CVD Diamonds: the new material of choice for cutting-edge applications

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Recent advances in the crystalline quality and purity of chemical vapor deposited (CVD) diamonds have enabled their use in a wide variety of cutting-edge particle and X-ray detectors, optical windows, heat spreaders and electro-chemical applications. The manufacturing process of growing single crystalline and polycrystalline diamond has greatly improved to the extent that large area (up to 150 mm), impurity free and transparent diamond windows can be produced with consistency and optimised for their exclusive application. By careful optimization of the growth process, the phonon side bands which impacts the electronic properties can be eliminated and diamonds with extremely low defect density can be produced. These device grade diamonds have been fabricated into a series of micro-strip and pixel particle detectors and their electronic properties and radiation hardness were characterized at CERN. Full charge collection can be easily achieved at very low bias field of 0.2V/mm. At 100K and above, both the holes and electrons mobility decreases with increasing temperature however the rate of decrease is different. The drift velocities of these diamonds were found to decrease linearly with increasing electric field. Xray topography images at different crystal orientation, 2D current map (X-ray responsivity) will also be presented and correlated with the electronic properties of diamond. Optical properties were evaluated using UV/VIS, FTIR, Raman/PL spectroscopy, birefringence microscopy as well as double crystal rocking curve imaging. We found that diamond’s low absorption and extremely wide transparency from deep ultraviolet (<220nm) to micrometres (>50mm) makes them a material of choice for optical windows. This unique optical property when combined with their exceptional thermal and mechanical properties makes diamond optical windows highly favoured over conventional optical materials in many cutting-edge optical applications. Moreover, thermal properties of different type IIa diamond plates and electrical conductivities of boron-doped diamonds, were also obtained. The relationship between crystal quality and the distribution of imperfections arising from the concentration of nitrogen and silicon vacancies in a diamond plate is presented. Based on the obtained properties, a methodology for selecting and categorizing electronic-, thermal- or optical-grade diamond plates are derived and proposed for existing and future industrial applications of large high purity diamond plates.