Large Area Continuous Position Sensitive Diamond Detector: First Tests

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Based on a polycrystalline chemical vapor deposition (pcCVD) diamond plate, a Large Area Continuous Position Sensitive Detector (LACPSD) of 30 mm×30 mm sensing area was fabricated and tested in Cave B. The beam used was ^{54}Ni of 1.7 AGeV and the beam intensities varied from a few kHz up to 10^7 particles/s.

The LACPSD is designed in parallel-plate geometry. A thin resistive layer of diamond like carbon (DLC) is deposited on the pcCVD diamond growth surface serving as the sensing electrode [1]. The surface resistance of the DLC layer amounts to $R_\square \sim 10$ kΩ. The 2D position information is obtained by the simultaneous measurement of the signal charge divided between four collecting pads, which are located at the corners of the DLC sensing electrode (Figure 1 left).

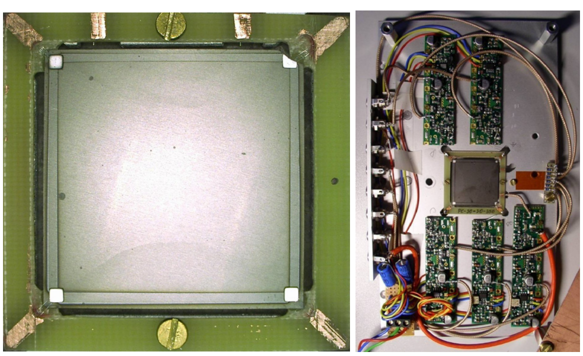

Figure 1: Left: top view of the LACPSD. At each border of the main DLC layer are DLC strips added which are placed between the four charge-collecting pads. This layout is intended to decrease the cushion error. Right: the LACPSD mounted at the centre of the board, which caries the five amplifier cards. This first test assembly has been tested with the diamond in air.

We have used four charge sensitive amplifiers (CSAs [2]) to measure the charge collected at each corner and one CSA for the back electrode to measure the total charge generated by each particle (Figure 1 right). The resistive electrode guides the particle-induced charge generated at the impact position towards the collecting contacts. From the charge q_i measured at each of the four contacts we can estimate the position of the particle impact. By assuming a uniformly resistive quadratic layer of surface L^2 the relative position is given by:

$$x = \frac{(q_2+q_3)-(q_1+q_4)}{q_1+q_2+q_3+q_4}\frac{L}{2}, y = \frac{(q_1+q_2)-(q_3+q_4)}{q_1+q_2+q_3+q_4}\frac{L}{2}.$$

A significant increase of the base line instability was observed when the detector was connected to the CSAs. We attributed this fact to the high total detector capacitance of $C_{DET} = 133$ pF and to the resistance distribution of the DLC layer with a total value of $R_\square \sim 10$ kΩ. In order to minimize this instability we have applied a lower feedback resistance and a higher feedback capacitance compared to the original CSA design. However, this action was at the expense of decreasing charge responsivity and increasing noise level. The lumped equivalent scheme of the next detector prototype will consist of a resistor and a capacitor of values, which have to be less than those used in this experiment.

The obtained results confirm the detectors good rate capability. Figure 2 shows the reconstructed profile of the traversing nickel beam. It has to be noticed that due to experimental constrains given by the main experiment, the diamond sensor was placed at the very end of the FOPI spectrometer with all other detectors placed in beam direction in front of it. An additional contamination of the nickel data is assumed due to ionization of the air near the detector electrodes.

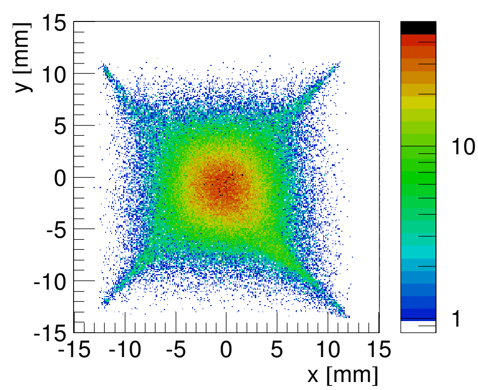

Figure 2: Reconstructed beam position and profile obtained from all unfiltered events recorded. The total range in x and y corresponds to the total sensing area (±15 mm) shown in a bin size of 10 μm/ch. The data (log-scale) are only corrected for gain differences between CSAs.

For the next test we are preparing an assembly with a FEE capable of decreasing base line instabilities and cross talk and where the LACPSD is isolated from the surrounding air. The final goal of this study is the development of LACPSD sensors using Diamond-on-Iridium(DOI) plates.

References

[1] M. Pomorski et al., Phys. Stat. Sol. A, 206, pp. 2109-2114, (2009).

[2] M. Ciobanu et al., IEEE NSS Conf. Rec., N30-20, pp. 2028-2032, (2008).