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X-Ray Imaging Systems for NDT and General Applications

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Abstract

Imaging X-ray Detectors. X-ray detectors are offered and applied on the basis of a variety of different physical principles and technical implementations. There are memory systems and real-time systems. The classical storage medium is the X-ray film, which still offers the highest local resolution. Frequently, due to higher computer compatibility, radiographic films are subsequently digitized. However, the chemical development process, non-reusability, and noise contribution by the granulation of the film adversely affects the range of applications.
Storage phosphor screens ("image plates") reduce the exposure time by about 50% to 90% compared to X-ray film systems. In the crystals of these storage media, electrons are trapped on deep levels after interaction with imaging X-rays. Thus, image information is stored in form of a latent picture. The trapped electrons can be stimulated by irradiation with visible laser light. The laser light results in a photo-stimulated fluorescence light, which is used for final image generation. An example of a storage phosphorus is $BaFBr:Eu^{3+}$. The irradiation by He-Ne laser (λ=633 nm) produces fluorescence light with λ=390 nm. The information stored on the image plate can be erased by illumination with white light.
Real-time detectors are needed for in-situ investigations and X-ray tomography. These detectors generate the information from the image directly in computer-readable form. Basically, there are two groups of real-time detectors: 1) *indirect converting sensors,* converting X-rays into visible light; and 2) *direct converting sensors* with direct release of electrical charges caused by the absorbed X-ray quanta.
Well-known indirect converting systems are image intensifiers. The systems are composed of a vacuum tube with a photo-cathode on one side and a luminescent screen on the opposite side. Amid both screens, the electron beam system scans the photo-cathode and generates the image on the luminescent screen. The visible luminescence light is registered.
Today *scintillating detectors* are more important. Scintillating screens convert the incoming X-rays into visible light. The classical set-up for scintillating systems consists of NaI:Tl with a photo-multiplier. In modern systems, scintillating screen and read-out electronics are assembled into a compact unit. Nowadays, efforts are made on exploring more effective scintillating materials (see chapter 5). In principle, the dual radiation conversion is unfavorable reducing the sensor efficiency.
Direct converting X-ray sensors represent the newest, most promising development line. The sensor principle is based on direct interaction of X-rays with the semiconductor material and generating Electron-hole pairs. In the applied electrical field, the electrical charges move to the edges of the semiconductor where they are read by microelectronic circuits. Amorphous, polycrystalline and single-crystal semiconductors are used today. At present, the development of direct and indirect converting semiconductor detectors is rapid and promises applications in new fields.