BL-14A, BL-14C/2013G708

Development of next-generation X-ray pixel sensor using SOI technology

Toshinobu Miyoshi[1,*]
[1]KEK-IPNS, Tsukuba 305-0801, Japan

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). The sensors were evaluated with monochromatic X-rays at KEK-PF beamlines, PF BL-14A and BL-14C1. This document describes a part of the experimental results.

2 Experiment

The experiment was done in 2 beamlines in FY2013. The summary is shown in Table 1. In PF BL-14A, 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. In BL-14C1, a large-area and uniform beams in high X-ray energy (25-50 keV) is available and so it was used for tests of the refraction- and absorption-contrast imaging.

Table 1: Experiment summary

Beamline	Beam time [year/month]	Beam Energy [keV]	Subjects
14C1	2013/11	45	Imaging
14A	2013/12	12	QE
14A	2014/1	8	Sensor gain

3 SOI pixel sensors

SOI image 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 [1-4]. In FY2013, Wafer quality was improved and an integration-type pixel sensor, INTPIX4, with 500 um-thick and N-type Float Zone (NFZ) wafer can be used under fully depleted condition. So we demonstrated X-ray absorption imaging with high X-ray energy in BL14C1. We obtained clear X-ray image of a watch with higher X-ray energy, 45 keV, as shown in Fig.1. Even though the silicon thickness is about 500 um and quantum efficiency in 45 keV is very low, the image can be obtained within reasonable net irradiation time, 5 sec. In this fiscal year, we also developed double SOI sensors for the first time. 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 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 8 keV monochromatic X-rays in BL14A we measured sensor gain of integration-type SOI sensor, INTPIXh2, fabricated with N-type Czochralski (NCZ), NFZ, and double SOI wafer. We realized the sensor gain was low in double SOI sensor, and therefore we will modify the pixel structure and circuit to optimize the sensor.

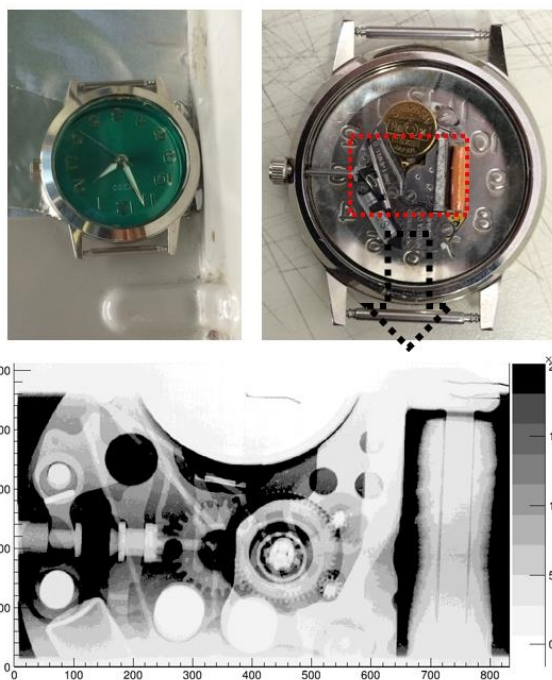

Fig. 1: An absorption image of a watch by NFZ-INTPIX4.

4. Future plan

In FY2014, integration-type pixel sensors with dual storage capacitors and counting-type pixel sensors with double SOI and p-type wafer will be fabricated. Those sensors will be tested and demonstrated with monochromatic X-ray in FY2014.

References

[1] T. Miyoshi et al., Nucl. Instr. And Meth. A, Vol. 636, Issue 1, Supplement 1, Pages S237-S241 (2011).
[2] T. Miyoshi et al., Physics Procedia, Vol.**37**, 1039-1045 (2012).
[3] T. Miyoshi et al., Nucl. Instr. And Meth. A, Vol. 732, pages 530-534 (2013).
[4] T. Miyoshi et al., JINST 9 C05044 (2014).
* tmiyoshi@post.kek.jp