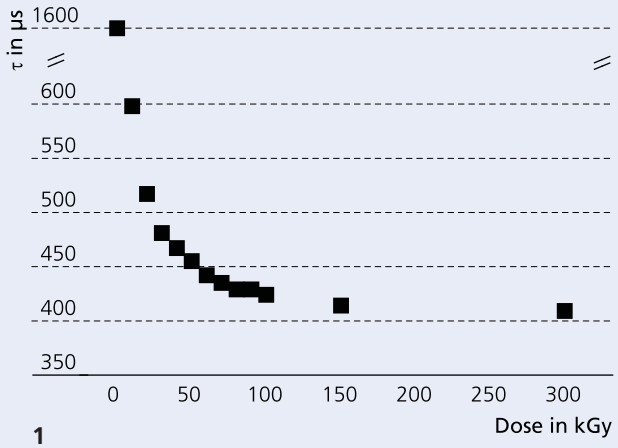

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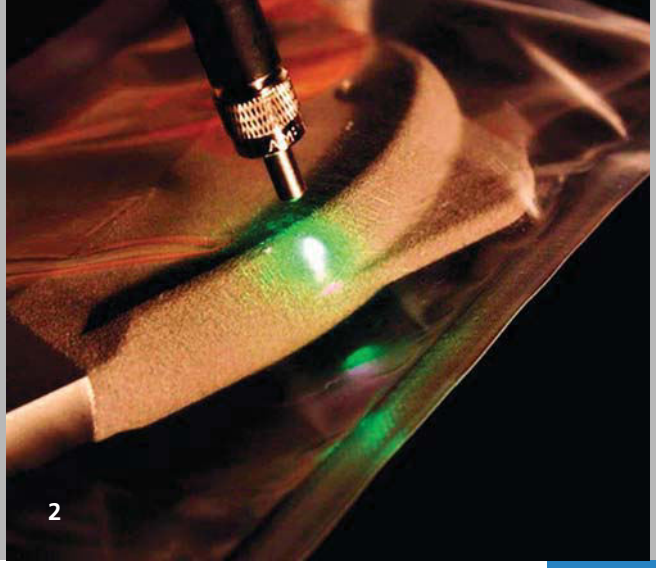

2

TAPE AND 3D DOSIMETRY FOR THE MONITORING OF ELECTRON BEAM PROCESSES

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The sterilization of surfaces via electron e-beam in the low-energy range is important considering, for example, the aseptic packaging of products. Highly sensitive medical devices, surfaces of food packaging, thermolabile plastics, sensitive electronics or functional, biological materials can be sterilized with low-energy electrons. However, there is no in-situ method to verify a successful electron beam sterilization so far, which increases the cost for qualtiy assurance.

At Fraunhofer IKTS, a method was developed which allows to control the sterilization process reliably and with high lateral resolution. Powdery inorganic luminescent materials, which change their optical properties in the course of the electron irradiation, were used on that account. These luminescent materials react to optical stimulation, for example via infrared light, with distinct luminescence. For this purpose, so-called up-conversion materials are particularly interesting. In this material class, the electronic interaction of host crystal lattice and doping causes the emission of a high-energy quantum after the absorption of two low-energy light quanta (photons). Thus, infrared light (IR) is transformed into visible light in the crystal lattice.

The luminescence decay time of ceramic luminescent materials provides information about the incorporated radiation dose via electron beam. Figure 1 shows the optical response after stimulating the pigments with short light pulses. After the energy input through the sterilization process, a clear reduction of the luminescence lifetime τ can be observed, which is dependent on host lattice and doping regarding its distinctiveness. With increasingly applied radiation dose, the luminescence lifetime is further reduced.

By integrating the inorganic pigments directly into the packaging materials (e.g. plastic tapes) or applying them onto the surface of test bodies, quality control of the irradiation process is possible. During the development, it was apparent that the physical integration via compounding process is most suitable as it represents a ready-to-use procedure.

Tapes cast with inorganic luminescent materials are used as dosimetry tapes at Fraunhofer IKTS for the proof of electron and gamma radiation (Figure 2). Furthermore, the coating of three-dimensional test body surfaces with pigments is possible. This allows for the dosimetric analysis of complicated surfaces, for example screw threads on food packaging. So far, such surfaces with fine structures posed a major challenge for dosimetric strips.

Besides the high lateral dose resolution, the wide dynamic range of the reaction on the applied dose (up to > 100 kGy, highest sensitivity up to 25 kGy) is another major advantage of inorganic pigments. Moreover, the luminescence measurement can take place instantly, i.e. without further preparation of the dosimetric tape or the coated surface. For this reason, the method can be applied in-situ at irradiation facilities and used for process control. In special cases, a local repitition of the sterilization procedure is possible.

Hence, in respect of continuously increasing requirements regarding quality assurance, inorganic luminescent materials have considerable advantages in contrast to conventional dosimetric processes.

1 *Dependence of the luminescence decay time τ on the applied radiation dose.*
2 *Packaging material with integrated inorganic pigments under infrared stimulation.*

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