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Y DE LA FUNCIÓN PÚBLICA



Plan de Recuperación,
Transformación
y Resiliencia



PERTE
Chip

20
26

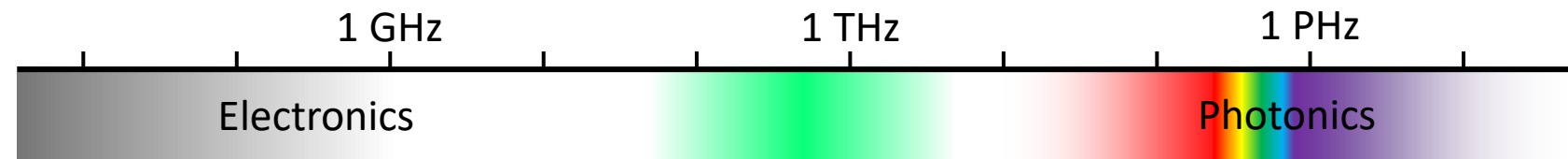
España | digital

New packages for spacial THz devices

PhD Student: Sergio Rivera Lavado
Supervisor/s: Jesssica César-Cuello,
Daniel Gallego and Guillermo Carpintero

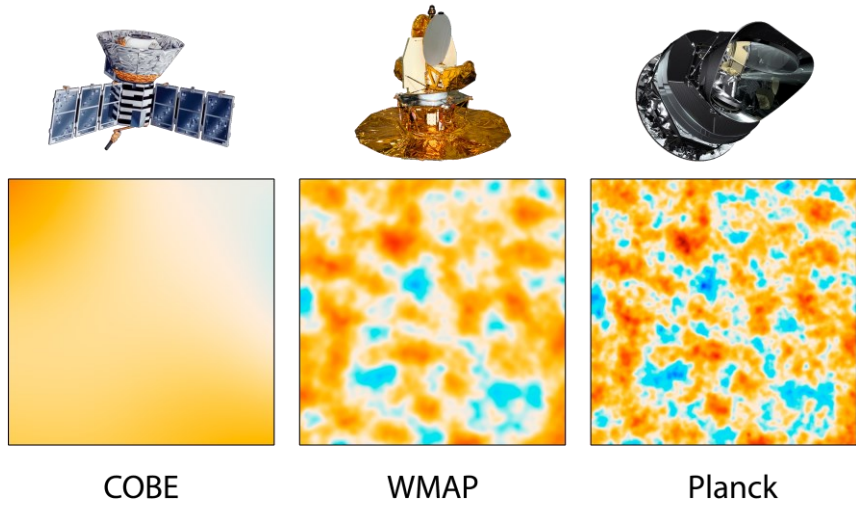
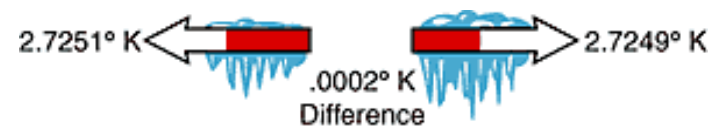
PhD Aerospace Engineering UC3M
Doctoral Meetings 2026
2nd and 3rd June 2026

- Packaging
 - Packaging Roles
 - Bandwidth Connectivity
 - Interconnections density
 - Power consumption (Thermal Dissipation Power)
 - Radiation Protection
 - Signal Domains
 - Remote Sensing
 - High-Speed Communications
 - On-board Processing
 - Power Distribution



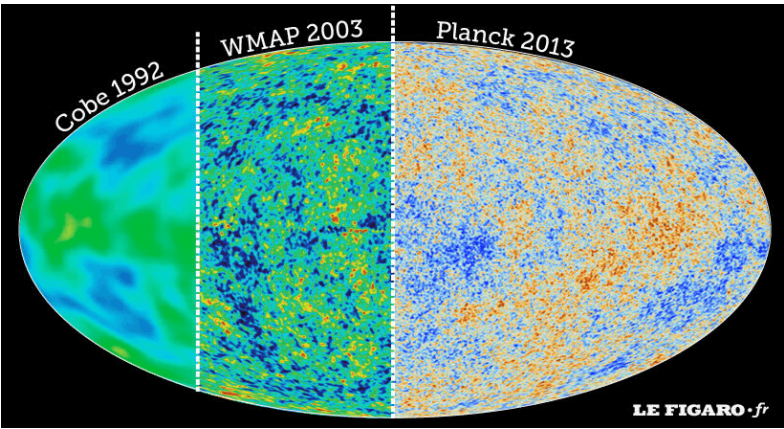
■ Terahertz (THz) Radiometry

Cosmic Microwave Background



Source: NASA website

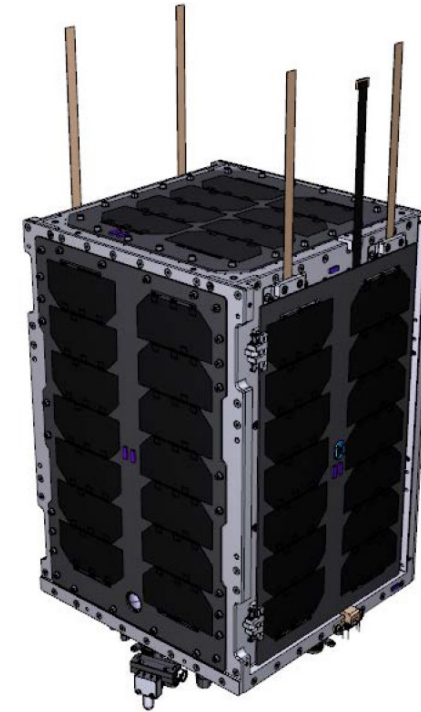
J. A. Vázquez, et al., “Inflationary cosmology: from theory to observations”.



Satélite	Dimensiones [m²]	Peso [kg]	Potencia [W]	Criogenia	Radiómetro	Resolución [°]
COBE (1989)	5.49 x 8.53	2270	750	✓	LNA(MESFET)	7
WMAP (2001)	3.6 x 3.6	840	419	✓	HEMT	0.21
Planck (2009)	4.2 x 4.2	1900	-	✓	HEMT/Bolómetro	0.07

The SWaP Constraint

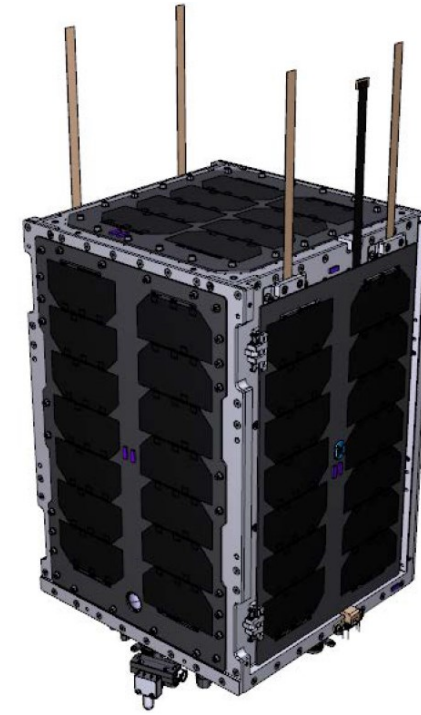
- SWaP (Size, Weight, and Power)
 - Size
 - Components must be miniaturized
 - Mass
 - Interconnects and cables add significant weight
 - G-Force (Must withstand extreme launch vibrations, $F=m \cdot a$)
 - Power
 - Photonic systems outperform electronics in efficiency



Nanosatélites

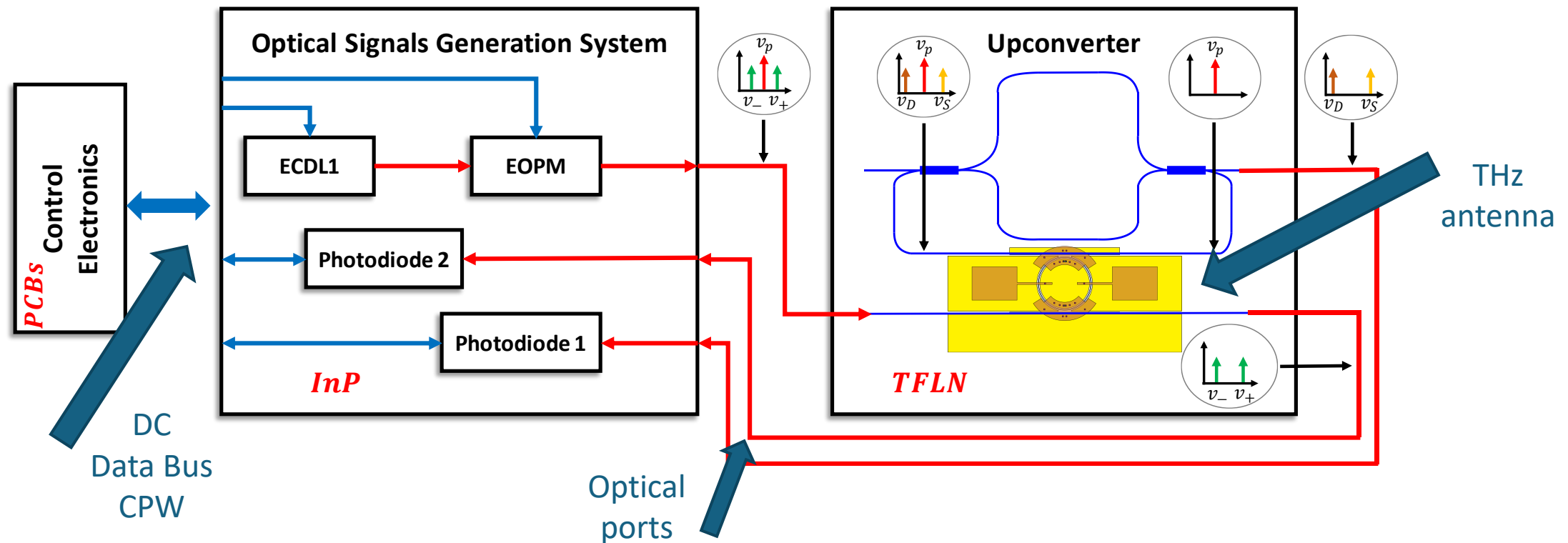
The Photonic Solution

- Size
 - Integrated photonics significantly reduces footprint.
 - Mass
 - Optical interconnections replace heavy copper cables
 - Free-space optical coupling via microlenses
 - Combined silicon rods and optical microlenses
 - Power
 - Photonic signal processing
-
- Sengupta, K., et al. "Silicon-based terahertz circuits and systems." IEEE Transactions on Microwave Theory and Techniques. (justificar el uso de guías de silicio).

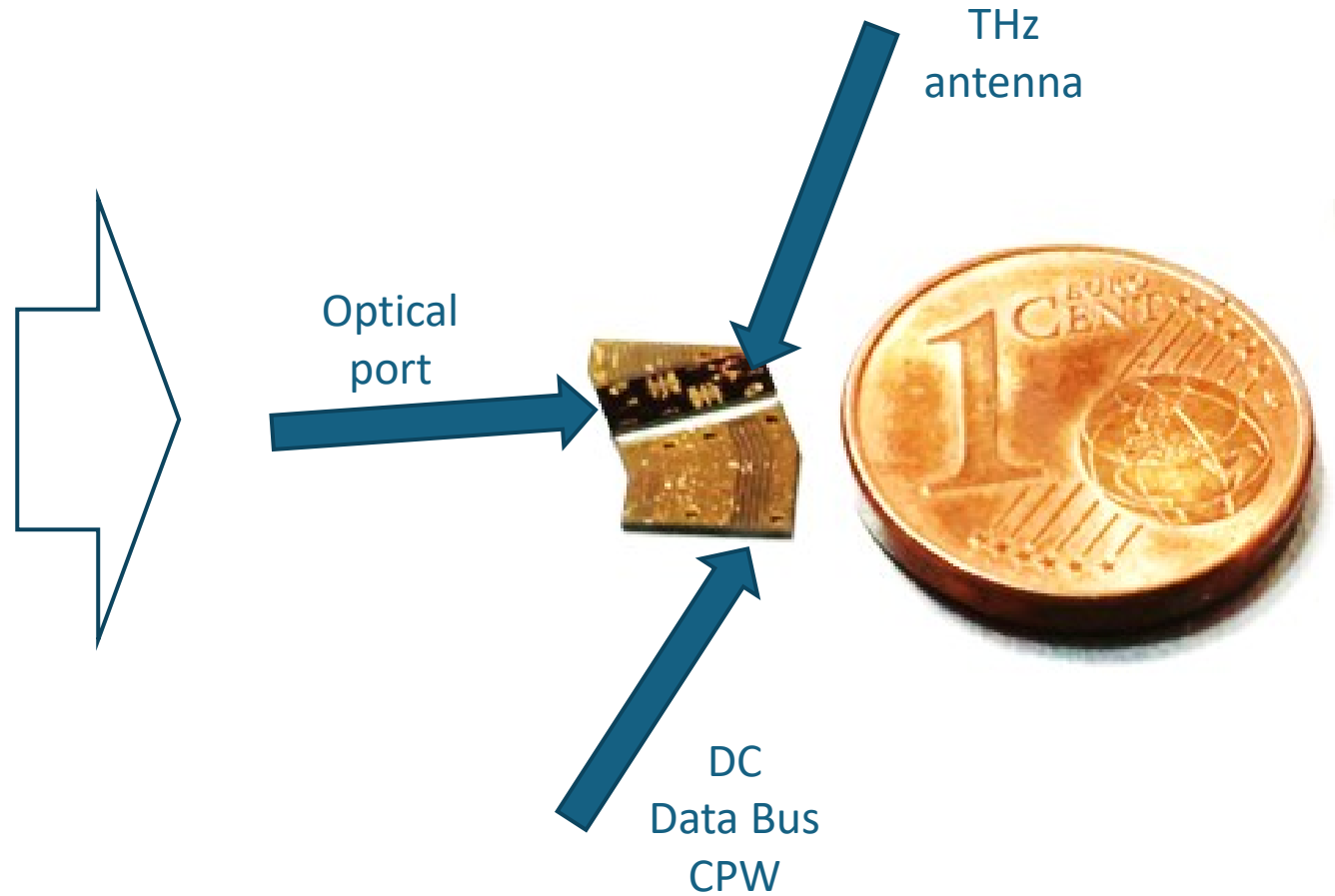
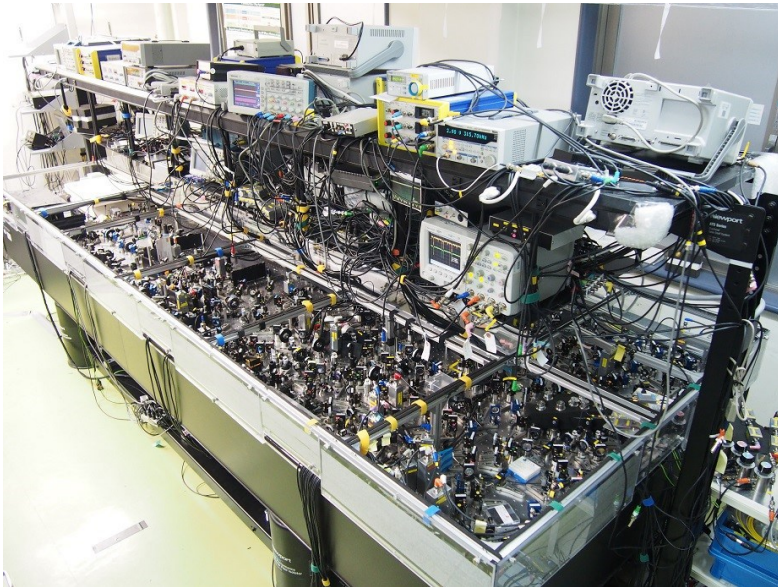


Nanosatélites

- **Photonic payload:** RF signal upconversion to the optical domain.

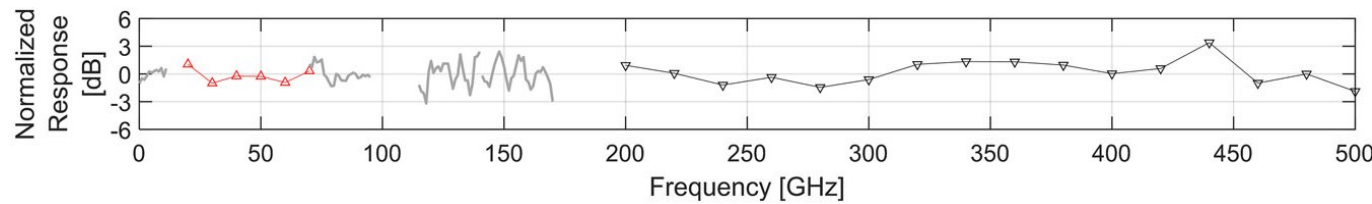


- Processsing, communication, powering



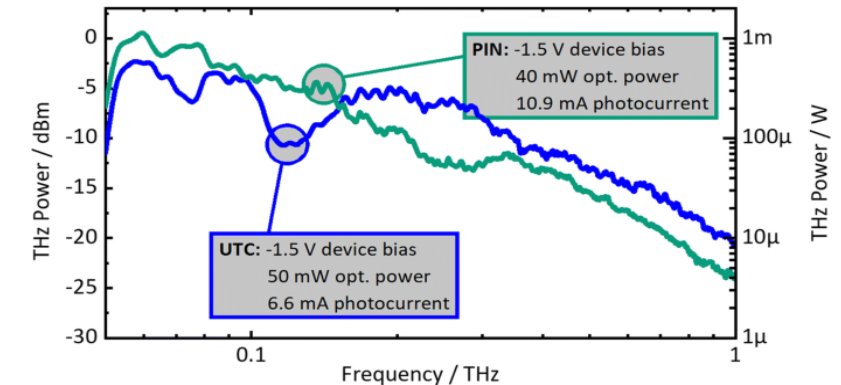
- Optical: Ultra-fast processing, guided or free-space transmission
- THz: High-speed interconnection and remote sensing
- Electrical: DC/Low frequency for power and control data buses

High-Speed Optical Modulators (Plasmonic, TFLN)

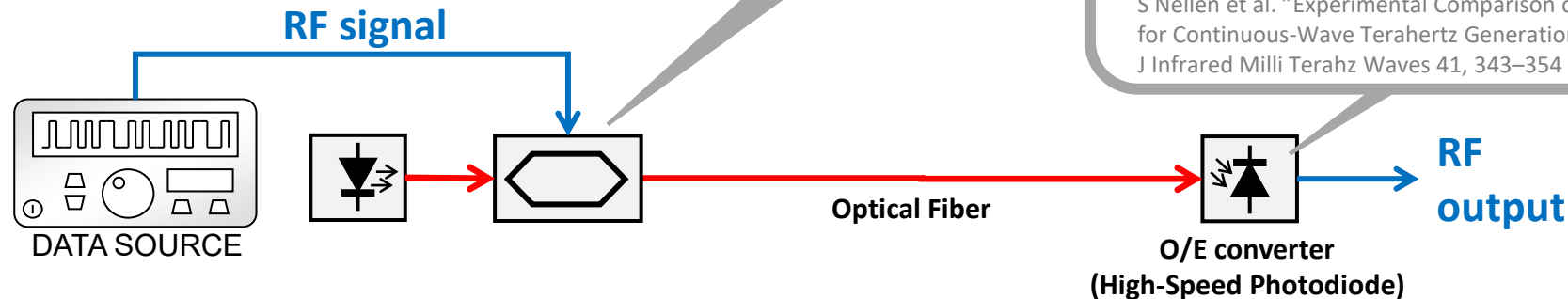


M Burla, et al "500 GHz plasmonic Mach-Zehnder modulator enabling sub-THz microwave photonics"
APL Photonics 1 May 2019; 4 (5): 056106

High-Speed Photodiodes (PIN, UTC-PD)



S Nellen et al. "Experimental Comparison of UTC- and PIN-Photodiodes for Continuous-Wave Terahertz Generation"
J Infrared Milli Terahz Waves 41, 343–354 (2020)



Photonic design and measurements

- Lasers
 - Tuning & Mapping
 - MZI Simulation, Wavelength mapping
- Filters
 - Bandpass Selection
 - MZI vs Ring resonators
- Modulators
 - Signal Modulation
 - Ring Resonator, Mach Zehnder (MZI)

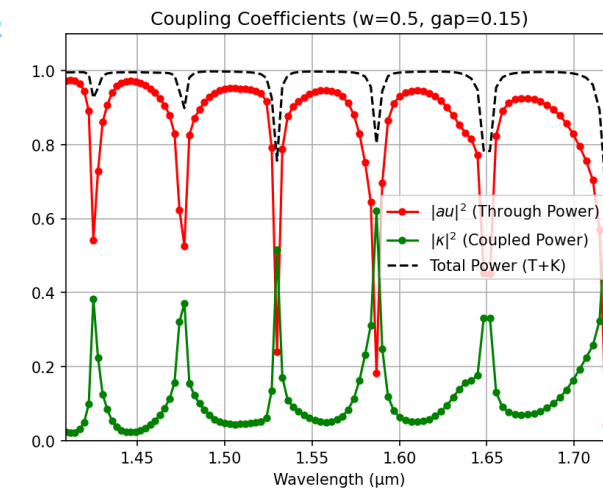
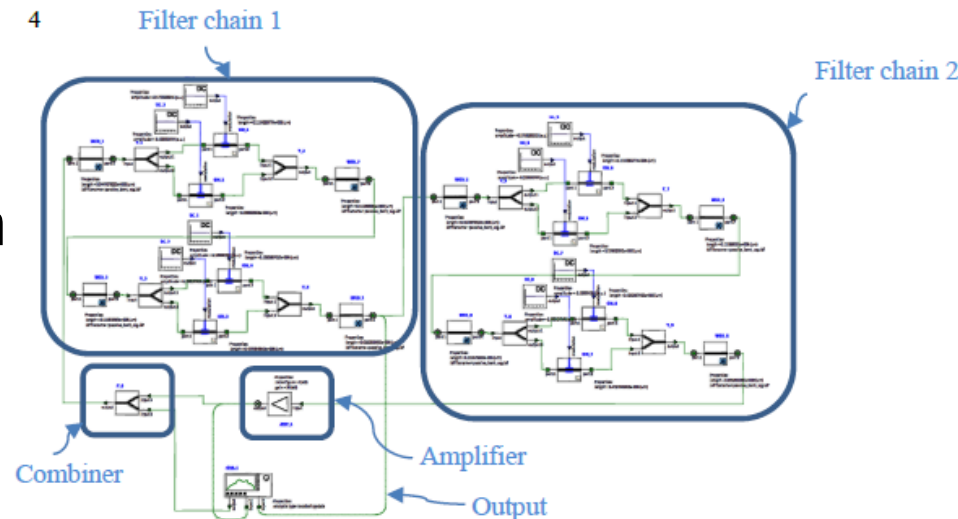
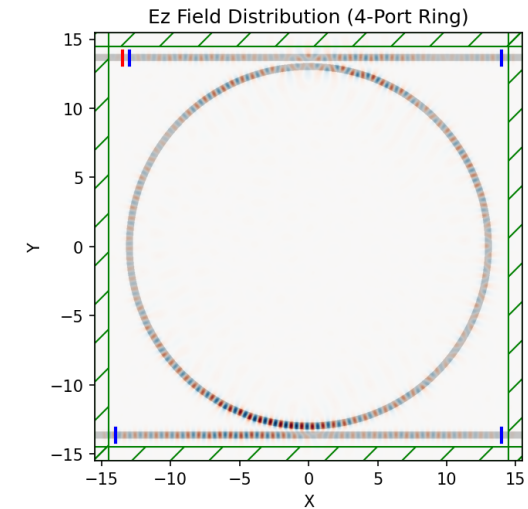
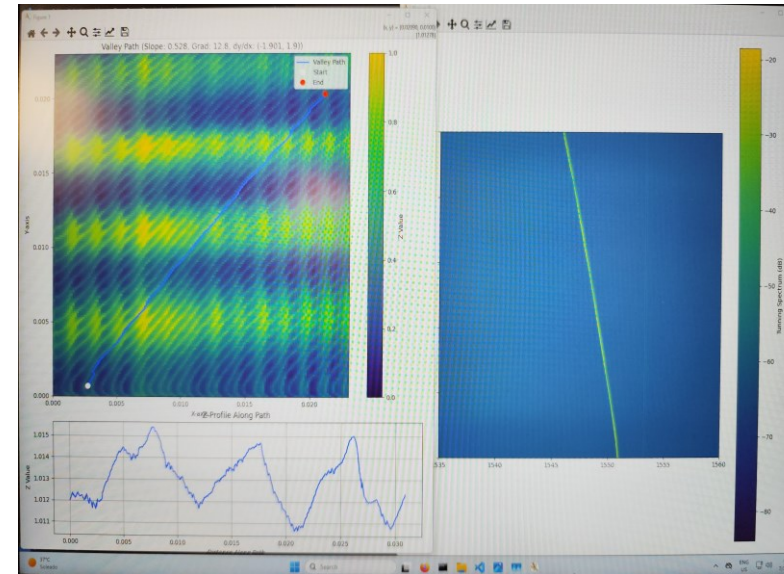
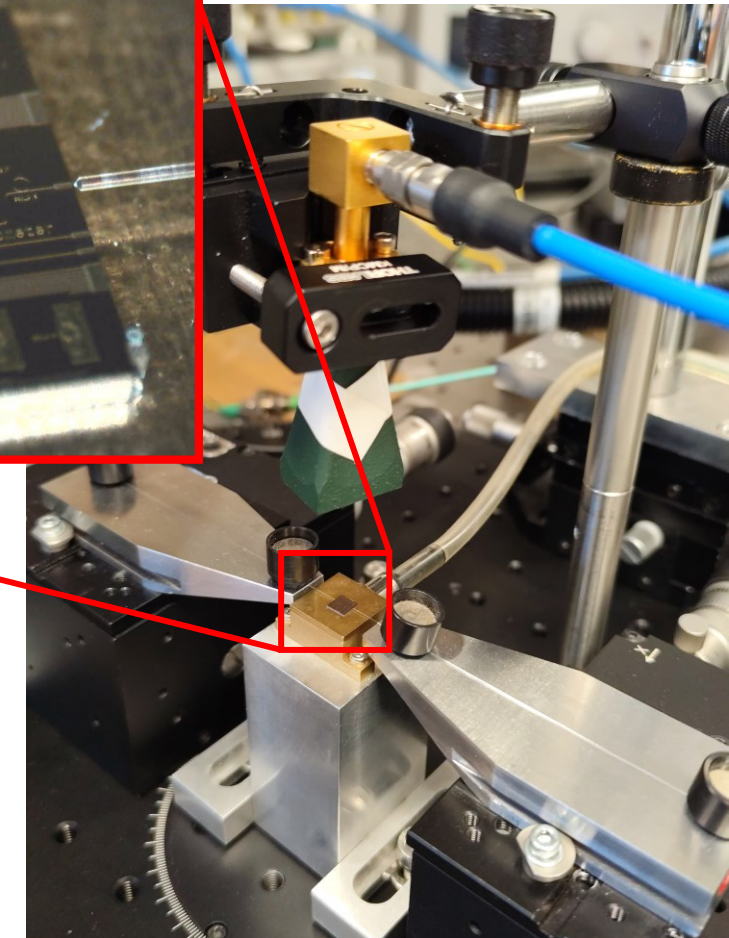
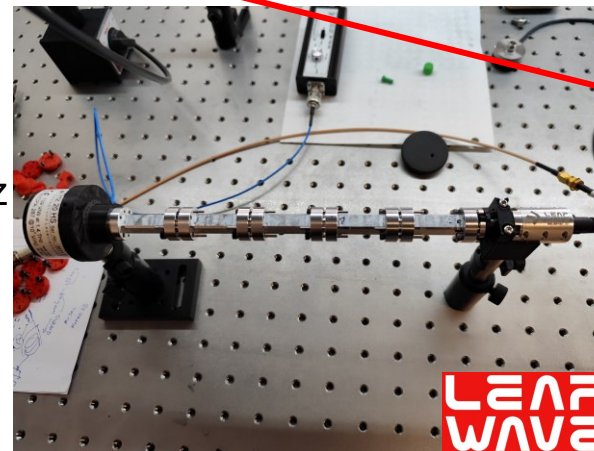
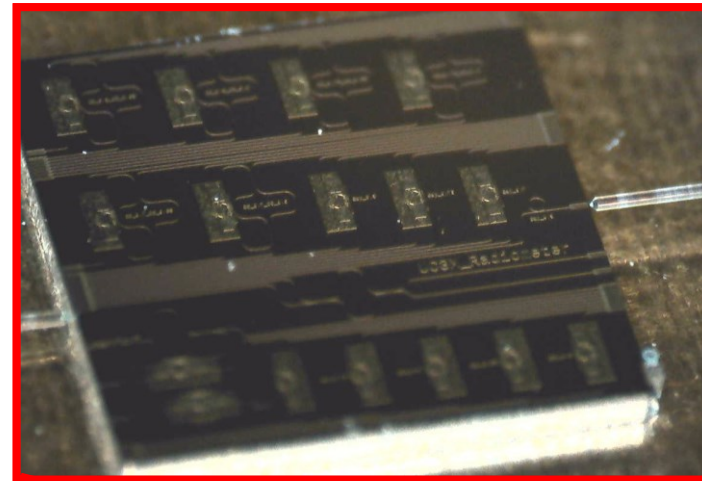
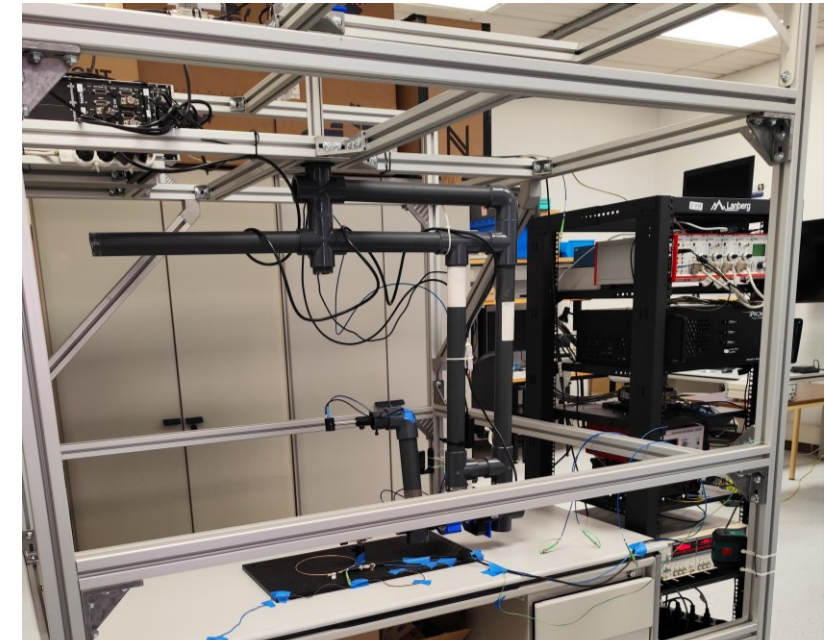
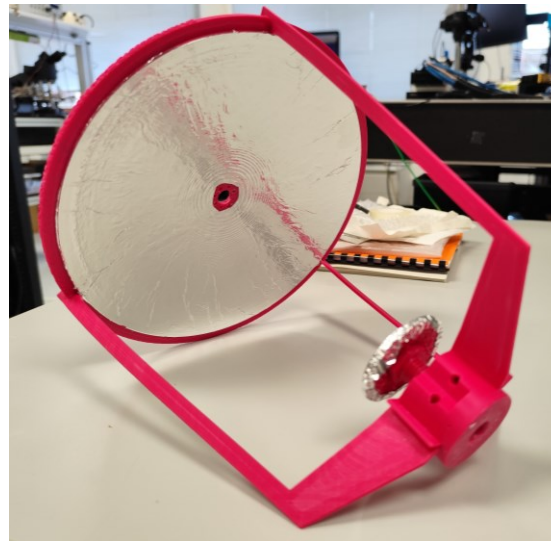
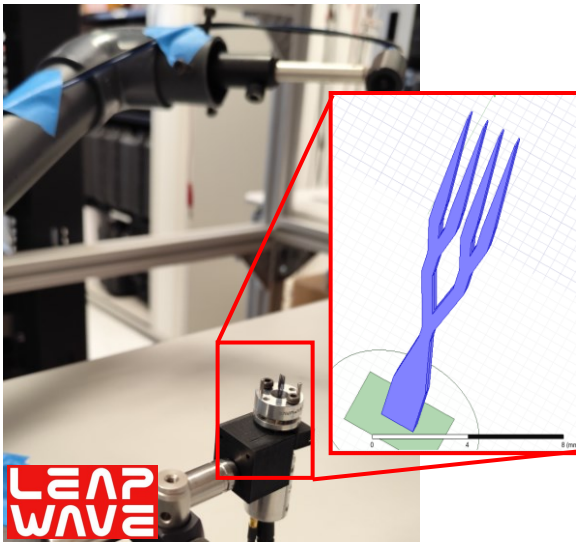


Fig. 3. Schematic of the optical circuit tested and developed using Lumerical INTERCONNECT.

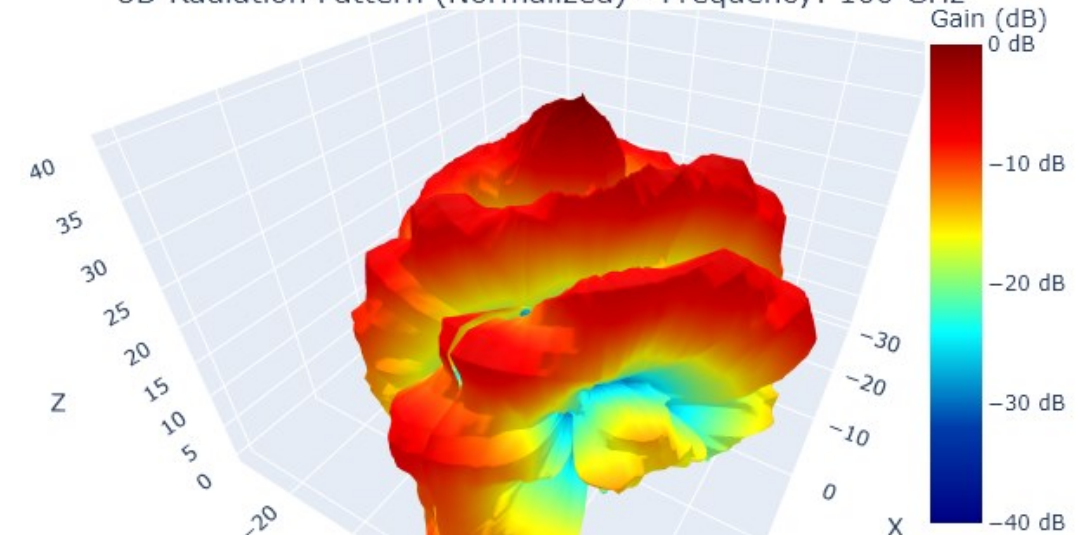
- Utilizing 2nd order **non-linear effects to generate THz waves** on electro-optic substrates
 - UTC-PD (Unitraveling-Carrier Photodiode, Leapwave)
- Ring Resonators for frequency upconversion
- Nahata, A., et al. "A wideband coherent terahertz spectroscopy system using optical rectification and electro-optic sampling." Applied Physics Letters.



- Antenna design (HFSS)
- Measurements of silicon antennas
- Fabrication of THz reflector
- THz measurement setup

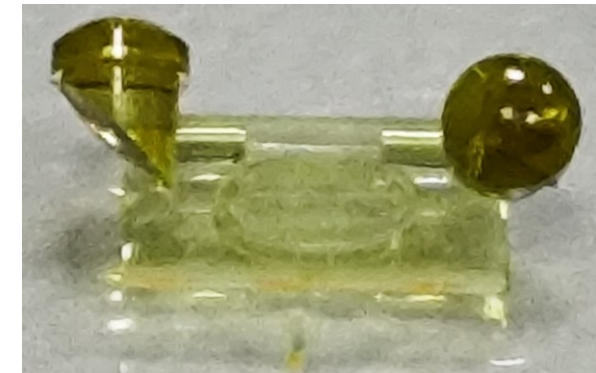
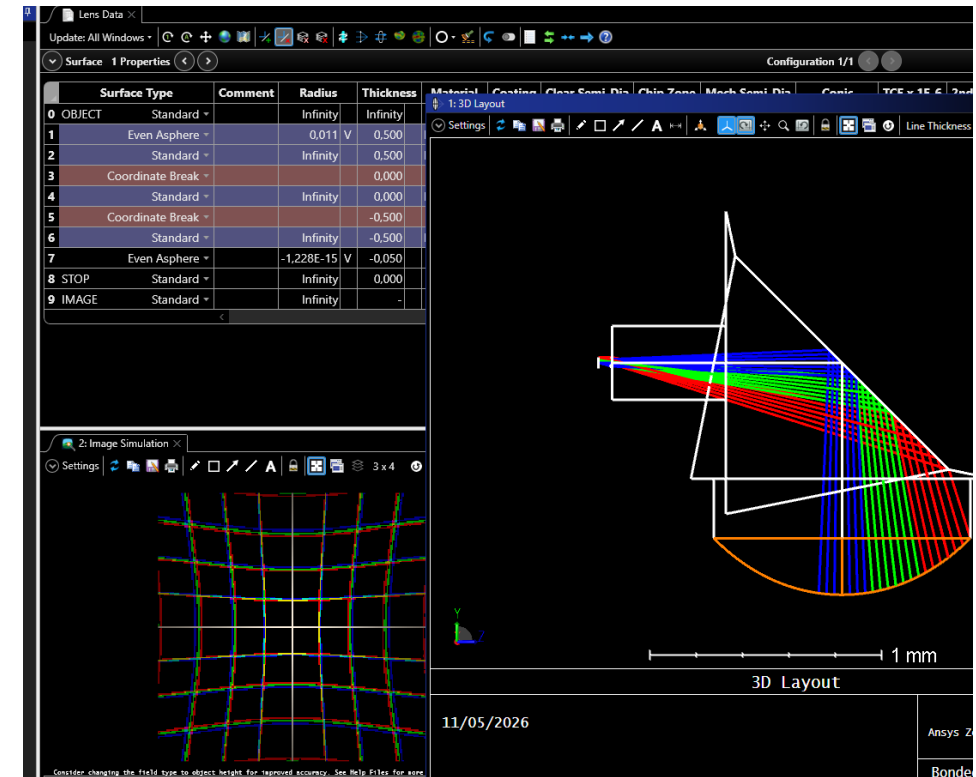
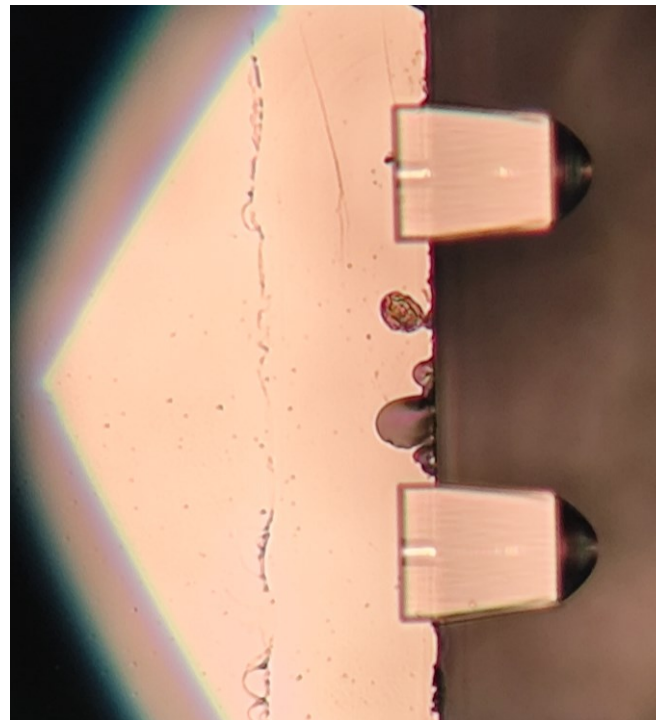


3D Radiation Pattern (Normalized) - Frequency: 100 GHz



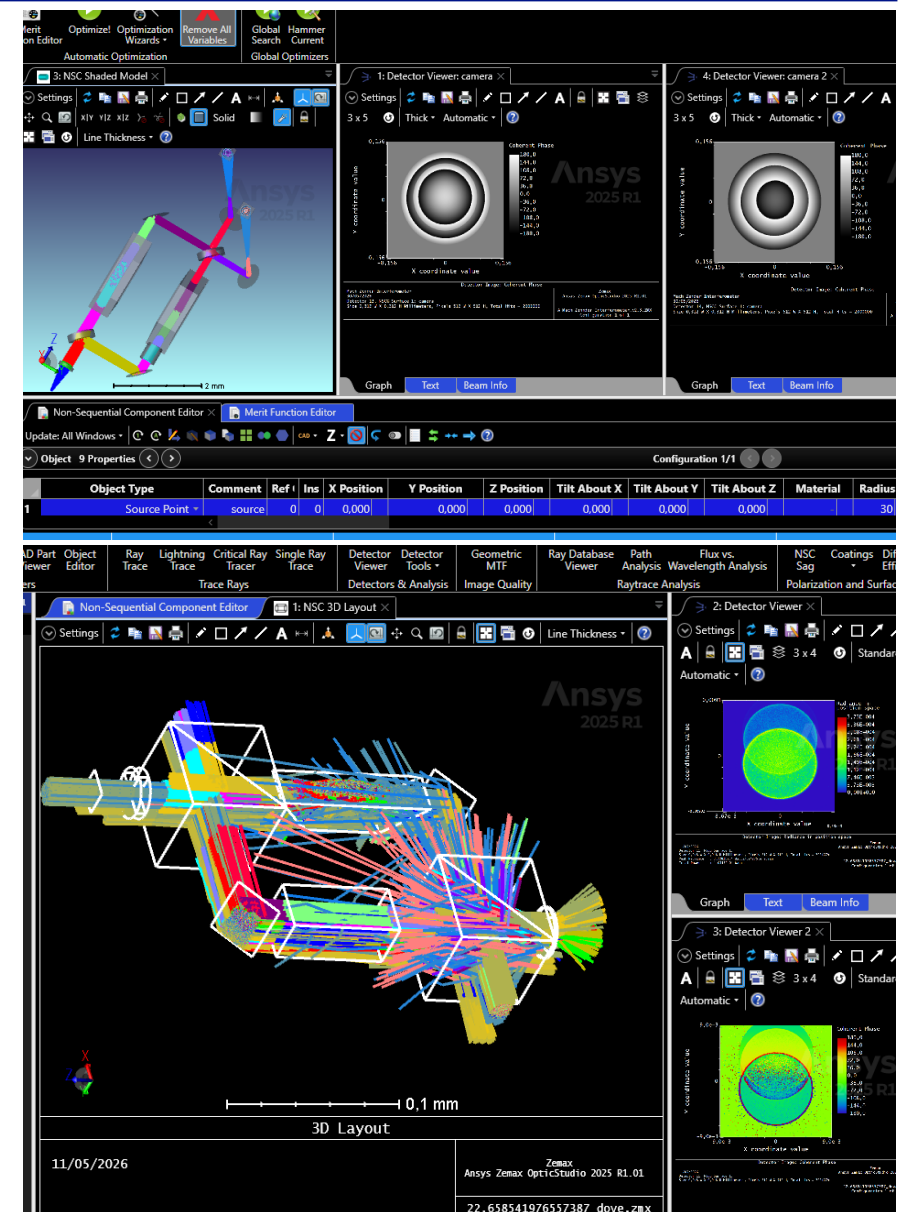
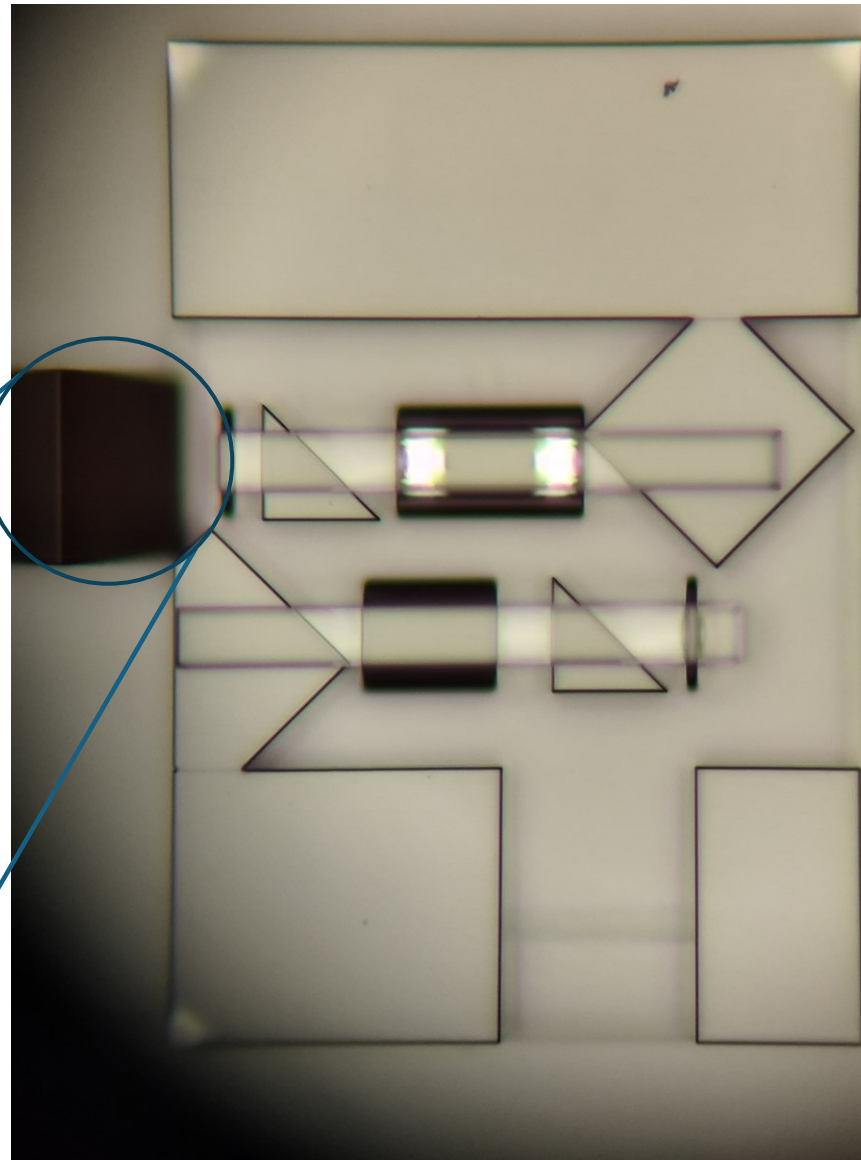
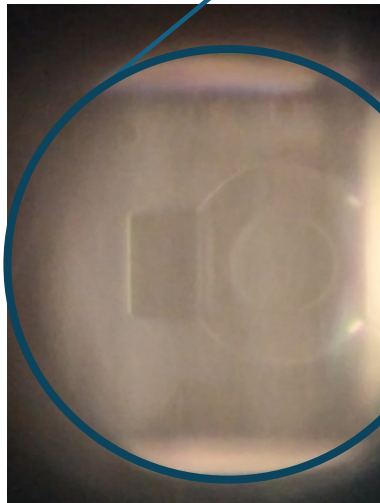
Optical Interconnections: Microlenses fabrication & testing

- Nanoscribe
- Zemax
- Simulations
- Fabrication
- Measurements



Microoptical circuits fabrication & testing

- Nanoscribe
- Zemax
- Simulations
- Fabrication
- Measurements



- Jeppix (PICs test and desing)
- Tyndall (PICs test and desing)
- VLC (PICs test and desing)
- Zemax (Optical system design)

■ Journal Papers

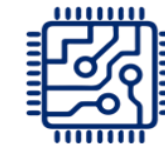
- Rivera, Sergio, Jessica César-Cuello, Daniel Gallego, and Guillermo Carpintero. 2025. "Tunable Band-Pass Filters with Long Periodicity Using Cascaded Mach-Zehnder Interferometer Networks" *Photonics* 12, no. 12: 1154. <https://doi.org/10.3390/photonics12121154>

■ Conference Papers/Presentations

- Rivera, S., César, J., Gallego, D., & Carpintero, G. "Optimizing PIC Design for High Performance using Genetic Algorithms". ECIO 2025 - <https://link.springer.com/book/9783032296726>
- Rivera, S., César, J., Gallego, D., & Carpintero, G. (2026, March). Laser modeling for fast design of photonic integrated circuits. In *Smart Photonic and Optoelectronic Integrated Circuits 2026* (Vol. 13901, pp. 126-134). SPIE. <https://doi.org/10.1117/12.3078442>
- Rivera, S., César, J., Gallego, D., & Carpintero, G. "Efficient THz Generation via Amplitude Intracavity Laser Modulation". IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (Nemo) 2026. Accepted.
- K. Spanidou, L. González-Guerrero, T. Qian, P. Liebermann, S. Rivera Lavado, D. de Felipe, N. Keil, and G. Carpintero, "On-Chip Wavelength Monitoring in a Widely Tunable Hybrid InP/Polymer Photonic THz Source," 2026 Optical Fiber Communications (OFC), Accepted.
- Jessica César-Cuello, Alberto Zarzuelo, Sergio Rivera Lavado, and Guillermo Carpintero, "Study of Thermal Interaction in an Integrated Optical Heterodyne Source", 26th International Conference on Transparent Optical Networks ICTON 2026.



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Thank you! Questions?



EPICPACK

TECNOLOGÍAS AVANZADAS DE TEST
ENSAMBLAJE Y ENCAPSULADO
DE CIRCUITOS INTEGRADOS
ELECTRÓNICOS Y FOTÓNICOS