A single photon counting pixel detector system for synchrotron radiation applications

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Abstract:

PILATUS (Pixel Apparatus for the Swiss Light Source) is a challenging project to develop a large area single photon counting pixel detector for synchrotron radiation experiments. The PLATUS single module detector has been developed in collaboration between the Paul Scherrer Institute (PSI) and Japan Synchrotron Radiation Research Institute (SPring-8) [1-4]. Although the PILATUS-I detector was a prototype with about 5% defective pixels in the readout chip due to the DMILL 0.8 μm CMOS technology, it realized a sufficiently high capability to allow the methodological study of its fields of applications. Recently, the PILATUS-II detector has been developed with the UMC 0.25 μm CMOS technology. A module has a single, continuously sensitive, 300 μm thick silicon sensor. 195 × 487 pixels of size 172 μm × 172 μm, leading to a 34 mm × 84 mm area. An array of 2 × 8 custom CMOS readout chips is indium bump-bonded to the sensor. Each pixel contains a charge-sensitive amplifier, a single level discriminator and a 20-bit counter. Pixels are individually addressable, and each pixel has a 6-bit threshold trim adjustment DAC, which can be set to minimize threshold dispersion across the chip. An individual pixel is thus capable of being operated in a single photon counting mode. The PILATUS-I chip with 44 × 78 pixels was fabricated in the DMILL process, and even fully screened chips showed 5 % defective pixels. A subtle design oversight also caused the counters in the pixels to miscount under some circumstances. A redesigned PILATUS-II readout chip with 60 × 97 pixels in the 0.25 μm process has been developed to replace the PILATUS-II detector. Both of above problems have been overcome in the PILATUS-II chip. Major improvements have been the speed of the single photon counting circuit and a much higher yield of working pixels/chip. The PILATUS-II detector achieves 2×10^6 X-rays/s/pixel without counting errors, but which was limited to about 10^4 X-rays/s/pixel in the PILATUS-I. The yield of ‘good’ chips was about 35% in the DMILL CMOS process, but even good chips still have around 5 % defective pixels. In the 0.25 μm COMS process, on the other hand, the yield of perfect chips was more than 80%. The PILATUS-II single module detector has a desired performance with almost zero defective pixels and a fast frame rate up to 100 Hz.

The PSI is developing the PILATUS-6M detector with the 5 × 12 modules for the

protein crystallography. Its quarter size with the 5 × 3 modules is currently under fabrication, already showing excellent, and the 6M detector will be completed soon. The PILATUS-6M will realize the fine ϕ-slicing mode with rotating a sample continuously and define the exposure time by the electronically gate. Now we are designing 1M or 2M pixel detectors for small angle scattering and other applications. The PILATUS-1M will be available at SPring-8 in 2006.

Reference:

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