First Results of CVD-Diamond Detectors Grown on Large Iridium Substrates*

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A promising course for large-area 'quasi' single-crystal CVD diamond (scCVDD) is the heteroepitaxial growth on the multilayer structure Ir/YSZ/Si(001) [1] - as developed at the University of Augsburg on 4inch wafers. Key issue is the similarity of the lattice constants of diamond (d_{Dia} = 3.567 Å) and Iridium (d_{Ir} = 3.834 Å).

Figure 1 shows characterization results of two Diamond-on-Iridium (DoI) samples compared to commercial scCVDD and polycrystalline CVD-diamond (pcCVDD) detectors [2]. DoI549a (top- and central-right data) is a polished freestanding film of 230µm thickness, where a 30µm layer has been removed from the nucleation side. The thickness of DoI724b (bottom left and right data) was optimized for Transient-Current Technique (TCT) measurements with ^{241}Am-α-particles: an iridium mesh was added in the depth of the α-range providing $d_D \approx$ 12µm.

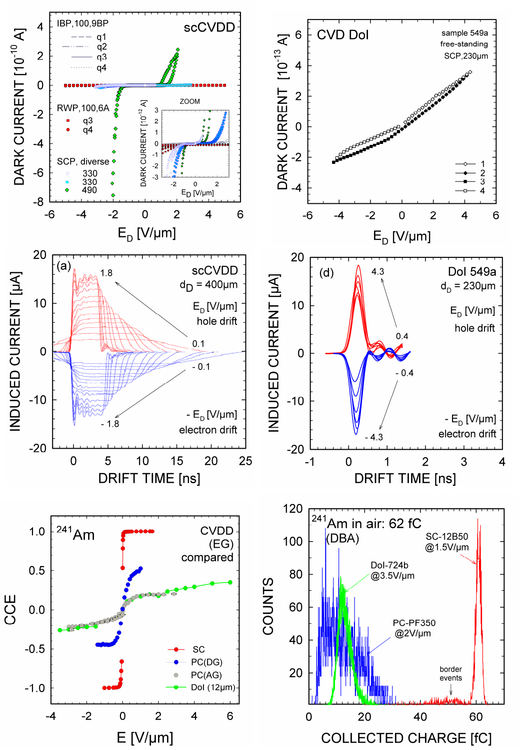

Figure 1: Characteristics of early DoI samples compared to scCVDD and pcCVDD: (top) $I_{dark}(E_D)$ curves; (central) TCT for internal E_D profile, charge-drift, and trapping; (bottom-left) Charge-Collection Efficiency (CCE) vs. E_D; (bottom-right) Collected Charge distributions.

The unexpected low dark current of DoI films is discussed in the next section. The triangular TCT signals (Fig. 1, central-right) demonstrate significant trapping of the excess charge in the vicinity of generation. The charge losses are due to the high dislocation density of present DoI CVDD [2]. In contrast, the trapezoidal signals of defect free scCVDD samples (Fig. 1, central-left) confirm a homogeneous internal field and full drift of the ionized charge to the opposite electrode. The CCE ≈ 0.4 measured for DoI724b (Fig.1 bottom-left) is presently as high as of 'as grown' (AG) pcCVDD. However, the energy resolution (Fig.1, bottom right) is significantly better, even compared with 'detector grade' (DG) pcCVDD, confirming homogeneously distributed dislocations. The amplitudes of the TC signals are similar to those of best scCVDD sensors (Fig.1, central-right and left plots). Excellent heavy-ion timing at ion rates >> 10^9ions/s is expected by minimizing detector and stray capacitances.

Electrical Conduction

We studied the dark current behaviour of DoI549a in the electric field range - 4.3 ≤ E_D [V/µm] ≤ 4.3 at temperatures from 300 K to 673 K. Two types of sandwich electrodes were tested (in vacuum): a) both sides ohmic (i.e. Ti-Pt-Au metallization); b) one side blocking (pure Al), second one same as a). As in previous studies of scCVDD [3] we found the IV characteristics of DoI films up to T = 400 ^{0}C independent of the contact metal. However, the high activation energy of 1.53 eV extracted from Arrhenius plots suggests minor contribution of the bulk defects to the dark current and points to an 'interface-controlled' conduction mechanism. We applied dedicated fitting to the data, due to which eventually pure field emission (Fowler-Nordheim) or pure trapping-detrapping (Poole-Frenkel) conduction could be excluded, while a mixing of various processes appears most likely, with Schottky Emission the dominant mechanism at temperatures 472 K - 672 K and fields E_D >1 V/µm. Similar barrier heights $\Phi_b \approx (1.72 \pm 0.01)$ eV have been estimated for both electrode types. The studies are ongoing.

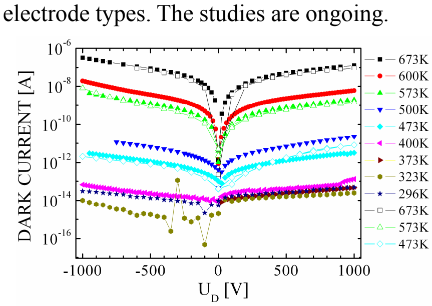

Figure 2: $I_D(U_D)$ at high temperatures. a) solid symbols: ohmic/ohmic b) open symbols: ohmic/blocking contacts.

References

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