Instrumentation and Technique

14A, 14B, NE7A/2009G617

Evaluation experiment of SOI X-ray image sensors

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Introduction

The SOIPIX group is developing monolithic X-ray SOI-CMOS image sensors. The development project has started as an important subject in KEK Development and Technology Project (KEK-DTP). To evaluate the basic properties of the SOI image sensors, KEK-PF beamlines, PF BL-14A, BL-14B, and PF-AR NE-7A, were used. This document describes a brief summary of the evaluation experiment.

Experimental Summary

The evaluation experiment was done in 3 beamlines. The summary is shown in Table 1. The machine time period is from Oct. 2009 to Jun. 2011, but the final period (Apr. – Jun. 2011) was cancelled due to the earthquake. In PF BL-14A, wide range X-ray energy is available for various X-ray detector tests and therefore it was used for sensor gain and quantum efficiency (QE) measurement. In PF BL-14B, uniform beams in medium X-ray energy (10-17 keV) are available and thus it was used for demonstration on the DEI phase-contrast imaging and evaluation on spatial resolution. In PF-AR NE-7A, uniform X-ray beams in high energy (25-40 keV) is available and so it was used for absorption-contrast imaging and evaluation on spatial resolution. The SOI sensors were compared with commercial X-ray CCD.

Table 1: Experiment summary

Beam line	Beam time [year/month]	Beam Energy [keV]	Subjects
PF 14A	2009/11	12-18.5	Sensor gain
PF 14A	2010/2	12-18.5	Sensor gain, QE
PF 14A	2010/6	6-18.5	Sensor gain, QE
PF 14A	2010/12	20-30	Sensor gain, QE
PF 14B	2009/12	17	DEI
PF 14B	2010/3	16	Spatial resolution
PF 14B	2010/5,10	14	Spatial resolution
AR NE 7A	2010/2	25-33.1	Imaging, Spatial resolution
AR NE 7A	2010/11	25-40	Imaging, Spatial resolution
AR NE 7A	2011/2	25-33.1	Imaging, Spatial resolution

SOI image sensor chips

SOI image sensors were developed within multi-project wafer (MPW) runs every year in which various LSI designs were gathered in a common process mask [1]. Therefore, various SOI image sensors were evaluated in each experiment. In the first PF experiment, we used the integration-type pixel detector, INTPIX3a, in which new process, Buried P-Well (BPW), was adopted for the first time. In 2010, the INTPIX3b/3c which are modified version of INTPIX3a were developed and evaluated. In the middle of 2010, the quality of SOI wafer was improved and then Float-Zone- (FZ-) SOI wafer was utilized for the detector fabrication. In Nov. and Dec. 2010, FZ-SOI pixel sensors were tested and compared with the existing Czochralski- (Cz-) SOI pixel sensors. From the end of 2010, the large-area integration-type image sensor (the pixel size 17 μm and 832 x 512 pixels), INTPIX4, was successfully operated and it showed excellent spatial resolution with the beam in PF-AR NE-7A as shown in Fig.1. Experimental data are in analysis and a part of them were already shown in the publication [2].

Future Plan

The SOI pixel sensors were well developed for two years and qualities of them were improved. Since updated version of the sensors is developed in every year, we will continue the evaluation experiment. Additionally, we will start application experiment of SOI image sensors.

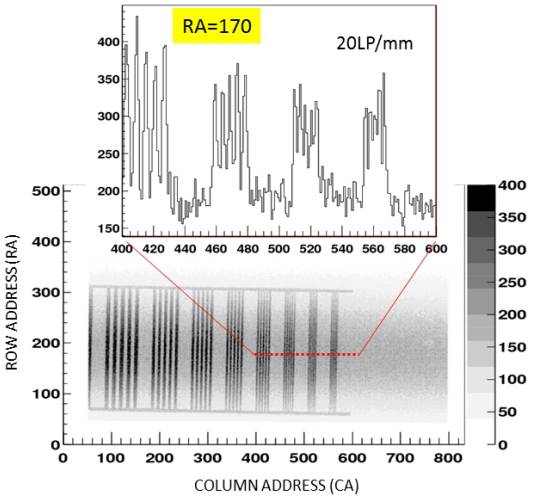

Fig.1 X-ray test chart image with 33.1keV X-ray.

References

[1] T. Miyoshi et al., Nucl. Instr. And Meth. A, Vol. 636, Issue 1, Supplement 1, Pages S237-S241 (2011).

[2] T. Miyoshi, “Recent progress in development of SOI pixel detectors”, IEEE Nucl. Scien. Sympo. Conference Record, page 1885, Knoxville, TN, Oct. 30-Nov.6 (2010).

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