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

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

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

2 Experiment

The experiment was done in 2 beamlines in FY2014. 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-14B, a large-area and uniform beams in medium X-ray energy (10-20 keV) is available and so it was used for tests of the phase- and absorption-contrast imaging.

Table 1: Experiment summary

Beamline	Beam time [year/month]	Beam Energy [keV]	Subjects
14B	2014/12	16	Imaging
14A	2014/12	16	QE

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 [1-5]. In FY2014, Wafer quality was improved and an integration-type pixel sensor, INTPIX4, with 500 μm-thick and N-type Float Zone (NFZ) wafer can be used under fully depleted condition. So we demonstrated X-ray phase-contrast and absorption imaging with medium X-ray energy in BL14B. We obtained clear X-ray phase-contrast images of 80 μm-bumps with X-ray energy, 16 keV, as shown in Fig.1. The image can be obtained within reasonable net irradiation time, 200 msec (1msec/frame x 200 frames). 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 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. For example, another implantation structure between pixels might be required to increase charge collection efficiency.

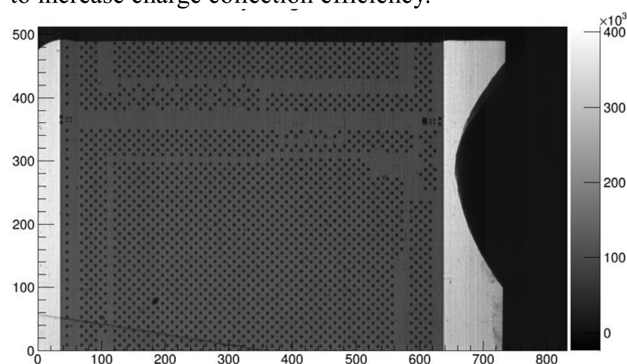

Fig. 1: A example of phase-contrast images of 80 μm bump measured by INTPIX4.

4 Future plan

In FY2015, we will continue the SOI studies. 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.

References

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