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Mixed gamma/neutron field in-vivo dosimetry using Metal-Oxide Semiconductor Field-Effect Transistor for Accelerator-Based Boron Neutron Capture Therapy

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Introduction

BNCT systems have their specific neutron energy spectra extending from thermal to fast neutron (FN) range of up to a few MeV and contamination. Since the cross-section for neutron capture is the highest for thermal neutrons, to reach deeper tumours, epithermal neutrons are used and thermalised within the patient. Production of the epithermal neutron beam requires sophisticated moderation assembly, therefore, QA tools to measure the fluence and quality of the beam entering the patient are crucial.

Materials and Methods

We proposed a disposable, miniature Metal-Oxide Semiconductor Field-Effect Transistor (MOSFET) detector with different converters for in-vivo dosimetry of the BNCT epithermal neutron beam components. MOSFET is particularly attractive due to its low voltage or passive operation; the possibility of sensitivity adjustment by biasing the gate during irradiation and/or thickness of the gate oxide (sensitive volume (SV)); the small size of $0.6 \times 0.8 \times 0.35\ mm^3$; the ability for on-line readout or immediately after irradiation. Two converters were proposed on top of MOSFET - ^{10}B and polyethylene (PE) as well as no converter geometry to measure fluence of thermal/epithermal neutrons, fast neutrons (FN), and γ components, respectively.Geant4 simulations of the MOSFET response covered with ^{10}B, PE and without converter irradiated with $3 \cdot 10^8 \frac{n}{cm^2\ s}$ epithermal neutron beam, in free-air geometry and on the surface of an 18 cm diameter spherical water head phantom were performed for 1-3 m ^{10}B and 0.2-3 mm PE converter thickness. A one cm diameter spherical target with 40 ppm ^{10}B was placed at 0.5, 1, 1.5 and 2 cm depths in the head phantom. The dose deposited in the SV of the MOSFET and in a 1 cm diameter target was simulated by tracking all secondary particles and their kinetic energy.

Results

The difference in responses between the MOSFET with ^{10}B converter placed on the surface of the phantom and in free air was about 30% due to albedo neutrons. The dose deposited in the SV of the MOSFET with 1 m ^{10}B converter was much higher than for 1 mm PE converter and should be taken into account when selecting the gate oxide thickness of the MOSFET to provide reasonable sensitivity. Correlation of the MOSFET with 1 m ^{10}B response placed on the surface of the head phantom and dose in a target will be presented. The thickness of 1 m ^{10}B and 1 mm PE converters, were found to be optimal for measuring the entrance thermal/epithermal and fast neutron fluence components, respectively.

Conclusion

MOSFET detector with ^{10}B and PE converters can be used to control the epithermal beam quality at the entrance point as a form of in-vivo QA for patients treated with AB-BNCT, and to estimate the dose at different depths within the patient.Next steps will include simulation of a pixelated $10\ cm \times 10\ cm$ 2D transmission detector for real-time monitoring of the 2D flux distribution of the beam components in AB-BNCT.

Speakers Gender

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Level of Expertise

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Do you wish to take part in the poster slam

Yes

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