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Evaluation of radiation detector systems for mammography x-ray units

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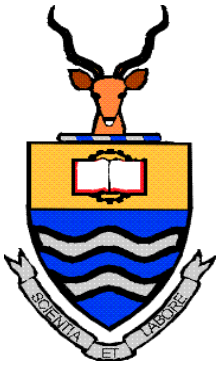
EVALUATION OF RADIATION DETECTOR SYSTEMS FOR MAMMOGRAPHY X-RAY UNITS

Risimati Dazmen Mavunda



Submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, South Africa, in fulfillment of the requirement for the degree of

Doctor of Philosophy

March 2008

DECLARATION

I declare that this thesis is my own, unaided work and it has not been submitted before for any degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg, South Africa.

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ABSTRACT

Nine polycrystalline (Detector and Optical Grade) and Single Crystal CVD diamond detectors were characterised in terms of their defects and impurities with the specific aim to provide the much needed tool for selecting materials suitable for use in radiation detectors and in spectroscopy when exposed to alpha particles radiation or mammographic X-rays. The effectiveness of electron spin resonance (ESR), ultra-violet (UV) absorption, Raman broadening and thermo-luminescence (TL) emission as tools for performance evaluation were analyzed. The study has shown that defects (e.g. grain boundaries) and impurities (e.g. single substitution nitrogen concentration) played a role in the performance of CVD diamond wafers when used as dosimeter or spectrometer. In particular the observed higher values of single substitutional nitrogen concentrations, higher UV absorption and Raman broadening but lower TL emission values in the Optical Grade CVD diamond wafers were associated with their improved performance as detectors of alpha particles. The lower ESR, the lower UV absorption, higher TL emission values and lower Raman broadening were related to the better performance of both the Detector and Single Crystal CVD diamond wafers when used for alpha spectroscopy.

An adopted and extended method developed for the correction of the 'as accumulated' spectra that takes into account the detector's efficiency gave rise to an X-ray mammography spectrum that is independent of the detector type. This was used to justify the use the Monte Carlo simulated spectrum to evaluate the comparative responses of

pure diamond to that of the CVD diamonds wafers when exposed to simulated and actual X-ray exposures respectively.

The research has provided an evaluation technique for selecting detectors suitable for different applications. The research furthermore, suggests that for the detection of X-ray photons, using a Detector Grade CVD diamond wafer is best suited for the task but generally the most consistent radiation detector material is the Single Crystal CVD wafer.

I dedicate this thesis to my parents

The late Mzamani and Njhakanjhaka Mavunda

Who brought me to this harsh world

To my wife, Hilda

To my sons Amukelani, Vunwe and Ntila

To my brother

Samson

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