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Towards real-time dose control during cancer radiation therapies based on full-organic wearable dosimeter

Mechanical flexibility, portability, low cost of fabrication, scalability onto large areas and human tissue equivalence are crucial properties which make organic and hybrid semiconductors excellent candidates for the development of wearable proton dosimeters. Among others, their employment in the medical field (i.e. during proton therapy treatments) to monitor in real-time and in-situ the dose delivered to the patients is extremely interesting.
In the last years the scientific community has put big efforts to look for alternative technologies, with the aim to overcome the main limitations presented by conventional materials and to achieve novel important properties requested by novel applications. We recently reported the results achieved with an innovative fully-organic indirect detector, where a flexible phototransistor (OPT) based on dinaphtho[2,3-b:2′,3′-f]thieno[3,2-b]thiophene (DNTT) is coupled with a plastic scintillator based on polysiloxane (i.e. homopolymer poly-methylphenylsiloxane and polyvinylphenyl-co-phenylmethyl). This preliminary test has been performed at LABEC Ion Beam Center (INFN-Firenze, Italy) under 5 MeV proton beam to mimic the end-of-range conditions typically present at the border of the target during the prostate cancer treatment. To describe the detecting signal, we developed a kinetic model able to precisely reproduce the dynamic response of the device under irradiation and to provide further insight into the physical processes controlling it.
Here, the assessment of this technology as flexible personal dosimeter will be shown. With this aim, the detector has been tested in actual clinical conditions employing an anthropomorphic phantom mimicking the human pelvis, and a therapeutic proton beam provided by the TIFPA proton therapy center (Trento Institute for Fundamental Physics and Applications, TN, Italy) typically employed for prostate cancer treatment (energy in the range [70-200] MeV) (Figure a). The detector has been placed in two different positions in accordance with the Monte Carlo simulation shown in Figure b: (i) centered on the target of the beam (i.e. in the prostate position) and decentered from it, in the region surrounding the tumor (i.e. the rectum which is one of the organs at risk that would benefit from a real-time monitoring of the impinging radiation). The gafchromics reported in Figure b showed the positions of the detector during the tests. The dynamic curve shows that this device is able to monitor in-situ and in real-time the presence/absence of radiation for the accurate recording and mapping of the dose delivered during a treatment plan.
Finally, the detector has been characterized as dosimeter when placed centered in the target position under 200 MeV proton beams and, as reported in Figure c,d, it presents dose linearity and provides a stable response even after hard and long-lasting proton irradiation (up to 2 · 10^10‘ protons, 30 min of operation).

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