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Effects of impurities and defects on the performances of synthetic diamond crystals when used as radiation sensors for medical applications

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Abstract content
   (Max 300 words)

Diamond is attractive for medical applications due to its remarkable dosimetric properties such as bio-compatibility, high sensitivity, high spatial resolution, non-toxicity, and more cost effective as it was shown in a previous study that a single synthetic diamond probe could perform effectively in both low-energy X-rays and mega-voltage electron beams. The dosimetric performance of a diamond crystal to radiation is well recognised to be dependent on the types of defects and impurity levels within the crystal, however to date their influence on the performance of synthetic diamond crystals when subjected to low-energy X-rays and high-energy electron therapy beams has not been fully investigated. This study was therefore aimed at evaluating the dosimetric performances of synthetic diamond crystals when used as radiation sensors for both radiation types by highlighting some of the defect/impurity types that either enhance or degrade crystal performance in order to select suitable crystals. The sensitivities of synthetic diamond crystals of various types (HPHT and CVD diamond crystals of optical grade (OG) and detector grade (DG)) were evaluated and compared based on their defect/impurity levels. The crystals were characterised by Raman spectroscopy and Electron spin resonance. Linearity measurements with dose were verified both for X-rays and electron beams. The results of the study showed that the HPHT and OG diamonds had much higher levels of single substitutional nitrogen (Ns) impurities and were less sensitive compared to DG diamonds. The sensitivities of the diamond crystals to radiation were found to vary strongly with defect density and impurity levels. The sensitivities of the diamond crystals were largely influenced, in particular by Ns impurities which act as recombination centres and degrade crystal performance in this study suggesting that Ns levels ought to be the foremost criteria used in the selection of sensor material. As DG CVD diamonds have very low Ns impurities such crystals ought to be the radiation sensors of choice for medical applications.

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