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## Characterization of Sintef 3D diodes with trenches geometry before and after neutron irradiation

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Detectors with high radiation tolerance and high time resolution are required for charged particle in high physics and space applications.

3D detectors were introduced by S. Parker [1] in the middle 90' and they represented a starting point for evolved device able to work at fluency up to  $2 \times 10^{16} \text{ neq/cm}^2$ . A limit to 3D detector is the not uniformity of electrical field that translates in a not uniform charge collection efficiency after high radiation doses and an uneven timing for the signal.

Different solution has been proposed in the last decade (eg. Hexagonal geometry of the electrodes) but many TCAD device simulations suggest parallel trenches as best solution [2]. Two different geometries have been taken into consideration both with parallel trenches. The distance between trenches of opposite sign is  $25 \mu\text{m}$  in both case and the distance between trenches with equal sign is fixed to  $50 \mu\text{m}$ . The main difference is trenches length that is respectively of  $100 \mu\text{m}$  and  $50 \mu\text{m}$ . They have been designed and fabricated by SINTEF MiNaLab, Oslo, Norway on SI-SI, high resistivity, float zone substrates ( $6-12 \text{ k}\Omega \text{ cm}$ ) with an active thickness of  $100 \mu\text{m}$ .

The neutron irradiation of the sensors has been carried out at the TRIGA Mark II reactor at JSI (Ljubljana, Slovenia) in May 2018 and the characterization was performed afterwards.

The functional characterization has been performed by using a position resolved laser and by using a setup designed for this type of measurements.

The radiation source is a pulsed laser with a wavelength of  $1064 \text{ nm}$  that allow a quasi-uniform release of charge in the silicon substrate and a nominal pulse of  $40\text{ps}$ . The laser source is integrated in a microscope optics that can be moved in the 3 axes with a precision on the micrometer range. In addition, the detectors are located in a vacuum chamber that avoid problems related to the humidity/hoarfrost when the detectors works at low temperature. The detector is connected by using two tungsten micro-needles connected to the readout circuits.

The results are two-dimensional maps of the signal across the 3D single basic cell. The measure has been repeated for different voltages and temperature.

The data are then normalized to the signals acquired on non-irradiated samples.

At the conference we will report on the device design and technology, as well as on selected results from the electrical and functional characterization.

[1] S. I. Parker et al., "3D-A proposed new architecture for solid-state radiation detectors", Nucl. Instrum. Methods A, vol. 395, pp. 328-343, 1997.

[2] R. Mendicino, et al. "3D trenched-electrode sensors for charged particle tracking and timing." Nucl. Instrum. Methods A 2019.

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