On the Crystal Structure of Intrinsic CVD Diamond-on-Iridium Sensors*

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Ion Beam Induced Current (IBIC) experiments were performed with high-quality Diamond-on-Iridium (DOI) sensors aiming to visualize shape and spatial distribution of crystal dislocations in this new detector-grade diamond type. For the first time, DOI samples were irradiated with ^{12}C microbeams of 3.6 and 11.4 AMeV kinetic energy in two crystallographic directions, the [001] (i.e. along the surface normal) and the [110] (lateral) direction. Different ion energies enable the imaging of the Collected Charge (CC) in diverse crystal planes lying in depths corresponding to the Bragg maxima (here: 25µm and 170µm, respectively). Stopped, mono-energetic ions generate the same amount of electron - hole (e-h) pairs in intrinsic single crystal sensors - independent of the point or angle of the ion incidence. Ideal detectors have a CC efficiency (CCE) equal unity showing uniform maps, whereas real sensors reveal reduced CC and maps modified by crystal defects.

Sample Preparation and Mounting

A sensor of 265µm thickness and (5x5) mm² area [1] was re-metallized with six edgeless stripe electrodes connected in parallel to an SMA connector used for biasing and readout (Fig. 1, left). Edgeless contacts are difficult but indispensable in lateral IBIC tests. They produce occasionally abnormal leakage currents disturbing bias stability and energy resolution. Figure 1 (right) shows two sensors mounted for lateral experiments.

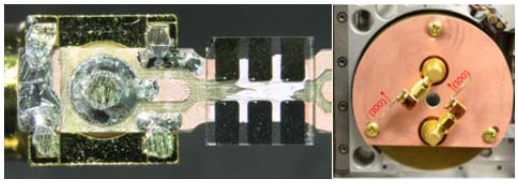

Figure 1:(left) Edgeless DOI sensor mounted on an SMA. (right) Two sensors aligned for lateral IBIC tests.

First IBIC Results

In Figures 2 and 3, examples of top-view (001) and lateral (110) maps are presented, obtained from layers in 25µm (at 3.6 AMeV) and 170µm depth (at 11.4AMeV) behind the corresponding diamond surface. In each case, areas of (288 x 232) µm² have been irradiated.

The selected pulse-height conditions used are indicated in the right spectra. The X-axes of the CC distributions are calibrated in energy values, assuming 13.4 eV per ion-induced charge carrier in diamond. The 3.6 AMeV data are presented in the range 0 - 45 MeV in 1keV/ch and the 11.4 AMeV in the range 0 - 290 MeV in 100 keV/ch, respectively. Note that, the colour values (i.e. the CC plot

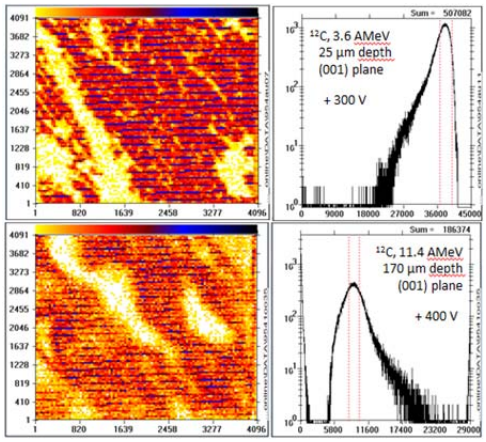

Figure 2: (001) IBIC maps (left) obtained with the conditions shown in the spectra (right). The data correspond to layers below the contact in a depth of 25µm (top) and 170µm (bottom), respectively.

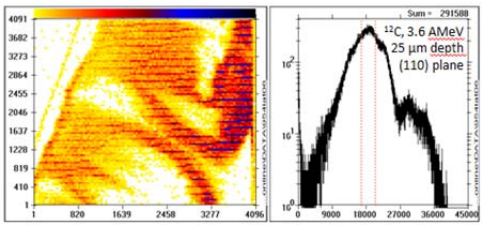

Figure 3: (110) Lateral IBIC maps and spectra (s. text).

ted on the Z-axis of the 3D maps) do not represent pure signal amplitudes, since these are generated by weighting each pulse height with the number of events at that place. However, considering the strict homogeneous irradiation performed with the micro-beam facility, the maps confirm predominantly areas of high, rather homogeneous CCE.

Preliminary Conclusions

Top-view and cross-section maps differ significantly in the CC pattern. In top view, granular structures are visible with a characteristic length of 50 -100 µm. In contrast, the cross-section maps are dominated by stripes along the growth direction of a slightly tilted angle. Both observations show intriguing similarities to the shape and alignment of threading dislocations bundles observed by mapping the Raman-line widths [2]. Further studies are required to establish the preliminary results and to elucidate the influence of the contacts on the CCE patterns.

References

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