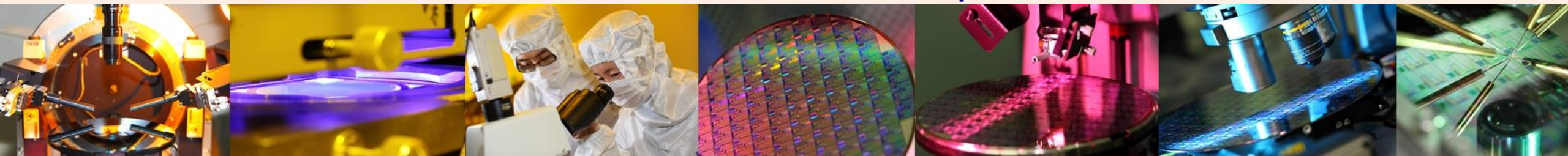


Development of 3D Pixel Sensors via an 8-inch CMOS-Compatible Process☆

Huimin Ji, Manwen Liu, Kuo Ma, Yanwen Liu, Dengfeng Zhang, Zheng Li, Zhihua Li, Jun Luo

Institute of Microelectronics, Chinese Academy of Sciences (IMECAS)

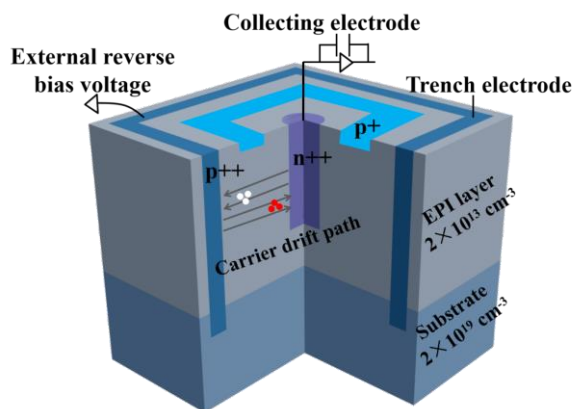
☆Work performed in the framework of the CERN-DRD3 collaboration -WP2 project Novel silicon 3D-trench pixel detectors based on 8-inch CMOS process



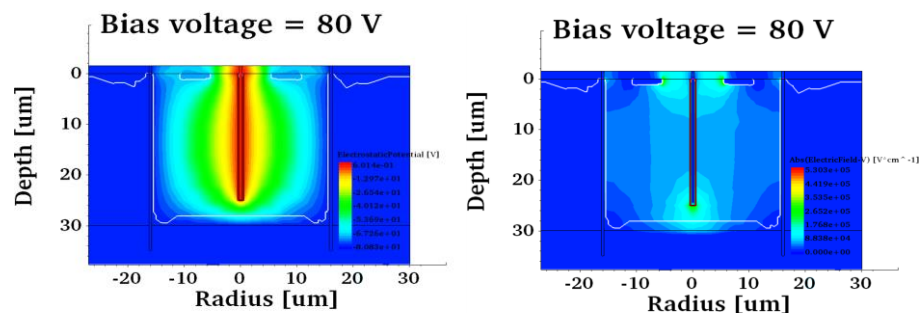


1. Design, simulation and fabrication of the 3D pixel sensors

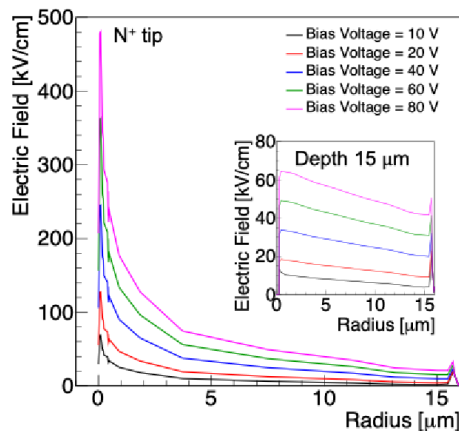
➤ The novel 3D trench-column sensors have been proposed.



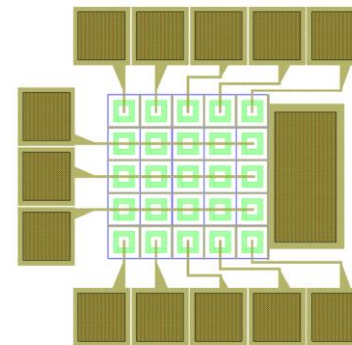
The schematic of the 3D trench-column Sensor.



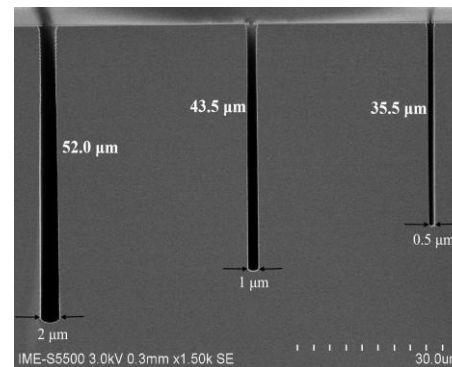
Electrostatic potential and Electric field.



1D electric field



layout

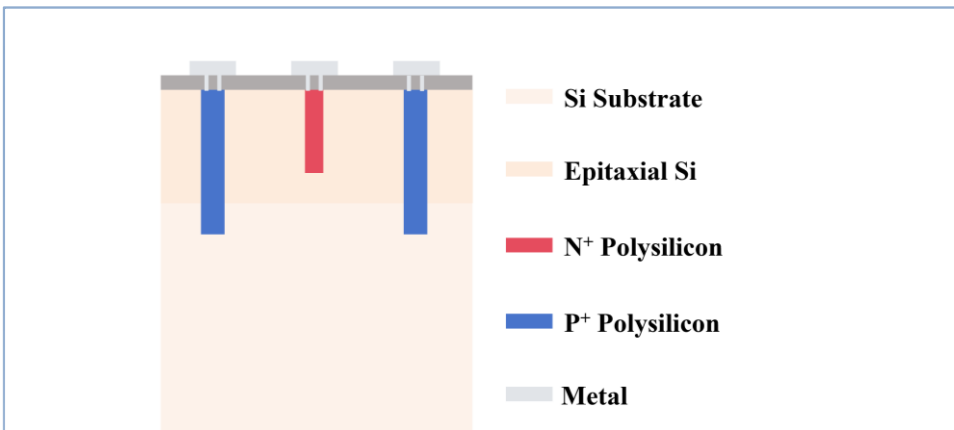


SEM micrograph in cut view of the 3D trench. (Aspect ratio 70: 1)

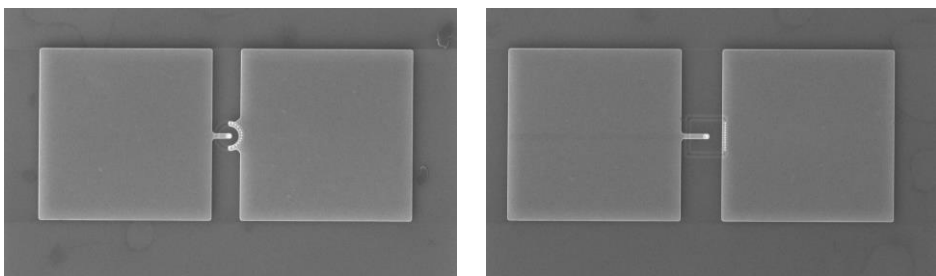


1. Design, simulation and fabrication of the 3D pixel sensors

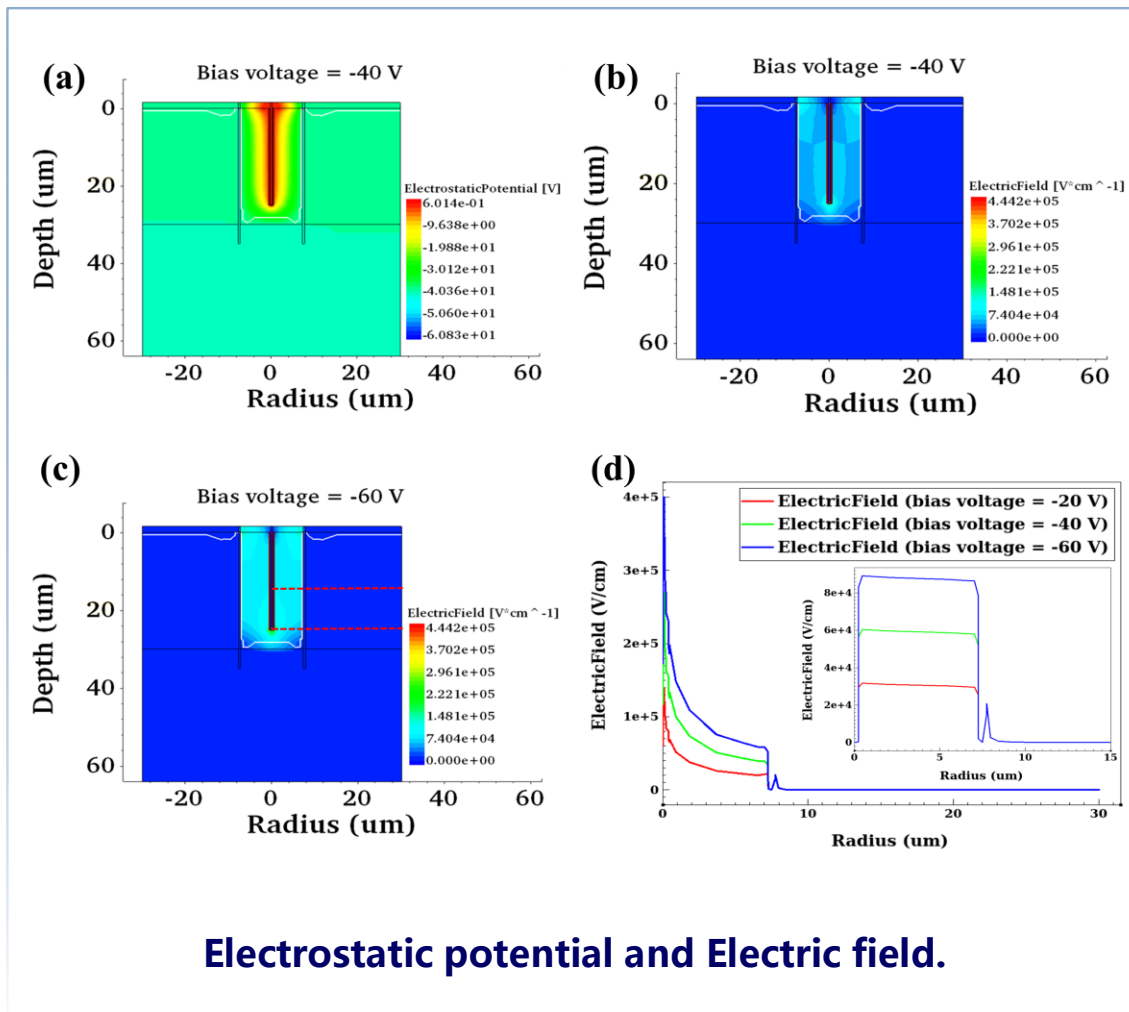
➤ The novel 3D trench-column sensors have been proposed.



The schematic of the 3D trench-column Sensor.



SEM micrograph in surface view of the sensor.



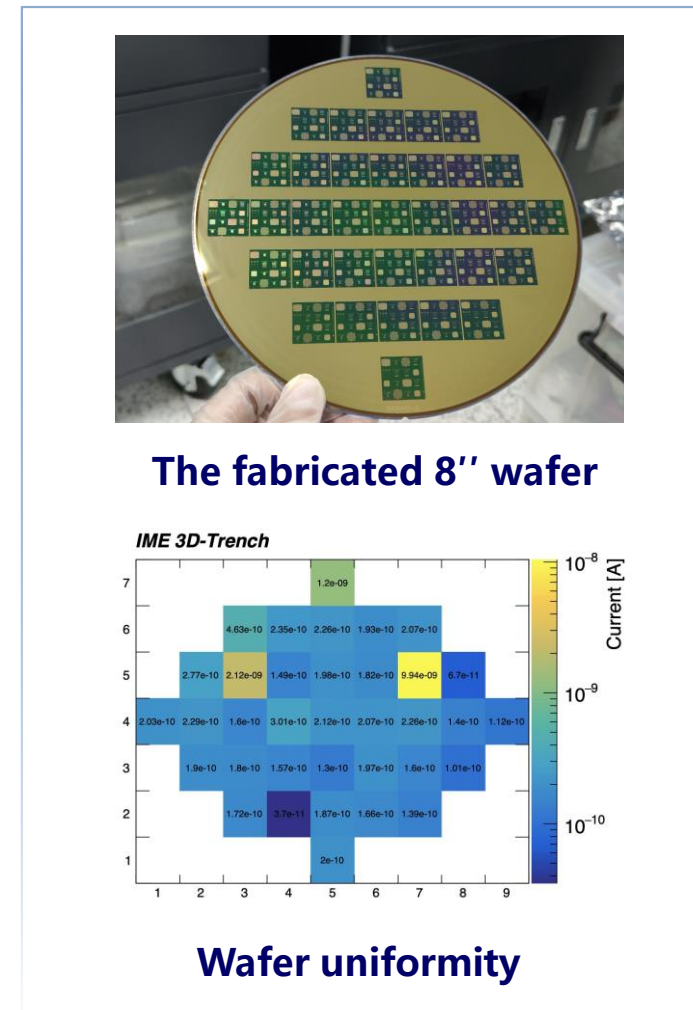
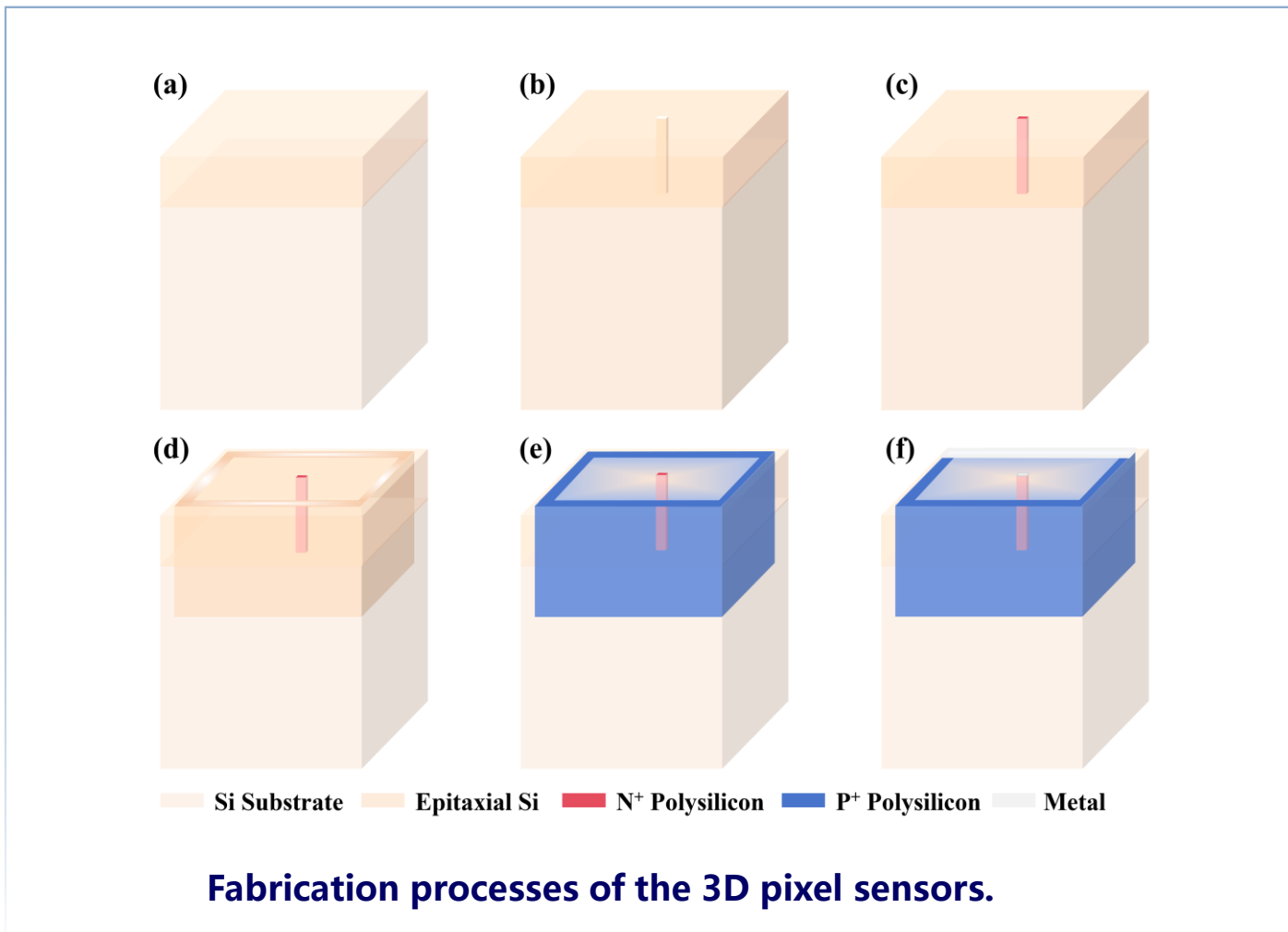
Electrostatic potential and Electric field.



1. Design, simulation and fabrication of the 3D pixel sensors

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- The novel 3D trench-column sensors have been fabricated at the IMECAS using the 8 inch CMOS process technology.

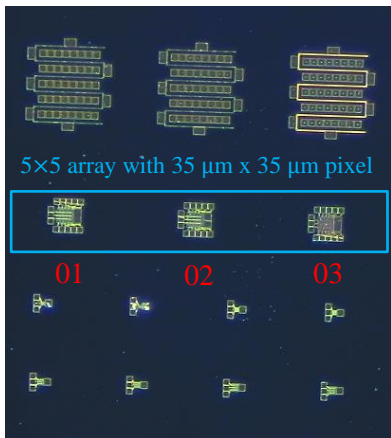




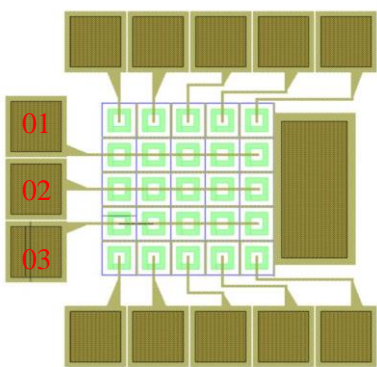
2. Measurements of the 3D pixel sensors

IMECAS

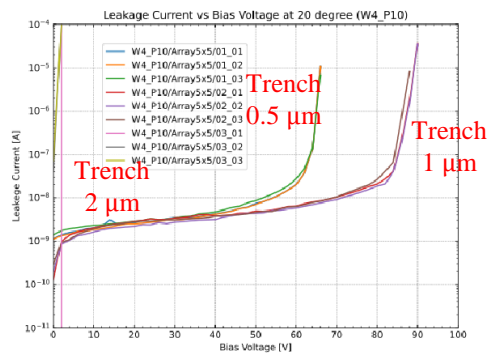
- The preliminary measurement results of Current-Voltage (IV), Capacitance-Voltage (CV), Charge Collection Quantity (CCQ) and Timing Performance before irradiation have been presented.



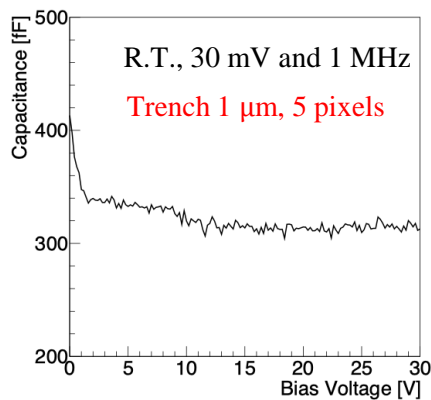
5×5 arrays



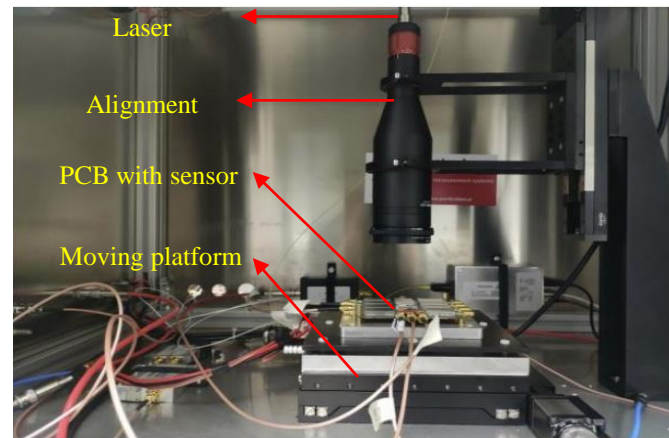
35 μm x 35 μm pixel



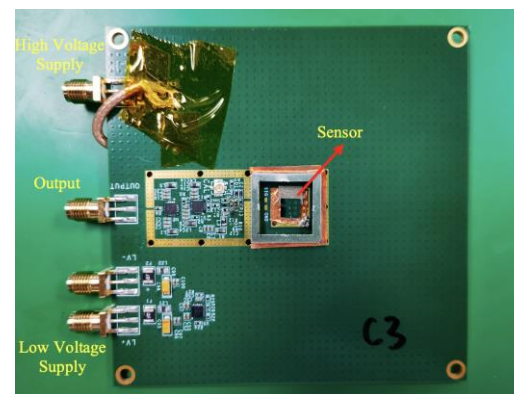
The IV curves



The CV curves



TCT testing system



PCB board

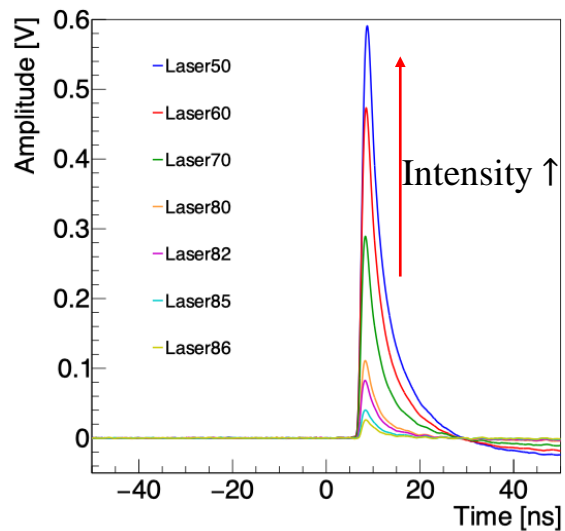
- Temperature: room temperature
- 3D trench-column sensor: 35 × 35 μm² pixel size and 1 μm trench width
- Laser: 1064 nm (infra-red), < 11 μm beam spot (FWHM)
- Trigger: laser sync. signal
- USTC Amplifier board: Designed for Low Gain Avalanche Detectors (LGADs)
- Oscilloscope
 - Sampling rate: 40 Gs/s (two channels)
 - Time window: -50 ns ~ 50 ns
 - Full bandwidth



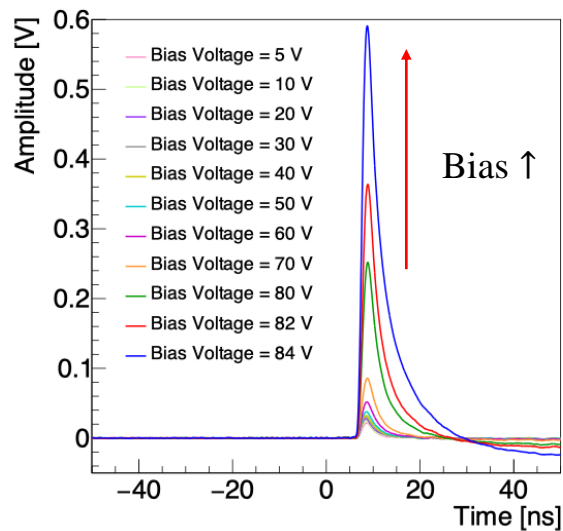
2. Measurements of the 3D pixel sensors

IMECAS

- The preliminary measurement results of Current-Voltage (IV), Capacitance-Voltage (CV), Charge Collection Quantity (CCQ) and Timing Performance before irradiation have been presented.

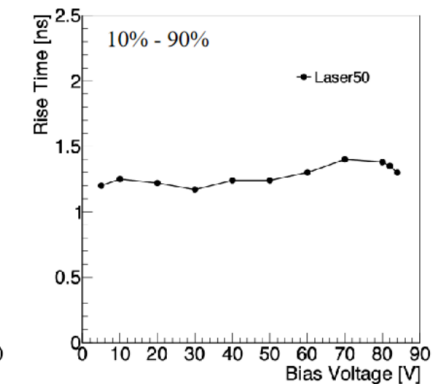
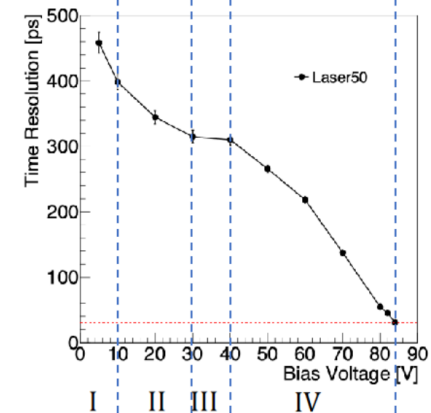
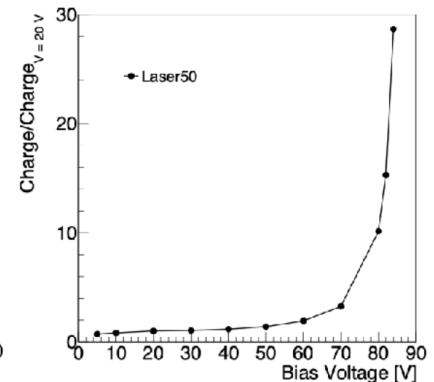
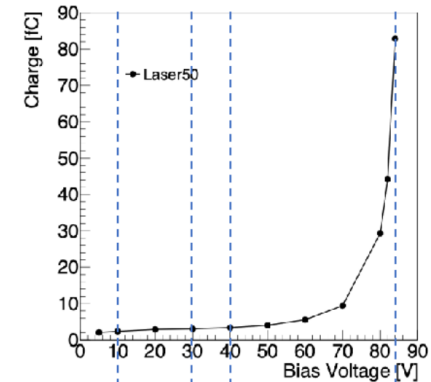


The averaged waveforms at different Laser intensity



The averaged waveforms at different bias voltages

During the test, the laser perpendicularly passed through the sensor from the topside and the center of the laser was adjusted to be between the trenched and columnar electrodes



The collected charge and time resolution

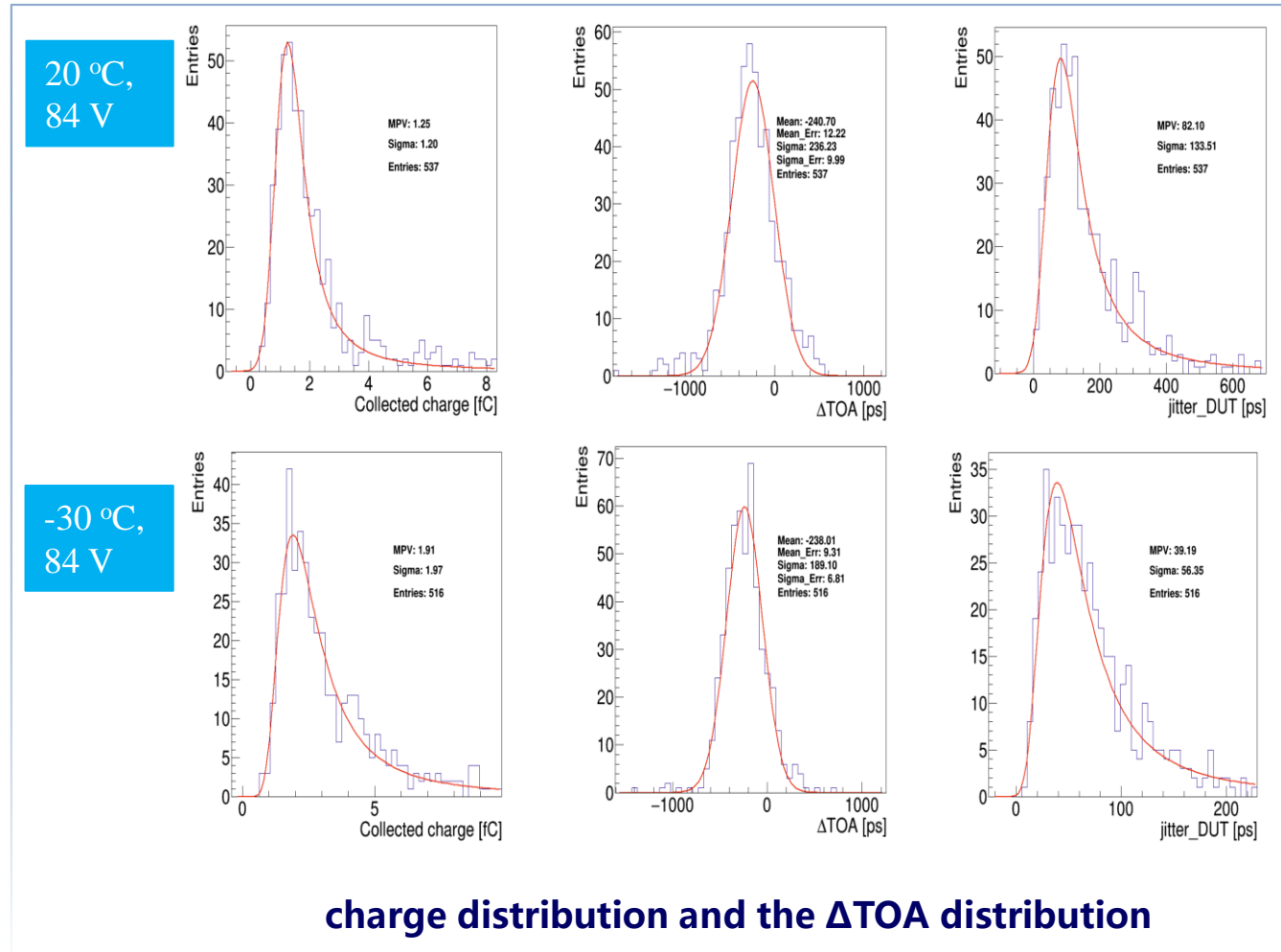


2. Measurements of the 3D pixel sensors

IMECAS

- The preliminary measurement results of Current-Voltage (IV), Capacitance-Voltage (CV), Charge Collection Quantity (CCQ) and Timing Performance before irradiation have been presented.

- Temperature: 20 °C and -30 °C
- 3D trench-column sensor: $35 \times 35 \mu\text{m}^2$ pixel size and 1 μm trench width
- Reference & Trigger: HPK Type 3.1 sensor @180V (60.25 ps at 20 °C, 49.71 ps at -30 °C)
 - Pattern Trigger: 30 mV for DUT, 100 mV for Trigger
 - Sampling rate: 40 Gs/s (two channels)
 - Full bandwidth

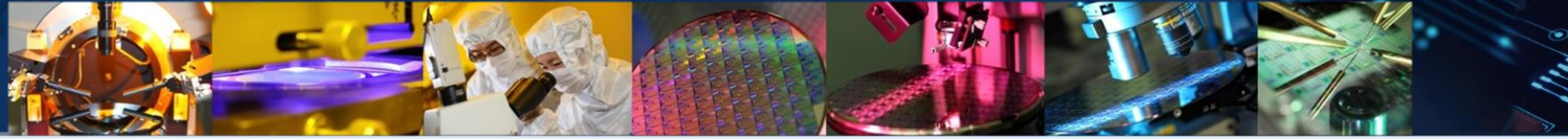




4. Conclusion

IMECAS

- The novel 3D pixel sensors featuring a deep trench enclosing a central column electrode has been designed and successfully fabricated at the 8 inch CMOS pilot line at the Institute of Microelectronics of the Chinese Academy of Sciences (IMECAS).
- Sensor leakage current is in the order of 10^{-9} A, and its capacitance is about 300 fF.
- Both the TCT measurements with infra-red laser (1060 nm) and beta-scope measurements with a ^{90}Sr -source **vary the internal gain occurs** when the bias voltage is above 40 V as the TCAD simulation expected.
- Through TCT measurements, the collected charge and time resolution as a function of bias voltage can reflect the depletion and E-field status of the sensor
- The ^{90}Sr -source tests show that the gain is about 4.17 and 6.37 at 20 °C, 84 V and -30 °C, 84 V for the minimum ionizing particles (MIPs).



Thanks!

