ESRF	**Experiment title: Investigations of local defect properties and their influence on the evolution of diamond detection response**	**Experiment number**: MI 679
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Shifts: 12	**Local contact(s)**: Olivier DHEZ & Remy TUCOULOU-TACHOUERES	*Received at ESRF:*

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Report:

Chemical vapour deposited diamond (CVD) is of great interest for the fabrication of detection devices in various domains such as medical physics radiotherapy facilities or photon beam monitoring in synchrotron beam lines especially for soft X-ray detection due to the low atomic number of carbon that enables semi-transparent devices to be permanently inserted in beam lines. However state of the art devices made from this material exhibits responses variation of few percent and occasional instabilities that cause non linearity in beam monitoring applications. Such behaviour can be attributed to the presence of deep level traps in the band gap caused by dislocations, impurities vacancies etc…The presence of these traps in the diamond band gap is known and has been demonstrated from TSC as well as TL measurements. Further, the charged state also exhibits a strong influence on the diamond detector response. The aim of these experiment was to investigate the relation between the localised grain responses under micro-beam X-ray irradiation and the effect of the initial charged state of defects in CVD diamond detectors.

Knowing that temperature induced detrapping techniques is a way to investigate the defect populations within semiconductors (e.g. TL, TSC), the current experiment were conducted in order to locally probe the geographic distribution of the defect levels in diamond from the measurement of the photocurrents probed under synchrotron X-ray light. In order to establish the effect of thermal detrapping the sample was heated up to varying temperatures and the sensitivity maps probed simultaneously. The results show no evidence of temperature effects at low temperatures, values that are known to induce shallow defect level detrapping (up to 100°C) (**Fig.1**). Similar results are obtained when the sample is measured at room temperature after subsequent annealing at 300°C. In fact, this shows that the region of the sample investigated is immediately repumped by high the impinging X-ray light (dose rate evaluated above 10^5 Gy/s) as produced by micro-focused X-ray beam. This result confirm the weak influence shallow levels may have in diamond detection devices when used for synchrotron beam metrology, or in other words that the relative expected non stability of synthetic polycrystalline diamond devices caused by trapping/detrapping phenomena may not be a real limitation for the present application concerns.

To check the homogeneity of the grain structure and its influence on the X-ray response, measurements were conducted over extremely large areas. Results give evidence of strong variations on a 4x4mm area, with few localised region appearing to exhibit extreme sensitivities (**Fig.2**). They appear as "white lines" on the plots since the decay time is extremely long with respect to the horizontal scan displacement, thus affecting the signal when measured on the following points. On the "white spots", the detector behaviour could be related to persistent photocurrents with sensitivities greater by over one order of magnitude probed.

The temporal response has been measured on both regions of the sample (photoconductive region and bright spot) in order to investigate if this behaviour could be explained by variations in the localisation of trap levels in the sample. **Fig 3**(a) and (b) seem to indicate that trapping and detrapping phenomena appear in localised areas. On the bright spot a slow evolution of the signal with time is observed, with very high current levels and long decay times (<100s).

Other measurements have focused on full thermal detrapping conditions (above 300°C) on a bright spot (**Fig.4**). An increase of the photocurrent is clearly visible around 180-200°C followed by decrease of the signal above. This behaviour can be compared with the known signatures of TSC or TL on poly-X diamond showing that bright spot could be associated with the presence of deep level defects. The measurements conducted here seem therefore to have demonstrated that persistent photocurrents could be related to located defects spread across the surface of polycrystalline diamond detectors. Correlation with other techniques will enable there identification.

The results obtained during this work have been accepted for publication in Diamond and Related Materials and will be the base of a comparative defect study from other defect characterisation techniques in diamond.

Fig 1

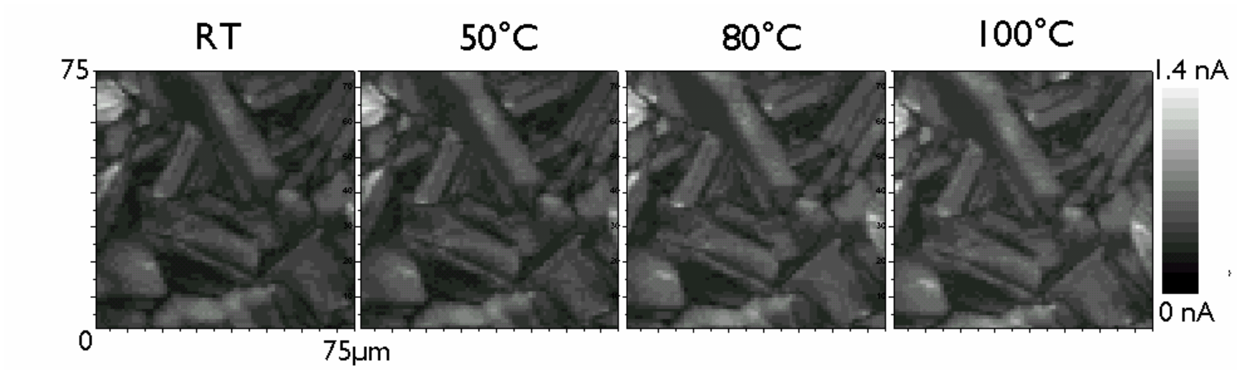

Fig 2

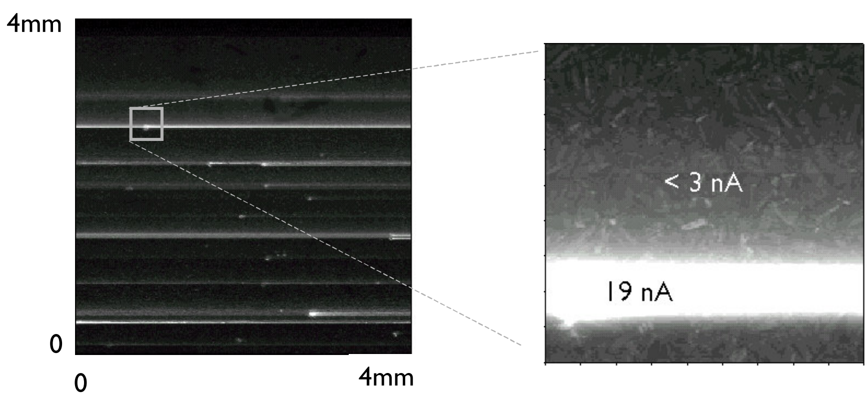

Fig 3a & b

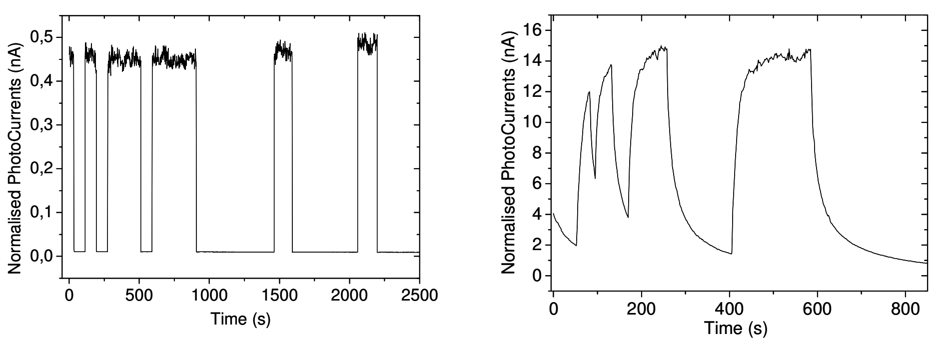

Fig 4