Characterization of Si Detectors through TCT at Delhi University

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• When a particle hits the sensor, it creates e-h pairs that induce signal at the electrodes by their drift in the electric field within the reverse biased Si sensors.

• LHC Phase II Upgrade will result in an integrated luminosity of about 3000 fb^{-1} & a luminosity of about 10^{35} $cm^{-2}s^{-1}$: Delhi University is contributing in Phase 2 Outer Tracker Upgrade!

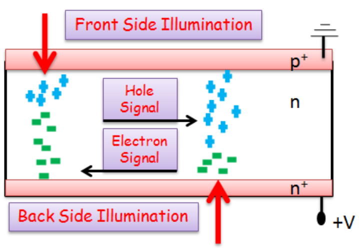
• Radiation damage effect on CMS Si Tracker : Breakdown voltage decreases, Depletion voltage increases, charge collection efficiency (CCE) decreases.

• New silicon sensors that are radiation hard and have higher breakdown voltage, lower depletion voltage, higher CCE, are required.

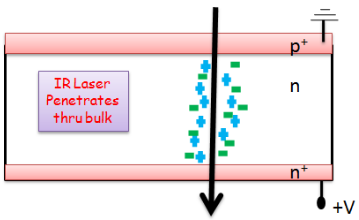
• Transient Current Technique is a dynamic characterization technique for sensors.
It is the study of time evolution of charge carriers generated when a laser light is shone on the Device Under Test (DUT). These charge carriers (q) then induce charge (Δq) on the electrodes in proportion to the displacement (Δx) of these charge carriers through the detector depth (d).

$$\Delta q = (\Delta x/d) \cdot q$$

TYPES OF TCT TECHNIQUES



• Red Laser TCT
- Creates electron–holes (e-h) on the surface.
- Output signal from charge carrier that travels in the active bulk.
- To find drift velocity, trapping time, CCE.



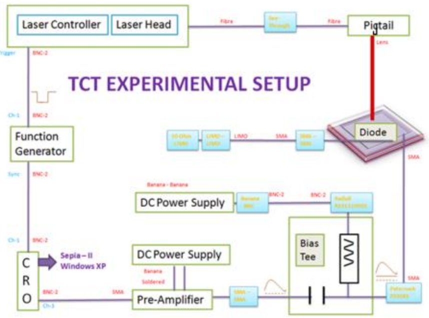
• Infrared Laser TCT
- Moderate e-h created in bulk.
- Output signal fis a contrubution rom both the charge carriers.
- To measure CCE.

Silicon Sensors R&D group of Delhi University (with C. Gallrapp)

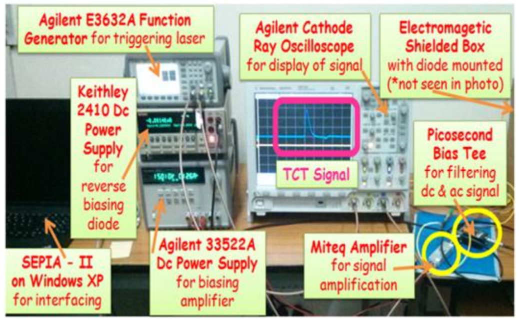
G. Jain (Presenter)

Red Laser TCT Setup Devoloped At Delhi University

DU Circuit Diagram



DU TCT Setup

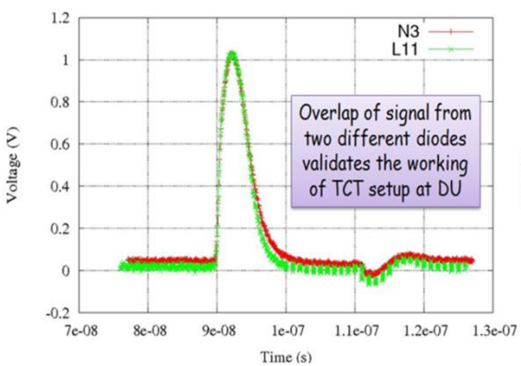


SETUP SPECIFICATIONS FOR MEASUREMENTS

- Function Generator: Freq. = 200.0Hz, Amp. = 1.0V, Offset = -500.0mV
- Laser wavelength 660nm
- Keithley 2410: Bias = 0 to ±1000V
- Agilent DC Supply: Bias = 0 to +15.0V
- Cathode Ray Oscilloscope: Bandwidth = 1.0GHz, Sampling rate = 4.0GSa/s
- Bias Tee: Resistance = 3.127kΩ, Capacitance = 2.2nF
- Amplifier: Gain = 58.0dB

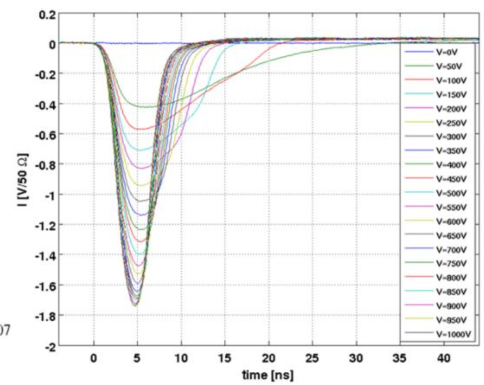
Results and Observations

Frontside TCT Signal of 2 p-in-n FZ pad diodes @ 200V



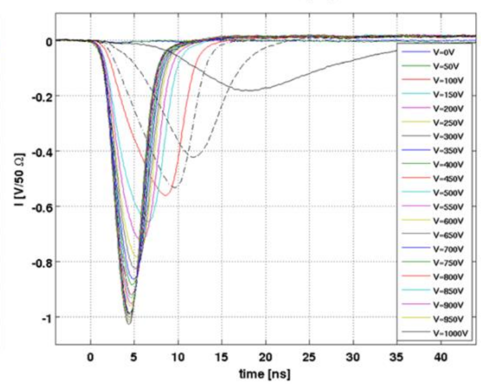
@ DU, G. Jain

Frontside TCT Signal voltage scan on MCZ n-in-p pad diode



@ CERN, H. Neugebauer

Backside TCT Signal voltage scan on MCZ n-in-p pad diode



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✓ Overlap of TCT signal from 2 same type, i.e. p-in-n FZ pad diodes, validates the TCT setup at DU.

✓ Rise in signal is due to movement of the charge carriers.
✓ A bend in the rising edge of the signal is seen when the first carrier is collected at the electrode.
✓ Decrease in the signal is voltage dependent, & depends on the drift of the carriers.

SUMMARY

- TCT setup using red laser (660 nm) is installed & commissioned at Delhi University.
- Measurements on diodes are in good agreement with each other, validating the TCT setup installed at DU.
- To complement the measurements, MixedMode TCT simulations using Silvaco TCAD tool are being done.
- Infrared Laser (1060 nm) TCT capability will be added to the existing setup for calculating CCE.

Acknowledgement : Authors are thankful to UGC-JRF, DST & ISJRP for financial research support and to PH-DT Lab at CERN &Dr. Christian Gallrapp for help in setting up of TCT setup.