

THERMOLUMINESCENCE CHARACTERISTICS OF SILICON OPTICAL FIBRE  
DOPED WITH YTTERBIUM AND YTTERBIUM – TERBIUM AS PHOTON  
DOSIMETER.

MOHD. HILMI BIN SAHINI

UNIVERSITI TEKNOLOGI MALAYSIA

THERMOLUMINESCENCE CHARACTERISTICS OF SILICON OPTICAL FIBRE  
DOPED WITH YTTERBIUM AND YTTERBIUM – TERBIUM AS PHOTON  
DOSIMETER.

MOHD. HILMI BIN SAHINI

A thesis submitted in fulfillment of the  
requirements for the award of the degree of  
Master of Science (Physics)

Faculty of Science  
University Teknologi Malaysia

JUNE 2014

## **ACKNOWLEDGEMENT**

My most humble and sincere thanks to first and foremost, my supervisor, Prof. Dr. Husin Wagiran for his believe in me and opportunities given to further my studies. Not to forget, Dr. Imam Hossain who also had helped throughout the completion of this research.

To my extraordinary family, thanks for their endless love and support in completing this study. My profound thanks to my fiancée, Nor Amiera for her patience and support for me. They have truly been the foundation under this author.

I would like to express my immense gratitude to En. Hassan Ali, Science Officer of Department of Oncology And Radiation Therapy, Hospital Sultan Ismail for his generous assistance and expertise in this research.

I wanted to thank the government of Malaysia in providing a funded Master scholarship. Not to forget also the Ministry of Higher Education of Malaysia for providing research grant for this research.

## ABSTRACT

The study of SiO<sub>2</sub> commercial optical fiber explores the useful thermoluminescence (TL) properties and reveals its potential as a TL dosimeter. The present work describes the TL dose response, reproducibility, fading and minimum detectable dose of SiO<sub>2</sub>: Yb and SiO<sub>2</sub>: Yb, Tb optical fibers as compared to TLD-100. The optical fibers were placed in a solid phantom and irradiated with 6 and 10 MV X-rays using LINAC Primus MC 3339 and 1.25 MeV gamma ray from gamma cell. Scanning electron microscopy analysis was performed to determine the dopant concentration and the effective atomic number,  $Z_{\text{eff}}$ . The dopant concentration of Yb for SiO<sub>2</sub>: Yb optical fiber was found ranging between 0.23 – 0.35 mol% and for SiO<sub>2</sub>: Yb, Tb; the dopant concentration of Yb and Tb were in the range of 0.03 – 1.46 mol% and 0.12 – 0.39 mol% respectively. The  $Z_{\text{eff}}$  value for SiO<sub>2</sub>: Yb and SiO<sub>2</sub>: Yb, Tb were 11.19 and 12.27 respectively, which is higher than that of soft tissue (7.42), but close to bone (11.6 – 13.8). In term of TL dose response and sensitivity, SiO<sub>2</sub>: Yb, Tb optical fiber demonstrated better results than SiO<sub>2</sub>: Yb optical fiber, but both TL materials were still inferior when compared to TLD-100. SiO<sub>2</sub>: Yb, Tb optical fiber had the lowest percentage lost in fading of about 5.83%, 15.65% and 18.55% for day 7, 21 and 28 respectively, compared to SiO<sub>2</sub>: Yb optical fiber which has higher fading of about 55.17% and 95.87% for day 14 and 30 respectively. SiO<sub>2</sub>: Yb, Tb optical fiber shows good reproducibility results compared to SiO<sub>2</sub>: Yb optical fiber. The minimum detectable dose of SiO<sub>2</sub>: Yb and SiO<sub>2</sub>: Yb, Tb optical fibers were 333 mGy and 19 mGy respectively. In general, it can be concluded that SiO<sub>2</sub>: Yb, Tb optical fiber is a much better optical fiber to be developed as a new TL dosimeter compared to SiO<sub>2</sub>: Yb optical fiber.

## ABSTRAK

Kajian gentian optik komersial  $\text{SiO}_2$  meneroka ciri luminesens terma (TL) berguna dan keupayaan sebagai dosimeter TL. Kajian ini membincangkan sambutan dos luminesens terma, kebolehulangan, kepudaran dan dos pengesanan minimum gentian optik  $\text{SiO}_2$ : Yb dan  $\text{SiO}_2$ : Yb, Tb dan berbanding TLD-100. Gentian optik diletakkan di dalam fantom pepejal dan disinarkan dengan sinar-X 6 dan 10 MV menggunakan LINAC Primus MC 3339 dan sinar gama 1.25 MeV dari sel gama. Analisis mikroskop pengimbas elektron (SEM) dilakukan bagi menentukan kepekatan dopan dan nombor atom berkesan,  $Z_{\text{eff}}$ . Kepekatan dopan Yb bagi gentian optik  $\text{SiO}_2$  ialah dalam julat 0.23 – 0.35 mol% dan kepekatan dopan Yb dan Tb bagi  $\text{SiO}_2$  : Yb, Tb masing-masing ialah 0.03 – 1.46 mol% dan 0.12 – 0.39 mol%. Nilai  $Z_{\text{eff}}$  bagi gentian optik  $\text{SiO}_2$  : Yb dan  $\text{SiO}_2$  : Yb, Tb masing-masing ialah 11.19 dan 12.27, iaitu lebih tinggi daripada nilai tisu lembut (7.42), tetapi hampir dengan tulang (11.6 – 13.8). Dari aspek sambutan luminesens terma,  $\text{SiO}_2$  : Yb, Tb memberi keputusan yang lebih baik berbanding  $\text{SiO}_2$  : Yb, tetapi kedua-dua bahan masih tidak dapat menandingi TLD-100. Gentian optik  $\text{SiO}_2$  : Yb, Tb mempunyai peratus kepudaran yang lebih rendah iaitu 5.83%, 15.65% dan 18.55% masing-masing pada hari ke-7, 21 dan 28 berbanding dengan  $\text{SiO}_2$  : Yb yang mempunyai peratus kepudaran yang lebih tinggi sebanyak 55.17% dan 95.17% pada hari ke-14 dan 30. Hasil kajian menunjukkan gentian optik  $\text{SiO}_2$  : Yb, Tb menunjukkan keputusan sifat kebolehulangan yang lebih baik berbanding gentian optik  $\text{SiO}_2$  : Yb. Dos pengesanan minimum bagi gentian optik  $\text{SiO}_2$  : Yb dan  $\text{SiO}_2$  : Yb, Tb masing-masing ialah 333 mGy dan 19 mGy. Secara umum dapat disimpulkan bahawa gentian optik  $\text{SiO}_2$  : Yb, Tb adalah lebih sesuai untuk dimajukan sebagai dosimeter TL berbanding gentian optik  $\text{SiO}_2$  : Yb.