ESRF	**Experiment title:** Investigation of surface defects in polycristalline diamond for X-ray spectroscopy applications	**Experiment number:** MI-347
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Report:

Preliminary experiment report (MI347)

Since 1994, CEA/LETI is working on the development of electronic grade CVD diamond for radiation detection applications such as nuclear instrumentation, medical physics and experimental physics. Recently, CVD diamond probes have been developed for the in-line monitoring of synchrotron light beams. The devices were tested during several experiments at ESRF (MI212, MI258, MI380).

The development of radiation detectors based on high purity IIa type natural diamond was severely limited by the availability, reproducibility and cost of such crystals. Advances in Chemical Vapour Deposition (CVD) of diamond has allowed to overcome this problems. However, the polycrystalline nature of CVD diamond has an important influence on the transport properties and thus on the detection performances. As can be seen on figure 1 representing a pulse-height distribution recorded with a CVD diamond detector exposed to a mono energetic alpha particle source, the resolution of the detector is strongly affected by the presence of grains of different quality and size. The major task of this experiment was to investigate the role of the polycrystalline feature on four CVD and three natural diamond samples on the free carrier transport properties relevant for radiation detection applications. For each sample, the current induced was measured as a function of the position in order to perform high resolution sensitivity maps of the detectors. For the natural diamond crystals, the luminescence was simultaneously measured with a 4-quadrant silicon photodiode placed in front of the sample.

The measurements performed at ESRF on this detector have given evidence of the role of grain boundaries in the detection properties. Sensitivity maps of the surface have been measured by scanning the detector surface with a micro-focus beam (spot size ~ 1x1 μm^2). It can be observed that the induced current is lower close to the grain boundaries and higher in the middle of the grains. Further, differences in sensitivity between different grains have been observed. Figures 2.a and 2.b show the correlation between the sensitivity map of the scanned area and the morphology of the sample.
Measurements performed on high quality natural diamond samples from TRINITI Institute (Moscow, RUSSIA), have shown that the crystal is not uniform but shows regions with different regions. During this experiment, the induced current has been measured simultaneously with the luminescence of the sample. The regions with lower sensitivity have a higher luminescence light yield, which is attributed to a high concentration of defects (see figure 3.a and 3.b).

A detailed analysis of the results obtained during the experiment will provide helpful information for the understanding of the macroscopic transport properties of CVD diamond. For the first time, correlation between the sensitivity maps and the morphology of the samples (grain size and orientation) could be clearly demonstrated. Further experiments at ESRF are needed to complete the study:

- Sensitivity maps performed at different photon energies will enable to study the role of surface and bulk defects.
- Spatially resolved luminescence measurements to characterise the defect concentration. The photodetector system used in this experiment was not sensitive enough to perform the measurement on CVD diamond.
- Spatially resolved measurements of the transient current (in the 16 bunch mode) using fast electronics (>1 GHz).

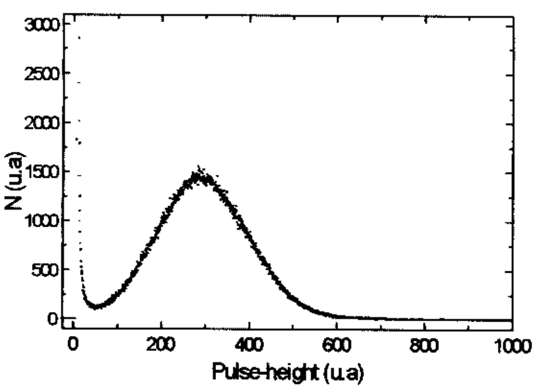

Figure 1: Pulse-height distribution of a 5.5 MeV alpha source recorded with a CVD diamond detector.

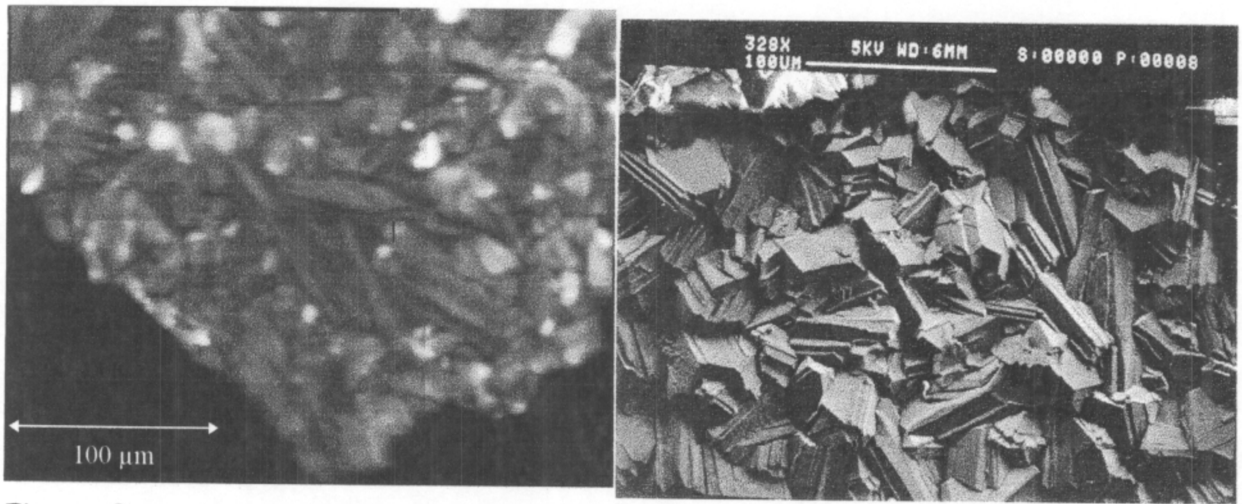

Figure 2. Sensitivity map of a CVD diamond detector (a) measured at ESRF, compared to the SEM photograph of the same area (b).

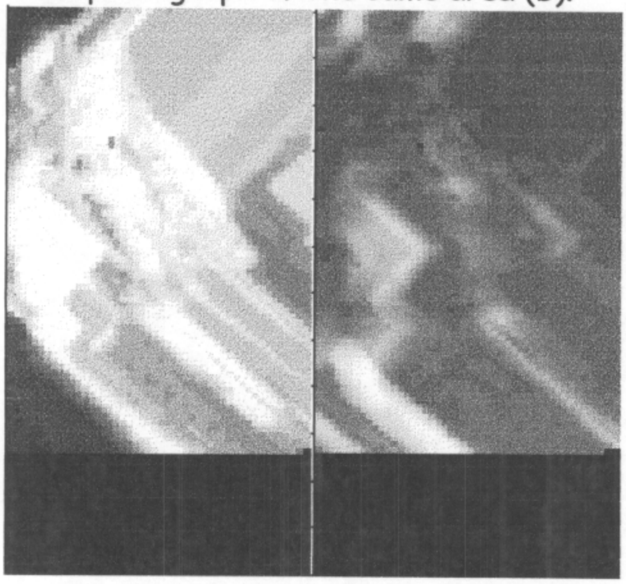

Figure 3. Sensitivity (a) and luminescence yield (b) map of a high quality natural diamond detector.