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High-flux CdZnTe Sensor Characterization at the European XFEL

The European X-ray Free-Electron Laser (European XFEL) [1] is an international user research facility located in Schenefeld, in the Hamburg area. It currently features three undulators, providing spatially coherent X-rays for seven experimental stations in the energy range of 2608239;eV to 258239;keV. Using superconducting cavities, the facility can provide up to 2700 pulses of up to 10¹⁴ photons and fs-length with a repetition rate of up to 4.58239;MHz in 10 equidistant X-ray pulse trains per second. Future upgrades will enhance accessibility to photon energies in the 25-508239;keV range.
Within the framework of the development of new detectors, the European XFEL has recently started an effort to build in-house knowledge regarding high-Z sensor materials, which would offer enhanced quantum efficiencies and protection of the sensitive detector electronics behind them at energies above 20thinsp;keV with respect to the currently used silicon sensors. One of the main goals is the qualification of the performance of these alternative sensor materials against the operational requirements dictated by experimental conditions at the facility: while single photon sensitivity as well as high dynamic range of 10³ to 10⁴ photons/pixel are both needed, the sensor's response must be compatible with MHz operation. Additionally, the user community expressed interest in an enhanced spatial sampling rate capability, therefore the development is setting its target towards an imager featuring a pixel pitch in the order of 1008239;µm.
To work towards this goal, the already fruitful collaborations with partners at Deutsches Elektronen-Synchrotron (DESY), the Paul Scherrer Institute (PSI), and the Science and Technology Facilities Council (STFC) have been expanded to include tests with high-Z hybrid assemblies. Versions of the Large Pixel Detector [2] (STFC), the JUNGFRAU [3] (PSI), and the Adaptive Gain Integrating Pixel Detector [4] (DESY) were equipped with high-flux CdZnTe sensors produced by REDLEN Technologies, which have improved charge carrier dynamics with respect to their spectroscopic counterpart and respectively reduced polarization effects caused by the large amount of charge generated by intense light pulses. While CdZnTe has been studied extensively at synchrotrons and also showed promising results at low repetition FELs, we have for the first time investigated its compatibility with intense pulses with a repetition rate in the MHz range.
The response of the high-flux CdZnTe sensors shows good linearity within the achieved range of up to about 4×10⁵ 188239;keV photons/mm²/pulse and the residual signal after 4008239;ns was well below 1% of the respective initial signal caused by the photon pulse. Although the physically brittle sensors exhibit noticeable charge sharing due to their increased thickness and further investigations are required to fully deconvolute the sensor's response from electronic effects, CdZnTe is a promising candidate to be used as high-Z sensor material at high repetition FELs.
References:
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Workshop topics

Sensor materials, device processing & technologies

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