

ULTRAVIOLET LINE-SCANNER USING SOI BASED-SCHOTTKY BARRIER DIODE

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ABSTRACT

A schottky barrier diode (SBD) which consists of aluminum (Al) electrode and phosphorous doped single crystalline silicon is investigated for the photo-detectors. The SBD with silicon on insulator (SOI) structure has the advantages such as simple fabrication process and fast response time. The proposed SBD based on SOI structure is performed as ultraviolet (UV) detector, because the external quantum efficiency (EQE) is 1.89 % at 360 nm. The sensitivity of the detector is found as 116.2 mV/mW·cm². The SBD pixel array with response time of approximately 1.3 ms is used for the UV line-scanner.

INTRODUCTION

Schottky-barrier diode (SBD) technology has been applied to photo-detectors, RF detectors, rectifiers, and mixers, etc. Especially, the SBD has advantages in terms of simple structure and high speed, since a Schottky contact forms at the interface between metal film and semiconductor substrate. Silicon on insulator (SOI) technology can be utilized to form a Schottky contact on a single crystalline silicon (single crystal Si) layer, because single crystal Si has higher quantum efficiency (QE) than poly crystalline Si. Moreover, the SOI structure prevents a leakage current which decreases an insulating region.

In this study, SBD using SOI structure is designed and fabricated for a photo-detector. Because the fabricated SBD has high performance characteristics at UV range, the SOI based-SBD array is utilized for UV line-scanner. The proposed UV line-scanner is expected to be applied to the various fields such as flame detection, blue-ray optical storage system, and high performance liquid chromatography (HPLC) detectors.

DETECTOR FABRICATION

SBDs using SOI structure are designed and fabricated as shown in Figure 1. The SBDs were fabricated on a silicon direct bonding (SDB) wafer with approximately 1-μm-thick buried-SiO₂ and 520-μm-thick substrate-Si. The detector pixels were patterned on top silicon layer of the SDB wafer by reactive ion etching (RIE). Then, phosphorus ion is implanted with a dose of 1×10^{15} cm⁻². A silicon dioxide film with a thickness of 0.5 μm was deposited by tetraethyl orthosilicate (TEOS). Next, contact holes were opened for metallization. Finally, 1-μm-thick Al electrode was formed by sputtering and patterning.

EXPERIMENTAL RESULTS & DISCUSSION

The EQE characteristic of the fabricated SBD is shown in Figure 2. In the plot of Fig.2, the device has high sensitivity in the near UV spectral range. The highest value of EQE was found as 1.89 % at 360 nm. Table I presents a comparison between this study and other publications.

When the power of 3.0 V at 1 mA supplied to the detector under the various intensity of light, the sensitivity of the SBD was 116.2 mV/mW·cm² with a correlation coefficient of 0.981 as shown in Fig. 3.

Figure 4 shows the response time of the SBD, when the light turned on and off. The falling and rising delay times were 448 μs and 860 μs. And the cut-off frequency of the detector was 764.5 Hz.

A 1×4 SBD pixel array using the SBDs was operated for line-scanner. The output result of each pixel was observed in a sequential order of the shifted light as shown in Fig. 5.

CONCLUSIONS

This work suggested that a SBD based on SOI structure had a high sensitivity in UV spectral range. The measured maximum EQE was 1.89 % at 360 nm. The UV detector has the light sensitivity of 116.2 mV/mW·cm² and response time of 1.308 ms. SOI based-SBD array was possible to operate as a line-scanner.

REFERENCES

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TABLE AND FIGURES

Table 1: Photo-detectors working in the UV region.

Ref.	Substrate	Structure	Max. EQE (%)	Wavelength [nm]	Active area
[1]	SiCN	n-i-p	0.79	280	-
[2]	GaN	MSM	0.175	340	$50 \times 50 \mu\text{m}^2$
[3]	SOI	MOS	0.4	445	$50 \times 50 \mu\text{m}^2$
[4]	AlGaN	p-i-n	7	290	$652 \mu\text{m}^2$
This study	SOI	MSM	1.89	360	$100 \times 100 \mu\text{m}^2$

* MSM : Metal-Semiconductor-Metal

n-i-p: n-type semiconductor-insulator-p-type semiconductor

p-i-n: p-type semiconductor-insulator-n-type semiconductor

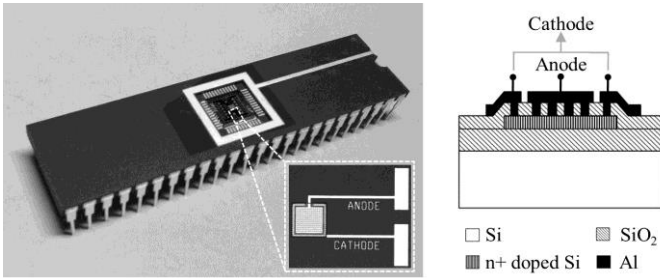


Figure 1: Photographic image and schematic cross section of the SBD based on SOI investigated in this work .

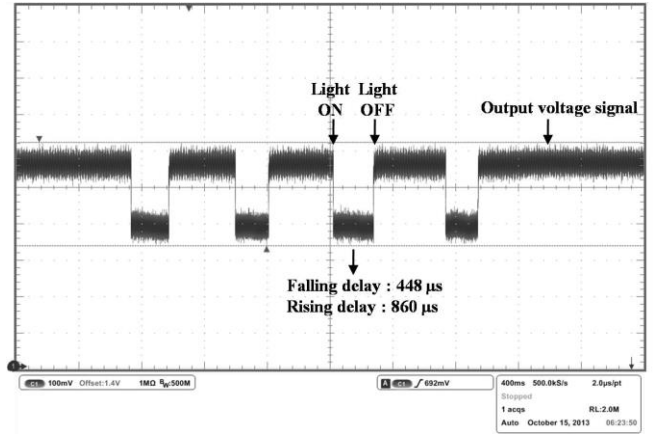


Figure 4: Measured falling and rising delay time of the UV detector

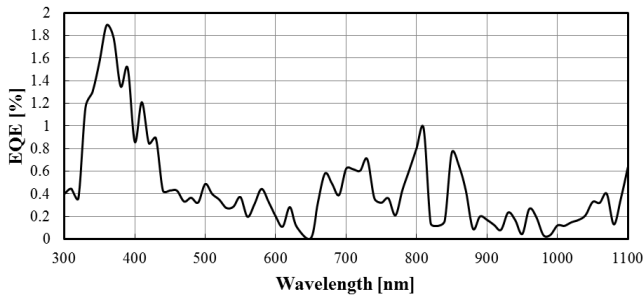


Figure 2: External quantum efficiency of the proposed photo-detector.

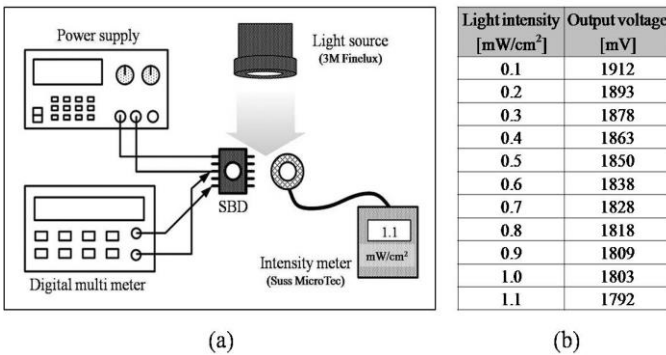


Figure 3: Response of the SBD based on SOI to various levels of incident light. (a) Schematic of the measurement set-up (b) measured output voltage results.

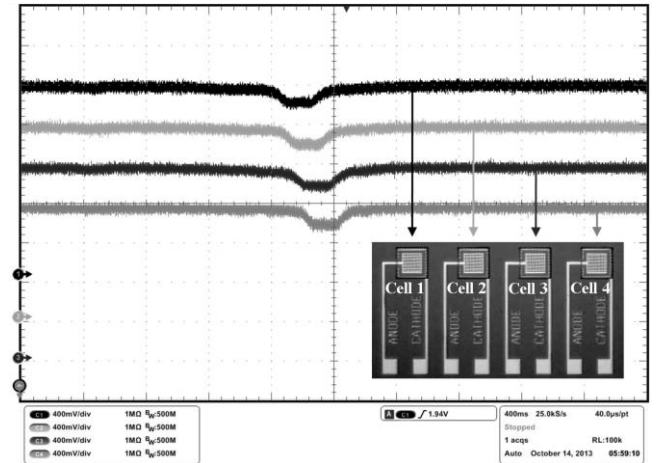


Figure 5: Sequential output voltage of the line scanned 1×4 SBD pixel array.