고체형 검출기를 위한 핀 포토다이오드 제작

Fabrication of PIN Photodiode for Solid-state Detector

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PIN photodiode has been used in solid-state detector for x-ray detection· as a photosensor of visible light from scintillator. Since the light from CWO is short wavelength having peak at 490nm, the light is absorbed within a very shallow layer near the surface of the photodiode before arriving at the depletion layer and does not contribute to the signal. In designing the PIN photodiode, it is important to make the p-layer as shallow as possible (1), (2). In order to achieve a shallow junction, the optimum conditions of ion implantation such as the thickness of SiO_2 oxide barrier, the tilting angle of the wafer with respect to incident ion beam, and the annealing conditions have been determined by computer simulations. In this work, we used ATHENA tool, which provides general capabilities for numerical, physically-based, two-dimensional simulation of semiconductor processing (3). Process parameters for ion implantation obtained by simulation are given in Table 1.

Table 1. Fabrication Parameters for ion implantation

Parameters	Value
Ion beam type and energy	BF_2 beam, 40 keV
Thickness of Oxide barrier layer	200Å
Tilting angle	7
Annealing condition	750-900 ℃, 30 min.
Orientation	(1 0 0)

According to the simulation results, we fabricated the PIN silicon photodiode on a n-type silicon substrate with high resistivity of 1,200~4,000 Ω · cm, intrinsic and total layer thickness of 30μm and 250μm, respectively. To assess the performance of the photodiode, the leakage current, capacitance, and spectral response were measured and compared with two commercial photodiodes, one from Detection Technology (customized photodiode) and another from Hamamatsu (S2551). Fig. 1 is the leakage current measured as a function of the applied bias with a semiconductor parameter analyzer (HP 4155A). At zero bias, leakage currents of all three diodes are a few pA (pico Ampere), but increase with reverse bias. Particularly, the current of the photodiode of this work is about ten or one hundred times higher than those of DT or Hamamaatue. The measured results of the capacitance by precision LCR meter (HP 4285A) are shown in Fig. 2. Junction capacitances of the photodiode of this work and DT, at zero bias, are about 40 pF and decreases as bias increases. The diode of Hamamatsu is much lower relative to two other diodes. The spectral responses of photodiodes of this work, DT, and Hamamtsu are 0.4, 0.3, and 0.2, respectively. Fig. 9 also shows the photodiode of this work has larger response relative to those of other photodiodes until 900nm, particularly remarkable in the range of 500 to 900nm.

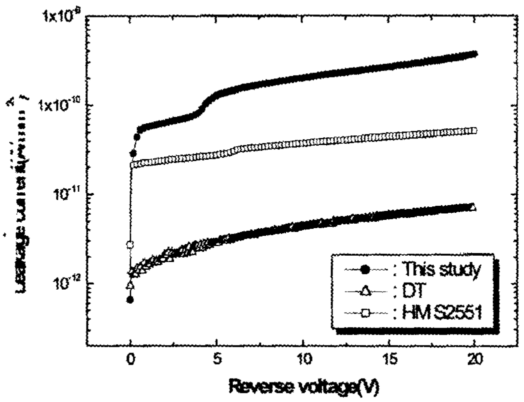

Fig.1 Leakage current of a photodiode developed in this study and two commercial photodiodes. The leakage current of the photodiode fabricated in this work is much higher than other two commercial products as bias increases

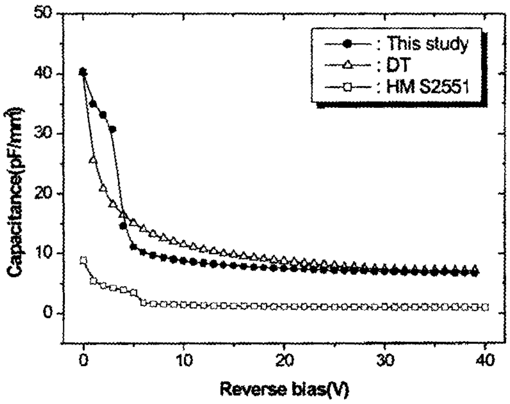

Fig.2 Capacitance of a photodiode developed in this study and two commercial photodiodes. At zero bias where the photodiode is operated, the junction capacitance is about 40 pF in both this work and DT and about 9 in Hamamatsu.

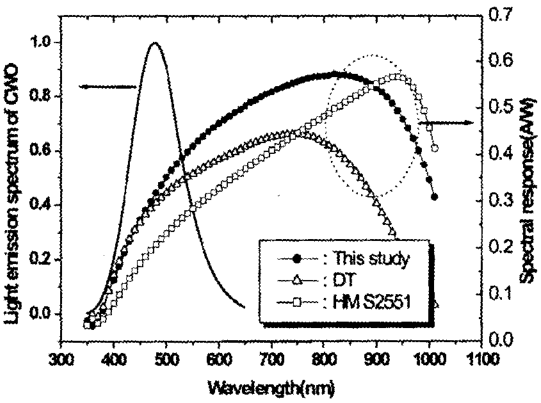

Fig. 9. Spectral response (A/W) of a photodiode developed in this study and two commercial photodiodes. This figure shows that the photodiode of this work has better light sensitivity than those of commercial product in the range of 400nm to 900nm.

1. Thor-Erik Hansen, *"Silicon Detectors for the UV- and Blue Spectral Regions with Possible Use as Particle Detectors"*, *Nucl. Instr .Meth,.* A235, pp249-253, 1985.
2. T. Maisch, R. Gunzler, M.Weiser, S. Kalbitzer, W. Welser and J. Kemmer, *"Ion-implanted Si pn-Junction Detectors with Ultrathin Windows"*, *Nucl. Instr. Meth.,* A288, pp19-23, 1990.
3. *ATHENA Users Manual*, Silvaco International, 1998.