Spectral Responsivity of in-house Fabricated Silicon PIN Photodetector for Scintillator Coupling

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1. Introduction

As a part of Establishment of Research Infrastructure for Radiation Equipment project (NRF-2001-0030465), Radiation Equipment Fab. Center was built and full-scale operation was started from the Sep. of 2016. Semiconductor based CMOS process is possible in the fab. and wafer scale process optimization is in progress. Si PIN photodetectors were fabricated for coupling with scintillator for detecting radiation [1-3]. Scintillation type radiation detectors are widely used for medical equipment, radiation monitoring system, security inspection system etc. In this paper, spectral response of in-house fabricated Si PIN photodetector for scintillator coupling were investigated.

2. Methods and Results

In the first section, fabrication process of Si PIN photodetectors will be described and electrical characteristics and spectral responsivity measurement results will be shown at the second and third section.

2.1 Si PIN photodiode device Fabrication

The process flow of Si PIN photodetector (1cm x 1cm) is schematically described in Fig. 1. Starting with the double side polished n-type high resistivity (>10KOhm) Si substrate of (100) orientation, 500nm SiO2 layer was formed by wet oxidation. Back side SiO2 layer was removed and POCl diffusion process was carried out for N+ layer formation followed by protecting oxidation. After guard ring and edge area open by photolithography, B11 implantation was performed. Second photolithography was carried out for active area open, BF2 was implanted followed by thermal activation. After metallization lithography, Al/Au was deposited and lift off was performed. Back side global metallization was also carried out and antireflection layer was deposited. Up to now, front-end process was completed and back-end process started. Wafer level device array was cut into single device by dicing machine and each device packaged to ceramic substrate with wire bonding equipment.

2.2 Electrical Characteristics

Fig. 2 shows the leakage current versus reverse biased region of Si PIN photodetector. Measurement was performed by semiconductor parameter analyzer with probe station in the dark box. Reverse bias was applied from 0V to -100V with 0.1V increment. Soft or hard breakdown was not observed up to -100V but leakage current was ~40nA at 80V. Not a few reverse leakage current might be due to the fabrication process, so further process optimization is needed for low leakage current device.

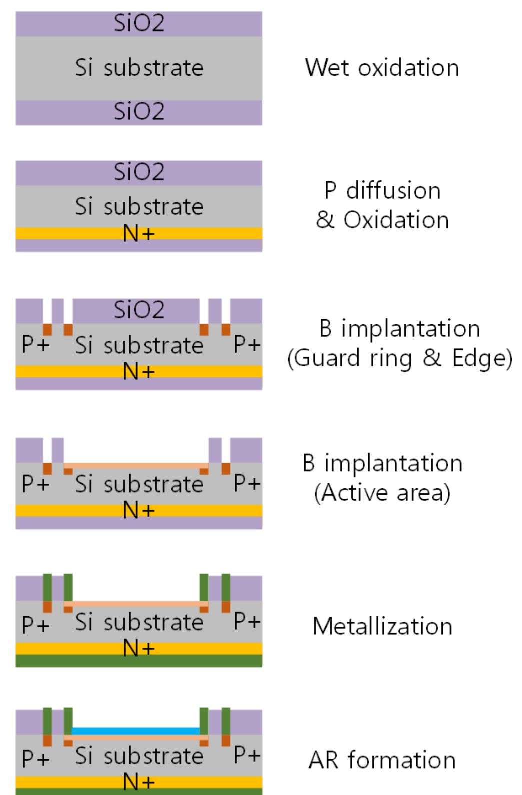

Fig. 1 Schematic process flow of Si PIN photodetector fabrication.

2.3 Spectral responsivity

Fig. 3 shows the spectral responsivity of fabricated Si PIN photodiode compared with KRISS standard photodetector. Similar spectral responsivity trend was shown but lower value compared with other results [4]. The spectral responsivity can be enhanced by changing the thickness and Anti-Reflection coating material, electrode design etc.

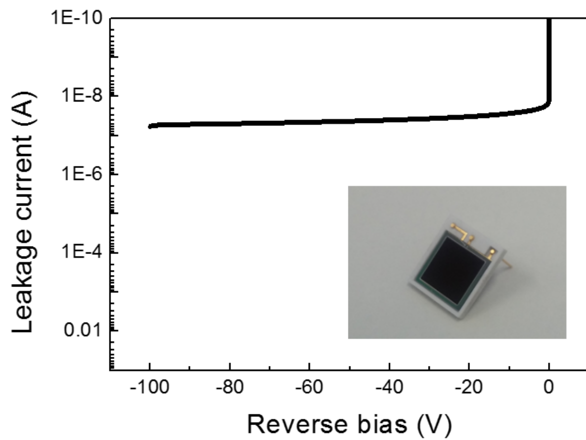

Fig. 2. I-V characteristics of Si PIN photodetectors at the reverse biased region. Inset is the picture of ceramic packaged Si PIN photodetector.

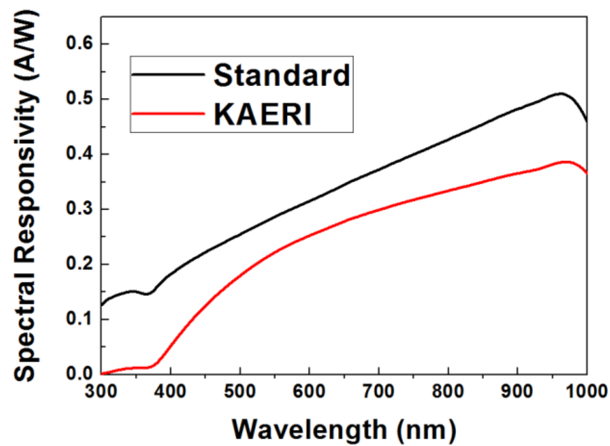

Fig. 3. Spectral responsivity of in-hpouse fabricated Si PIN photodetector compared with KRISS standard photodetector.

3. Conclusions

Started from the full operation (Sep. of 2016) of Radiation Equipment Fab. Center, Si PIN fabrication process have been optimizing as one of research and develop theme. Si PIN device can be used to photodetector for scintillator type radiation detector and direct type radiation detection of low energy X-ray and gamma-ray. The device performance so far were reported in this paper with I-V characteristics and spectral responsivity. Almost of hundreds of each fabrication process steps were optimized but process fine funning is needed for high performance devices.

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