Sensors, a smart dose of medicine for cancer treatment

November 2 2005

New sensor systems being developed will help treat cancer and improve the accuracy and reliability of existing radiation treatments. They should help improve patient care and outcomes. The results will go straight to commercialisation when finalised next year.

The IST programme-funded INVORAD project developed systems for real-time radiation monitoring for patient dosimetry in Intensity Modulated Radiotherapy (IMRT). IMRT is a radiation therapy for cancers that improves clinical outcomes by more accurately targeting tumours and minimising the amount of radiation absorbed by healthy tissue.

Initial work on IMRT started some 10 years ago. IMRT works by modulating the intensity of radiation beams aimed at a tumour, and it sends beams at different angles to cover the asymmetric shapes that tumours acquire. The beams are moved over the area of the tumour, and a multi-leaf collimator modulates and shapes the beams so that the tumour receives a uniform dose.

The result is that patients only receive a high radiation dose where they need it and healthy tissue is preserved.

Typically radiotherapy patients receive daily fraction doses of 2 Gray during a period of 30-40 days, totalling 60-80 Gray for the whole treatment. "By comparison, a chest X-ray check would deliver a dose of just a few milli-Gray," says Aleksandar Jaksic, coordinator of the

INVORAD project and a researcher at the Tyndall National Institute in Cork, Ireland.

Verifying receipt of radiation

The problem with IMRT so far, however, is that it becomes increasingly difficult to verify that patients receive the prescribed dose of radiation. "IMRT prescriptions are based on very complex computer simulations, so it is important to validate these simulations by verifying exactly how much radiation is reaching the patient and where it is landing," says Jaksic.

INVORAD developed two sensors that can do just that: a silicon diode and a p-channel metal-oxide semiconductor field-effect transistor (MOSFET), also known as a RADFET. "Several features, such as miniature size, response to types of radiation involved in radiotherapy, compatibility with microprocessors that enables real-time read-out and low cost, make these semiconductor sensors eminently suitable for the intended application," says Jaksic.

The diode sensor system is based on semiconductor diode arrays, arranged in a series of modules containing 1069 individual diodes that can pick up incoming radiation.

"These diodes need to be very small and while there are commercial packaged diodes out there we needed diodes in bare die form with some novel properties so we developed the diodes ourselves, here at the Tyndall Institute," says Jaksic.

The arrays are extremely accurate and can track radiation at micro-Gray resolution over millimetres of spatial resolution.

These are then linked to a read-out unit and a PC with dedicated software. The read-out unit is based on ASIC (Application Specific Integrated Circuit) and microprocessor technologies and its function is to communicate with, and retrieve data from, the sensor arrays. The PC and software provide system control, connectivity to other parts of an overall radiotherapy system, such as record and verify packages, and patient-specific data storage.

INVORAD also developed a cylindrical 'body phantom'. The 'phantom' is given the prescribed dose and the diode sensors pick up the dose actually delivered. "The two modular 2D diode arrays are placed in orthogonal positions inside the phantom, so we have data in 3D over time," says Jaksic.

If the 'phantom' treatment matches the prescription of the simulator, the patient is given treatment. If not, the treatment plan needs to be corrected. "We created modifications on the diodes and diode arrays, improving their specifications for this project. In fact, every element of the project we worked on received some sort of improvement on current systems," says Jaksic.

Some types of MOSFETs can also detect radiation. In the INVORAD MOSFET-based system these are used in-vivo, mounted in medical catheters in the form of linear arrays, entering the patient through a cavity.

Commercial prospects

"We're currently testing that device in patients with our clinical partner, the Clatterbridge Centre for Oncology, one of the largest oncology centres in the UK. Scientists from City University London are also involved in the project. Of the two devices, the diode system is the most commercially viable. However, the MOSFET system is working and we'll have the results of patients trials in the next few months," says

Jaksic.

Work continues on the INVORAD project. Says Jaksic: "We need to further optimise some parameters of the diode sensor system, but from the work we've done so far we know how to solve these remaining issues."

Jaksic believes it is worth the wait. "Unlike most projects, this device will go straight to market and our commercial partner, ScandiDos in Uppsala, Sweden, is a start-up created for the manufacture and marketing of the device."

"I'm really pleased with the results we've achieved. We developed a functional device to a very, very tight specification and I admit I had some doubts it would be possible to meet the spec at the beginning of the project," says Jaksic. But the team combined a variety of techniques to achieve their goals.

Jaksic is particularly pleased because the new sensor systems will improve treatment verification for a large number of cancer patients.

"The prevailing opinion is that IMRT improves treatment outcomes," says Jaksic. "Crucially, IMRT reduces the side-effects patients often suffer from radiotherapy and improves accuracy of dose delivery, and these are the most important impacts in the treatment of cancer."

Source: IST Results