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P1:56: Experiment of EMPIX prototype detector for MeV ultra-fast electron diffraction and microscopy

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EMPIX[1] is a high dynamic range diamond pixel detector for MeV ultra-fast electron diffraction and microscopy. The prototype readout ASIC integrates 32×8 pixels electronics with each pixel consisting of a dual range charge integrator, a correlated double sampler and a 12-bit Wilkinson type ADC. The strong penetration of MeV electrons brings possibilities for electron microscopy of thick samples, but also challenges both the sensor and the readout circuit. By adaptive gain adjustment design, the ASIC is skilled at signal processing and readout for applications of high brightness pulsed particle sources. From our previous simulation studies, we chose diamond as the sensor for MeV electron microscopy.

Through re-distribution layer (RDL) fabrication at wafers, 20 prototype readout chips are packaged together to a module that can be bump bonded to 32×128 pixel detectors of 150 μm pitch (not all pixels are used). A detector prototype, that is, four of the RDL chip modules bump bonded to a diamond sensor with full matrix of 128×128 was tested. Fig.1 shows the 4 modules that are wire bonded to the evaluation board.

The data of the chips is read through a high-speed data acquisition system with a maximum bandwidth of 80 Gbps, and then transferred to computer via 2 lane optical fibers (Fig.1). Corresponding electron microscope camera systems have also been designed, including vacuum, refrigeration, and other items. The detector and chip are placed in the vacuum for direct electron detection, and the temperature is set to about -20 ℃. The data acquisition system is outside the vacuum, and the two are connected through a vacuum feedthrough and flexible circuit board. The entire system is also equipped with a water cooling device to remove heat from the vacuum.

The performance of the detector was evaluated and some imaging experiments were conducted. We evaluated and calibrated the noise, linearity, and energy resolution characteristics of the detector in the air. After that, using the camera system, ultra-fast electron diffraction (UED) experiment was performed on a 2.6 MeV high-energy pulsed electron source in Accelerator Laboratory of Tsinghua University.

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