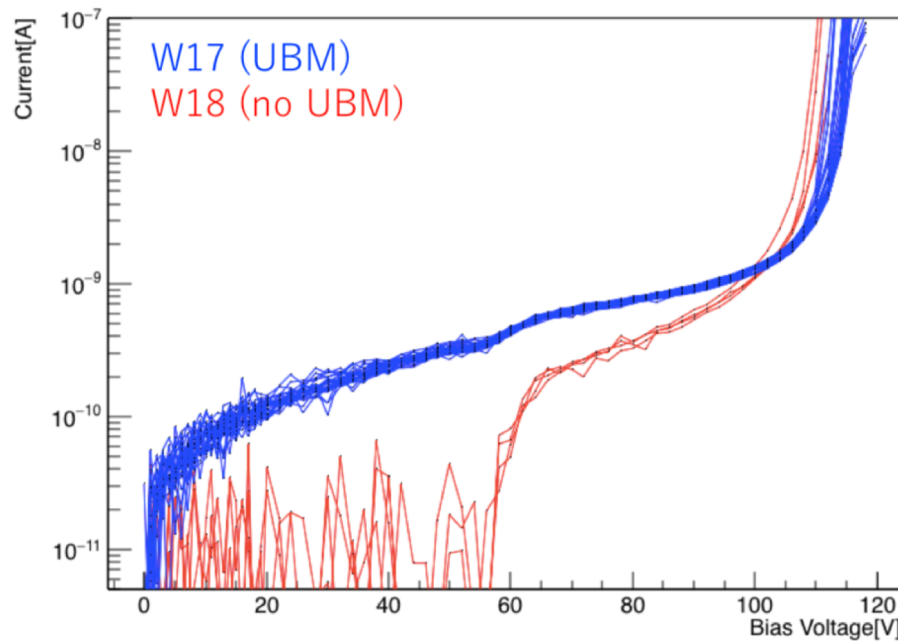
I-V testing



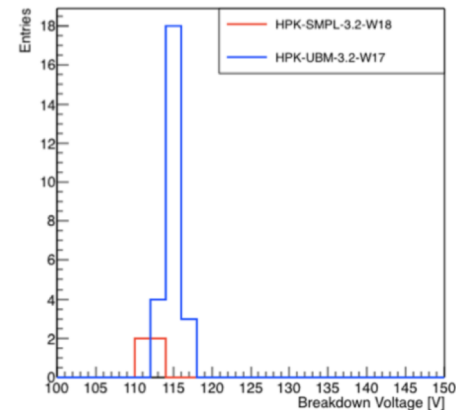
Major question:

- Breakdown and leakage current before and after irradiation
- Breakdown and leakage current before and after bump bonding

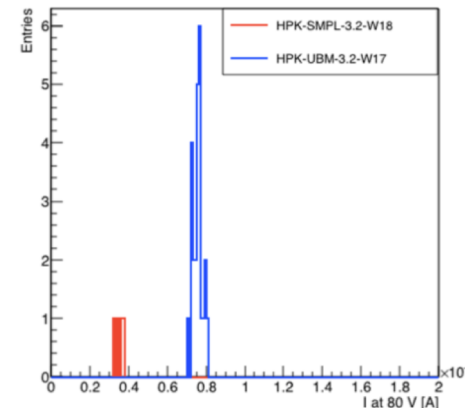
Comparison of HPK 5x5 with and w/o UBM for type 3.2



Change of slope around 60V (full deletion voltage).

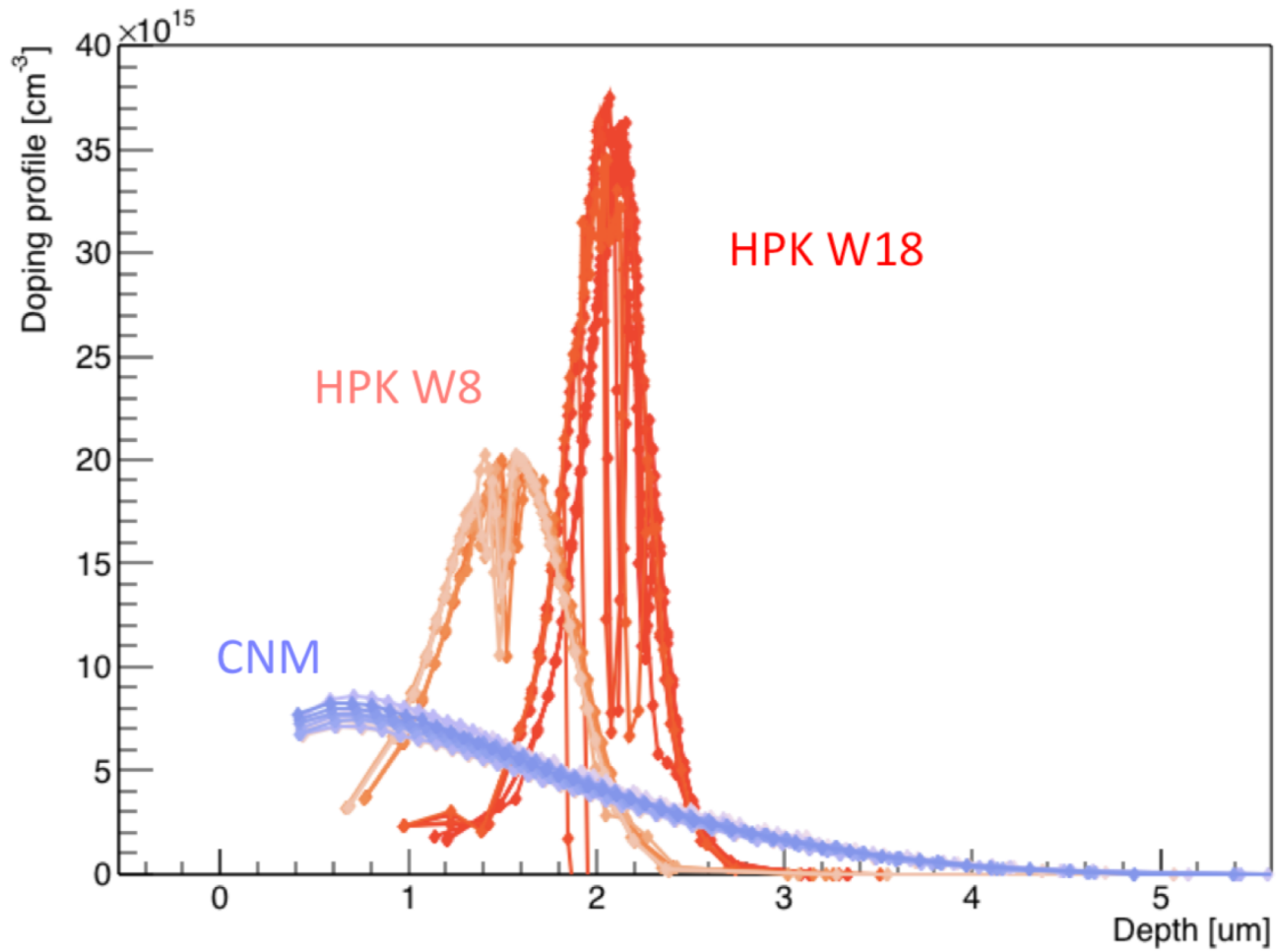


Breakdown voltage:
Higher VBD with UBM.



Current at 80 V:
Higher dark current
with UBM.
(This comparison
needs to investigate
further test)

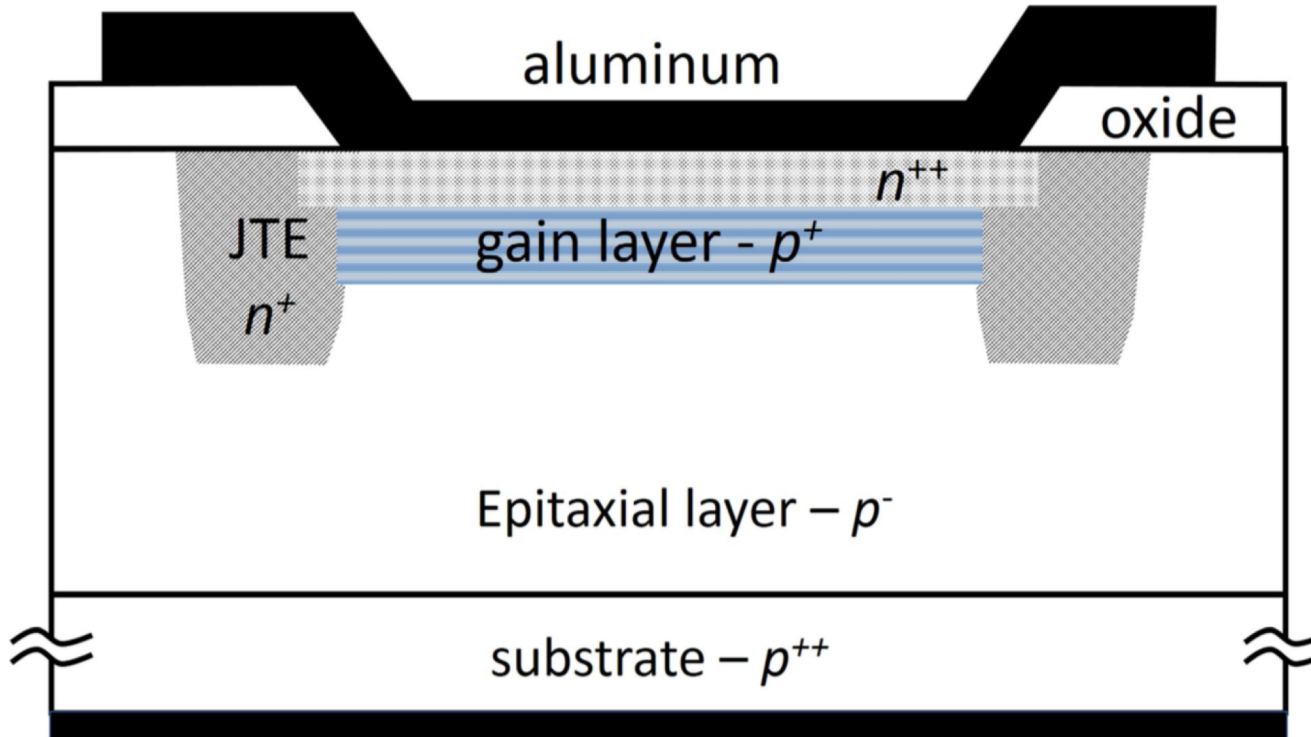
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Development of LGAD sensor in China

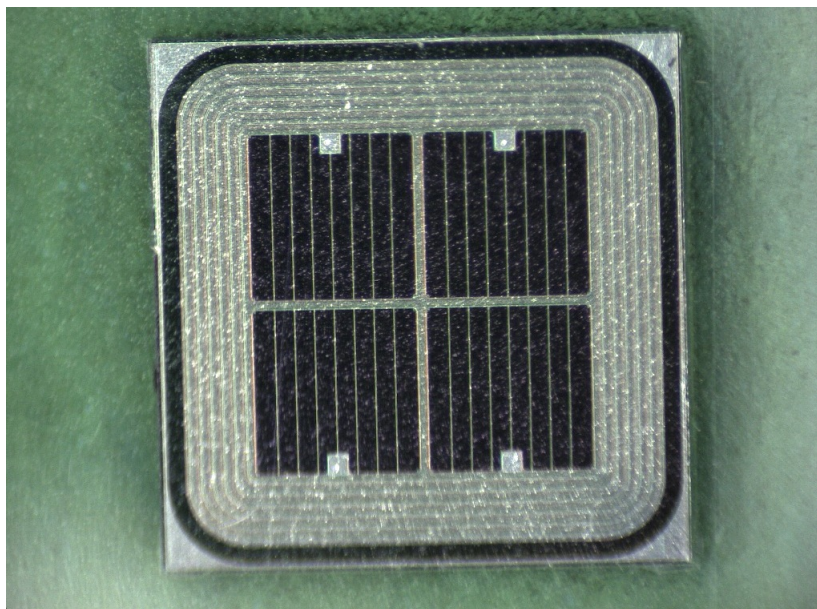
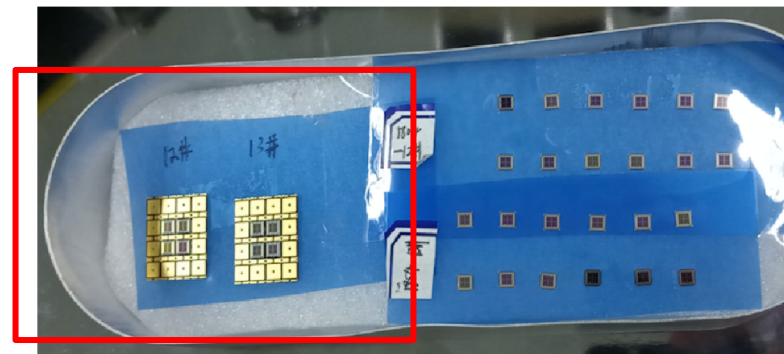
- Two R & D approach

- Epitaxial layer (collaboration with Beijing Normal University)
- Thin high resistance wafer + low resistance bonded wafer
 - (collaboration with Tsinghua University)

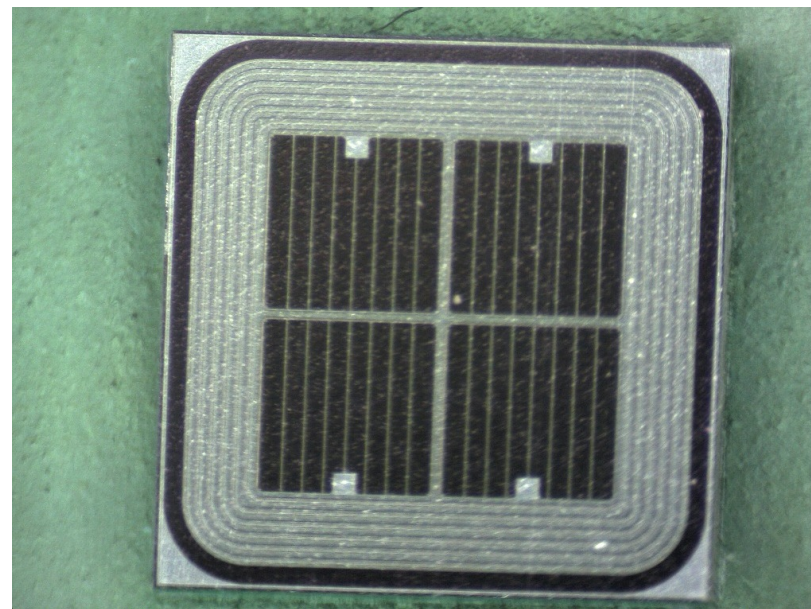


New LGAD sensors from Beijing Normal University

Epitaxial layer



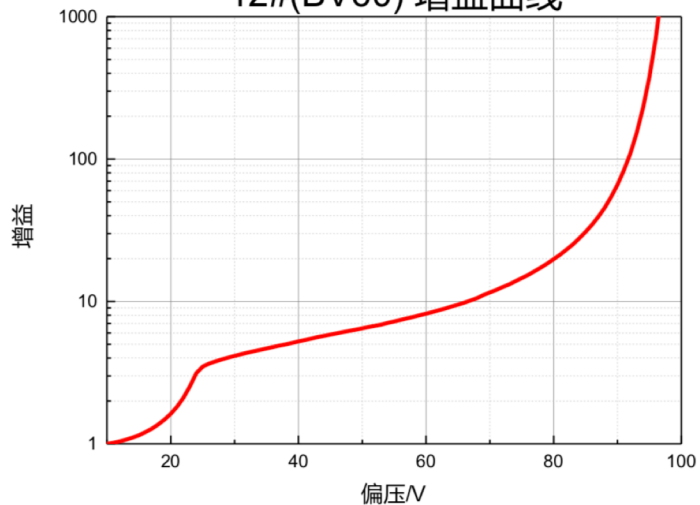
BV60-50-B



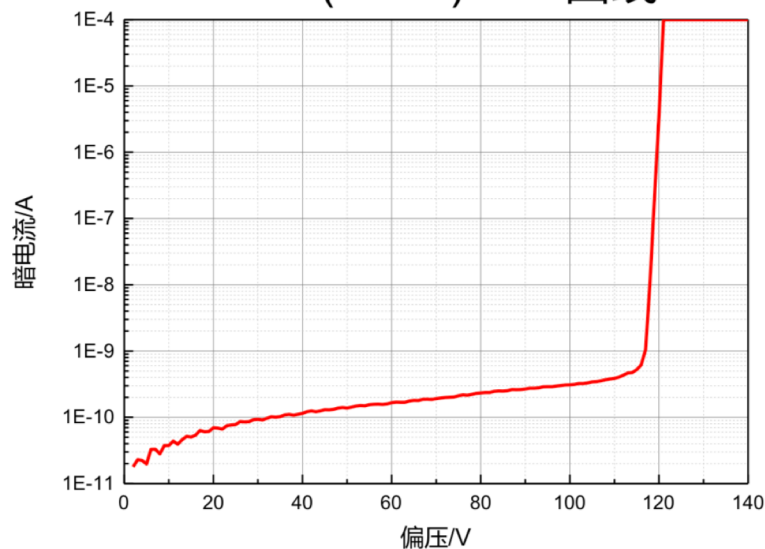
BV170-30-B

New LGAD sensors from Beijing Normal University

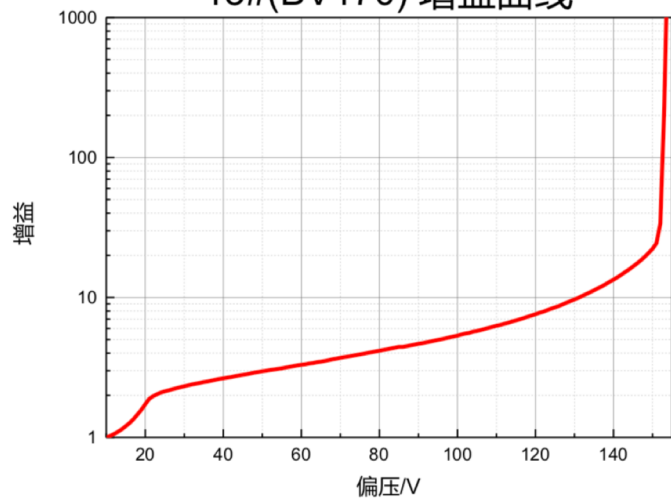
12#(BV60) 增益曲线



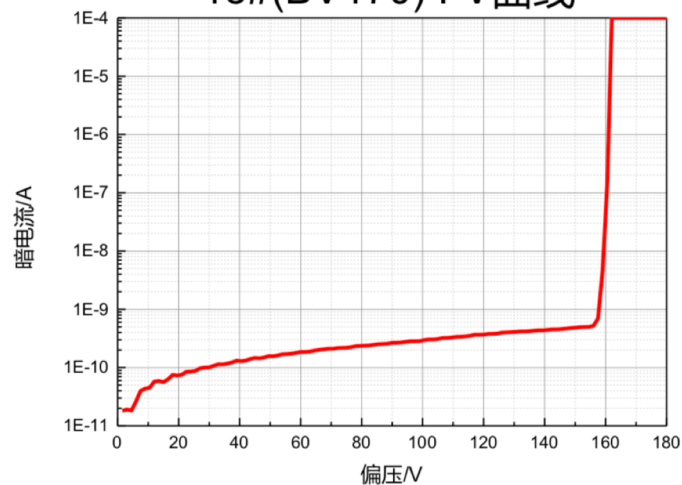
12#(BV60) I-V曲线



13#(BV170) 增益曲线



13#(BV170) I-V曲线

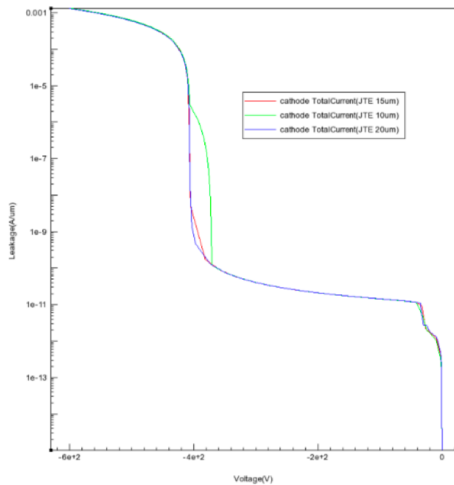


R & D with bonded wafer

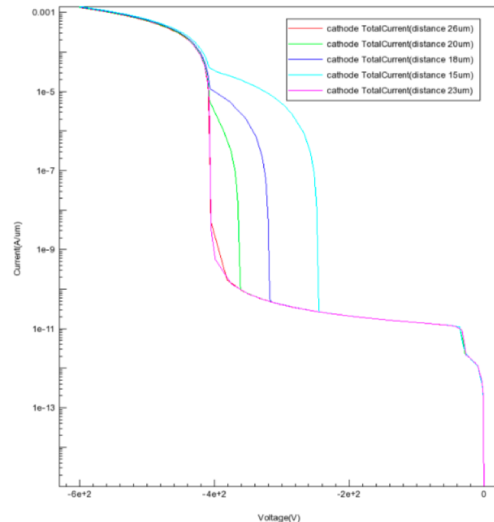
- Design is key task for this R & D for now
 - Layout design and simulation
 - Irradiation hard design: Guard ring and carbon injection ?

Simulation

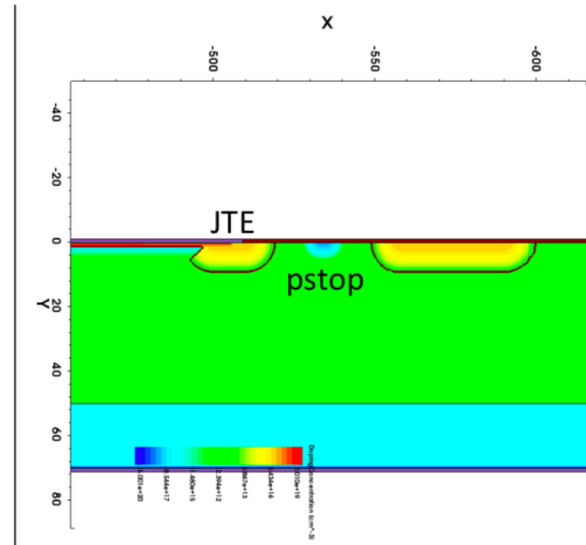
- JTE width
- Distance between JTE and pstop



JTE width: 10,15,20um



Distance between JTE and pstop
26um, 23um, 20um, 18um, 15um



Results show that they affect the breakdown voltage much.

Irradiation hard design

- Need more design and modeling for Gamma irradiation effect
- for non-EM irradiation damage we know accept removal is the major effect.

