Project Number: 870522

Project Acronym: SIPHODIAS

Project title: Space-grade Opto-electronic Interfaces for Photonic Digital and Analogue Very-high-throughput Satellite payloads

Publishable Summary Report

Period covered by the report: from 1/01/2020 to 31/12/2020

Periodic report: *[1st]*

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Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)
This section should include information on:

- What is the problem/issue being addressed?
- Why is it important for society?
- What are the overall objectives?

Following their widespread installation within terrestrial datacenters, photonics are gearing up for their penetration into modern communication satellites. The new class of satellites dubbed "VHTS – Very High Throughput Satellite" - is considered to offer a technologically advanced expansion of the terrestrial communication network capable to deliver both high-end corporate-level and consumer-level connectivity in diverse end-user locations. To do so, VHTS is requested to push the next frontier in the Terabit/second range under stringent SWaP boundary conditions driving the migration towards photonics. This migration is already "going live"; Thales Alenia Space is the first prime to introduce optical interconnects in a commercial system and this is expected to open the opportunity for photonics penetration in every part of the satellite payload. To complete the effort, a new class of photonic building blocks – these are the opto-electronic (O/E) interfaces, i.e. transceivers, modulators and photodetectors are necessary. These components are installed in the highest volumes and are used to optically interconnect the satellite payload equipment – the same way as O/E interfaces are used to optically interconnect racks and boards of equipment within datacenters. The current O/E component generation is still lacking in terms of speed, power consumption and size and an upgrade of performance accommodated by reliability has to be demonstrated.

SIPhoDiAS aims to advance these components to address opto-electronic performance, size and power, and at the same time, demonstrate their reliability targeting a TRL 7, enabling the next generation of VHTS P/L systems. SIPHODIAS invests in state-of-the-art SiGe BiCMOS, GaAs and InP manufacturing technologies as well as innovative assembly and module packaging to deliver high-speed digital optical transceivers, high-bandwidth electro-optic modulator arrays and miniaturized analogue photodetectors. The optical transceivers are designed to deliver >100 Gb/s optical interconnects within the P/L digital processor whereas modulators and photodetectors will enable operating frequencies in the Q and V-band respectively. By realizing its S&T objectives, SIPhoDiAS will present for the first time photonic P/L systems that hit the right performance and SWaP targets and enable the sustained entry of photonics into modern communication satellites.

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Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

During its first period, SIPHODIAS has achieved the following:

- Complete definition of system architecture and module requirements considering the satellite photonic payload application.
- Completion of the critical design of the 112 Gb/s optical transceiver (OTRx) chipset consisting of a 4x 28 Gb/s VCSEL driver and TIA receiver circuits. Successful tape-out was launched in IHP SG13RH process and IC delivery is planned within 2021.
- Completion of the critical design of the 112 Gb/s (4x 28 Gb/s) optical transceiver (OTRx) module including optical, RF and mechanical design. Parts procurement and module assembly, integration and test launched. Module delivery is planned within 2021.
- Completion of the critical design of the high-bandwidth GaAs modulator array including mechanical, optical and RF design. The module hosts two modulators with each modulator expected to deliver a bandwidth in excess of 50 GHz. Module delivery is planned within 2021.
- Completion of the critical design of the high-bandwidth analogue photodetector including mechanical, optical and RF design. The module is expected to deliver a bandwidth of 40 GHz. Module delivery of the first Ka-band module is planned within 2021.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

SIPHODIAS has just completed the first year of its lifetime which was dedicated to circuit/module design and launch of the manufacturing phase. The next period will complete the fabrication and will perform the experimental activities which will facilitate the benchmark against the state-of-the-art. However, the design activities that have been completed provide already an indication of the advancements that are expected by the SIPHODIAS photonic modules in terms of key functional and physical characteristics. Specifically progress is expected as follows:

- The 112 Gb/s OTRx IC chipset is expected to meet a power consumption target of 161 mW which corresponds to an efficiency of 5.7 mW / Gb/s per channel.
- The 112 Gb/s OTRx module is expected to weigh <6.5 grams and consume a PCB area of ~675 mm^2. Packaging is compliant to the COBO standard for mid-board optics transceiver modules.
- The GaAs twin modulator array is expected to deliver a bandwidth of 50 GHz per modulator within a small form factor package with a footprint of 9 cm^2 and an aggregate bandwidth per unit area of >7 GHz / cm^2.

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- The analogue photodetector is expected to deliver a bandwidth of 40 GHz within a package that weighs <16 grams and occupies an area of 2.35 cm^2 corresponding to a bandwidth per unit area of ~17 GHz / cm^2.

The achievement of these targets are fully in line with the project system objectives and the end-user roadmap as well as they constitute significant advancements in the application area of hi-rel digital and analog O/E modules. Within the second year of the project execution these targets will be verified through the prototype assembly, integration and testing.

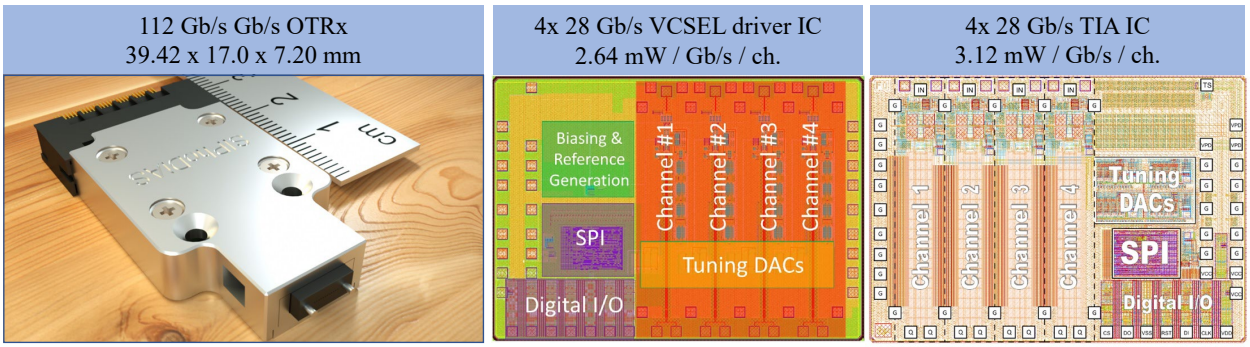

Figure: SIPHODIAS space transceiver technology: (left) 112 Gb/s mid-board optics OTRx module, (middle) 4x 28 Gb/s VCSEL driver SiGe BiCMOS IC, (right) 4x 28 Gb/s TIA SiGe BiCMOS IC.

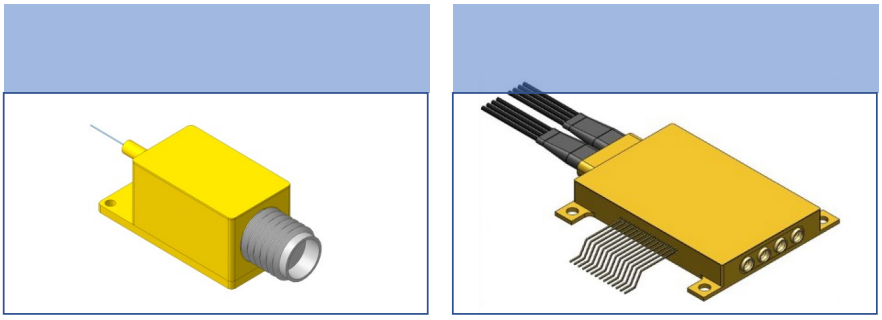

Figure: SIPHODIAS microwave photonic modules: (left) 40 GHz analogue photodetector and (right) GaAs twin modulator array

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