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Characterization of Ultra-Fast Silicon Detectors for High Energy Physics Applications

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Ultra-fast silicon detectors (UFSD) are a specialized type of radiation detectors based on Low Gain Avalanche Detectors (LGADs) that are designed to have extremely fast response times, typically in the range of picoseconds or even femtoseconds. The exceptional temporal resolution of UFSD enables the precise determination of the particle arrival time and helps disentangle overlapping collision events in the context of High-Luminosity Large Hadron Collider (HL-LHC). This information is crucial for accurate reconstruction of particle trajectories and identification of rare or short-lived particles.
This work presents detailed results on the study of 50 μm thin-LGADs with different doping concentrations produced by Micron Semiconductors Ltd. A temperature dependent study of the leakage current and the breakdown voltages are examined using current-voltage (IV) characteristics. Additionally, frequency dependence of the Capacitance-Voltage (CV) measurements is also presented in this work. Laser characterization of these sensors is carried out using Transient Current Technique (TCT) to study the charge collection and gain characteristics, and the comparison is made on the basis of Laser wavelength (Red –658nm and IR –1064 nm) and the position of illumination (top and bottom). Temperature dependent measurements of gain as a function of voltage are also presented here. We observed the influence of different doping concentration and JTE width on the gain. The collection of TCT signals within 2 ns after the sensor is fully depleted refers to the fast signal processing that offers exceptional timing performance. A detailed study of timing resolution using source measurements will be carried out in the near future.

Your name

Fasih Zareef

Institute

AGH University of Science and Technology, Krakow (PL)

Email address

fasih.zareef@cern.ch

Author: ZAREEF, Fasih (AGH University of Science and Technology (PL))

Co-authors: OBLAKOWSKA-MUCHA, Agnieszka (AGH University of Science and Technology (PL)); DOCHEVA, Aleksandrina (University of Glasgow (GB)); Dr MANEUSKI, Dima (University of Glasgow (GB)); BULLOUGH, Mark (Micron Semiconductors (GB)); COOKE, Naomi (University of Glasgow (GB)); MOFFAT, Neil (Consejo Superior de Investigaciones Cientificas (CSIC) (ES)); Dr BATES, Richard (University of Glasgow (GB)); SZUMLAK, Tomasz (AGH University of Science and Technology (PL))

Presenter: ZAREEF, Fasih (AGH University of Science and Technology (PL))

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