Fabrication and study detector work in the visible region prepared by thermal evaporation

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Abstract

In the present paper silicon p-n junction detector of 600 ± 25 nm peak response has been characterized. This peak was obtained by depositing high purity Pt metal thin film onto sensitive side of the p-n junction (donor-side), this film reduce the responsivety in the near-IR region (800-1100) nm and lead to peak response at 600 nm. The white light photovoltaic characteristics, spectral responsivity, and quantum efficiency are greatly depended on photon transmittion of Pt film .Experimental results showed that the detector responsivity in the near IR region was reduced to about 18.5% from its initial value after depositing 50 nm Pt film.

Key words: visible region detector , p-n junction

تصنيع كاشف يعمل في المنطقة المرئية من الطيف مصنع بطريقة التبخير الحراري بالفراغ

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الخلاصة

في هذا البحث، تم تصنيع ودراسة خصائص كاشف سيليكوني نوع ثنائي الوصلة يمتلك قمة استجابة عند المنطقة المرشية (600 ± 25 nm) وجرى تقليل استجابة الكاشف عند المنطقة تحت الحمراء القريبة nm(800-1100) من خلال ترسيب غشاء رقيق من معدن البلاتين عالي النقاوة على المنطقة الحساسة) المنطقة المانحة (للضوء للكاشف السليكوني .إن نتائج كل من الفولتية للضوء الأبيض، الاستجابة الطيفية ، والكفاءة الكمية تعتمد بشكل كبير على ظاهرة النفاذية لغشاء البلاتين. لقد أوضحت النتائج العلمية إن استجابة الكاشف للمنطقة تحت الحمراء القريبة قد انخفضت إلى 18.5 % من قيمتها الأصلية بعد إجراء ترسيب غشاء البلاتين و بسمك 50 nm.

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Introduction

p-n junction silicon detectors are widely used in many applications of the 300-1200 nm range detection, this comes from the silicon band gap (1.12 eV) [1-4]. Previous researchers in Si p-n junctions approved that peak response of these detectors lye in the 900 ± 25 nm wavelength [2-6]. In certain applications (e.g, spectrometer detector, flame sensors, satellite applications, and visible lasers detections), it is required to use detectors operate in the 400-700 nm wavelength (i.e, visible spectrum). In this range, conventional Si detectors with interference filters or IR-cutoff filters are used, these additions will raise the cost [4]. In the spectrum work, p-n Si detectors were coated by a metal on the sensitive surface. This technique is based on the fact the most metals have good reflection in the IR region as compared with there reflection in the visible region. The used metal in this work was Platen (Pt).

Experimental work

Single crystal (111) Si wafers of p-type conductivity, 3Ω.cm resistivity and 500± 15 μm thick grown by Cz technique were used in this study. These wafers were cut into individual square shape pieces of 5 mm length. On side of the wafer was polished to mirror-like surface with aid of 0.25μm diamond paste. Cp-4 etchant was used to remove native oxides [7]. Then the waver was thoroughly cleaned and degreased. The p-type silicone was doped with donor impurities (phosphor) by thermal diffusion to produce p-n junction Si detector. In this technique, the simples are immersed in $pocl_3$ solution and then are put into evacuated furnace (10^{-3} Torr) at 880°C for 8 min. after this progress, the diffused simples were rinsed by HF acid for about 1 min to remove phosphor residuals from si surface, high purity Pt ultra-thin film was deposit on sensitive area of the detector (n-type) by thermal resistive technique. The thickness of this film was 50 nm. Ohmic contacts were made by depositing Al and Au electrodes on n-type and p-type of the detector respectively. Cross sectional view all the final detector is presented in the Figure 1. Spectral responsivity was measured by using monochromator of the range 400-1100 nm after making a calibration with aid of power meter. Optical transmittance of the Ni-metal thin film was measured with the help of spectrophotometer for simple prepared at glass substrates. Reverse I-V characteristics under illumination were characterized.

Results and discussion

Optical transmittance of the Pt thin film that was prepared on glass substrate is shown in figure 2. It is obvious from the figure that transmittance is higher at short wave length (visible and ultraviolet) but it is decreased with increasing wavelength. This result reflects that Pt film should act as a good visible and UV filter. The figure shows that transmittance decreases to 3% at 1100 nm wavelength when the thickness is 50 nm, this indicates that Pt film can be considered as ideal filter, particularly at this thickness.

Reverse current of an coated and Platen -coated detectors in the dark and illumination condition is illustrated in figure 3-a and 3-b. for the uncoated detector (figure 3-a), it is noted that dark current increases with bios voltage shows break-down behavior. This behavior is not obeyed to the Schokley’s diffusion model of p-n junction [8]. On the other side, the photocurrent in this figure shows significant increases as compared with dark current. After Pt-deposition (Figure 3-b), no observed variation is registered on dark current but significant decreasing in photocurrent is observed.

Shown in figure 4 is the spectral current responsivity (S) of Si detector before and after Pt deposition. The figure demonstrates that beak response of thin detector is shifted from 900 ± 25 nm wavelength (the peak response of Pt -coated detector). Peak response is essentially related with the type of deposited film by the following equation [9]:

$$\lambda_p = \frac{4nt}{2k+1} \quad \ldots\ldots (1)$$

Where n is refractive index of the deposited film, and k=(1,2⋯.).

The present shift in peak response that occurred after Pt -deposition can be elucidate of the optical properties of Pt thin film that are explained elsewhere in figure 2. The Pt thin film has high optical reflectivity at IR region as compared with its reflectivity at visible and UV regions

[9,10]. Therefore, Pt thin film can act as a filter with narrow bandwidth about 200 nm, which calculated from FWHM (full width at half maximum).

Figure 5 depicts the quantum efficiency (Q.E) as a function of wave length of uncoated and Pt -coated Si detector where Q.E displays similar influence to that mentioned in the paragraph of responsivity.

Conclusion

On the base of the result that have mentioned before, one can concluded that Pt coating of silicon detectors is a feasible technique to produce IR-blind visible detector with peak response around 600 nm instead of 900 nm for conventional Si detectors . Pt -coating of passivated Si detectors is currently under progress.

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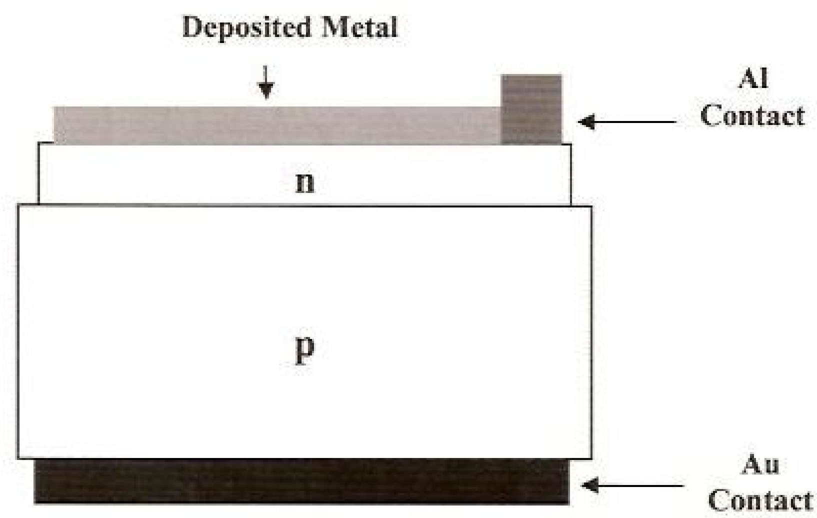
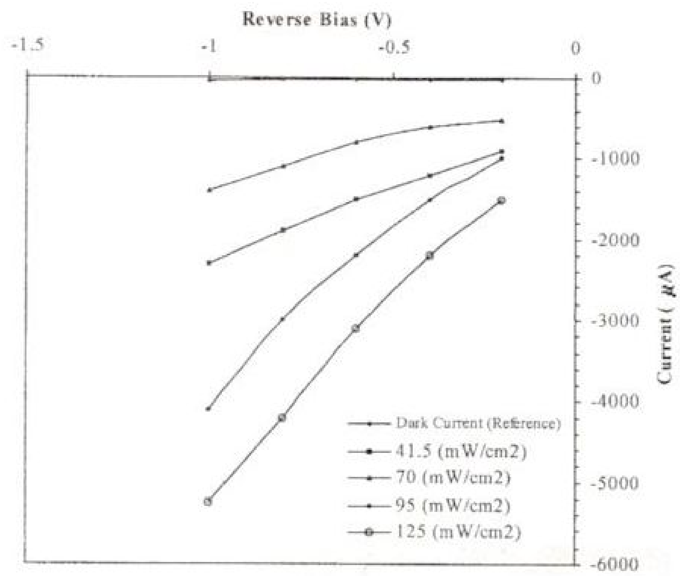
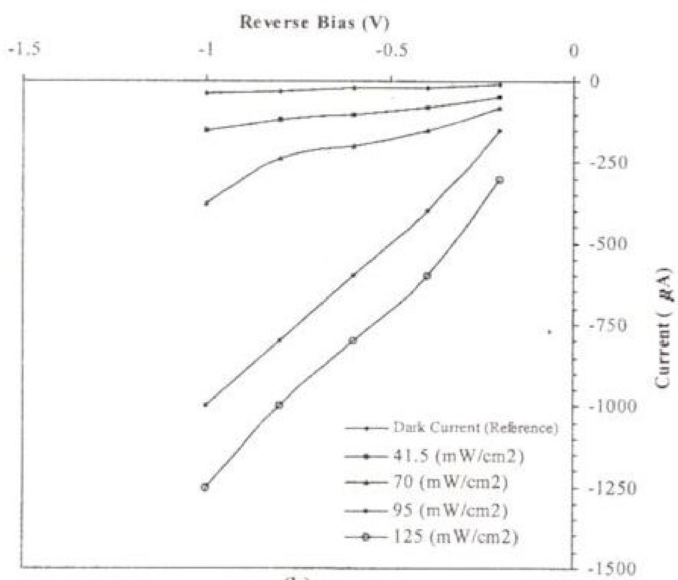


Figure 1. Sectional View of the Final Detector.


Reverse Bias (V)
-1.5
-1
-0.5
0
0
-1000
-2000
-3000
-4000
-5000
-6000
Current (μA)
Dark Current (Reference)
41.5 (mW/cm2)
70 (mW/cm2)
95 (mW/cm2)
125 (mW/cm2)

(a)


Reverse Bias (V)
-1.5
-1
-0.5
0
0
-250
-500
-750
-1000
-1250
-1500
Current (μA)
Dark Current (Reference)
41.5 (mW/cm2)
70 (mW/cm2)
95 (mW/cm2)
125 (mW/cm2)

(b)

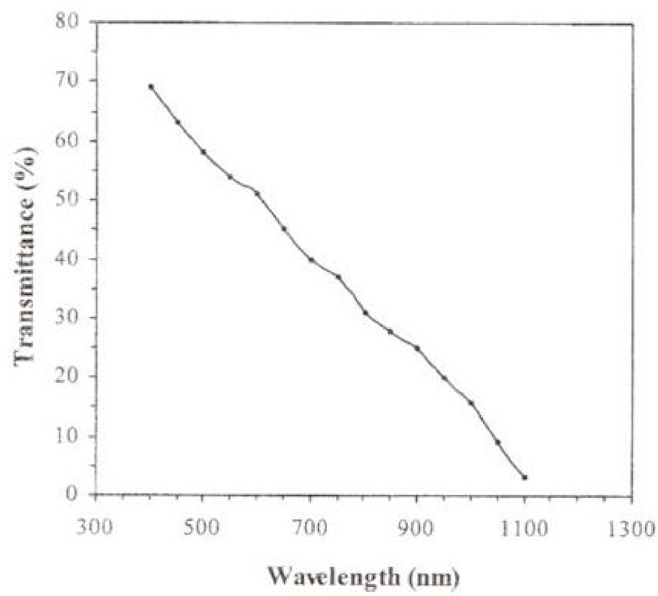


Figure 2. Spectral Transmittance of Pt Thin Film

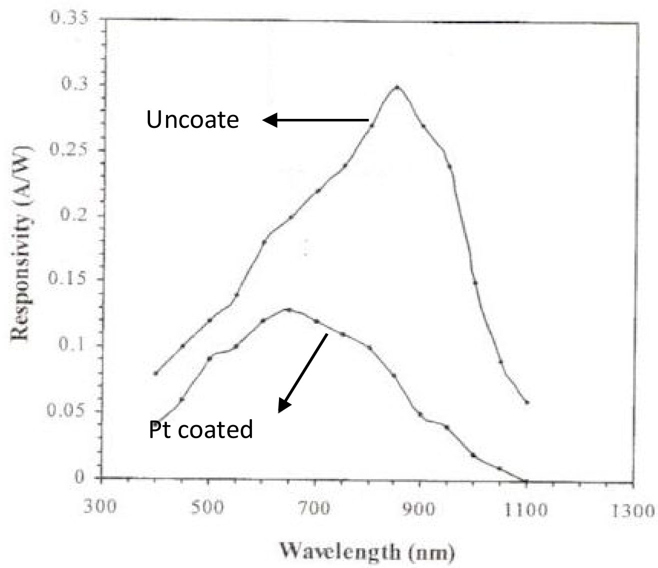


Figure 4. Spectral Responsivity of Si Photodetector before and after Pt deposition

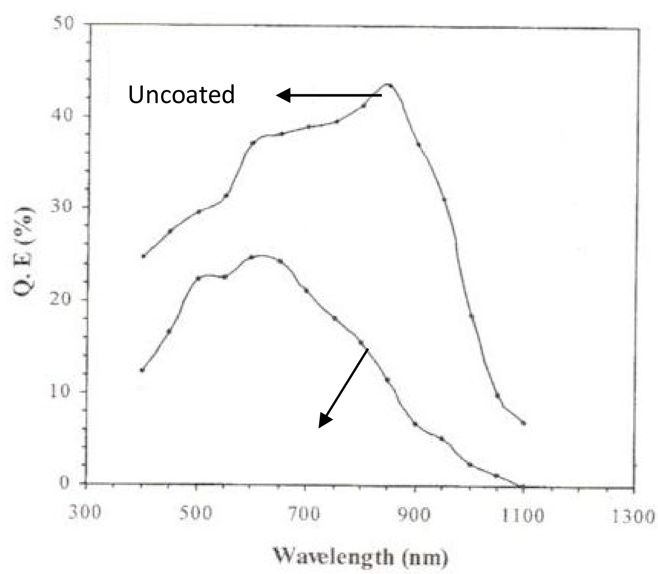


Figure 5. Quantum Efficiency of Si Photodetector before and after Pt deposition .