Development of Heteroepitaxial DoI Plates for Diamond Detectors[*]

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Typical size of the chemical vapor deposition (CVD) homoepitaxially grown diamond material (also known as the single crystal - SC) is limited to some 5 x 5 mm^2 due to the availability of growth substrates made from the high-pressure high-temperature (HPHT) diamond. Presently, the only material readily available for the production of diamond detectors with larger area ($\sim$10 cm^2) is polycrystalline (PC) film grown on silicon wafers with electronic characteristics far inferior in comparison to SC material.

In order to produce a large-surface high-quality material for diamond detectors different techniques for heteroepitaxial growing of diamond films are being investigated and developed at the University of Augsburg. By using yttrium-stabilized zirconium oxide (YSZ) buffer layer to produce iridium terminated substrate on silicon wafers [1] one can grow diamond films (also know as the diamond on iridium - DoI) that are far more homogeneous than PC, however, still burdened with defects. In last few years a remarkable improvement in lowering of the level of impurities and defects was achieved so that the presently produced samples - while still not comparable to SC material - are far superior to any PC material.

Most significant structural defect arising in heteroepitaxial growth are dislocations.In a recent study [2] in which the density of threading dislocations was determined by few methods over a large sample thickness, an inverse growth depth behaviour was found. While this at least in principle confirms that films with very low density of dislocations can be grown, presently procedure would not be economically effective therefore different growing techniques - *e.g.* epitaxial lateral overgrowth - are being developed.

In order to assess the quality *i.e.* electronic characteristics of new DoI samples a typical measurement of the charge collection efficiency (CCE) is performed by using the transient current technique (TCT). Alpha particles (^{241}Am) are used to test the sample with different polarizations and drift fields so that the properties for both types of charge carriers can be evaluated. In Fig. 1 the set of measurements with a recent DoI sample of 190 μm thickness at different drift fields is presented showing the saturation at values above 0.8 V/μm. While the overall triangular shape of wave forms indicate the presence of the charge recombination defects, additional flat-top slope is related to losses due to the charge carrier trapping within the sample. For this sample we have measured an average CCE of about 60% for holes, which is below the level of the best samples tested (>90%) [3]. On the other hand, the CCE for electrons (shown in Fig. 2) of about 40% is much better than previously measured ($\sim$10 %). In this case the saturation is observed at the higher drift field of 1.2 V/μm.

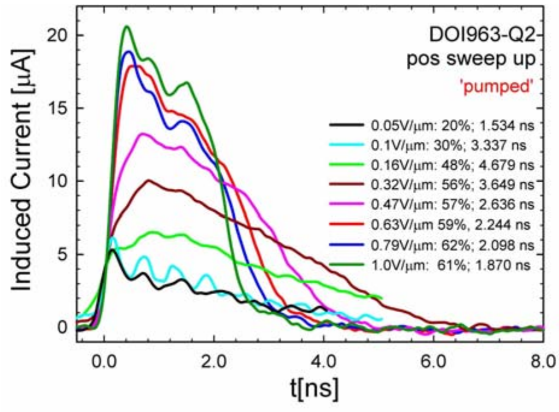

Figure 1: Pulse-shapes (waveforms) obtained for the drift of holes across the sample. The CCE is determined by waveform integration. Each waveform is an average from 1000 recorded events.

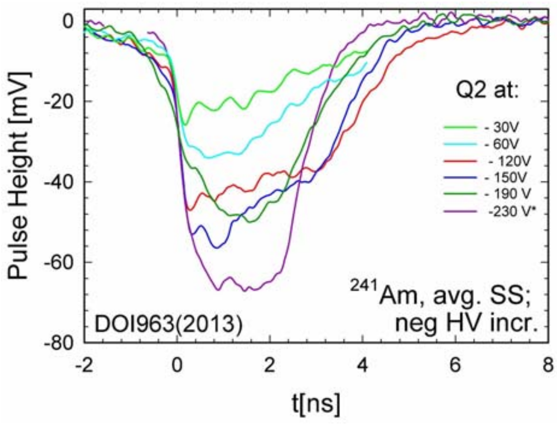

Figure 2: Pulse-shapes for the drift of electrons across the sample with 42 dB pre-amplification.

References

[1] S. Gsell *et al.*, Appl. Phys. Lett. 84, 4541 (2004)

[2] C. Stehl *et al.*, Appl. Phys. Lett. 103, 151905 (2013)

[3] E. Berdermann *et al.*, GSI Sci. Rep. 2011, 245

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[*] This work was supported in part by HadronPhysics3 (grant agreement No 283286 under the EU FP7.)

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doi:10.15120/GR-2014-1-FG-S-FRS-07