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Advanced diamond materials for timing applications

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Recent progress in the production of high-quality 'electronic grade' diamond materials by Chemical Vapour Deposition (CVD) processes enables the development of timing detectors for charged particles of unprecedented time resolution and rate capability. We present the characteristic properties of the three most relevant undoped diamond types for detector applications, which are single crystal CVD diamond plates (scCVDD) grown homoepitaxially on high-quality diamond substrates (produced by High-Pressure-High-Temperature (HPHT) processes), polycrystalline CVD diamond samples grown on silicon (pcCVDD), and 'quasi singlecrystal' Diamond films grown by
heteroepitaxy on Iridium wafers (DoI). The thickness of the samples is adjustable between ~ 10 and several hundreds of micrometers.
The dark conductivity of the different diamond materials is correlated to the structural bulk defects as well as to the morphology and roughness of the diamond surfaces, which influence in addition significantly the internal electric field profile of the sensors. The potential of the diamond crystals for timing or/and spectroscopy applications is evaluated by the analysis of the transient current signal shapes generated by short range 241Am particles readout with the Diamond Broadband Amplifiers (DBA) developed at GSI for heavy-ion detection with diamond detectors.
The Charge-Collection Efficiency (CCE) and the corresponding Collection Distance (CD) is measured with high-resolution (silicon) spectroscopy amplifiers developed at the Technical University of Darmstadt (CSTA2 preamplifiers) followed by commercial standard nuclear electronics.
Time resolution data are presented, which have been obtained with scCVDD and pcCVDD sensors readout with different new FEE designs developed from the HADES, the FOPI, and the CBM Collaborations at GSI. A variety of heavy and light ion probes as well as relativistic protons have been used at the SIS of GSI. All data presented are limited by the electronic noise. The best relativistic heavy-ion
result (si = 25ps) has been achieved with 'as grown = unpolished' pcCVDD
detectors of 100 mm thickness readout with a broadband amplifier and discriminator card FEE1 (FOPI), whereas the highest resolution for relativistic protons has been obtained from scCVDD sensors of 400mm thickness readout with a low capacitance
setup (HADES). Preliminary results of a beam test with 6Li ions of 2 AGeV using the latest setup with 100 mm thick diamonds have shown an intrinsic diamond time resolution of 20ps.

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