ID de Contribution: **53** Type: **12mOral**

Sagara1212: A wafer-scale, 5,000 frames per second, 4 megapixel CMOS Image Sensor for direct electrons and light detection

mardi 19 novembre 2024 17:07 (17 minutes)

CMOS image sensors (CIS) are the leading imaging technology today. Sensors as large as a wafer can be manufactured thanks to the so-called stitching method. The architecture of existing wafer-scale CIS products is fairly simple, with the sensors representing only a relatively limited advantage in terms of speed, with respect to other technologies, e.g. a-Si panels or CCDs. This work presents the design and characterisation of a high-speed, 5,000 fps (frames per second), 4-megapixel CIS. The pixel rate of this sensor exceeds 20 Gpixel per second. This represents a step-change in frame rate for sensors of this type and the sensor architecture used to achieve this is patented.

The sensor was developed for cryo-TEM (Transmission Electron Microscopy). Cryo-TEM has utilized CIS since the early 2010s, a transformation that played a crucial role in its progress, culminating in the Nobel Prize in Chemistry in 2017 for advancements in cryo-electron microscopy (cryo-EM). For example, the COVID structure was determined using Cryo-TEM with CIS.

Cryo-TEM demands high frame rates to mitigate radiation damage to samples, which occurs rapidly when exposed to electron beams. Recent developments in TEM have focused on reducing the electron beam energy from 300keV to 100keV. This shift presents new challenges for detector technology. At 100 keV, electron interactions cause increased spreading within the detector's pixels, necessitating larger pixels and, consequently, a larger imaging array to maintain image resolution.

Our CIS Sagara1212 was developed for TEM at lower electron energies. It features a wafer-scale 4-megapixel array with frame rates up to 5,266 fps at 8-bit resolution. The sensor has a programmable bit depth, allowing the trade-off between frame rate and pixel bit depth to be explored. The chosen accuracy can vary between 4 and 10 bits, with the frame rate changing from 7,267 to 3,303 fps. The radiation-hardness as well as other performance of the pixel were tested in a prototype. The CIS works in rolling shutter and it features column-parallel programmable gain amplifiers and ADCs. The total number of ADCs is 24,384 for the whole sensor. The high frame rate requires 216 sub-LVDS lines running at 1GSa/s. To connect the sensor with the TEM computer, we also developed the readout electronics, which is capable of capturing data at a rate of 216Gbit/s.

These capabilities ensure that the sensor can capture high-quality images at high speeds, which is essential for applications like cryo-EM. Although the sensor was designed for this application, it is also sensitive to light, thus making it suitable for other applications requiring a large number of pixels and high frame rate.

The paper details the Sagara1212 sensor's architecture, the measures taken to achieve its high frame rate, its corresponding camera for data capture, and the test results which have been acquired. Figure 1 shows the sensor integrated into the Chip-On-Board (COB) assembly, highlighting the design and integration process. Figure 2 presents the sensor's floorplan. The system is currently undergoing tests within a Cryo-TEM microscope.

Auteurs principaux: BOFILL, A; FONT, A; MOLLÀ, A; M. SCOTT, Andrew; BAUZÀ, C; GARGALLO, M; GIULIONI, M; SANNINO, M; GIFREU, R; Dr TURCHETTA, R; LLADÓS, Ò

Orateur: M. SCOTT, Andrew

Classification de Session: Monolithic sensors

Classification de thématique: Monolithic sensors