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Design and Development of an Event-driven SOI Pixel Detector for X-ray Astronomy

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We have been developing monolithic active pixel detectors based on the silicon-on-insulator (SOI) pixel technology, named "XRPIX", for future X-ray astronomical satellite missions. The XRPIX series offers good time resolution (~1 μs), fast readout time (~10 μs), and wide energy range (0.5–40 keV) in addition to having imaging and spectroscopic capabilities comparable to charge coupled devices (CCDs) which are current standard detectors. A comparator circuit in each pixel is also implemented in order to output hit trigger (timing) and two-dimensional hit-pattern (position) so that signals are read out only from X-ray-detected pixels. X-ray readout by this function is called "event-driven readout".

We have designed many types of devices to realize event-driven readout and improve performance. In our previous studies, we successfully demonstrated the event-driven readout using small-area devices. We designed the first prototype of a large-area device for satellite loading. The device is 24.6 mm $\times$ 15.3 mm in size and consists of 608 $\times$ 384 (= ~233k) pixels. The pixel size and the imaging area are 36 μm $\times$ 36 μm and 21.9 mm $\times$ 13.8 mm, respectively. We have introduced a data processing circuit to obtain pattern information of detected events. This circuit allows us to determine the event type within several operating clocks. We report on the design architecture and evaluation results of the large-area device in the event-driven readout.

We also fabricated a different device with a new pixel structure using Double-SOI wafer to improve the X-ray spectroscopic performance. It is evaluated in the frame readout mode, which reads all pixels periodically analogous to CCDs. We finally achieved the readout noise of about 10 e^- (rms) and the energy resolution of about 190 eV (FWHM) at 6 keV.

Primary author: Dr TAKEDA, Ayaki (University of Miyazaki)

Co-authors: Dr MORI, Koji (University of Miyazaki); Mr NISHIOKA, Yusuke (University of Miyazaki); Mr TAKEBAYASHI, Nobuaki (University of Miyazaki); Mr YOKOYAMA, Shoma (University of Miyazaki); Mr FUKUDA, Kohei (University of Miyazaki); Prof. TSURU, Takeshi (Kyoto University); Dr TANAKA, Takaaki (Kyoto Univsersity); Dr UCHIDA, Hiroyuki (Kyoto University); Mr MATSUMURA, Hideaki (Kyoto University); Mr TACHIBANA, Katsuhiro (Kyoto University); Mr HAYASHI, Hideki (Kyoto University); Mr HARADA, Sodai; Dr KOHMURA, Takayoshi (Tokyo University of Science); Dr HAGINO, Kouichi (Tokyo University of Science); Mr OONO, Kenji (Tokyo University of Science); Mr NEGISHI, Kousuke (Tokyo University of Science); Mr YARITA, Keigo (Tokyo University of Science); Prof. ARAI, Yasuo (High Energy Accelerator Research Organization (JP)); Prof. KURACHI, Ikuo (HIgh Energy Accelerator Research Organization); Prof. KAWAHITO, Shoji (Research Institute of Electronics, Shizuoka University); Dr KAGAWA, Keiichiro (Research Institute of Electronics, Shizuoka University); Dr YASUTOMI, Keita (Research Institute of Electronics, Shizuoka University); Mr KAMEHAMA, Hiroki (Research Institute of Electronics, Shizuoka University); Mr SHRESTHA, Sumeet (Research Institute of Electronics, Shizuoka University); Mr NAKANISHI, Syunta (Research Institute of Electronics, Shizuoka University)

Presenter: Dr TAKEDA, Ayaki (University of Miyazaki)

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