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Quad-Detector Realized by Segmented Photodiode for Beam Tracking and Communication in Optical Laser Communication Terminals

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Abstract: We present in this paper Quadrant devices designed for high speed, with small detection area suitable for 25Gb/s and high sensitivity application with a large photodiode that can reach a sensitivity of -55 dBm. The successful integration of such a sensor will cause a reduction in the number of optical components and a reduction in the required laser power for a given bitrate (bit/s). This will in turn contribute to the safety, cost-effectiveness, lower weight and simplicity of the overall LCT system.

1. Introduction

A large variety of optical laser communication terminals (LCT) are being developed, for applications in ground stations as well as airborne and space terminals to meet the needs of the Dutch high-tech industry. The sensors are realized by a segmented photodiode, or quad cell.

Progress is being made in developing sensors with ultra-small gap size, high speed, high sensitivity, and position stability. The successful integration of such a sensor will cause a reduction in the number of optical components and a reduction in the required laser power for a given bitrate (bit/s). This will in turn contribute to the safety, cost-effectiveness, reduced weight and simplicity of the overall LCT system.

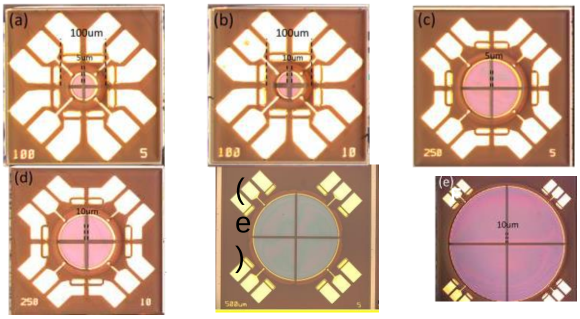
We are focusing on integrating a quad PIN photodiode in either high speed or high sensitivity devices and investigating the device's performance to construct the desired high-reliability integrated detectors.

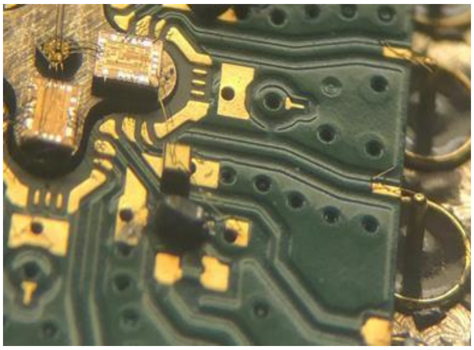
2. Quad Detector Design and Characterization

Design and fabrication of Quad Detectors with various active areas and quadrant separation gap size were performed. Different quad cell active areas are intended to be applied to investigate the relationship between the detector size and the sensitivity of beam tracking, the high bandwidth of data communication.

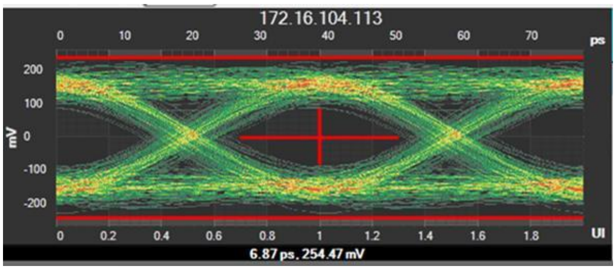
2.1 High speed device:

The quadrant photodiodes as Fig. 1 (a), are separated with a different gap size that is indicated by the cross in the middle. Each quadrant is supposed to be connected to a TIA (transimpedance amplifier), such as the prototype in Fig. 1 (b) for current readout. The package method is designed with wire bondable TIAs for high-speed data communication applications. Fig. 1 (c) reveals a measured open eye pattern of one high speed device, which was tested at 25.78125 Gbps.





(a) **(b)**

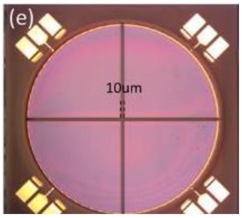


(c)

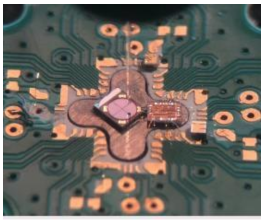
Fig. 1 (a) Top left, Sample of a quad photoreceiver. (b) Top right, Prototype of a high-speed quad detector device with a quad photoreceiver in the middle, and transimpedance amplifiers connected around. (c) Bottom left, eye pattern of a high-speed device measured at 25.78125 Gbps.

2.2 High sensitivity device:

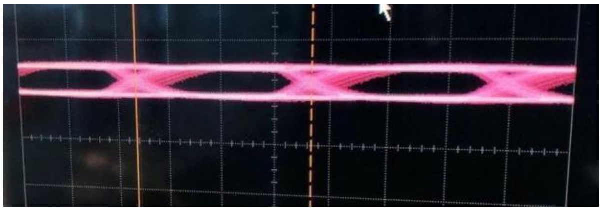
In the following Figure 2 a, the devices with 10 micrometers gap are shown for the 1000-micron diameter devices. The detector has been connected with a TIA and measured at 150 MHz. The eye diagram is open, as shown in Figure 2 c, The measurement in Figure. 1 (d) illustrates the trendline of SNR (Signal-to-noise ratio) given the specific received optical power and bandwidth.



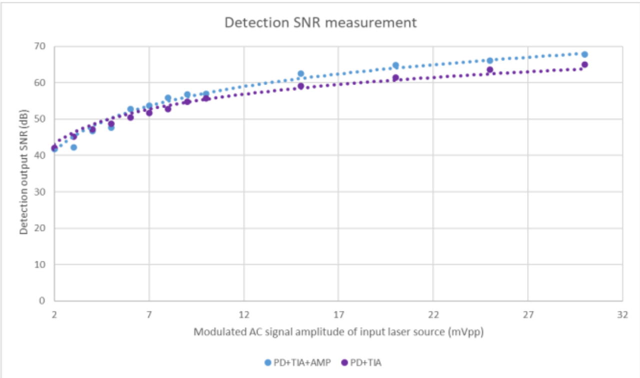
(a)



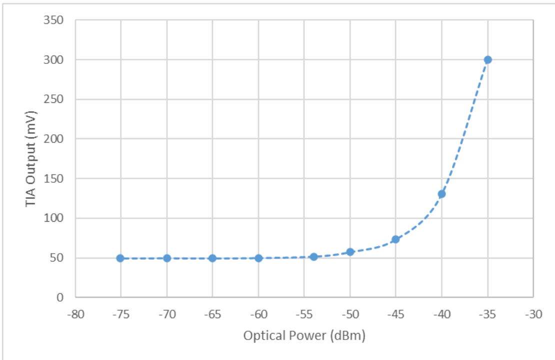
(b)



(c)



(d)



(e)

Figure 2 :(a) 1000µm 10µm gap chip, (b) 1000µm 10µm packaged with a Transampidance amplifier (c)open eye diagram at 150 MHz on 1000 um PIN Photodiode. (d) SNR measurement performed on a high sensitivity device with 1530 nm modulated laser at 20 kHz 400mV DC (-31 dBm) and 200mV DC (-40 dBm). (e) Sensitivity measurement of 1000um to characterize the operating power level and the linearity of the detector response.

3. Conclusions and Future Work

We demonstrate the results of two different quad-detector devices packaged with the help of **Bay Photonics.** where one design was able to achieve a speed of 25 Gbit/s per Quadrant and as for the other design with larger area a sensitivity of -55 dBm per Quadrant is met.

We aim for the future to design and package a high-performance 4 quadrant APD detector, combining high sensitivity and speed [1], that would improve the performance of ground-based communication systems for satellites, and reduce their cost and complexity, by lowering the number of tracking detectors and wave front sensing to remove aberrations from atmospheric turbulence effects, and combining traditionally sensing systems (reducing the device's weight).
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4. References

[1] Large Diameter, High Speed InGaAs Receivers for Free-Space Lasercom H. R. Burris1 , M. S. Ferraro2 , C. I. Moore1 , P. G. Goetz3 , W. D. Waters4 , W. R. Clark4 , W. S. Rabinovich3 , L. M. Wasiczko1 , M. R. Suite 1 , R. Mahon5 , J. L. Murphy6 , M. F. Stell 7 , W. S. Scharpf 1 , and G. C. Gilbreath8

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