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Dosimetric characterization of synthetic diamond detectors of various types and sizes under small high-energy photon field conditions

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Abstract content
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Selection of a suitable detector for small-field dosimetry within a 3% accuracy is challenging due to the volume effect of detectors in small fields. Although it is known that the safest way to exclude the volume effect is to choose a detector which is small enough, the experimental relationship between detector and field size is yet to be established. This contribution investigates the influence of detector size relative to field size by analyzing output factors (OFs) measured with a reference diode detector, an ion chamber and synthetic diamond crystals of various types and sizes in the dosimetry of a 6 MV photon beam with small fields down to 0.3x0.3 cm². The examined diamonds included two HPHT samples (HP1 and HP2) and six CVD crystals of optical grade (OG) and detector grade (DG) qualities with sizes between 0.3 and 1.0 cm. Each diamond was encapsulated in a tissue-equivalent probe housing which can hold crystals of various dimensions up to 1.0x1.0x0.1 cm³ and has different exposure geometries ('edge-on' and 'flat-on') for impinging radiation. For fields below 4x4 cm², the relative differences between the OFs measured with the detectors and the diode were found to increase with increasing detector size. It was observed that the HPHT samples showed an overall better performance compared to the CVD crystals with the 'edge-on' geometry being a preferred geometry for OF measurement especially for very small fields. For instance, down to a 0.4x0.4 cm² field a maximum dose difference of 1.9% was observed between the OFs measured with the diode and HP2 in the 'edge-on' geometry compared to a 4.6% difference in the 'flat-on' orientation. It was approximated from a relationship between the dose difference and the ratio of detector to field size for the detectors that the dose difference would be > 3% when the detector size is > 3/4 of the field size. A sensitivity of 313 nC/Gy/mm³ was obtained in a 1x1 cm2 field with HP2 compared to a value of 206.2 nC/Gy/mm³ established with the diode. This study therefore concludes that with careful selection of a suitable crystal type of a given size and orientation the OFs measured with the diamond probe in small fields would agree favourably within 2% with that measured with a small-field detector but with a higher sensitivity value.

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