PhD Thesis title: 'IMPLEMENTATION OF SILICON BASED DOSIMETERS, THE DOSE MAGNIFYING GLASS AND MAGIC PLATE FOR THE DOSIMETRY OF MODULATED RADIATION THERAPY'

Author: Jeannie Hsiu Ding Wong
Email: Jeannie.wong@ummc.edu.my
Institution: Centre for Medical Radiation Physics, University of Wollongong, Australia
Supervisors: Professor Dr. Anatoly Rosenfeld, Professor Dr. Peter Metcalfe & Dr. Martin Carolan
Graduation Date: December 2011
Available on line: http://ro.uow.edu.au/theses/3348

ABSTRACT:
New cutting edge radiation therapy techniques such as Intensity Modulated Radiation Therapy (IMRT), Stereotactic Radiosurgery (SRS), Helical TomoTherapy and most recently the Volumetric Modulated Arc Therapy (VMAT) produce radiation dose maps with high dose modulation and tight gradients between the high and low dose regions. Difficulties in the dosimetric verification of these new complex treatment methods using existing dosimeters has led to the need for a new generation of fast responding real time dosimeters with submillimeter precision. This thesis describes two detector systems based on silicon substrates that were developed to address this need.
The first detector system was a silicon strip detector called the "Dose Magnifying Glass" (DMG). It consisted of 128 detectors spaced 0.2 mm apart. It was coupled to a TERA ASIC chip that enabled simultaneous readout of multiple channels at high temporal resolution. The first part of the thesis involved investigation of the basic characteristics of the DMG followed by its application in the dosimetric verification of IMRT, SRS and Helical TomoTherapy treatment deliveries. The high spatial resolution of this device was ideal for the measurement of high dose gradients in IMRT and small fields encountered in SRS. When compared with film dosimetry, DMG measurements showed agreements within 3% for a SRS treatment plan. The DMG was also successfully employed as an independent quality assurance tool for the verification of helical Tomotherapy machine binary MLC leaf parameters.
The second detector was a two dimensional array detector so named the "Magic Plate" (MP). The diode is based on epitaxial technology and has a very thin sensitive volume of 50 µm. The MP comprised of 11 × 11 epitaxial diodes mounted on a 0.6 mm thick Kapton substrate. This detector was designed to be used either as a transmission detector or to measure dose distributions in a solid water phantom. Preliminary testing of the MP in a clinical IMRT treatment delivery was carried out. The MP dose distribution measurements demonstrated good agreement with EBT2 film measurements and with treatment planning system predicted dose distributions.

References to author publications that relate specifically to the dissertation:

1. J. H. D. Wong, M. Carolan, M. L. F. Lerch, M. Petasecca, S. Khanna, V. L. Perevertaylo, P. Metcalfe and A. B. Rosenfeld, "A silicon strip detector dose magnifying glass for IMRT dosimetry", Med. Phys. **37** (2), 427-439 (2010).

2. J. H. D. Wong, D. Cutajar, M. L. F. Lerch, M. Petasecca, T. Knittel, M. Carolan, V. L. Perevertaylo, P. Metcalfe and A. B. Rosenfeld, "From HEP to medical radiation dosimetry – The silicon strip detector dose magnifying glass", Radiat. Measur. **46** (12), 1615-1618 (2011).

3. J. H. D. Wong, N. Hardcastle, W. A. Tome, A. Bayliss, R. Tolakanahalli, M. L. F. Lerch, M. Petasecca, M. Carolan, P. Metcalfe and A. B. Rosenfeld, "Independent quality assurance of a helical tomotherapy machine using the dose magnifying glass", Med. Phys. **38** (4), 2256-2264 (2011).

4. J. H. D. Wong, T. Knittel, S. Downes, M. Carolan, M. L. F. Lerch, M. Petasecca, V. L. Perevertaylo, P. Metcalfe, M. Jackson and A. B. Rosenfeld, "The use of a silicon strip detector dose magnifying glass in stereotactic radiotherapy QA and dosimetry", Med. Phys. **38** (3), 1226-1238 (2011).

5. N. Hardcastle, A. Bayliss, J. H. D. Wong, A. B. Rosenfeld and W. A. Tome, "Improvements in dose calculation accuracy for small off-axis targets in high dose per fraction tomotherapy", Med. Phys. **39** (8), 4788-4794 (2012).

6. J. H. D. Wong, I. Fuduli, M. Carolan, M. Petasecca, M. L. F. Lerch, V. L. Perevertaylo, P. Metcalfe and A. B. Rosenfeld, "Characterization of a novel two dimensional diode array the ``magic plate'' as a radiation detector for radiation therapy treatment", Med. Phys. **39** (5), 2544-2558 (2012).