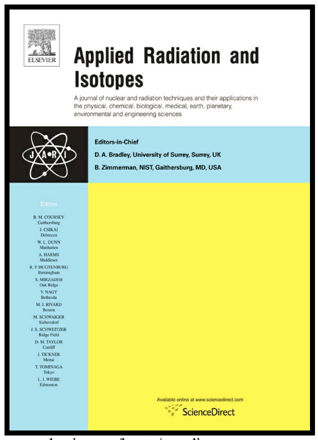
Author's Accepted Manuscript



www.elsevier.com/locate/apradiso

Feasibility study on the use of 3D Silicon Microdosimeter detectors for microdosimetric analysis in Boron Neutron Capture Therapy

N. Hu, R. Uchida, L.T. Tran, A. Rosenfeld, Y. Sakurai

PII: S0969-8043(17)31256-3
DOI: https://doi.org/10.1016/j.apradiso.2018.06.022
Reference: ARI8404

To appear in: *Applied Radiation and Isotopes*

Received date: 15 January 2018
Revised date: 31 May 2018
Accepted date: 28 June 2018

Cite this article as: N. Hu, R. Uchida, L.T. Tran, A. Rosenfeld and Y. Sakurai, Feasibility study on the use of 3D Silicon Microdosimeter detectors for microdosimetric analysis in Boron Neutron Capture Therapy, *Applied Radiation and Isotopes,* https://doi.org/10.1016/j.apradiso.2018.06.022

Feasibility study on the use of 3D Silicon Microdosimeter detectors for microdosimetric analysis in Boron Neutron Capture Therapy

N. Hu[1], R. Uchida[1], L.T.Tran[2], A.Rosenfeld[2], Y. Sakurai[3]
[1] Graduate School of Engineering, Kyoto University, Kyoto, Japan
[2] Centre for Medical Radiation Physics, University of Wollongong, Wollongong, Australia
[3] Research Reactor Institute, Kyoto University, Osaka, Japan

Abstract
This paper presents the feasibility study of a novel 3D mesa bridge microdosimeter and its use for BNCT dosimetry. The performance of the microdosimeter was studied using Monte Carlo simulation. The clinical BNCT field at Kyoto University Reactor (KUR) using both thermal and epithermal irradiation modes were used in this study. Results show that this microdosimeter can be utilised as an effective tool to measure microdosimetric spectrum in the BNCT field and experimental validation will follow once KUR is operational.

Keywords:
BNCT, Microdosimetry, SOI, Monte Carlo simulation,

Introduction

Boron neutron capture therapy (BNCT) is an emerging radiotherapy modality using a neutron beam collectively with boron-10 containing pharmaceutical to treat patients with cancer. The principal of BNCT is the local energy deposition by the alpha particles produced from the thermal neutron capture reaction, $^{10}B(n,\alpha)^{7}Li$ (Larsson et al., 1996; Locher, 1936). The lithium ion and alpha particles are high linear energy transfer (LET) particles that deposit their energy in ranges of 4.1 μm and 7.7 μm respectively, which is on the order of the diameter of a typical human cell (Nichols et al., 2005). In contrast to conventional radiotherapy, the types of radiation present in BNCT consists of many distinct radiation components, each having a different biological weighting factor (Daquino and Voorbraak, 2008). In addition to the dose due to B-10 neutron capture, protons are present from epithermal and fast neutrons interacting with both hydrogen and nitrogen in tissue and gamma rays originating from thermal neutron absorption by hydrogen in tissue and from the neutron source and surrounding material. Microdosimetry is an effective dosimetry technique in a mixed radiation environment, such as BNCT. Using microdosimetry, it is possible to derive the relative contributions of different radiation modalities (Booz et al., 1983). The separation of different radiation components is important due to the varying biological effectiveness of each of the components.

Microdosimetry was explored by Rossi et.al. in the late 1950's and stochastic quantities such as lineal energy deposition and specific energy related to stochastic deposition of ionizing energy event by event in micron size sensitive volume (SV) were defined (Kellerer and Rossi, 1971; Rossi, 1960, 1959; Rossi and Zaider, 1996). Quantities relating to microdosimetry were defined in ICRU report 36 (Booz et al., 1983). Microdosimetric quantities are often characterised by lineal energy spectra. The lineal energy y is the microdosimetric quantity used to describe the deposited energy in a SV divided by the mean chord length, given by:

$$y = \frac{\varepsilon}{l}$$

where ε is the energy deposited in a volume with a mean chord length l. The mean chord length is the mean length of randomly oriented chords in that volume. It is determined by using the $4V/S$ expression, where V is the volume of the microscopic SV target and S is the surface area of the SV.
The probability distribution of lineal energy $f(y)$ or dose distribution $d(y)$ are fundamental functions in microdosimetry. The relationship between $f(y)$ and $d(y)$ is: