

Optically stimulated luminescence dosimetry: system characterisation and application in remote dosimetry audits in radiotherapy photon and electron beams

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Independent dosimetry audits contribute to quality improvement in radiotherapy (RT) practices and enhance consistency of dosimetry between audit participating institutions. Audits can be a valuable tool in detecting systematic errors and determining adequacy of established dosimetry practices. They have an important role in effective reaching of cancer treatment goals and in the safe and accurate implementation of new radiotherapy modalities and techniques.

In dosimetry audits, the operational level typically refers to the degree of complexity of involved, from basic dose audits under reference conditions to more advanced that check multiple parameters in advanced RT techniques. At the highest level, comprehensive audits test the entire treatment process to verify the accuracy and reliability of prescribed dose delivery. Successful remote dosimetry audits rely on detectors that have high sensitivity, can be mailed and irradiated in simple geometries, retain the dosimeter signal after irradiation, can be reproducibly read-out, and require only a limited number of correction factors evaluations to get the absorbed dose from the readout. Solid state dosimeters like thermoluminescent (TL), radiophotoluminescent (RPL) or optically stimulated luminescence (OSL) dosimeters are the dosimeters of choice for remote audits. They have been successfully used in a wide range of audit applications from beam output checks and dosimetry evaluations in non-reference conditions to clinically more relevant situations, end-to-end audits of advanced RT techniques.

Four institutions recently teamed up with a common goal: to establish and implement dosimetric audits for radiotherapy photon and electron beams under reference conditions at the national level. As part of a Technical Cooperation (TC) project with the International Atomic Energy Agency (IAEA), a new beryllium oxide (BeO) OSL dosimetry system has been acquired, comprising the myOSLchip reader (RadPro, Freiberg, Germany), 1000 dosimeters, and a bleaching unit. System characterisation is currently underway covering the determination of common performance features: signal fading, non-linearity dose response, beam quality dependence, bleaching (annealing) effectiveness, stability of dosimeters sensitivity, accumulated dose limit and correction factors related to the irradiation position within a solid water phantom insert. Individual characterisation of all OSLDs, denoted as the element sensitivity correction factors (SCF) determination, will be conducted for each batch of dosimeters. The repeated use of the OSLDs in real audits will be replicated by performing multiple cycles of irradiation, readout and bleaching. The change of dosimeters sensitivity with repeated irradiation-bleaching cycles will be investigated.

In this work, after concisely describing the underlying physics along with the dosimeter optical stimulation and readout mechanisms, we focus on the common OSLD system characterisation. We compare selected features of two dosimetry systems, one established, MicrostarII reader with nanoDOT dosimeters (Landauer, Glenwood, Ill, USA) and another, the recently acquired myOSLchip. An overview of the irradiation and readout protocol is presented, including the design of the dosimeter irradiation insert. Moreover, we further show preliminary considerations and concepts on the design of dosimeter holders for use during the dosimetry audits themselves.

Systematic dosimetry system characterisation and a thorough understanding of the system's features and limitations are critical to ensure the accuracy of dose measurements in RT, the derivation of the uncertainty budget relevant for acceptance limits determination, and the development of remote dosimetry audit protocols at a national level.

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