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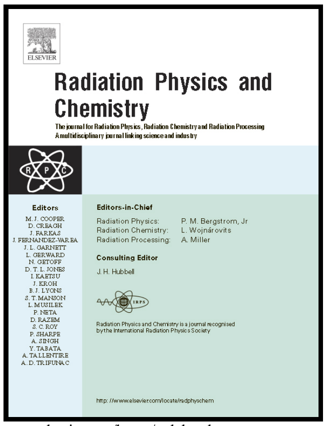

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An Evaluation of a Novel Synthetic Diamond Probe for Dosimetric Applications

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Abstract

A study is presented that characterises the dosimetric performances of two synthetic diamond sensors (HP1 and HP2) when either one or both detectors are subjected to clinical beams of various types under large as well as small-field conditions. Detector performances were evaluated using a prototype probe housing constructed of tissue-equivalent materials. The probe can accommodate diamond sensors of various sizes and is configured for radiation detection in different exposure orientations without having first to re-orient the sensor plate within its body. Also, the diamond sensor is aligned in the same configuration as its rectangular housing and the probe is designed to be compatible with commercially available electrometer systems. Dosimetric measurements were conducted using mammography X-rays (25-32 kVp) and megavoltage electron (6-21 MeV) and photon (^{60}Co γ-ray, 6-18 MV X-ray) beams. Whereas HP1 was evaluated using all beam types under large-flied conditions and small-photon-beam fields down to 0.7x0.7 cm^2, HP2 was evaluated using small-electron and photon-beam conditions down to 0.3x0.3 cm^2 6 MV photon field. Using HP1 sensor, the synthetic diamond probe was found not to require daily pre-irradiation as long as it is properly shielded from ambient light and its response stabilised. Furthermore, the diamond probe exhibited linear response characteristics with absorbed dose and on exposure parameters to various beam types, negligible energy dependence and almost no variation in angular response. Exposing the sensor HP2 under a 0.4x0.4 cm^2 6 MV photon radiation field, a sensitivity value of 197.3 nC Gy^{-1} mm^{-3} was established compared to a value of 136.1 nC Gy^{-1} mm^{-3} obtained with a small-field diode detector. Also, a figure of 5.5 x 10^3 for the SNR was established for the sensor in the same radiation field. Relative beam data measured with the diamond sensors were found to agree within 1-2% with data obtained with reference detectors. The presentation illustrates that once a suitable diamond sensor is incorporated into the probe's housing, then near-tissue equivalent synthetic diamond probe could be utilised as a multi-purpose radiation detector for the clinical dosimetry of various beam types under large as well as small radiation fields.

Keywords: Diamond Probe, Tissue-equivalence, Dosimetry, Exposure orientations

1. Introduction

Air ion chambers and silicon diodes which are frequently used for the clinical dosimetry of electron and photon beams have a range of applicability limited by the design and inherent properties of their respective detector materials (Heydarian et al., 1993). Whereas large-size ion chambers are not appropriate for high spatial resolution measurements due to the volume averaging effect (Haryanto et al., 2002; Lee et al., 2012; Wuerfel, 2013), the use of ion chambers with very small physical sizes leads to extremely low sensitivity to radiation as a result of the low density of air (Heydarian et al., 1993). Diode detectors have high spatial resolution and are highly sensitive to

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