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P1.35: Development and Characterization of an EUV/soft X-ray Single-Photon Sensitive sCMOS Camera

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Ultrafast X-ray spectroscopy has recently been defined revolutionary in chemical dynamics [1], but despite the above-mentioned excellent progress, its full potential still needs to be uncovered. A significant challenge in X-ray spectroscopy is the ability to measure very small changes of the absorption near the K-edges of the atomic elements [2] under investigation with a very high signal to noise ratio. Schemes with high detection efficiency in the soft X-ray spectral range and high-speed readout for "pump-on"and "pump-off"measurements are a prerequisite for the success of these experiments with low photon-flux tabletop sources.
In this respect, greateyes GmbH is developing X-ray cameras adapted to time-resolved X-ray spectroscopy, including newly developed CMOS-based detectors. The project aims to optimize an existing CMOS camera platform towards an EUV/soft X-ray sensitive sCMOS camera suitable for high-repetition rate imaging or spectroscopy as well as single photon detection and its application for the investigation of molecules in solutions with the help of absorption spectroscopy in the soft X-ray range.
A detailed comparison of this new technology with existing CCD technologies and associated charge transfer processes is presented to understand the pros and cons of each technology depending on the energy range, photon flux, repetition rate and other parameters. A first prototype of a sensitive sCMOS camera which is based on back-illuminated CMOS sensor offered by Gpixel with a 4 Megapixels resolution [3] is constructed. Key points and challenges in the development of the detector are presented, such as e.g.:
• a flexible Region-of-Interest (ROI) function implemented on a Field-Programmable Gate Array (FPGA) to further reduce the image acquisition time for high repetition rate experiments,
• development of a high-density electrical (UHV) vacuum feedthrough using flexible Polyimide PCBs
• design of a multi-stage thermoelectric sensor cooling system to achieve temporarily and spatially homogeneous dark current levels
Currently, a second camera protype is being built and recent results from its characterization in first proof-of-principle experiments with X-Rays are to be presented, that are obtained with the help of the experimental infrastructure for ultra-fast X-Ray spectroscopy at the Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy (MBI). Lastly, an outlook on future applications of the new sCMOS X-ray detector is given, which is planned to be used in experiments for the investigation of the dynamics of ultra-fast charge transfer processes in donor-acceptor complexes in a solution (i.e., push-pull chromophores) [4] and experiments with transient absorption of soft X-rays in collaboration with MBI.

[1] P. Kraus, M. Zurch, S.K. Cushing, D. M. Neumark, S, R. Leone, "The ultrafast X-ray spectroscopic revolution in chemical dynamics", Nat. Rev Chem. 2, 82–94 (2018).
[2] J. Stöhr, F. Sette, and Allen L. Johnson, "Near-Edge X-Ray-Absorption Fine-Structure Studies of Chemisorbed Hydrocarbons: Bond Lengths with a Ruler", Phys. Rev. Lett. 53, 1684 (1984)
[3] https://www.gpixel.com/products/area-scan-en/gsense/gsense400bsi-11-%CE%BCm-4mp-rolling-shutter-image-sensor/
[4] C. Kleine, M. Ekimova, G. Goldsztejn, S. Raabe, C. Strüber, J. Ludwig, S. Yarlagadda, S. Eisebitt, M. J. J. Vrakking, T. Elsaesser, E. T. J. Nibbering*, and A. Rouzée, "Soft X-ray Ab-sorption Spectroscopy of Aqueous Solutions Using a Table-Top Femtosecond Soft X-ray Source"J. Phys. Chem. Lett., 10, 52–58 (2019)

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