Characterization of a back thinned scientific CMOS imager with extended ultra violet and soft X-rays

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Introduction

Photon science with extended ultra violet (EUV) to soft X-ray photons generated by state of the art synchrotrons and FEL sources imposes an urgent need for suitable photon imaging detectors. Requirements on such EUV detectors include high quantum efficiency, high frame rates, very large dynamic range, single-photon sensitivity with low probability of false positives, small pixel pitch and (multi)- megapixels. Such characteristics can be found in few state of the art commercial detectors based on scientific CMOS (sCMOS), which have been recently developed for applications in the visible light regime. In particular back thinned sCMOS are suited for experiments in the photon energy range between 30 eV and 2000 eV, which requires vacuum operations.

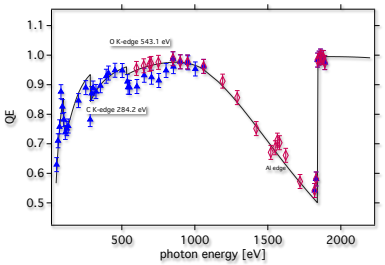
CMOS detector

The detector is a back illuminated sCMOS imager for soft X-rays in the energy range from 35 eV – 2000 eV. It comprises 2048 x 2048 pixels with a pixel size of 6.5 µm x 6.5 µm. The sensor exhibits a full well capacity of 48000 e- and a readout noise of 1.9 e- (rms) with a dynamic range of 88 dB. The integration time can be adjusted between 10 µs – 2 seconds. The maximum frame rate is given by 48 fps for the full frame. Vacuum compatibility has been obtained by sealing the carrier board of the sensor, which constitutes the barrier between vacuum and normal atmosphere, which allows to keep the entire readout and trigger electronics in air. At the moment a KF flange is utilized to attach the camera and subsequently sensor to the experimental vacuum chamber.

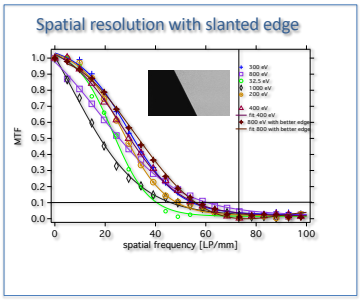
Measurements

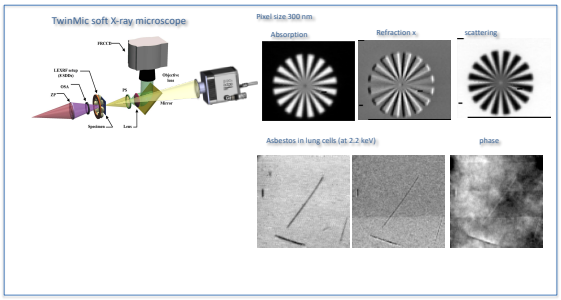
Quantum using a calibrated IUX photo diode

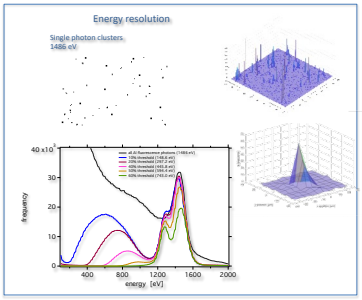
$$QE_{th}(E_\gamma) = F\left\{\frac{\mu_k(E_\gamma)}{\rho_i}\right\} = e^{-\sum_{i=1}^{N}\frac{\mu_k(E_\gamma)}{\rho_k}\cdot\rho_i\cdot x_i}\cdot\left(1-e^{-\frac{\mu_{Si}(E_\gamma)}{\rho_{Si}}\cdot\rho_{Si}\cdot x_{Si}}\right)$$

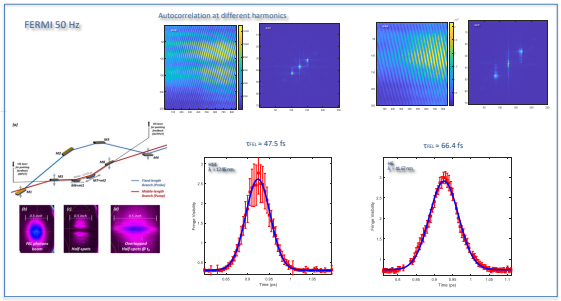


least square fitting results: 0.5 ±0.1 nm of atomic C, 12.3 ± 0.4 nm fatty acid, a 0.9 ± 0.2 nm insensitive Si layer and 9.9 ±0.1 nm SiO_2 passivation, Si epi layer of 10.3 ±0.2 µm

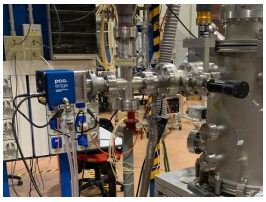


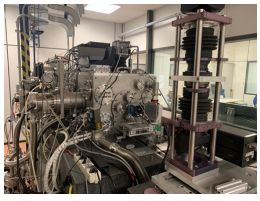


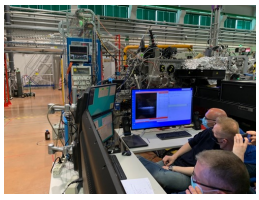


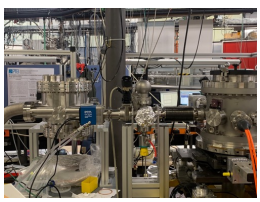


Installations

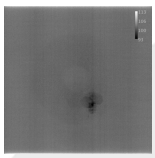








Radiation



Estimated dose for SiO_2 = 7331 Gy
Estimated dose rate for SiO_2 = 40 Gy/s

[1] R.H. Menk et al.» On the possibility to utilize a PCO Edge 4.2 bi scientific CMOS imager for extended ultra violet and soft X-ray photon detection»
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