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Spatial Response Uniformity of Silicon–Based CdS and PbS Heterojunction Laser Detectors

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Abstract: This paper demonstrates the spatial response uniformity (SRU) of two types of heterojunctions (CdS, PbS /Si) laser detectors. The spatial response nonuniformity of these heterojunctions is not significant and it is negligible in comparison with p^+- n silicon photodiode. Experimental results show that the uniformity of CdS /Si is better than that of PbS /Si heterojunction.

Introduction

The response uniformity of the laser detector sensitive area represents the major importance parameter for radiant power measurement. This type of measurement is more important where the area of incident beam A_L is much smaller than the detector sensitive area A_D ($A_L << A_D$).

Measurement errors will be produced when the detector sensitive area exhibits nonuniformity properties especially when the detector is used at different positions; hence error should be taken into consideration for the final accuracy of measurement.

The response uniformity of silicon homojunction (PAC-1) model EG&G UV- 444B has been evaluated by Campos *et al.* [1]. Due to the non-uniformity distribution of trapping sites beyond the depletion region, homojunction suffer from response nonuniformity [2].

Racheva *et al.* [3] showed that the heterojunction type In_2O_3 /Si photodiode can give significant response uniformity. This paper presents, for the first time, the experimental results obtained in the evaluation spatial response uniformity of some heterojunction, namely; CdS /Si and PbS /Si, laser detectors.

Experiment

CdS /Si heterojunction was fabricated by spray pyrolysis of CdS films onto n-type single crystal silicon, while PbS/Si heterojunction was fabricated by vacuum evaporation of PbS films onto p-type Si. Junction sensitive area of the fabricated detectors was 0.2 cm^2. More details of fabrication processes can be found elsewhere [4,5]. The radiant source is a He-Ne laser with parameters tabulated in Table (1). This wavelength is within the optimum spectral region (500-900) nm of the silicon–based photodetectors.

The heterojunction photodetector is placed on (x-y) micropositioning stage and the measurements were done at zero bias.

Table (1) The He-Ne laser parameters used as a probe.

Wavelength	632.8 nm
Power	1 mW
Beam Diameter	1 mm

Results and Discussion

The maps of spatial response uniformity (SRU) of CdS /Si and PbS /Si heterjunction photodetectors under zero bias are shown in Figs. 1 and 2 respectively.

It is obvious from these figures that there are percent point response deviation from the surface response. On the other hand, the response uniformity of CdS /Si detector is better than that for PbS /Si detector. This point can be attributed to the thickness homogeneous of CdS film over the sensitive area and may be due to several decolorized spots, randomly distributed over the sensitive area of PbS film. These surfaces inhomogeneous on the CdS film were not remarkable. Moreover, it can be seen that the points in the vicinity of surface edge of detector show a bigger deviation than the center region, these for if a smaller area was used, one can obtain high SRU.

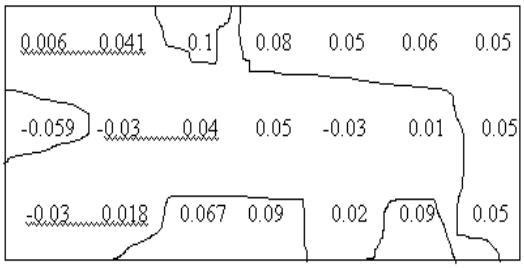

Fig. 1: Uniformity response map of CdS /Si photodetector.

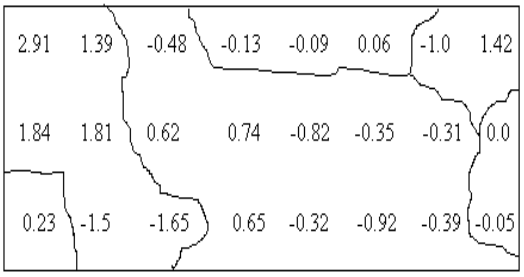

Fig. 2: Uniformity response map of PbS /Si photodetector.

A mean surface response (S) and its standard deviation (σ) have been calculated for CdS /Si and PbS /Si by averaging the point responses. Table (2) exhibits the value of σ / S and positive and negative differences between the surface response and the point responses (Δ_+ , Δ_-) respectively for CdS /Si, PbS /Si; and diffused silicon detectors. These results revealed that σ / S and Δ_+ , Δ_- for heterojunction are smaller than that for diffused junction, i.e. SRU is higher for heterojunctions. The results can be ascribed to inhomogeneous of junction depth a cross the area of diffused Si photodetector; which is arising from the high temperature step needed for diffusion which was absent in heterojunctions fabrication process.

Table (2) σ / S and Δ_+, Δ_- of various types of detectors.

Detector type	σ / S	Δ_+	Δ_-
P^+- n [1]	0.8	1.04	- 1.18
CdS /Si	0.0276	0.048	- 0.03
PbS /Si	0.0280	1	- 0.60

Conclusions

It is concluded that the heterojunction detectors have better spatial uniformity than homojunction detectors, hence the former can be used for high accuracy measurements. The measurements of spatial response uniformity should be used routinely to select standard photodetectors for radiometric measurements.

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الانتظامية في الاستجابة الموضعية لكواشف الليزر السليكونية الهجينية نوع **CdS /Si** و **PbS/Si**

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الخلاصة

جرى في هذا البحث دراسة الانتظامية في الاستجابة الموضعية لنوعين من كواشف الليزر الهجينة CdS /Si و PbS / Si . اظهرت النتائج ان اللاانتظامية في هذه الكواشف قليلة وغير مؤثرة ويمكن اهمالها مقارنة بالكواشف السليكونية نوع $n - P^+$. كما بينت النتائج ان كواشف CdS /Si لها انتظامية اكبر من كواشف PbS /Si .