# Characterization of Polycrystalline CVD Diamond Detectors with the Heavy Ion Microscope SNAKE

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## 1. Introduction

Diamond is an ideal material for in beam detectors. Special features are radiation hardness and fast signal collection. Currently larger area detectors as e.g. needed in the $R^3B$ detector setup [1] can only be produced from polycrystalline CVD diamond. As the charge carriers recombine at the grain boundaries charge collection efficiency depends on the crystallite size. We measured different charge collection efficiencies for the two manufacturers, IAF Fraunhofer in Freiburg, and Elemntsix in UK.

To determine the influence of the segmentation to the overall detection efficiency we produced small test detectors of 10 $\times$ 10 mm$^2$ from polycrystalline CVD diamond. The Al metallization is 64 strips on one side, this means a strip width of 110 $\mu$m and a gap between two strips of 30 $\mu$m, and 4 strips of 2 mm with a gap of 50 $\mu$m on the other.

For investigation of spacial charge collection efficiencies we tested different detector samples with the superconducting nanoscope for applied nuclear physics - SNAKE.

## 2. Setup

The detector was mounted in the focal plane of SNAKE and was followed by a silicon diode which provided a trigger signal. We used a 48 MeV low intensity Li beam. Each particle passes the diamond and is stopped in the diode.

## 3. Measurement

We scanned the diamonds in two different modes. The first was a rough scan with a step size of 5 $\mu$m in x and 10 $\mu$m in y direction. The second, a fine scan was 2 $\mu$m in x and 3 $\mu$m in y direction. Signal amplitudes for each individual strip on the detector were recorded.

### 3.1 Calibration

To calibrate the two different scans we used a defined metal grid. The rough scan is shown on the left hand of fig. 1, the fine scan on the right.

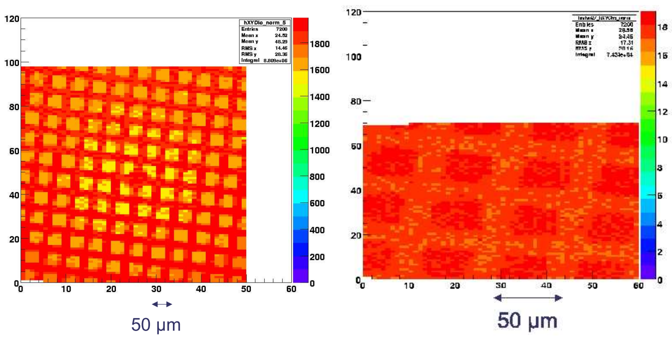


Fig. 1: The left histogram shows the metal grid in rough scan, the right one shows it in fine scan.

### 3.2 Signal map

Fig. 2 shows the rough scan across the strip boarder of a fourfold stripped 50 $\mu$m thick diamond from IAF Fraunhofer. Clearly the signal amplitudes on average drop in the 50 $\mu$m gap between two 2 mm strips. The y-projection shows a less efficient area with a width of 40 $\mu$m at the segmentation line.

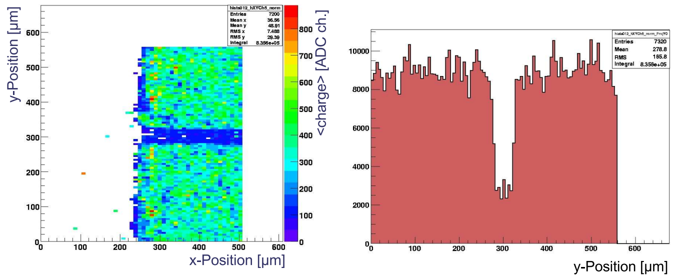


Fig. 2: The left figure shows the rough scan, the right figure shows its y-projection.

Also a fine scan showed the same behaviour. This means the influence of the gap on efficiency is about the gap width minus 10 $\mu$m.

### 3.3 Crystallite size

In a second test we were looking at the highly segmented front strips of a differnt detector made of 120 $\mu$m thick material from Elementsix. The fine scan nicely shows the amplitude pattern related to charge collction efficiency which nicely reflects the crystallites structure in the material. Even with the 30 $\mu$m segmentation the gap between two strips is still visible at a width of roughly 20 $\mu$m. Overall signal amplitudes roughly scale with the material thickness. No significant difference in the crystallite sizes were found even though the thicker material provides a better averaging.

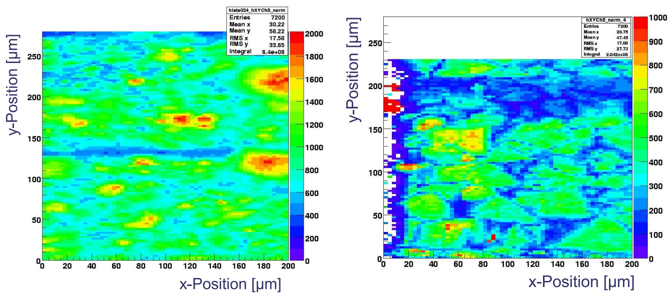


Fig. 3: The left figure shows the crystallites of the 100 $\mu$m thick substrate from Elementsix, on the right the 50 $\mu$m thick substrate from IAF Fraunhofer.

## 4. Outlook

As a conclusion of the amplitude drop at the segmentation line we want to produce smaller gaps of about 15 $\mu$m. So there should nearly be no inefficiency left at this area.

Another point is to produce larger detectors of about 50 $\times$ 50 mm$^2$. And the readout should be done by an APV chip which includes preamplifier and shaper. It is already in use at CERN.

### References

[1] $R^3B$-Collaboration, Technical Proposal for the Design, Constuction, Commissioning and Operation of $R^3B$, Dec 2005