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Quantum dots imaging tests on SPAD for nanodosimetric applications

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Purpose of this work: Nowadays it is well assessed that the particle track structure plays a key role in the damage of living cells[1]. Therefore, the quantification of the dose within nanometric volumes is of paramount importance for characterizing the effectiveness of cancer treatments with ion beams. There are currently several facilities suitable for the detailed on-line analysis of the number of ionizations left by an impinging ions into nanometer equivalent gas volumes.[2,3] Nonetheless, the realization of a portable system for nanodosimetry quantification would be extremely useful for the dose control in treatment plants. In this work we propose the use of Single Photon Avalanche Diode (SPAD) arrays for the luminescence imaging of quantum dots (QDs) structures.[4] In particular, the analysis of QD layers will be performed before and after ion irradiation in order to study how the released dose affects the optical properties of the system.
Materials and methods: The luminescence of CdSe/ZnS QD layers is excited with a pulsed LED (475 nm central wavelength and 20 ns pulse width).[5] The luminescence light is collected with a high-numerical aperture optics and delivered to the detector through an optical filter to eliminate the residual scattered excitation light (Figure 1a). A SPAD pixel array[6] is placed in the focal plane to collect the fluorescence map of the sample under analysis. The light signal is collected in time-gated mode in order to measure the QD lifetime before and after irradiation (Figure 1b). Moreover, time-gated detection can be used as a time-domain excitation filtering technique, thus simplifying the design of a portable and compact nanodosimeter.
Results: The luminescence intensity and lifetime of QD irradiated with different fluencies of 2.0 MeV protons and X-rays will be studied and compared with non-irradiated samples. The changes in light yield and lifetime will be correlated to the damage released by the impinging radiation through Monte Carlo calculations.
Conclusions: Although SPAD arrays have already been employed in the past for the sensing of QD luminescence, this is the first time that QD lifetime measurements is proposed as a probing tool applied to nanodosimetry. This preliminary study will give an experimental confirmation on the validity of the idea.

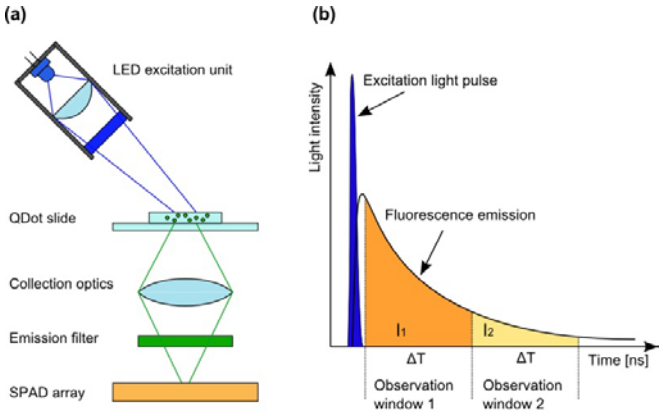

Figure 1. (a) Simplified system diagram (b) Illustration of time gated detection principle

Keywords: nanodosimetry, Quantum Dots, SPAD

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Evaluation of the usefulness of dose calculation algorithms in radiotherapy planning

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Purpose: One of the main goals of radiotherapy is to achieve tumor control and minimize probability of normal–tissue complications. For this reason radiation oncology requires high accuracy, which implies no more than 2 – 3% uncertainty levels in the treatment planning calculations [1]. That is challenging, when heterogeneous tissues such as lungs and bones are involved [2,3]. To verify the accuracy of the dose calculation algorithms numerous approaches might be performed. The most common are point dose, one-dimensional profile and two-dimensional isodose line comparison with experimental measurements [3].
Materials/Methods: In presented study, results of transport modeling and the deposited spatial distribution of the dose, obtained by Anisotropic Analytical Algorithm (AAA) and Pencil Beam Convolution algorithm (PBC), were compared to measurements recorded during the experiment. To achieve meaningful conclusions, three parameters: dose difference (DD), distance to agreement (DTA) and gamma parameter (γ) were taken into consideration and examined. The irradiation was performed using CIRS anthropomorphic phantom. For dose detection gafchromic EBT films were used and scanned after exposure using Epson Scanner. Measured and planned dose distributions were analyzed via FilmQA software.
Results and Conclusions: Preliminary results showed that the AAA, with its complex accounting of heterogeneities, provides more accurate dose calculation within an area of a high density gradient, than PBC does. The level of the data