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A Visible Light Blinded Photo-detector With an ITO/ZST/Si MIS Device Structure

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1. Introduction

Visible light blinded photo-detectors are useful for optic signal identification in day time. Si-based photodiodes exhibit advantages inherent to silicon technology, are the most popular devices for optical detection. However, spectral responsivity of Si based photo-detectors covered visible light so that is difficulty to discriminate the background white light from the object signal in infrared without using a filter. In addition, device aging due to exposure to high energy radiation become a critical issue for P-N junction base photo-detector in which generation of defects can degrade the interface property [1-3]. MIS is a cost effective device structure for a photo detector. However, the incident light is attenuated due to the strong absorption at the metal layer. We present the fabrication the fabrication of a MIS photo detector by using ITO as the metal contact and $Zr_{0.8}Sn_{0.2}TiO_4$ (ZST) as its dielectric layer on a p-type Si substrate to improve its photo sensitivity and to manipulate the optic property of the dielectric layer to achieve the function of a white light blind IR detector.

2. Device processing

Figure 1-(a) and 1-(b) show the top view and side view of the MIS device fabricated. First, an Al/Si film of 200 nm thick and 0.25 mm in diameter is deposited on a chemically cleaned p type Si(100) substrate by electron beam evaporation followed by annealing at 600 ℃ for 5 minutes in N_2 atmosphere to form ohmic contact.

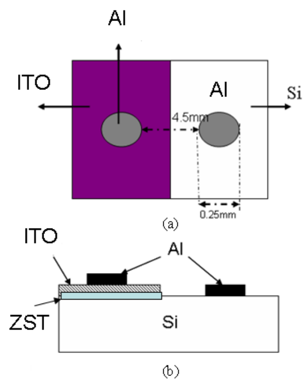

Fig.1. Dimensions and structure of the MIS device fabricated (a) on top view and (b) at side view.

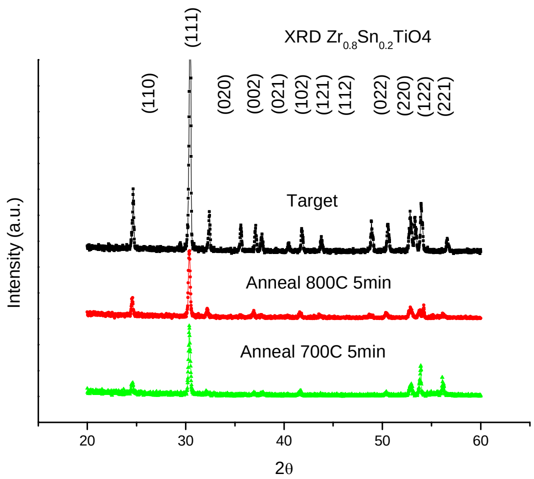

Fig.2. XRD scan of the ZST target, and deposited ZST thin film annealed at 700 ^{O}C and 800 ^{O}C.

Pulse laser deposition (PLD) has been demonstrated for the deposition of various dielectric thin films with almost the same composition as target elements without damaging to the processed surface [4-6]. The high energy photon of excimer laser is able to achieve ablation of the target within a short period of time and ejection of the micro-species of the target elements.

Since the deposition is initiated by laser pulse, the thicknesses of dielectric films can be precisely controlled by counting the number of pulses. Normally, a deposition rate of 0.01nm/pulse has been achieved. Figure 2 shows crystallographic property of the ZST target and deposited ZST film annealed at 700 ^{O}C and 800 ^{O}C by X-Ray diffraction and show that the quality of the deposited ZST film is very similar with the ZST target. At the end of the MIS device processing, a 300 nm thick layer of aluminum is deposited by e-beam evaporation on top of the dielectric layer for electric contact.

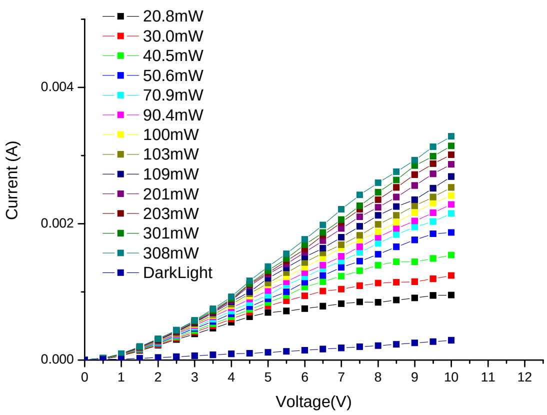

Fig.3. I-V characteristics of a fabricated ITO/ZST/Si MIS device with different spectral illumination.

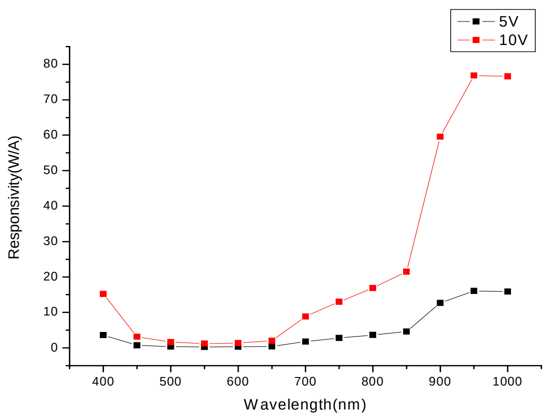

Fig.4. Spectral response of the ITO/ZST/Si MIS device at different bias.

3. Characterization & Discussion

An HP 4145 semiconductor parameter analyzer was used to measure the I-V characteristics and the photo-current of the MIS device under illumination. In order to test the photo-sensitivity of the MIS devices, the photo-current was measured under the illumination of a monocromative light from a 150W Xe arc lamp through a monochromator, which the illumination spectrum was calibrated by a Si photo-detector. Fig. 3 shows the I-V characterization of the Al/AlN/Si MIS device under various illumination with bias from 0 V to 10 V. Dark currents of the fabricated MIS photo-detectors are smaller than 5.0×10^{-7}A which can be attributed to both the good quality of the dielectric layer and the effective passivation of the Si interfacing with dielectric layer deposited by pulse laser deposition. Photo responsivity can be calculated by the illumination from a monochromator of which the power is calibrated by a calibrated photo detector. Figure 4 shows the spectral responsivity of the fabricated MIS photo-detectors by different biases. The responsivity can reach as high as 70 W/A due to the improvement of the transparency of the ITO layer. It shows that the MIS photo-detector with ZST dielectric layer and ITO as a conducting layer has high discrimination of the spectrum from 400 nm to 7000 nm against the IR detection responsibility. It reveals that the optical absorption property of the dielectric layer plays an important role to the spectral response of the MIS photodetectors. It provides an effective way to tune the spectral response of a Si based photo-detector by simply selecting the dielectric material.

Conclusions

In conclusion, we have demonstrated the fabrication of a silicone base MIS photo detector using ITO conducting layer and ZST dielectric layer to improve the responsivity about hundred times and to achieve white light blind IR photo detection at wavelength higher than 1000 nm. The thicknesses of dielectric films can be precisely controlled by counting the number of pulses, with good surface morphology and interface property of the MIS devices. The dark current as low as 5.0×10^{-7} A is achieved due to the good interface property of the deposited dielectric layer on Si substrate. It shows that the spectral response of the MIS device can be tuned by selecting the optical property of the dielectric material without compromise any complexity in device processing. Study of the performance of the fabricated MIS devices in variation of the dielectric layers are under going, and will be delivered in the future.

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