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Performances of the first full-scale HYLITE readout chip and the prototype module of SHINE XFEL

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SHINE (Shanghai High repetition rate XFEL and Extreme light facility) is the first XFEL facility working in the hard X-ray region in China. To fulfill the special requirements of SHINE, a new pixel array detector, STARLIGHT (Semiconductor Array detector with Large dynamic range and charge integrating readout), is being developed. HYLITE (High dynamic range free electron Laser Imaging detector) is the front-end readout chip of STARLIGHT, which works in the charge-integration mode with a dynamic range of 1~10000 photons @ 12 keV.

The initial phase of HYLITE development focuses on creating a 64×64-pixel chip with a 200- μm pixel pitch. HYLITE200F, the first full-scale chip in the HYLITE series, was manufactured using a 130 nm CMOS process. The maximum frame rate of HYLITE200F is 6.3 kHz in successive readout mode, with plans to enhance it to 12 kHz in the final version. To enable such high speed, a 10-bit Analog-to-Digital Converter (ADC) is integrated into each pixel, ensuring that the pixel outputs are in digital format. Performances of the HYLITE200F chip are fully tested. The signal-to-noise ratio is 8.7, which indicates the ability of single-photon resolution.

A prototype module was manufactured and preliminary tested. As the first step, four HYLITE200F chips are bump-bonded with a specially designed PIN sensor to make the 2×2-size module. The prototype module is mounted on a 2×8-size front-end PCB and read out via the back-end electronics which will be adopted in the final detector system. Imaging tests show that the function of the prototype and the architecture of the detector are correct. To verify the dynamic performance, a rotating chopper was placed before the module to block the X-ray. The frame rate of the detector was 1 kHz and the rotate frequency of the chopper was 100 Hz. Test results show that the images have the same pattern after every 10 frames, which indicates that the detector can work at the frame rate of 1 kHz.

Auteurs principaux: Dr LI, Mujin (Institute of High Energy Physics, Chinese Academy of Sciences); WEI, Wei (IHEP, CAS)

Co-auteur: ZHANG, Jie (IHEP)

Orateur: Dr LI, Mujin (Institute of High Energy Physics, Chinese Academy of Sciences)

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