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A Simple Test to Ensure the Quality of Spatial Response of Silicon Detector

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ABSTRACT

Testing the homogeneity of detector responsivity is very important to assure the quality of the product or services depending on optical measurements. This paper discusses a simple technique using light source, rectangular aperture, lens, and X, Y translation stage. By scanning a photo detector and plotting the out put signal versus the scan position we can infer if there is a defect in the detector homogeneity. The advantages of this technique are cheap, can be easy applied by manufacturers and end user for routine check, and time saving by factor of 5 or more depending on number of scan steps. The disadvantage of this technique is its over all low accuracy in identifying the area of the defect. However it can be improved by thinning the input light and decreasing the scan step. In this paper the effect of using different wavelength has been studied and shows insignificant effect in the results.
Key Words: Radiometry and photometry, optical detectors, responsivity, homogeneity, detector quality.

1 – INTRODUCTION

Spatial uniformity measurements of optical detectors work at different responsivity range depending on its buildup materials, ~~as~~ example of these responsivity curves expressed on figurer 1 quoted from NIST web site. [1]

The spatial uniformity was measured by scanning in equal steps for both directions for an optical detector using stabilized power laser system and a computer-controlled dual-axis translation stage. Accurate alignment to the optical detector surface perpendicular to the optical axis was preformed before each scan. [2, 3,8].

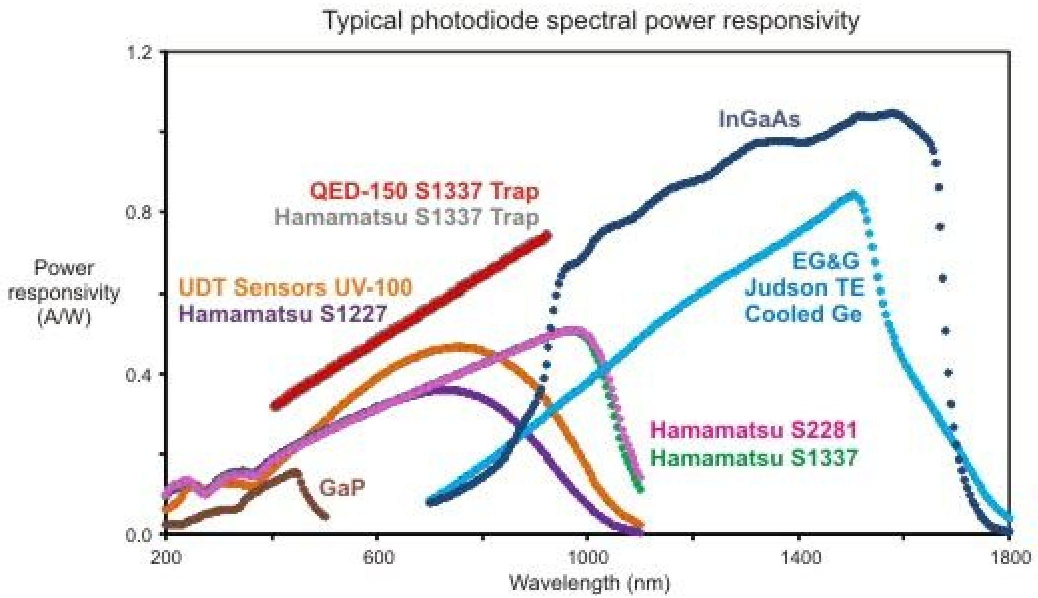

Figure -1: Absolute responsivity of different detectors working at different ranges.[1]

Manufacturers and calibration laboratory use many ways to represent the homogeneity or the uniformity of power response of a detector, but all yield to the same conclusion.

Mostly three dimensional presentation of X, Y and Z plot represents the uniformity as X, and Y for the positions and Z presents the out put of the detector (i.e. the power response of the detector at specified position identified by X, and Y position). Figure -2 shows different presentations has been used for a detector response homogeneity [4,5,6,7,9].

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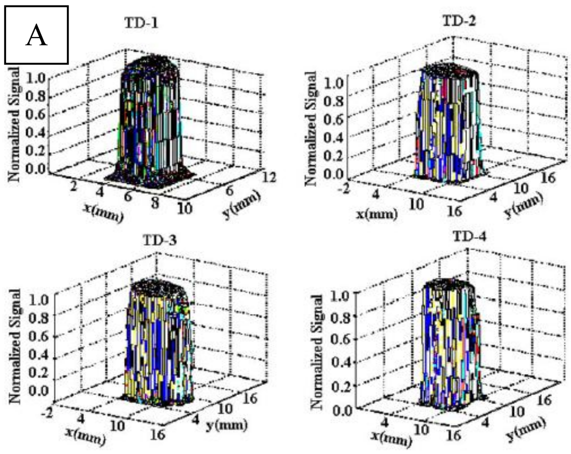

B

[illegible]	0,09	0,09	0,09	0,09	0,09	0,10	0,09	0,09	0,10
0,09	0,58	0,73	0,88	0,98	0,98	0,96	0,84	0,53	0,10
0,09	0,75	0,81	0,99	0,99	0,98	0,98	0,99	0,84	0,12
0,10	0,86	0,99	0,99	0,99	0,99	0,99	0,99	0,89	0,14
0,10	0,79	0,98	0,99	1,00	1,00	1,00	0,99	0,99	0,15
0,10	0,84	0,99	1,00	1,00	1,00	0,99	0,99	0,93	0,31
0,09	0,93	1,00	1,00	1,00	0,99	1,00	1,00	0,91	0,14
0,10	0,81	0,83	0,97	0,98	0,98	0,98	0,88	0,86	0,13
0,10	0,63	0,68	0,73	0,94	0,99	0,93	0,68	0,66	0,10
0,09	0,09	0,10	0,11	0,12	0,11	0,10	0,08	0,08	0,08

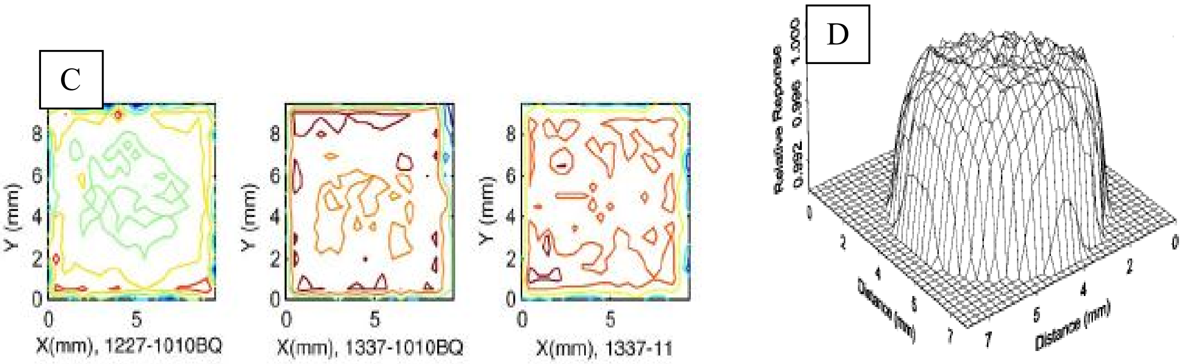

Figure 2: Presentation for the uniformity scan of a detector. A, and D are three dimensional presentation, C is two dimensional presentation, B is matrix of out put signal.

2- Experimental work:

2-1- **Equipments:**

- Monochromator (Newport, model MS257) with rectangle slit.
- Quartz Tungsten Halogen (QTH) Lamp (Newport, model 6333), installed in motorized dual source illuminator for Monochromators (Newport, model 7342).
- Suitable lens.
- Linear translation stage.

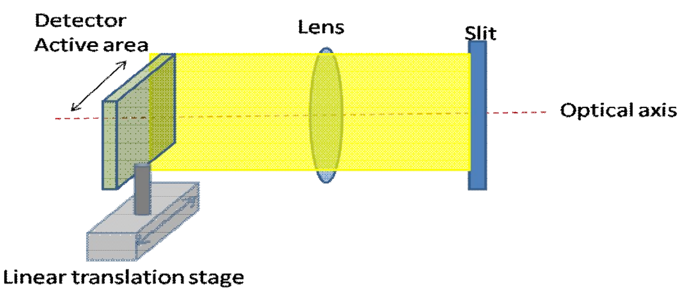

Figure 3: Sketch of the used experimental apparatus.

2-2- Procedures:

- Setup the detector on the linear stage facing parallel to the image of the rectangular slit , and perpendicular to the optical axis figure 4.

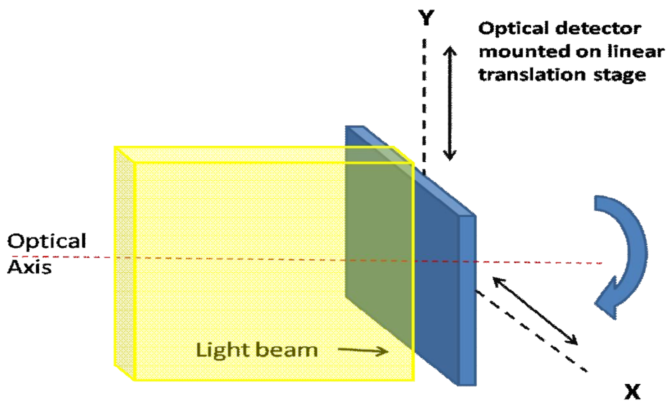

Figure 4: Sketch of the detector setup.

- Suitable wavelength was selected by the monochromator or interference filter when monochromator is not used.
- Make sure that the rectangular image of the slit is thin as possible ~~as~~ and longer than the detector dimensions.
- Scan and record the response of the detector at equal steps.
- Repeat the last three steps after rotating the detector 90^{o}.
- Plot the output signal of the detector (response) versus the step numbers,

3- RESULTS AND DISCUSSION

The following analysis has been performed in National Institute for Standards (NIS). Collection of silicon detectors with different shaped active areas and different responsivity ranges are tested.

Each detector scanned twice (X, and Y coordinates), figure 5 shows the assumed matrix of the detector surface. X position represent columns and Y axis represent rows.

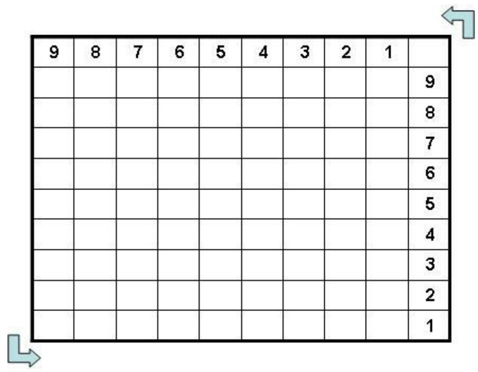

Figure 5: Sketch of the detector scans matrix and the rotation direction.

Figure 6 shows the relation between position of the detector and its out put signals at different wavelengths. It clarifies that there is no noticeable change in the uniformity at different wavelengths. The only observation appears at the strength of the output signal with respect to the wavelength.

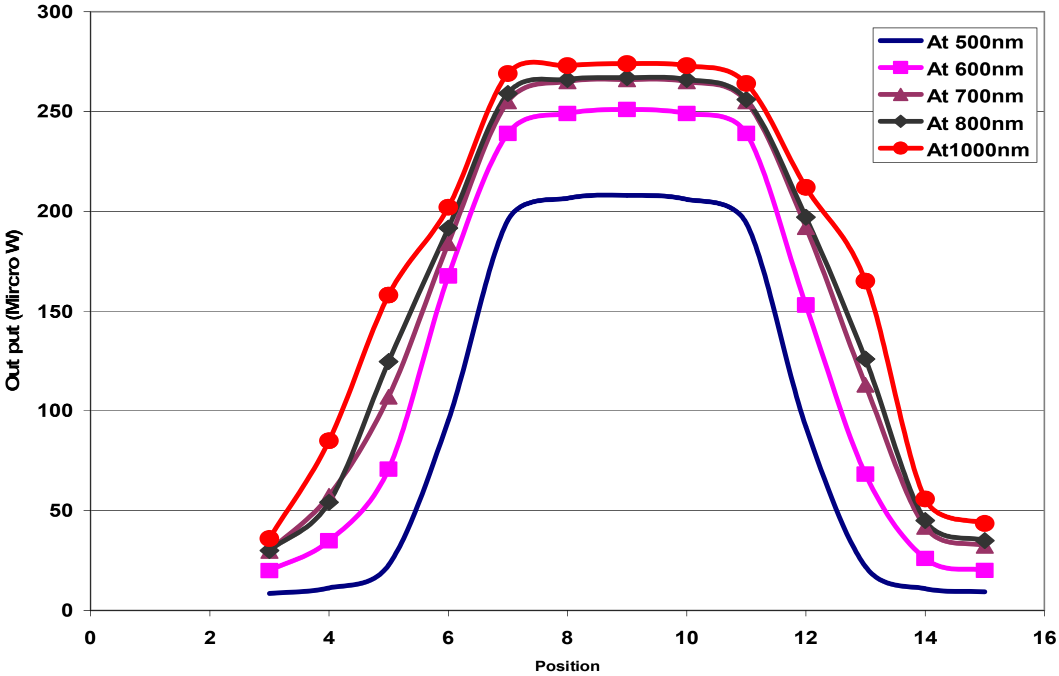

Figure 6: Relation between positions and output signals of a detector at each scan position for different wavelengths.

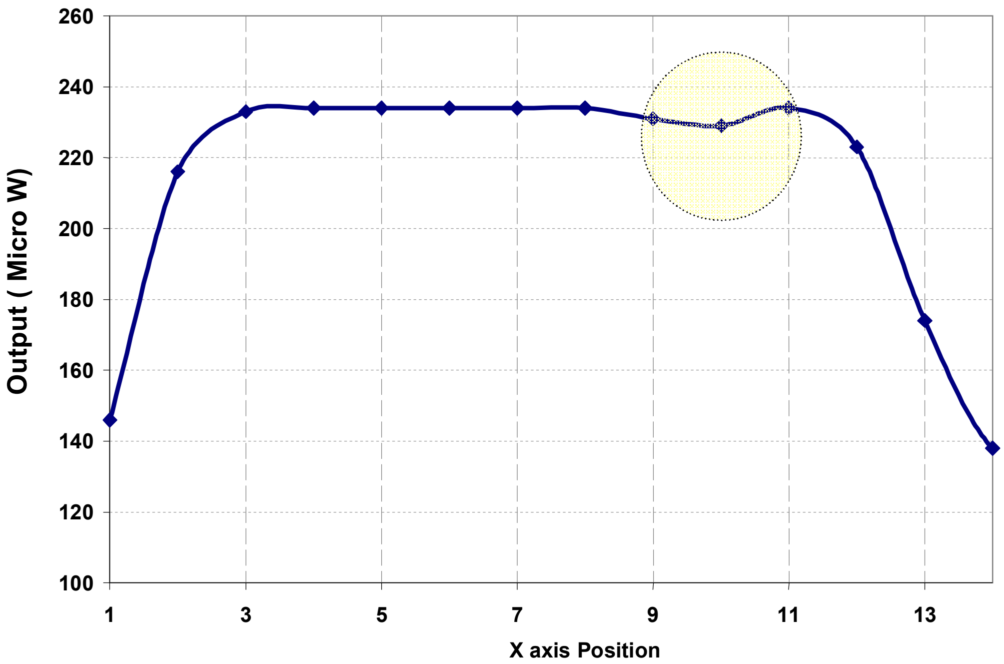

Figure 7: Relation between X axis scan positions and the out put signals of a detector with a response defect at position number 10.

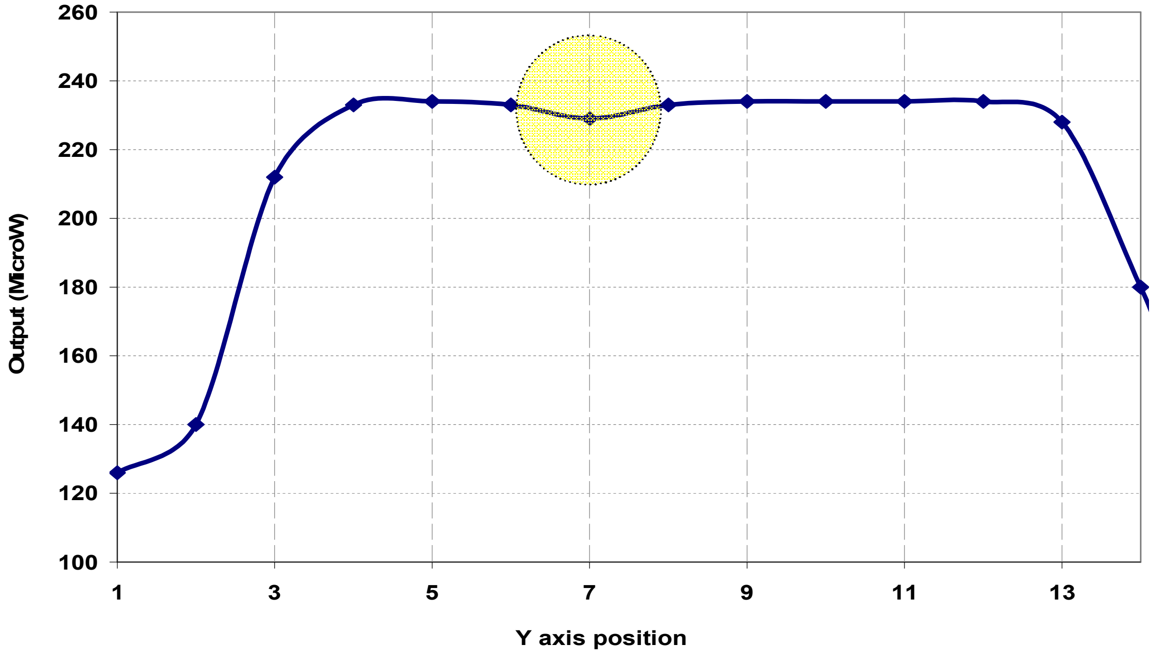

Figure 8: Relation between Y axis scan positions and the out put signals of a detector with a response defect at position number 7.

Scan plots of the same detector in figures 7 and 8 show defects at column number ten and row number seven respectively concluding that this detector have a defect in homogenous power responsivity . This defect can be localizes simply from the intersection of rows and columns numbers as the matrix shown in figure 9.

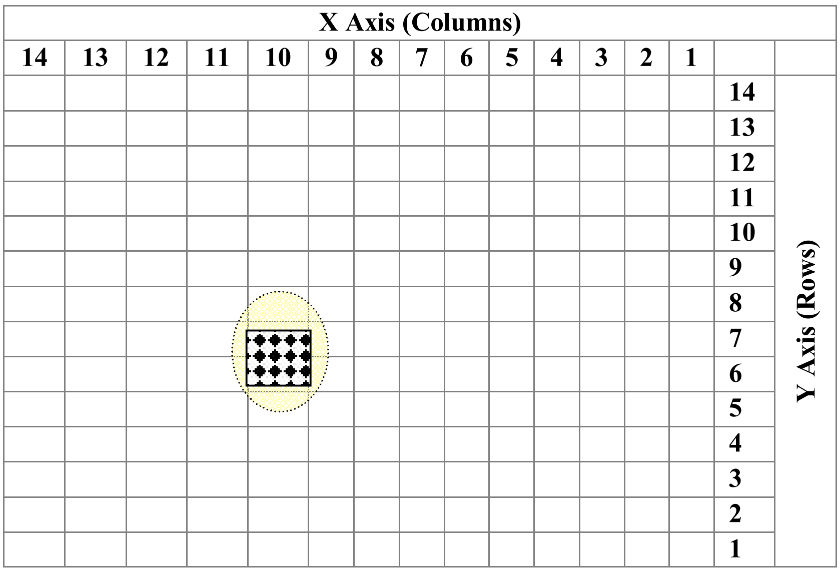

Figure 9: A sketch of a matrix represents the X and Y position, and define the defect position.

Significantly time saving is one of the benefits we can achieve using this simple method. As an example if one record requires 30sec so we need 30sec. X 28 position (14 columns and 14 rows) = 840sec =14 min. While if we use a point source (i.e. Laser source) to scan each point, [4, 5, 6, 7], we need 30sec X 14 X 14 = 5880sec = 98min. and finally we reach the same results by increasing the time by factor of 7.

4- Conclusion

Simple and applicable technique has been discussed to test the homogenous power response of any optical detector (photometer or radiometer). This technique consists of suitable light source, rectangular aperture, lens, and X, Y translation stage. Recording the out put of the detector due to light exposing and plotting a simple chart (position verses output), the result indicates directly the detector responsivity condition. Any unsmooth or asymmetric appears in the diagram means non-homogeneity (defect) in the detector response. For more conformation and detailed information, the same scan can be repeated by rotating the detector 90^{o}. The data of the two scans give accurate identification of the defect position also can represent the degree of defect, which may help for decision of continue using or replacement the detector. The simple equipment, easy applicable, and time saving are the advantages of this technique .The disadvantage of this technique is its over all low accuracy of identify the area of the defect. On the other hand this accuracy can be improved by thinning the light beam falling on the detector and decreasing the scan step. Also this paper shows that using monochromatic light source has insignificant effect on the results.

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