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AGIPD, a high dynamic range fast detector for the European XFEL

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AGIPD - (Adaptive Gain Integrating Pixel Detector) is a hybrid pixel X-ray detector developed by a collaboration between Deutsches Elektronen-Synchrotron (DESY), Paul-Scherrer-Institut (PSI), University of Hamburg and the University of Bonn. The detector is designed to comply with the requirements of the European XFEL, 4th generation free electron laser source being constructed in Hamburg, Germany. The key features of the XFEL will be the high brilliance pulses with a tight bunch structure. It is expected that the source will produce short (˜100 fs), highly coherent pulses with a peak brilliance of 10³³ ph/(s mm² mrad² 0.1%BW) in the energy range 0.3 –25 keV (depending on the experimental station). The pulses will be organized in bunch trains with a frequency of 10 Hz. Each bunch consists of 2700 pulses with > 10¹² photons of 12keV each separated by a 220 ns resulting in 4.5 MHz pulse frequency. Such a characteristics of the source put severe requirements on the detector readout electronics. The radiation tolerant Application Specific Integrated Circuit (ASIC) is designed with the following highlights. High dynamic range: from single photon sensitivity up to 10⁴ 12.5 keV photons, achieved by the use of the dynamic gain switching technique between 3 possible gains of the charge sensitive preamplifier. In order to store the image data ASIC incorporates 352 analog memory cells per pixel, allowing also to store corresponding gain bits (3 voltage levels). It is operated in random-access mode at 4.5 MHz frame rate. An external vetoing signal may be used to force the acquisition system to overwrite “bad”frames during the acquisition. The data is transferred then to the DAQ system and digitized during the 99.4 ms between the bunch trains. The AGIPD has a pixel area of 200x200 µm², a 500 µm thick silicon sensor is used. The full 1M pixel system will contain 4 quadrants of 4 modules each. 1 module consists of a single module sensor bump-bonded to 16 full scale chips.

Since the beginning of the project 5 prototype ASICs were manufactured and tested in order to prove the architecture principals and measure the characteristics. Extensive sensor wafer testing is done. The mechanical concept developed in the close contact with the XFEL beamline scientists and now is being produced. Presented will be a project design and it’s highlights with a corresponding measurements along with the experimental results achieved with the latest full scale ASIC “AGIPD 1.0”available.

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