

Temperature dependent charge transport studies in polycrystalline and single crystal CVD diamond detectors

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Abstract

Diamond has been regarded as a promising radiation detector material for the use as a solid state ionising chamber for decades. To improve detection performance, the parameters affecting the charge transport need to be understood, especially defects leading to degradation from the expected behaviour of an “ideal” crystal. Recently, chemical vapour deposited (CVD) single crystal diamond has become available, offering the opportunity to study the properties of this synthesised material independent of grain boundaries.

This work focuses on particle induced charge pulses studied as a function of temperature between 200 K and 296 K in polycrystalline and single crystal material. Thermally activated re-emission of holes out of shallow trap levels is clearly observed in this temperature range. The electrical characterisation is complemented by other techniques, such as polarizing microscopy and luminescence studies. Time resolved ion beam induced charge (IBIC) imaging on a single crystal was also performed. The charge collection efficiency of the devices hardly shows a temperature dependence in the investigated range, but polarisation and priming affect the detection performance. The pattern in the IBIC images of the single crystal reflects the spatial distribution of the luminescence signature of nitrogen impurities and dislocations, giving direct evidence of their degrading effect on the charge carrier mobility-lifetime product ($\mu \tau$). Additionally, there is some structure in the μ images evolving with the growth direction of the CVD material. The spatial distribution of internal electric fields will be discussed together with the effects of polarisation/priming processes.

The recent progress in high purity single crystal synthesis of CVD diamond is a major step for its application as a radiation detector with spectroscopic properties. The study of these single crystals will improve the understanding of the relation between defects and the bulk charge transport properties of diamond.