New tests of large area Continuous Position Sensitive Diamond Detector

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The first Continuous Position Sensitive Diamond Detector (CPSDD) was made on a single crystal (sc) based material [1]. The high efficiency of sc provides a high enough Signal to Noise ratio (S/N) to fully test the CPSDD with alpha particles.

The first Large Area CPSDD (LACPSDD) was made on a 30 x 30 mm^2 polycrystalline (pc) diamond plate [2], obtained by chemical vapor deposition. In beam tests with ^{54}Ni 1.7AGeV particles it shows an ion rate limitation due to the detector time constant.

We made two new pc LACPSDD, one having 10 x 10 mm^2 (x 110 µm) and the second one (Fig. 1) having 20 x 20 mm^2 (x 180 µm). On each detector side a DLC layer is deposited, equipped with two metallic charge collection electrodes. The relative impact position can be obtained by charge division measurement. Each detector is connected to four charge sensitive amplifiers (CSA).

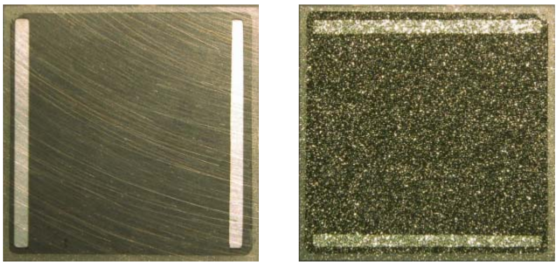

Figure 1: The 20 x 20 mm^2 LACPSDD. Left: view of the substrate side. Right: view of the growth side. On each side there are visible the DLC layer (dark) and the metallic electrodes for charge collection (light). The two pairs of metallic electrodes are oriented at 90°. The DLC layer has R_D ~ 30 KΩ/□, and capacitance between layers C_D ~100 pF.

Tests with alpha particles highlighted that the induced signal delay depends on particle impact position: it is maximal in the centre of the detector and minimal near the electrode. Since the peaking time of the CSA must be greater than the maximal delay, we have modified all the used CSAs [3] to have a 1.5 µs peaking time thus minimizing the ballistic deficit. We obtained a very good correlation between the total collected charges by the two layers and found that the main limitation is due to the small value of the S/N i.e. maximum of 16 in case of alpha particles (the energy lost by an alpha particle is 5.486 MeV, equivalent to an induced signal charge of approx. 67 fC). In addition, the pc material has a broad dispersion of the detection efficiency.

Detector was also tested in ^{12}C micro-beam at 11.4 MeV/A beam energy [4], which provides approx. 25 times larger S/N ratio for stopped particles. We have manually positioned the beam into 62 discrete positions and used the automatic beam micro-sweeps in small rectangles of 280 x 230 µm^2. Subsequently, the data were processed as follows:

1. Electrical calibration by using a pulse and 4 ways distributor; offsets and different gains were corrected.
2. For each position, the median centre (x.y) and standard deviation $\sigma_{x,y}$ were obtained. Data outside the centre $\pm 4\sigma_{x,y}$ and outside collecting strips were ignored.
3. The remaining points were fitted to 2D Gaussian distributions, providing higher accuracy for estimates of the measured centres.
4. For each of the 62 micro-beam positions, an error vector is derived, based on the known micro-beam focus and on the fitted actual position of the centre.
5. The x and y components of the error vectors are fitted by series expansions of 2D Legendre polynomials of 5th degree, which provides a continuous 2D coverage.
6. All data points that were not filtered out at step 2 were corrected by continuous 2D error vector (Fig. 2).

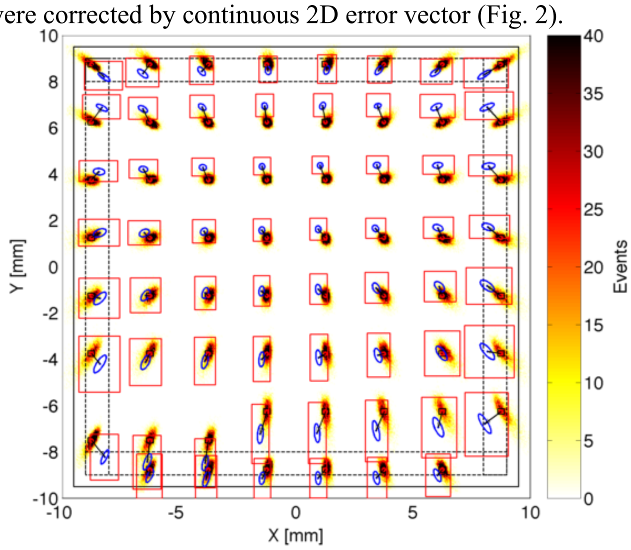

Figure 2: The original (blue contours), micro-beam injection frames (red) and reconstructed spots, after electrical calibration, data filtering (red rectangle contours) and geometrical calibration.

After correction, the 62 measured distributions agree very well with the micro-beam injection frames.

References

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