Ultra-fast Analog and Digital OE-Multichannel Signal Processing using PMD/OEP-Technologies

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Abstract: *This paper introduces the operation principles of new versatile opto-electronic semiconductor components called* ***OEP (Opto-Electronic Processor)****. These are sophisticated* ***PMD (Photonic Mixer Device)****-combinations which provide a large range of new powerful, low-cost, incoherent, and extremely fast OE-devices, e.g. enabling picosecond-3D-sampling, OE- and OO-digital logic like all-optical XOR, AND, NOR, furthermore OE/OO-analog signal processing, like OE-PLL and DLL-operations, optical interconnection and routing, OE-multiplexing and demultiplexing, OE-AD-Conversion, time-resolved spectroscopy, etc.*

1. Introduction

The PMD(Photonic Mixer Device) in Photo-Gate-PMD- or MSM-PMD-technology finally is going to solve the long awaited capability of fast 3D-vision enabling e.g. autonomous, mobile robots to navigate and handle by means of thousends of PMD-LIDARs (Light Detection and ranging) on a chip [1-3].

A combination of PMDs, preferable MSM(Metal Semi-conduktor Metal)-PMDs, provides the new basic component OEP, capable to revolutionize incoherent opto-electronic measuring techniques, signal processing, interfacing techniques, picosecond-3D-sampling, fast OE- and OO-logic and optical interconnection at Bitrates up to 50 Gbit/s due to MSM-photodiode bandwidth [3].

2. OEP basic structure and operation principle

In **Fig. 1** two similar MSM-structures as PMDs **a** and **b** (beside the equivalent circuit with similar illumination $P_{opt\ a,b}$) are feeding the same capacitance C, thus forming OEP-functionality, which is illustrated in more detail by **Fig. 3** [3]. The 1µm-stripes form anti-serial Schottky-diodes, one forward, the other reverse biased due to the voltage polarity. If we combine different polarities and amplitudes this MSM-OEP can be used as a controllable detector with sensitivities between **$-S_\lambda$ to $+S_\lambda$** and additionally as a **controllable OE-mixer** with a modulation contrast MC between **-100% and +100%.**

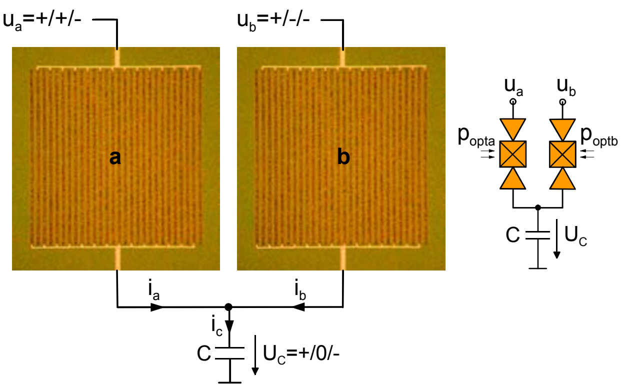

Fig.1. Basic OEP-structure formed by two MSM-PMDs, being switched off at odd polarity

The reason is: For even states $u_a = u_b$= (++) state or $u_a = u_b$= (--) state we get the total photo-current i_c fed to C positive respectively negative. Very important is the odd state $u_a = -u_b$ = (+-) state with **zero total current,** solving the problem of photo-diode switching-off. Thus the current is only rerouted. OEP-detector / mixer can be switched on / off extremely fast up to the 50 GHz range.

3. Applications and results

3.1 PLL / DLL using MSM-PMD or instead MSM-OEP

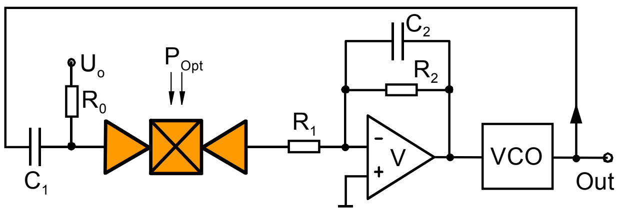

Fig.2. PLL / DLL using MSM-PMD or MSM-OEP

Fig. 2 stands for an example of miniaturisation and performance enhancement by means of MSM-PMD and MSM-OEP.technology. This PLL / DLL provides high selective correlation, low noise and high bandwidth using MSM-PMD. Applying the MSM-OEP of **Fig. 1** or **Fig. 3** instead will add new features like PLL- or DLL-control for sophisticated selectable clock regeneration in complex Code/P-DMA / TDMA / FDMA-modulation systems. It was tested at first using PG-PMD [4].

3.2 Realisation of the OEP-principle as a programmable, multi-functional 4-quadrant-PMD combination

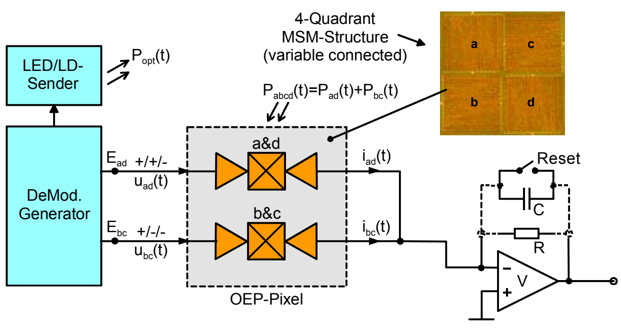

Fig.3. 4-Quadrant multi-functional MSM-OEP-pixel for OE-logic, 3D-sampling, routing, etc.

Fig. 3 shows a 4-quadrant OEP-equivalent circuit with a top view. Here the diagonal quadrants ensure homogenous light distribution and form two PMDs a&d and b&c. It can also be used as one single or four PMDs. The total current $i_A = i_{ad} + i_{bc}$ is controlled by $u_{ad}(t)$ and $u_{bc}(t)$. This device is ideally appropriated e.g. for multi-channel optical 3D-sampling and 3D-imaging in the subnanosecond range. P_{opt} is ignored during the odd state and is sampled positive or negative in the even state [5]. This operation will realize a picosecond-3D-stroboscope. The chip photo in **Fig. 4** shows a 64 (16x4) PMD-pixel array respectively a 32 OEP-pixel array.

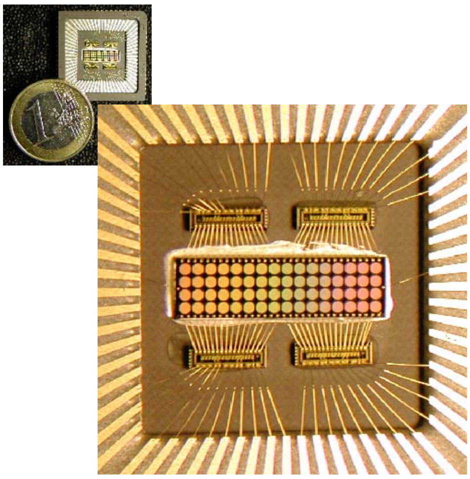

Fig.4. 16x4 PMD-array respectively a 32 OEP-array

3.3 Low-cost high performance PMD-, OEP-Routing and interconnection

Fig. 5 illustrates the function of a PMD- or OEP-router. Both profit from the extraordinary high background light suppression which enables a large number of channels. OEP additionally allows Code/Phase -, Frequency- as well as Time-Domain-Interconnection. For routers an array of LEDs or VCSELs or LWLs may be placed opposite to the PMD/OEP-Array. LED bitrates can also be processed by Photogate-PMDs. This scheme can be flexibly applied for interconnections on-chip, in-device, in-rack and for free-space communication in-house [6].

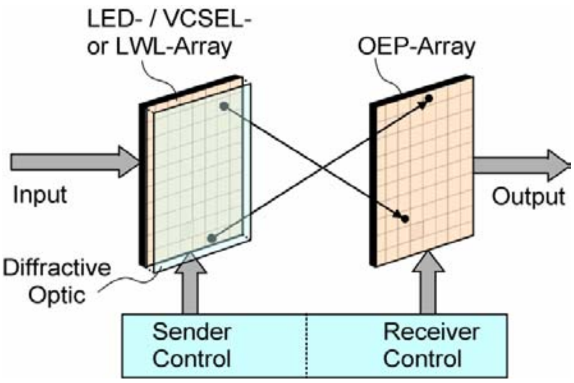

Fig.5. Scheme of an optical PMD / OEP-cross connect and router

Fig. 6 illustrates a common OEP-Device for extremely fast and direct processing of analog and digital optical and electrical signals, e.g., for

- multi-channel OE-Analog to Digital Conversion by parallel OE-Sample&Hold,
- digital logic, multiplexing and demultiplexing,
- on-chip and free-space optical interconnection, and
- high performance parallel computing.

An all-optical OEP-XOR has been proved in [3].

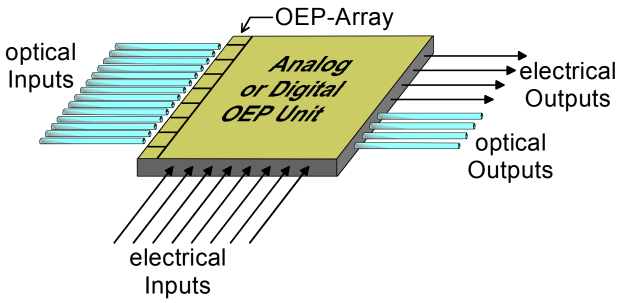

Fig.6. A general, programmable OEP-Unit for multi-channel analog and digital OE-signal processing

4. Conclusion and Outlook

Some innovative solutions and applications of OE-signal processing have been presented. In parallel to the PG-PMD-array development of 120x160 separate LIDAR-receivers for 3D-Videocameras the MSM-PMD-array will be enlarged, too.

5. Acknowledgement

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9. References

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