Contribution ID: **127** Type: **Talk**

Improving spatial and timing resolution of 3D diamond detectors

Thursday 20 February 2025 09:00 (20 minutes)

3D diamond detector is a relatively new concept that is characterised by an electrode array fabricated inside a Chemical Vapour Deposition (CVD) diamond plate using a femto-second laser, resulting in electrically conducting graphitic paths. This fabrication method allows for various complicated electrode structures, making it possible to design novel electrode geometries and optimise the spatial/temporal performance of 3D diamond devices. In this paper, multiple 3D diamond detector structures are modelled. Their electric fields are simulated using Sentaurus TCAD and the signal response is simulated with Monte Carlo method using Garfield++. Then a Deep Neural Network (DNN) based algorithm is built to analyse the signal waveform from hit events and improve the detector's spatial/temporal resolution by predicting the accurate hit position and time of arrival. Utilising these tools, the performance of different 3D diamond detector structures are analysed. To test the detector performance experimentally, detector prototypes with various structures are built with a femtosecond laser equipped with an optical correction using Spatial Light Modulators (SLMs). The Two Photon Absorption (TPA) technique is used to generate point-like charge distributions inside 3D diamond sensor, so that the detector response is examined with high spatial and temporal resolution.

Primary experiment

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Session Classification: Semiconductor 3D

Track Classification: Semiconductor Detectors