Temperature dependent emptying of grain-boundary charge-traps in CVD diamond

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We have used the technique of Ion Beam Induced Charge (IBIC) with a 2 MeV He^+ microprobe to image CVD diamond particle detector effectiveness as a function of temperature. The thermally stimulated current (TSC) of selected detectors show a peak current at 190°C which reveals information about trap dynamics. We find that these detectors display increased charge collection efficiency when heated above that temperature. However, for samples which display no TSC response, there is no significant change in the detector response up to a temperature of 300°C.

For the detectors which display an improved response at high temperatures the probability of detecting the impact of a single ion at room temperature was less than 2%, but this probability rises to over 80% at 170°C (see Figure 1). We propose that the improved response is a result of charge trapped at grain boundaries being liberated at elevated temperatures. Below 130°C ion impact signals arise from the high fields due to trapped charge predominantly at grain boundaries. At elevated temperatures the emptying of trapped charge results in a more uniform and higher average electric field distribution and therefore an increase in the active area. This is the first time CVD diamond ion detector devices have been demonstrated to function at such high temperatures.

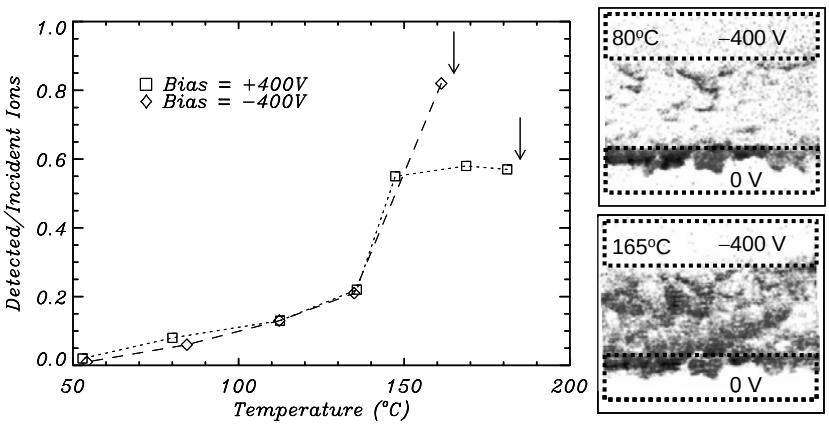

Figure 1: (left) The probability of a CVD diamond detector detecting a single ion impact as a function of temperature taking a room temperature silicon PIN diode as 100%. The maximum temperature for the measurement was 180°C, above which the leakage current through the device is too large to allow discrimination between noise and signals due to single ion impacts. (right) IBIC maps of the detector at 80°C and 165°C showing the increase in active area with temperature (Black indicates higher efficiency).