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Characterization of charge integrating detectors with iLGAD sensors in the soft X-ray energy range

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Soft X-rays are crucial to study the electronic structure and order of matter. Techniques such as ptychography, and resonant elastic and inelastic scattering in the soft X-ray domain benefit from the large area and the fast frame rate of hybrid pixel detectors (HPDs). State-of-the-art HPDs have become indispensable for scattering techniques with hard X-rays thanks to the large area, fast frame rate and large dynamic range/count rate capability. However, hybrid pixel detectors for hard X-ray detection show shortcomings in detecting soft X-rays due to the poor quantum efficiency (QE) and the low signal-to-noise ratio (SNR). The Detector Group from the Paul Scherrer Institut (PSI) has been working in collaboration with Fondazione Bruno Kessler (FBK) to optimize HPD sensors to increase both QE and SNR. In the framework of this collaboration, two technologies have been developed: the thin entrance window (TEW) and the inverse low-gain avalanche diode (iLGAD).
I will present the sensor development strategy at PSI and the performance of detectors with TEW and iLGAD sensors using the charge integrating JUNGFRAU readout electronics for photon energies below 2 keV. The TEW technology permitted achieving QEs above 60-80% at 250 eV, comparable to or better than commercial CCD and CMOS imagers broadly used for soft X-rays. The iLGAD technology achieved single photon resolution for photon energies down to 400 eV. Thanks to these two technologies the operation of PSI HPDs has been extended to the soft X-ray energy range. Based on these results, I will also discuss further QE improvement targeting values above 80%, of particular interest for experiments such as small grazing angles like resonant inelastic X-ray scattering (RIXS) and for the detection of low-energy electrons (as an extended application of HPD), and future iLGAD developments to extend the minimum photon energies down to the carbon edge (˜284 eV).

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