Medical Solutions

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Background Information: X-ray detectors

Today, computed tomographs (CT) have become an essential, medical tool. In less than a minute, they provide reliable image data for diagnosing different pathologies such as cancer – or in emergency cases they render a detailed view inside the body enabling effective treatment of, e.g. infarcts or accidents. Today's multi-slice CT technology allows for successful new clinical methods, such as examinations of coronary vessels without a single invasion. To increase the image quality and efficiency of a CT system, a performance-oriented detector system is needed in addition to the precise control of X-rays . "Detector system" is a technical term for the component in the CT system that captures the rays transmitted by an X-ray source.

In a computed tomograph, the detector and the X-ray source are located opposite one another on a ring measuring approximately one and a half meters in diameter. During the examination, both rotate about the human body. The X-rays penetrating the patient are attenuated differently in the body, depending on the type and density of the tissue. On the other side, they are acquired by the X-ray detector and converted into visible light. Using photodiodes, the light is transformed into electrical signals, similar to a digital camera and transferred to an image processor. This is how high-resolution images are generated in real time. Details of less than 0.4 millimeters in size are visible at great clarity.

Only highly effective detector materials as well as precise data processing provide CT images at low patient exposure and excellent image quality. For this reason, a CT detector consists of several components. The first is a scintillator that converts X-rays into light signals. Directly underneath the photo diodes are located which capture the

Siemens AG
Corporate Communications
Referat Press
80312 München

Informationno.: Med CT 200610.079 e
Referat Press Medical Solutions
Anja Süssner/Nicole Hinz
Postbox 3260, 91050 Erlangen
Phone: +49-9131 84-3278; Fax: -3047
E-mail: anja.suessner@siemens.com

fluorescent light and process it into electrical pulses. Via numerous electrical channels, the signals are transferred and processed into an image.

One rotation of the CT system generates more than 1000 exposure projections. This means that at three rotations per second, the detector has only fractions of a second in which an X-ray signal can be converted into digital data. If the detector requires too much time, subsequent information will be lost. Extremely fast detector scintillators are therefore the prerequisite for not losing information across projections.

UFC, or “UltraFastCeramics,“ are the detector material developed by Siemens Medical Solutions. It is especially fast and reacts within fractions of a second to changes in radiation attenuation through the patient. This is important since soft tissue allows greater X-ray penetration than bone. This transition is visualized in the CT image as bright-dark contrast. To keep the required X-ray dose as low as possible, detector materials have to be able to absorb and convert X-ray quanta especially well.

When converting radiation into light, the scintillator ceramic as such begins to glow. The faster the ceramic turns dark again, the sharper the image. This leaves the boundaries between dense tissue types clearly visible.
UFC allows for a 400 times faster decay of afterglow than the normally used yttrium gadolinium oxide (YGO). In addition to low afterglow, UFC provides for additional advantages: up to a few years ago, computed tomographs had only a single detector row creating not more than one slice image per rotation. UFC, however, can be cut to plates the size of a postage stamp which allow for multi-row imaging. The results are more than 16 slice images per rotation that simultaneously display a considerably larger body region.

For patients this means that the examination time is greatly reduced. This is especially advantageous when examinations of the thorax or heart are involved which require the patient to hold his breath to ensure artifact-free images.
For the detector system it means a significant increase in the number of pixels. The higher the image resolution, the greater the detail recognition of the human body. The

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Phone: +49-9131 84-3278; Fax: -3047
E-mail: anja.suessner@siemens.com

high precision of the manufacturing technology used has ensured pixel realization of sub-millimeter dimensions.

However, it is questionable whether the trend for increasing the number of slices at continuously higher resolutions will continue. Because beyond 64 slices, the clinical use – as compared to costs – is no longer proportional to the number of slices obtained. For this reason, new paths are being taken during the development and architecture of detector systems in addition to the continuous improvement of the UFC detector material. In the currently most modern computed tomograph, the SOMATOM Definition, two detector systems are used at the same time. The data rate is therefore almost twice as high.

In addition to that background information further images can be found under:
http://www.siemens.com/med-pictures/x-ray-detectors

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