ESRF	**Experiment title:** **Investigations of hydrogen surface layer properties on diamond films used for X-ray beam detection devices**	**Experiment number**: MI-609
Beamline:	**Date of experiment**: from: 7/12/2002 to: 9/12/2002	**Date of report**: Feb. 2004
Shifts: 8	**Local contact(s)**: Remi TUCOULOU TACHOUERES	*Received at ESRF:*
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Radiation detectors based on diamond have attracted considerable attention due to the intrinsic properties of the material and the wide possibilities of applications. One of them which have been previously investigated at ESRF is the control of synchrotron X-ray intensity and position beam monitoring. The results obtained on diamond based beam position monitors (BPM) have demonstrated promising perspectives as a new tool for synchrotron x-ray beam characterisation. Such detectors can be operated in the photoconductive and current integration modes using the whole volume of the intrinsic diamond sample as ionisation chamber.

Another approach is the use of surface doping to enable the fabrication of a rectifying junction to measure the X-ray intensity. Recent results obtained on diamond surfaces show the possibility to create a p-type layer from hydrogenation process. Until now the origin and the mechanisms of the H-layer formation are in discussion and very little is known on the factors governing the stability and homogeneity of the layer. The aim of these experiment was to investigate on the micrometer scale the H-layer conductivity behaviour and to gain information on the effect of the crystalline structure of diamond on the hydrogenated layer, and correlate the results obtained with the macroscopic experiments. Surface properties of hydrogenated diamond layers were characterised via the use of a micro-focused X-ray beam at low energy in order to induce local photo-currents and measure the total electron yield (Fig1.) in the common mode configuration.

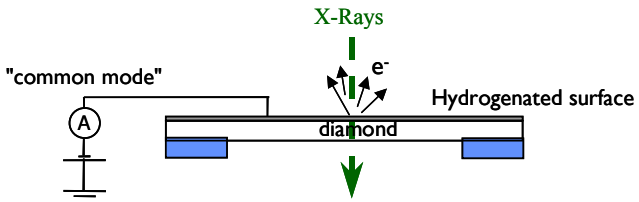

Fig1.experimental set-up

By scanning the micro-focused X-ray beam on the device surface, we gain information on the grain and grain boundaries of the crystal investigated and try to correlate if the surface hydrogen layer is influenced by the intrinsic properties or defects of the diamond substrate. Simultaneously, luminescence measurements were performed on device in order to correlate the luminescent defects with the electron emission.

The first step was to check the luminescence monitoring technique under a focused beam and to compare the map with a well known device in a classical detector configuration. Fig 2. shows the results obtained on CVD sample (on the left is the luminescence map, on the right the X-ray response map of device) with spot size below 1 µm and low energy (3 to 7 keV) in order to reduce the penetration depth and probe the surface properties. Red lines are indicated to guide the eye and show that both maps are partly correlated. The luminescence map was also compared with the results obtained on hydrogenated surfaces in the common mode where electron yield were estimated. Fig 3 shows the results obtained on the hydrogenated surface on a CVD sample (left : luminescence map ; right : electron yield measurements). The electron emission map is extremely uniform over the device surface and no fading effects are observed from a measurement to the following one, showing that there is no effect of time instability if the external conditions are kept constant. These methods of investigation have shown no evidence of the effect of surface coverage non uniformity due to the crystal structure.

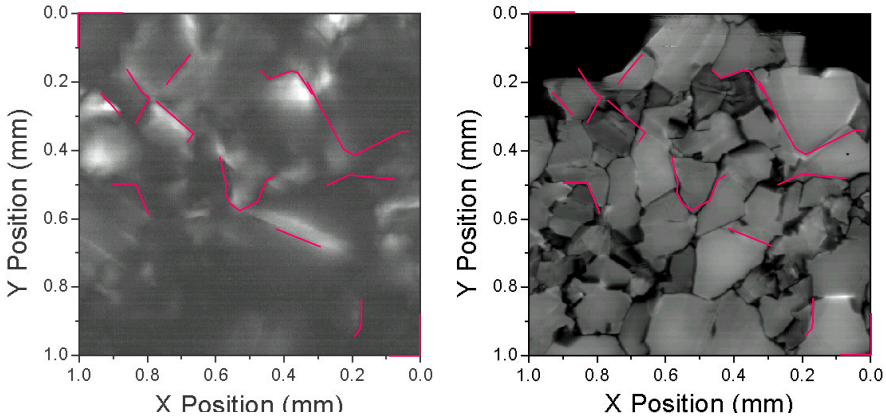

Fig 2. left : luminescence map; right : X-ray sensibility map (red lines are drawn to guide the eye

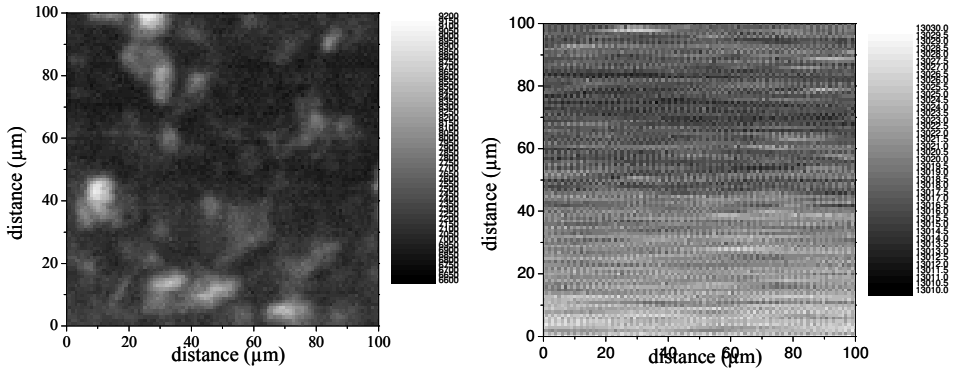

Fig 3. left : luminescence map; right : electron yield measurement in the common mode

Similarly, other measurements were performed on high quality natural and single crystal hydrogenated diamonds and results obtained are very similar : surface coverage seems to be uniform on the whole surface investigated and stable if external parameters are kept constant during the measurements.

The apparent uniformity of H-surface coverage measurements by electron emission is promising for intensity monitor device fabrication .The crystal structure and intrinsic defects seems to have little influence on the electron yield measurement and hydrogenated layers exhibit high electron emission under X-rays. Despite this, the main problem is the non compatibility with the vaccum presented on Fig 4. The properties of electron emission are strongly affected if the sample if measured in vacuum due to the modification of the H-layer under these conditions. These results are well correlated with those obtained on macroscopic scale and are explained by the modification of adsorbats population on diamond surface in vacuum. Hydrogenated surface and photoemission properties are recovered if sample is measured in atmospheric condition.

The use of an hydrogenated surface for the fabrication of diamond electronic devices is attractive due to the properties of intrinsic diamond. The results obtained during theses experiments have shown the good homogeneity of surface coverage and electron emission if the sample is kept in atmospheric condition or in neutral gases to avoid the effect of modification of H-surface properties observed in vacuum conditions.

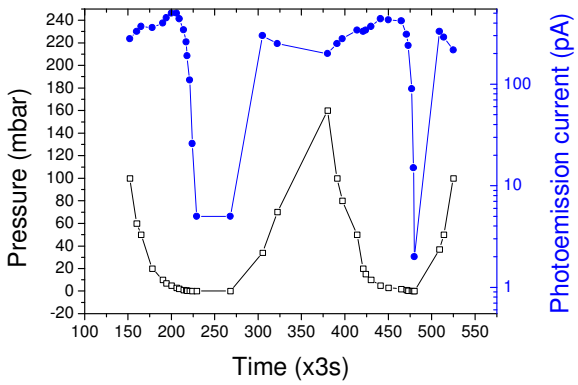

Fig 4. Evolution of photoemission current with respect to the pressure

References : E. Snidero, PhD thesis, Dec. 2003.
P. Bergonzo, R. Barrett et al. , comm. at "Surface and Bulk Defects in CVD Diamond Films VIII", Hasselt, 02/03.