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Development of a highly efficient, high resolution X-ray sensor based on self-organizing aluminum oxide

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State of the art X-ray imaging sensors comprise a trade-off between the achievable efficiency and the spatial resolution. For instance a scintillator with a high thickness (i. e. high absorption length), yields a high efficiency but suffers from a decrease in spatial resolution due to (optical) light spreading in the scintillation layer. For thinner scintillators the opposing case is observed. In general, an increase in spatial resolution leads to a decrease in efficiency and vice versa.

The goal of the Fraunhofer-internal project WISA Honeris, which has launched in March 2009, is to overcome such limitations to provide 'ready for the market'X-ray imaging sensors which offer both high efficiency and high spatial resolution.

This is achieved by filling structures (hexagonal arranged channels) of porous self-organized aluminium oxide (AlOx) matrices with appropriate scintillator materials. The process of self-organization itself is based on electrochemical oxidation. Due to its channel-like structures which act as light guides, the high spatial resolution is assured almost independently from the scintillator thickness. This permits the fabrication of very thick and therefore highly efficient scintillator matrices without losing spatial resolution.

We used Monte-Carlo X-ray simulations to determine the X-ray imaging quality of the AlOx matrices. Important factors which influence the behaviour of the matrices are: filling factor (ratio between channels and 'closed'AlOx), channel diameter, aspect ratio, filling method, filling material etc. Therefore we modelled the porous AlOx matrix with the MC X-ray simulation tool ROSI [1] and evaluated its properties in many different ways to investigate: the performance at different acceleration voltages, antialiasing possibilities, crosstalk between channels as a function of acceleration voltage and filling factor, achievable spatial resolution, homogeneity, etc.

We present the results of the simulations which incorporate the response of the matrix to be expected and give a comparison of these results with experimental characterisation measurements for both image and fabrication/filling quality and also a comparison with present available scintillator-filled matrices.

[1] J. Giersch, A. Weidemann, G. Anton: ROSI - an Object-Oriented and Parallel-Computing Monte Carlo Simulation for X-Ray Imaging. Nuclear Inst. and Methods in Physics Research A, 509:151–156, 2003.

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