BL-14A, BL-14B, BL-14C1/2015G649

Development of SOI pixel detector for X-ray imaging

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1 Introduction

The SOIPIX group is developing monolithic pixel sensors using SOI technology. The development project has started as an important subject in KEK Development and Technology Project (KEK-DTP). We have started a feasibility study of the SOI sensors for X-ray imaging. The sensors were evaluated with monochromatic X-rays at KEK-PF beamlines, PF BL-14A, BL-14B and BL-14C1. This document describes a part of the experimental results.

2 Experiment

The experiment was done in 3 beamlines in FY2015. The summary is shown in Table 1. In PF BL-14A and BL-14C1, a wide range of X-ray energy is available for various X-ray detector tests and therefore it was used for full depletion voltage, sensor gain, and quantum efficiency (QE) measurement and demonstration experiments of X-ray imaging. In BL-14B, a large-area and uniform beams are available and so it was used for tests of the phase- and absorption-contrast imaging and X-ray CT.

Table 1: Experiment summary

Beamline	Beam time [year/month]	Beam Energy [keV]	Subjects
14B	2015/11,2016/2	9.5	Imaging
14A	2015/12	16	QE
14C1	2016/3	30-50	Sensor gain

3 SOI Pixel Sensors

SOI pixel sensors were developed in multi-project wafer (MPW) runs in every year. Various LSI designs were gathered in a common process mask. Therefore, various SOI image sensors have been used in several beam times since 2009 [1-5]. Integration-type pixel sensors, INTPIX4-8, were developed using several wafers. We demonstrated X-ray phase-contrast and absorption imaging and CT in BL14B. We obtained clear X-ray CT images of dried sardine with X-ray energy, 9.5 keV, as shown in Fig.1. The images were obtained in net irradiation time of 2 sec (4msec/frame x 500 frames) per data set and totally in 181 data sets. We are also developing double SOI sensors. The wafer has two SOI layers. Top SOI layer was used for SOI-CMOS circuit, and the middle SOI layer was used as a shield to the back gate effect and the sensor-circuit cross talk. We can control the potential of middle SOI layer and it can compensate total ionization dose (TID) effect by high radiation dose. By using 16 keV monochromatic X-rays in BL14A and 30-50 keV in BL14C1 we measured sensor gain of integration-type SOI sensor, INTPIX8, fabricated with N-type Czochralski (Cz-n), N-type and P-type Float Zone (FZ-n, FZ-p), and double SOI wafer. We realized the sensor gain of double SOI sensor was higher than that of single (Cz-n, FZ-n, and FZ-p) SOI sensors. We are trying to find the reason why they had the difference. One possible reason is that the coupling capacitance between sensor and circuit is small in the double SOI sensor.

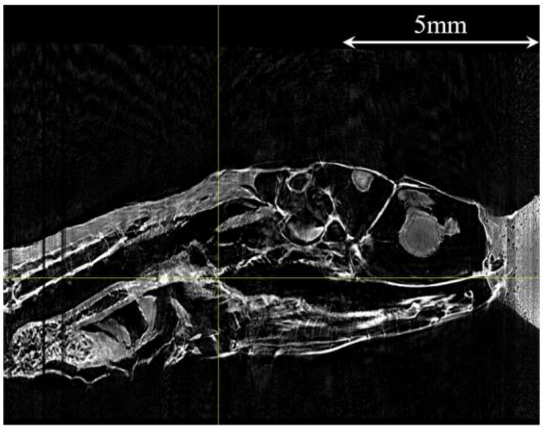

Fig. 1: A CT image of dried sardine measured by INTPIX5.

4 Future plan

In FY2016, we will continue the SOI studies. The DAQ for integration-type pixel sensors will be updated and applied for imaging experiments with monochromatic X-ray. The SOI detector system with a vacuum chamber for cooling is developing, and will also be applied for the experiments.

References

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