Abstract

In the field of X-ray imaging flat panel detectors which convert X-rays into electrical signals, are widely used. For different applications detectors differ in several specific parameters that can be used for characterizing the detector. These parameters include the basic spatial resolution, the modulation transfer function (MTF) and the contrast sensitivity. At the Development Center for X-ray Technology EZRT we studied the question how good these characteristics can be determined by only knowing the layer composition of a detector. In order to determine the required parameters, a Monte-Carlo simulation program was used while taking into account all primary and secondary particle interactions as well as the focal spot size of the X-ray tube. For the study, the Hamamatsu C9311DK, a scintillator based detector, and the Ajat DIC 100TL, a directly converting semiconductor detector, were used. The layer compositions of the two detectors were implemented into the MC simulation program ROSI [1].

In order to determine the basic spatial resolution, a duplex wire according to EN 462-5 was used in the measurement and implemented in the simulation. In order to accomplish the measurement of the MTF, an image of an almost completely absorbing tungsten object with a sharp edge was taken. The MTF could be calculated by fourier transforming the line spread function (LSF), which could be obtained by deriving the edge spread function (ESF). In the simulation, the LSF could be obtained directly by irradiating the detector with a thin fan beam. The CS and SMTR were measured and simulated using a step wedge with notches milled into it. The simulation results show the influence of internal detector scattering, but other effects which can blur the signal, like charge diffusion in semiconductors or diffusion of optical photons in scintillators, could not be covered by the MC simulation. To take these effects into account, further models had to be developed.

Introduction

• Description of X-ray detection → Simulation → calculation of detector characteristics
• Theoretical detector design according to application possible
• Calculation of energy deposition by Monte-Carlo-Simulation ROSI
• Propagation of optical photons in scintillator materials by DETECT2000 [3]

Detectors used for virtual characterization

Hamamatsu C9311DK

Technical data:
• Indirect converting scintillator
• Scintillator: CsI
• Pixel size: 100 µm x 100 µm
• Number of pixels: 1248 x 1152
• Area: 144.8 x 155.2 mm²

Modeled layer composition:
• 1 mm Al (front plate)
• 13.5 mm gap
• 650 µm CsI (scintillator)
• 1.5 mm Si (readout + electronics)
• 400 µm Cu foil
• 1.5 mm Pb (readout shielding)

Ajat DIC 100TL

Technical data:
• Direct converting semiconductor
• Sensor material: CdTe
• Pixel size: 100 µm x 100 µm
• Number of pixels: 252 x 1014
• Area: 25.2 x 101.4 mm²

Modeled layer composition:
• 100 µm Al foil
• 3 mm gap
• 750 µm CdTe (sensor)
• 3 mm Si (readout + electronics)
• 10 mm gap
• 1 mm Al (back cover)

X-ray source used in simulation setup

• Voltage: 30 kV (according to Feinfocus FXT-160 transmission tube)
• Focal spot size: 3 µm

Simulation setup, data analysis and results

Basic-Spatial-Resolution EN BPK 462-5 (BSR)

• 13 duplex wires with fix width
• Spacing between wires same as width
• Angle of 3.71° to detector
• Grey value profile perpendicular to wire averaging of 60% of their length
• Calculated contrast for each duplex wire with bilinear interpolation
• BSR corresponds to calculated theoretical width of duplex wire with 20% contrast

References:

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