Characterization of Si Detectors through TCT at Delhi University

G. Jain*, K. Lalwani, R. Dalal, A. Bhardwaj, & K. Ranjan
Centre for Detector & Related Software Technology, Department of Physics & Astrophysics, Delhi University, Delhi - 110007, India

• 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⁻²s⁻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 (∆q) on the electrodes in proportion to the displacement (∆x) of these charge carriers through the detector depth (d).

Δq = (∆x/d) . q

**TYPES OF TCT TECHNIQUES**

- **Infrared 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.

- **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.

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

- **G. Jain (Presenter)**

G. Jain, Delhi University, India

ELBA CONFERENCE – 24 TO 30 MAY, 2015
Red Laser TCT Setup Developed at Delhi University

**DU Circuit Diagram**

**DU TCT Setup**

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

**Results and Observations**

- 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.

G. Jain, Delhi University, India