Photonic Integration for Space Applications

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Technical lead

EPIC Meeting on Photonics for Space
Paris, France
21 September 2023

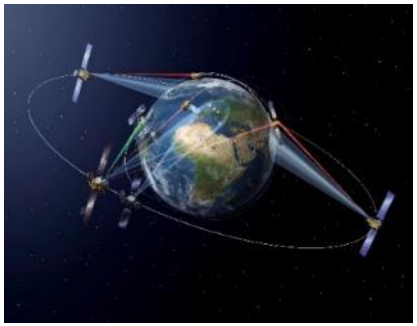
Antwerp Space: An introduction

- Antwerp Space is a leading Belgian Space company working (under different names) in space technology business since 1962.

- Antwerp Space is active in the field of Space based RF applications. It is now part of OHB SE, a European Space and Technology group that currently employs over 3000 people. Currently we have facilities in Antwerp and in Leuven.

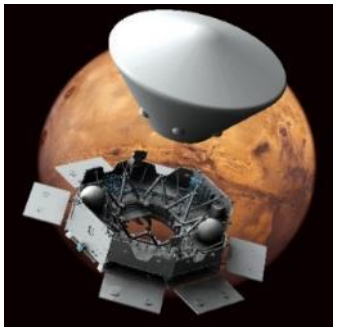
- Antwerp Space's core business is in the delivery of satellite communication-, navigation- and radar solutions as well as instruments for scientific and exploration missions

Antwerp Space contribution to Space missions



ARGO

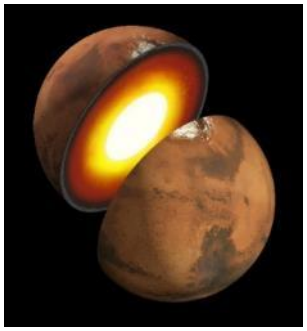
A highly innovative modem launched in 2020 and mounted on the International Space Station (ISS).



ExoMars

Communication subsystem on board the carrier module to fly to Mars.

(Delayed due to Russian invasion into Ukraine)



LaRa

The first instrument made in Belgium to ever land on the surface of Mars. Planned to be mounted on the Russian Mars Lander (descoped from ExoMars

Due to Russian invasion to Ukraine)

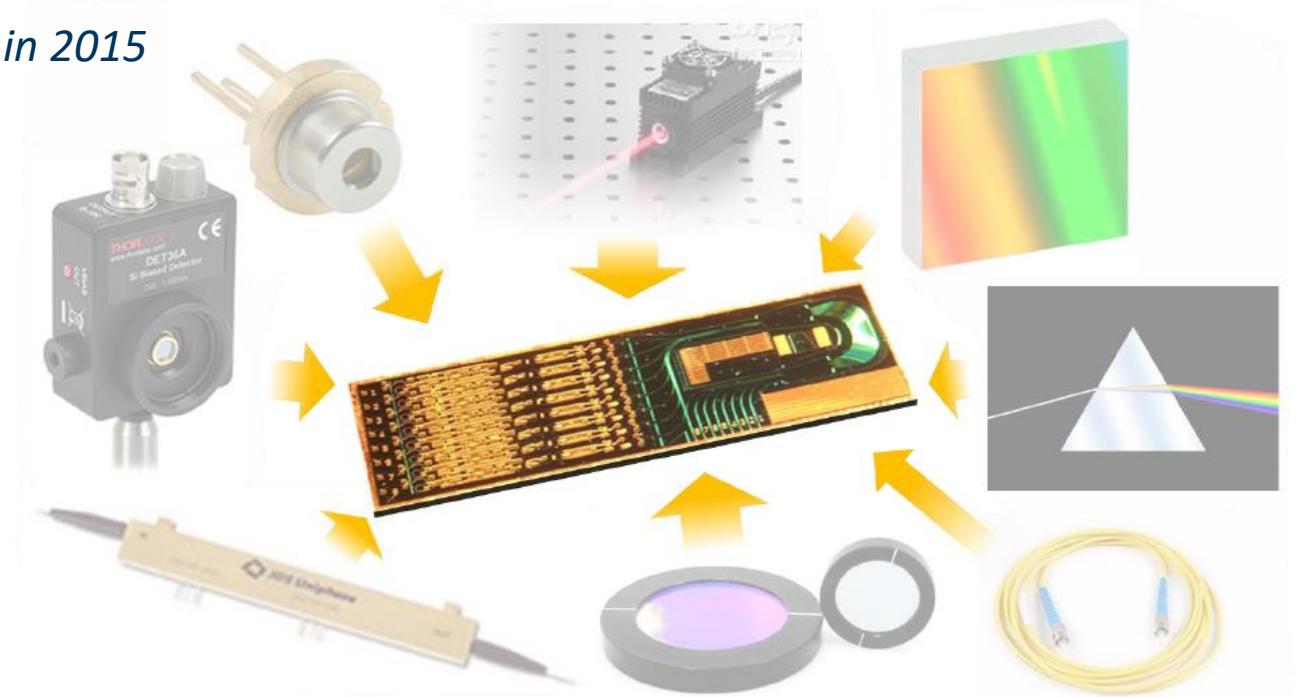
JUICE

Communication subsystem on ESA's mission to Jupiter and its moons (launched April 2023)

Photonics at Antwerp Space:
Photonic Integration Technology for Space Applications

Photonic integration: optical chips

Initiated in 2015



Presentation by

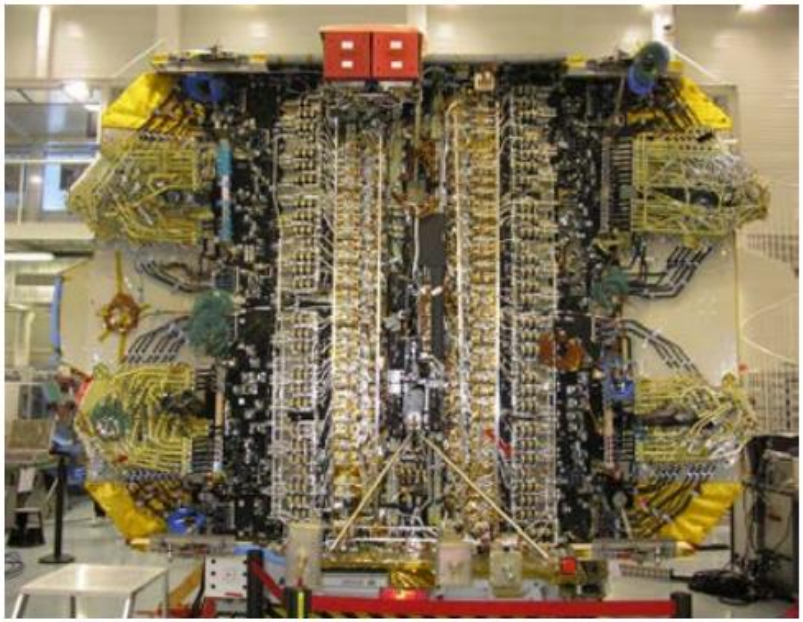
Prof. Martijn J. R. Heck- Scintific Director- Eindhoven Hendrik Casimir Institute

Why Photonics for Space Applications? Addressing challenges of COMSAT payloads

- COMSAT payload incorporate payloads with large quantity of conventional RF equipment, co-axial cables, waveguides, and harnesses, making the assembly, Integration, and Test (AIT) very complex

- COMSAT payloads challenges are

  - Payload Mass
  - Complex AIT
  - Size (volume)
  - Power consumption



Typical Panel Equipment Layout using Conventional RF Equipment

APPLICATION OF PHOTONICS IN NEXT GENERATION TELECOMMUNICATION SATELLITES PAYLOADS, J. Anzalchi, et.al, ICSO 2014.

Why Photonics for Space Applications? Addressing challenges of COMSAT payloads

- Fiber optics offer several advantages:

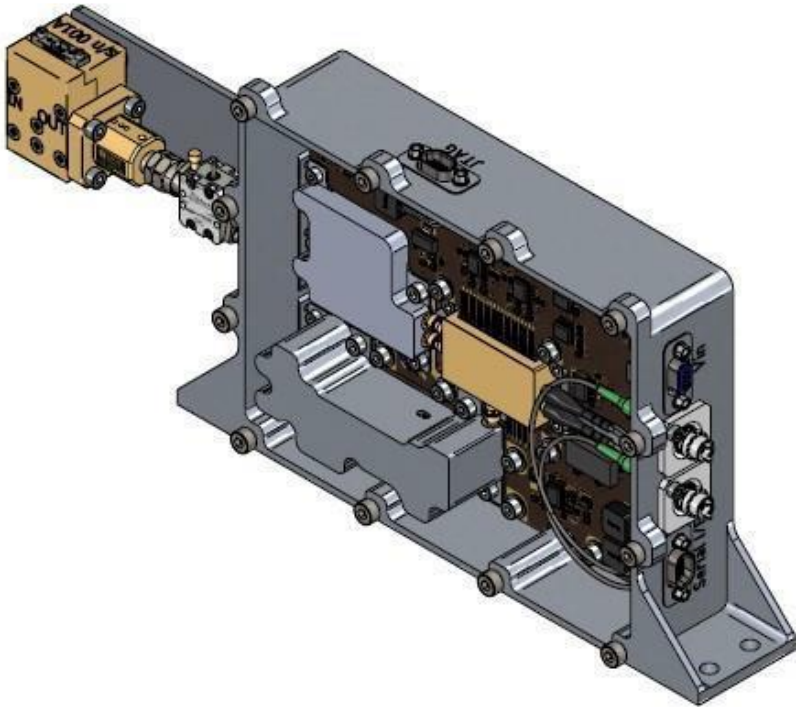
- Wide bandwidth: theoretically fiber optics offer several THz around 1550nm
- Offer a very low optical losses (0.5dB/km) at 1550nm
- Immunity to electromagnetic interference (EMI) and cross talk
- Light weight and low volume
- Mechanically flexible

Replacement of conventional RF payload equipment with their Photonic counterparts and using fiber optic cablesin place of coaxial cables and waveguides can enable dramatic reduction of mass for the terabit/s ***satellite***

Antwerp Space: PIC-based projects for space applications

- **EPFCV2:** A Q/V-band Electro-Photonic Frequency Converter (ESA project)
- **Spacebeam**: X-band Synthetic Aperture Radar for Earth Observation (EU project)
- **Photonic Lantern Receiver** (ESA Project)
- Hosting institute for **MWP4Space**: Marie-Curie PhD consortium for microwave photonic technologies for communication and sensing application in space
- PICs for quantum applications

EPFCV2: A Q/V band frequency converter module



Antwerp Space Q/V band Frequency Convertor Module. The gold package inside the module is the PPIC. One of the optical fibers is connected to the Tx while the other enable the optical connection to the Rx.

InP technology

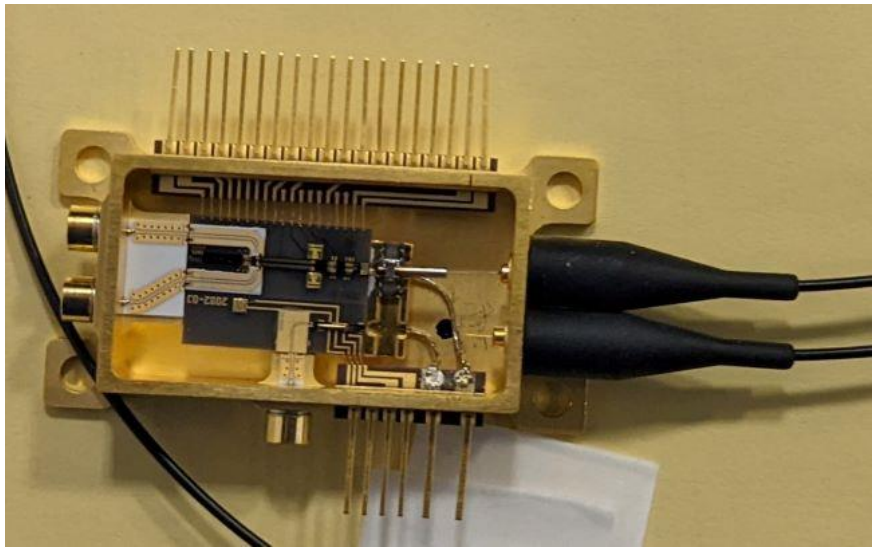
EPFCV2 Specifications

Specification	Value	Unit
Operational RF Frequency Range	47.2 to 50.2	GHz
LO Frequency	30	GHz
IF Frequency	17.2 to 20.2	GHz
F-conversion Technology	Photonic Integration	NA
Operational optical wavelength	C-band	nm
Optical Interface	Mini AVIM	N/A
RF, LO, and IF inputs	Feedthrough pins	N/A
RF input power range	-60 to -35	dBm

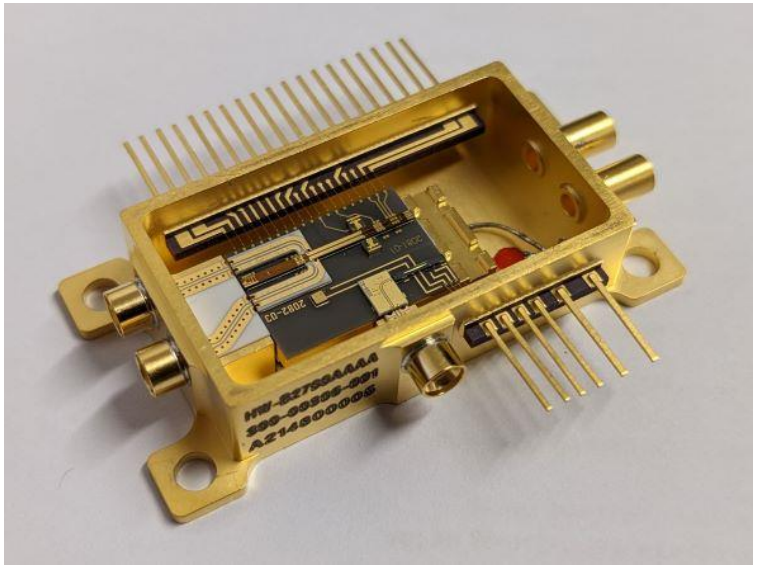
esa

antwerpspace
An OHB Company

Packaged Photonic Integrated Circuit (PPIC)

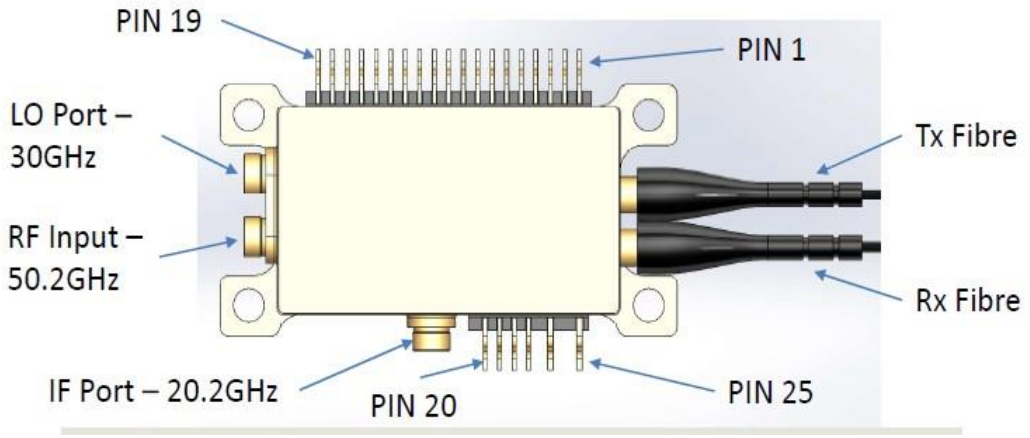


Designed and fabricated by Alter UK.



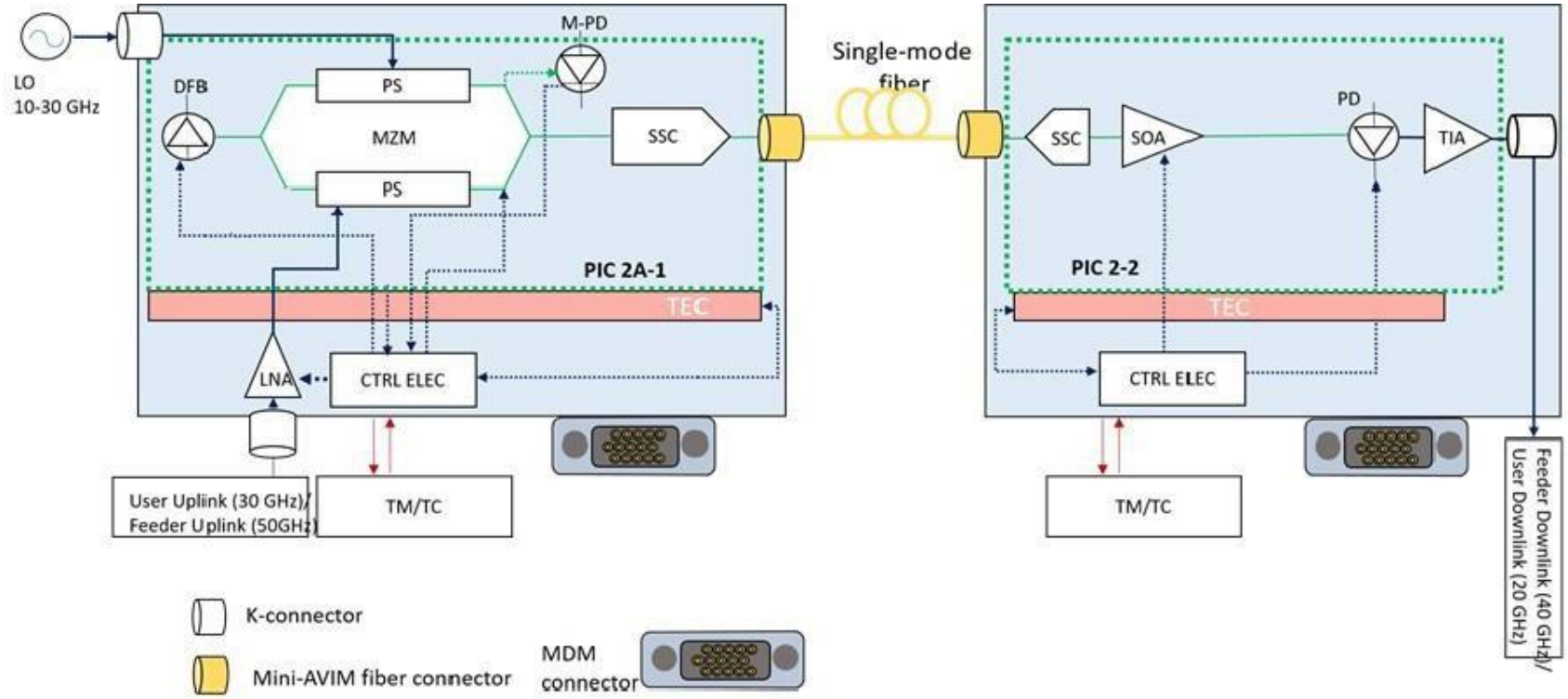
Designed and fabricated by Alter UK.

Hermetically sealed PPIC

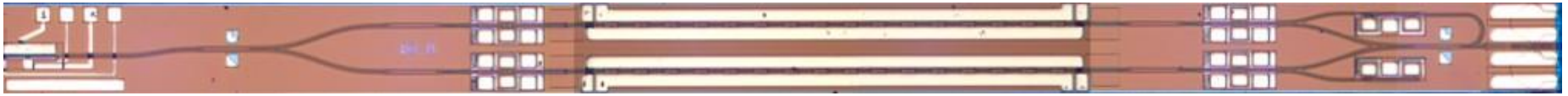


Specification	Value	Unit
PPIC size2	40 × 26 × 16	mm3
PPIC mass	<40	grams
PPIC components	Thermal, Optical, and RF parts	N/A

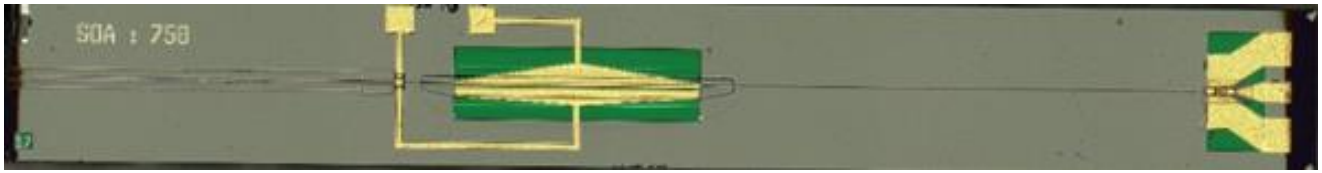
EPFCV2 integrated microwave photonic link



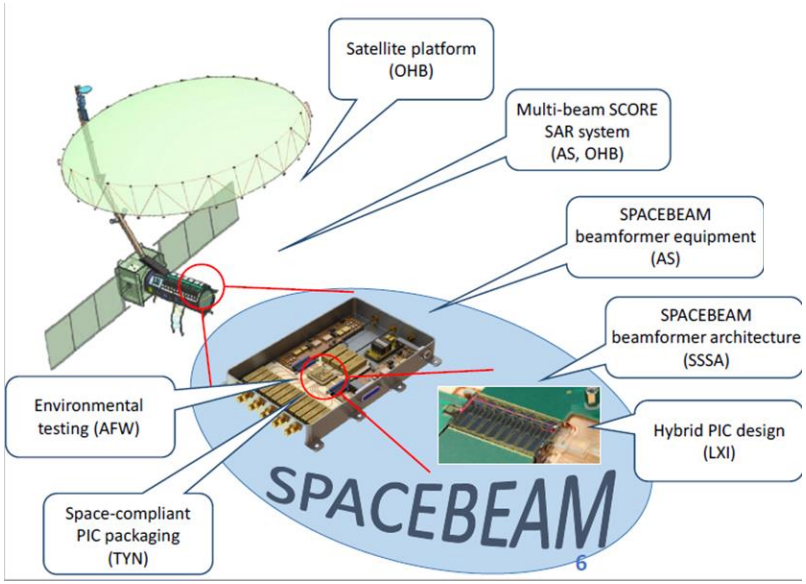
Fabricated Transmitter & Receiver chips



Metric	Value	Unit
IQM modulator 3dB Bandwidth	50	GHz
Wavelength range	C-band	nm
Laser type	DFB	N/A
Laser RIN	<140	dB/Hz
Laser linewidth	< 3	MHz
SMSR	40	dB
PD 3dB BW	<20	GHz
PD responsivity @ C-band	0.8	A/W
SOA Gain	20	dB



Spacebeam

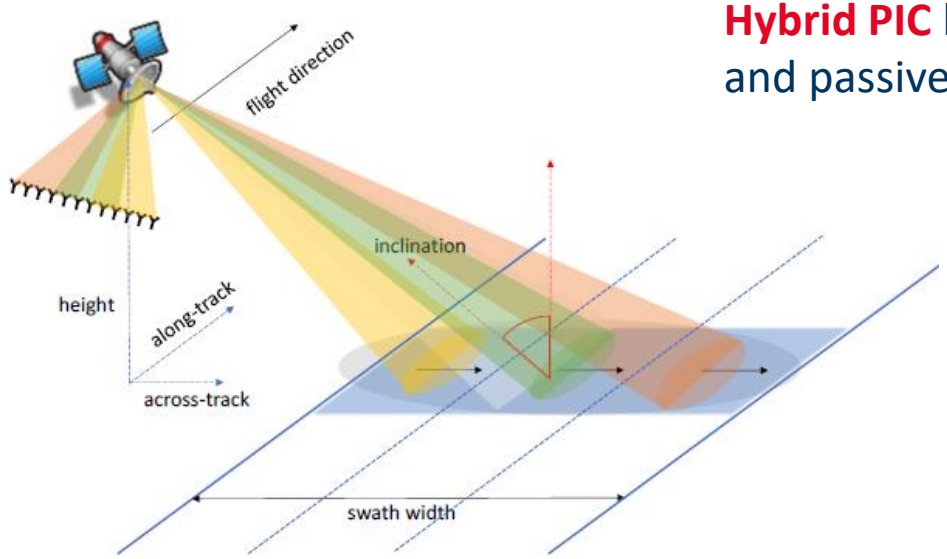


Parameter	Value
RF Frequency band	X-band
Bandwidth	390 MHz
Ground resolution	1.5-by-1.5 m
Orbit Height	LEO (400-800 km)
Swath	30 x 30 km
Dynamic range	30 dB
Beamshaping	PIC-based
Control	PZT

A reconfigurable multi-beam Scan-on-Receive SAR for Earth observation

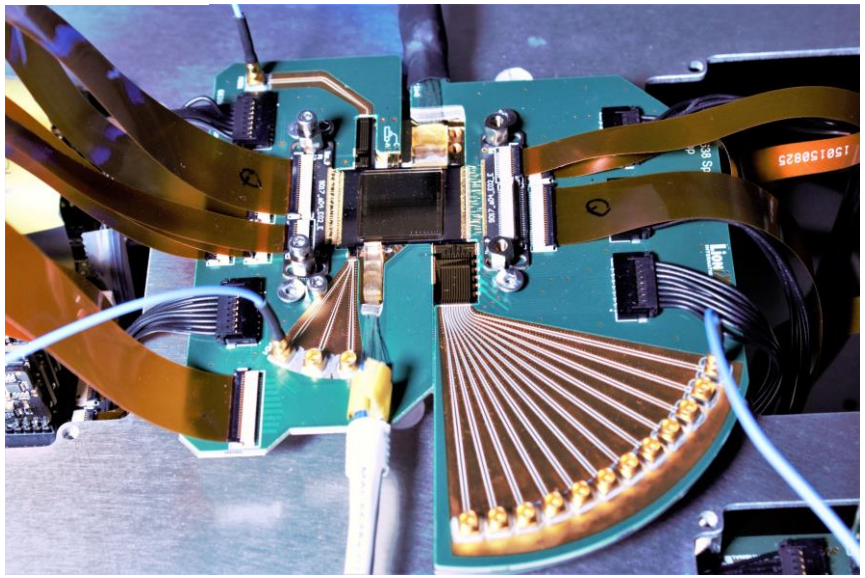
Spacebeam

Spacebeam:
A Scan-on-receiver (SCORE) Synthetic Aperture Radar Receiver for Earth Observation

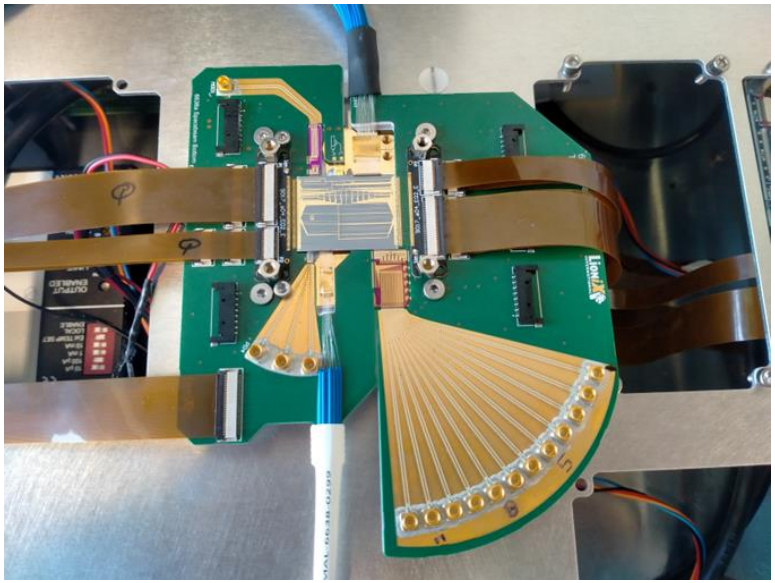


Hybrid PIC based on SiN and InP including active and passive functions

Spacebeam latest updates …

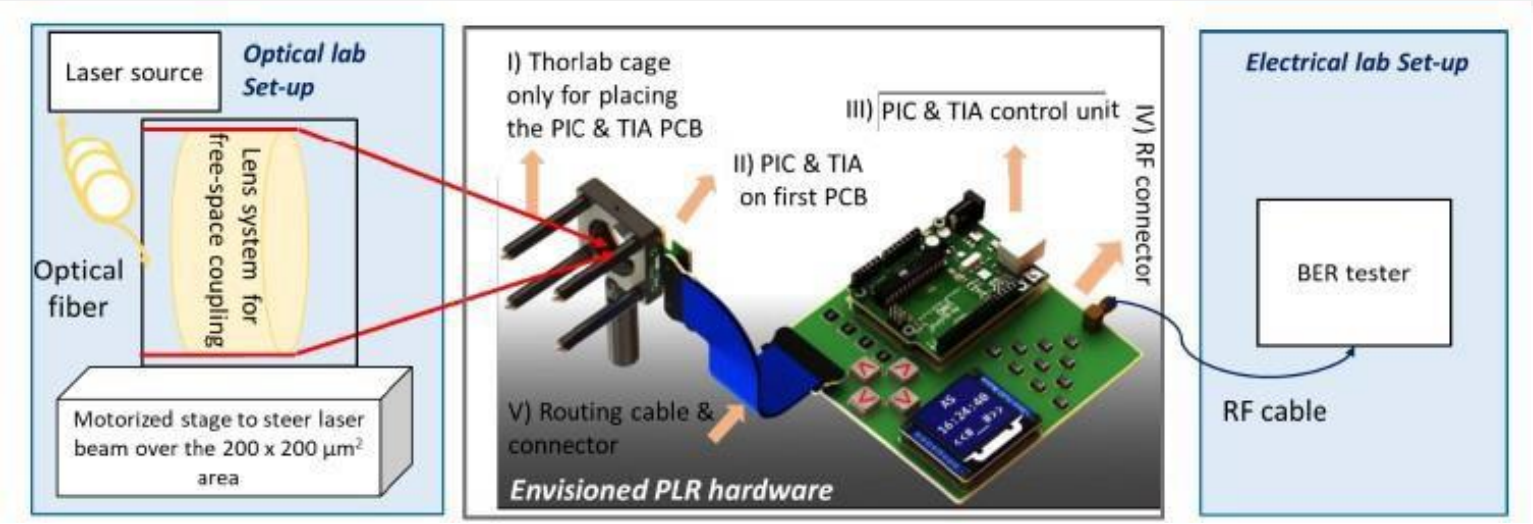


A PZT-based beamformer



A heater-based beamformer

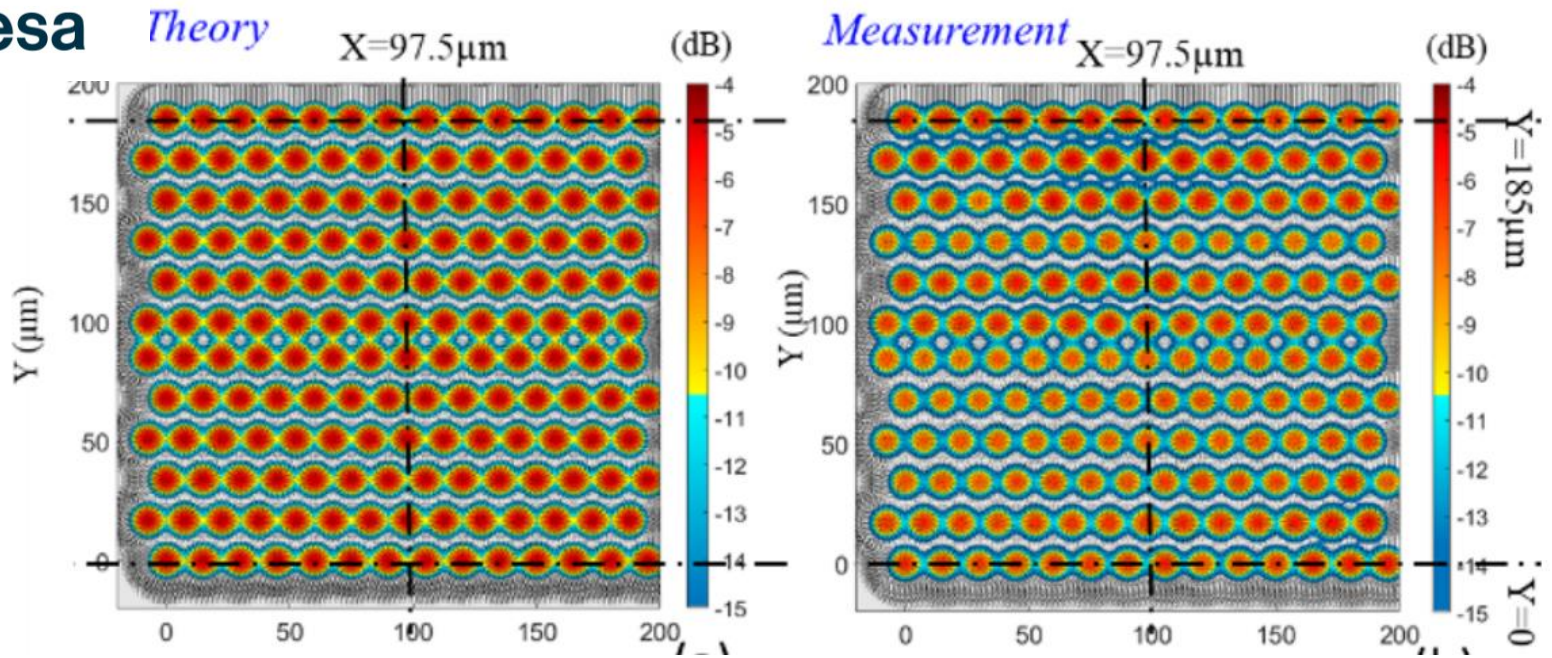
Photonic Lantern Receiver: Hardware & Test Strategy



Metric	Value	Unit
Receiving area	200 × 200	µm2
Optical insertion losses	-10.5	dB
Operating wavelength	1550	nm
Data rate	1.2	Gbps
PD responsivity @ C-band	0.8	A/W
Rx input requirement	Single Optical input	N/A
Rx output channel	Single RF signal output	N/A
Features	Non-mechanical, with an integrated PD, 4Q sensor, extendable surface area	

Silicon photonics

Photonic Lantern Receiver: Simulation and measurement results



Measurement of the photonic lantern receiver (a) designed , (b) actual measurement

Silicon photonic receiver for satellite laser communication terminals
Jeong Hwan Song, Tangla D. Kongnyuy, Mathias Prost, Hakimeh Mohammadhosseini, and Roelof Jansen.
Optics Letters, Vol.48, No.1, January 2023.

MWP4Space: Microwave Photonic Technologies for Communications and Sensing Applications in Space

- Marie Curie-Skłodowska PhD scholarship in the field of Microwave Photonic Technologies for Communications and Sensing Applications in Space
- Single micro-satellite SAR Payload based on photonics: 6-month secondment to AWS
- Distributed SAR system based on photonics: 12-month secondment to AWS
- RF electronics and QRNG for space-based QKD: 6-month secondment to AWS

MWP 4SPACE MicroWave Photonic Technologies for Communications and Sensing Applications in Space

Thank you !

Questions?

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