PhD Thesis title: 'Development of an *in vivo* MOSFET dosimeter for radiotherapy applications'

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ABSTRACT:
External radiotherapy is a well-accepted and efficient therapeutic modality for cancer treatment. In this technique, radiation beams are carefully directed toward the patient with the purpose of delivering a lethal dose to the tumor without inducing serious side effects in the patient.

The success of radiotherapy treatment is highly dependent on the dose delivery to the patient. In fact, the dose precision in radiotherapy is expected to be of the order of ±5%. However, guaranteeing this accuracy, *i.e.*, that the expected dose is properly delivered to the correct spot and with the desirable intensity, represents a challenging task. For this reason, the use of an *in vivo* dosimeter to ensure the quality of radiotherapy is fundamental because this is the only type of dosimeter that can measure the dose delivered to patients during their radiation treatment.

In this study, a low-cost MOSFET dosimeter suitable for *in vivo* radiotherapy applications was developed. This dosimeter combines an accurate readout procedure with a small size and cable/battery-free sensor. These characteristics contribute to very low attenuation of the radiation beam, the patient's comfort, and rapid setup. Also, this dosimeter has a simple reading procedure, which can be easily performed by any professional with no need for special skills or training.

The MOSFET dosimeter developed in this study uses the integrated circuit (IC) CD4007UBM (Texas Instruments) as the radiation sensor. This IC was chosen because its transistors have a gate oxide thickness of 120 nm, which provides adequate sensitivity for radiotherapy applications (7 mV/Gy). Moreover, this IC is of very low cost (US$ 0.5/IC) and small dimensions (area of 35 mm^2). Also, it can operate at relatively low supply voltage (*e.g.* V_{DD}*=3.3 V*).

MOSFET dosimeters sense the total dose through a change in the threshold voltage (V_T) on exposure to ionizing radiation. For this reason, the dosimeter design incorporated an accurate and low power constant-current (CC) V_T-extractor circuit, which directly determines the V_T. Furthermore, this circuit extracts a value for V_T which has physical meaning.

Experiments with ionizing radiation were carried out at the Oncological Research Center (CEPON-SC) in Florianópolis, Brazil, using linear accelerators to generate X-rays of 6 MV and 15 MV. The main results obtained for the CD4007 MOSFET dosimeter are as follows: radiation sensitivity 98.1 mV/Gy, thermal dependence 0.5 cGy/◦C, angular dependence 13%, energy dependence 1.3%, linearity 97.5% and radiation beam attenuation 0.14%.

References to author publications that relate specifically to the dissertation:

- M. B. Machado, **O. F. Siebel**, M. C. Schneider e C. Galup-Montoro, "MOSFET threshold voltage: definition, extraction, and applications," *Proceedings of Nanotech*, vol.2, pp.710-713, 2011.
- **O. F. Siebel**, M. C. Schneider e C. Galup-Montoro, "Low power and low voltage VT extractor circuit and MOSFET radiation dosimeter," *IEEE NEWCAS 2012*, pp.301-304, 2012.
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- **O. F. Siebel**, J. G. Pereira, M. C. Schneider e C. Galup-Montoro, "A MOSFET dosimeter built on an off-the-shelf component for *in vivo* radiotherapy applications," *IEEE LASCAS 2014*, pp.1-4, 2014.