PATTERN

Next-generation ultra-high-speed microwave **P**hotonic integr**AT**ed circui**T**s using advanc**E**d hyb**R**id i**N**tegration
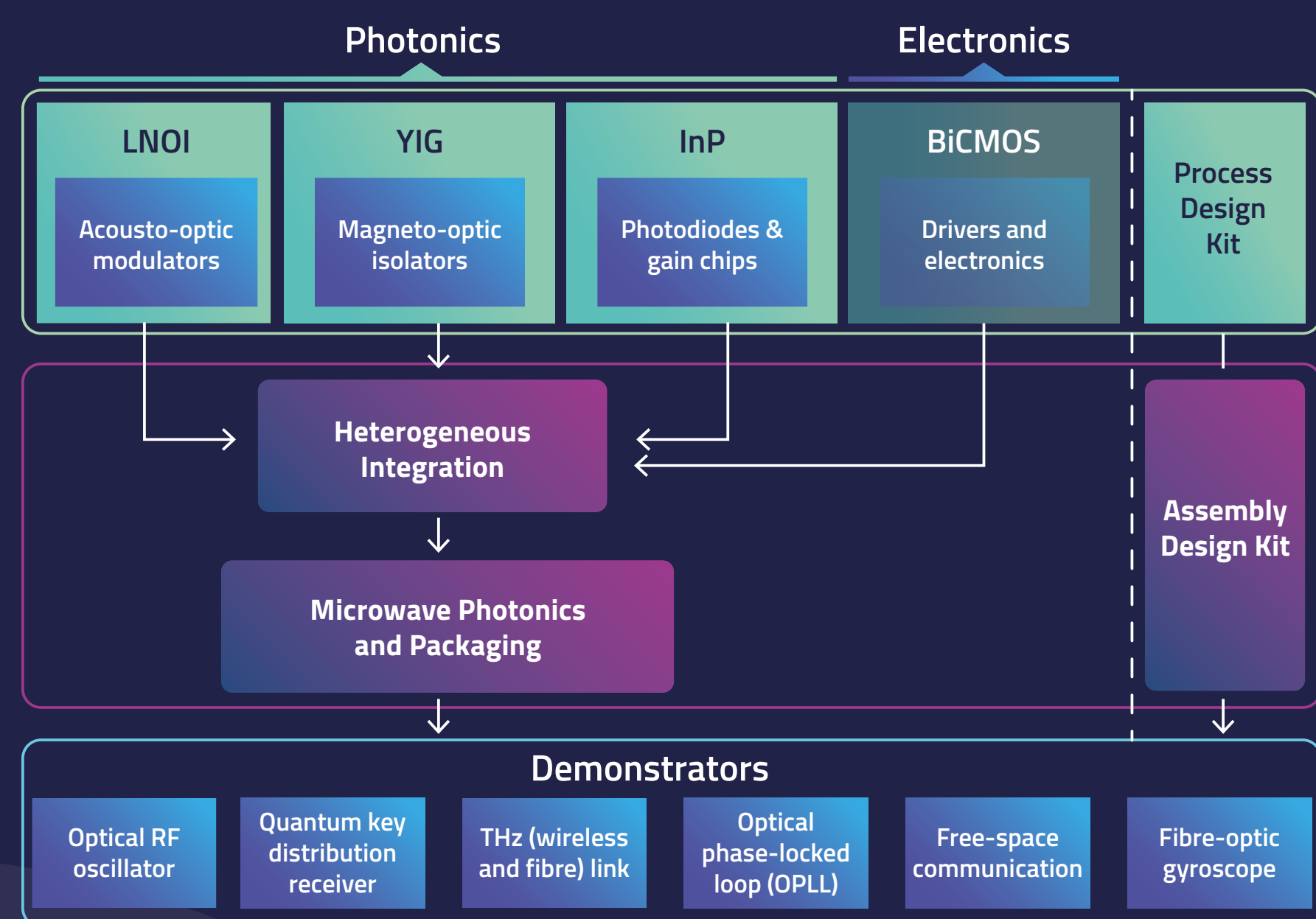
PATTERN'S MAIN GOALS

PATTERN addresses many **challenges in microwave photonics and PICs** at the same time. The main project goals are to:

1. **Integrate all major photonic functionalities on a single hybrid PIC:** light generation, transmission, manipulation and detection, as well as electronic co-integration.

2. Pave the way for a **new generation of advanced PICs** with **unrivalled novel functionalities**, which will serve a **wide range of applications** from telecom and 5G/6G to quantum, LiDAR, optical computing, and sensing technologies.
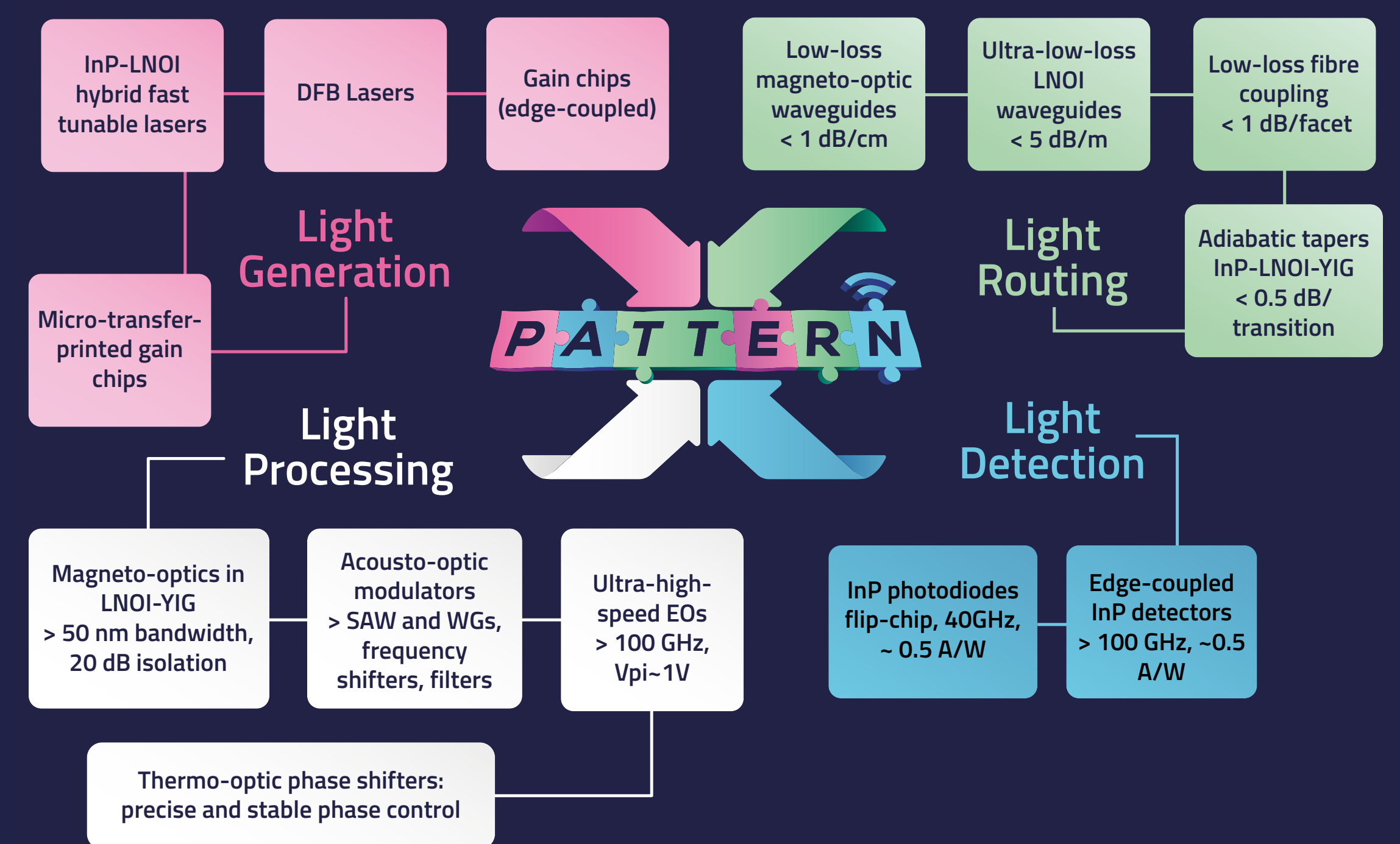
HETEROGENEOUS INTEGRATION METHODS

LNOI

BiCMOS Chip Flip-Chip

InP Chip Flip-Chip PDs

InP Chip Micro-Transfer Printing (µTP) SOAs

Flip-Chip of Photodetectors (PDs)

µTP of Semiconductor Optical Amplifiers (SOAs)

- Flip-Chip PDs
- LiNbO₃
- SiO₂
- Si
- Solder
- InP-MQW
- InP-PD
- InP
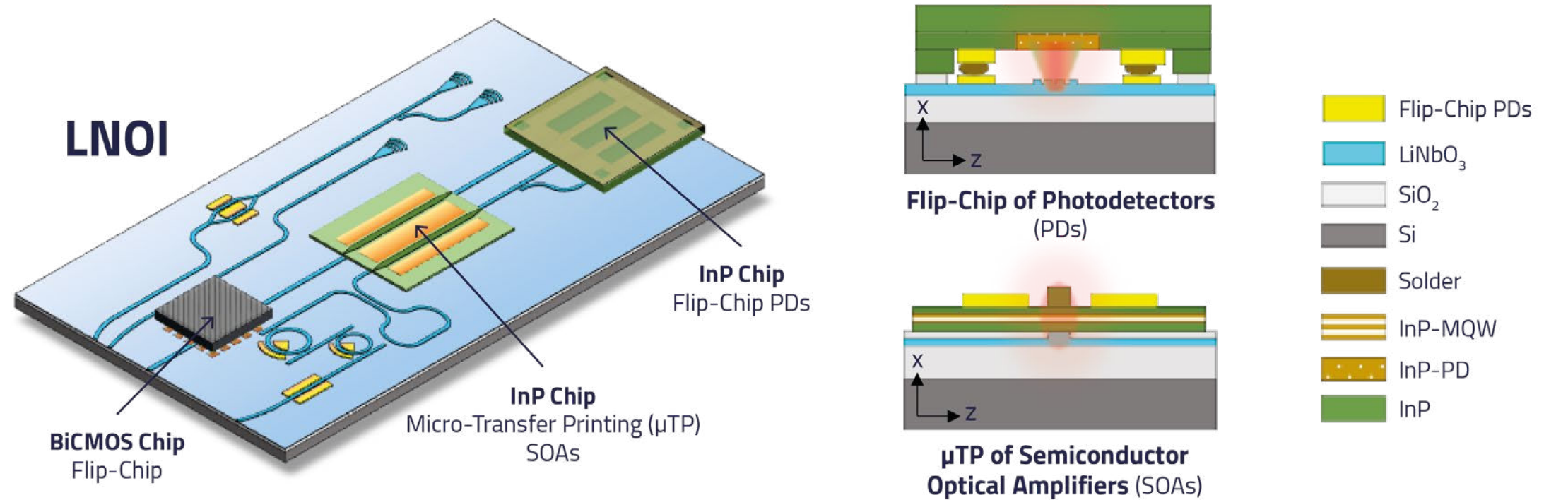
ALL FUNCTIONS ON ONE CHIP

Photonics — Electronics

LNOI	YIG	InP	BiCMOS	Process Design Kit
Acousto-optic modulators	Magneto-optic isolators	Photodiodes & gain chips	Drivers and electronics	

Heterogeneous Integration

Microwave Photonics and Packaging

Assembly Design Kit

Demonstrators

Optical RF oscillator	Quantum key distribution receiver	THz (wireless and fibre) link	Optical phase-locked loop (OPLL)	Free-space communication	Fibre-optic gyroscope

PATTERN'S ALL-IN-ONE PIC PLATFORM

Light Generation
- InP-LNOI hybrid fast tunable lasers
- DFB Lasers
- Gain chips (edge-coupled)
- Micro-transfer-printed gain chips

Light Routing
- Low-loss magneto-optic waveguides < 1 dB/cm
- Ultra-low-loss LNOI waveguides < 5 dB/m
- Low-loss fibre coupling < 1 dB/facet
- Adiabatic tapers InP-LNOI-YIG < 0.5 dB/transition

Light Processing
- Magneto-optics in LNOI-YIG > 50 nm bandwidth, 20 dB isolation
- Acousto-optic modulators > SAW and WGs, frequency shifters, filters
- Ultra-high-speed EOs > 100 GHz, Vpi~1V
- Thermo-optic phase shifters: precise and stable phase control

Light Detection
- InP photodiodes flip-chip, 40GHz, ~ 0.5 A/W
- Edge-coupled InP detectors > 100 GHz, ~0.5 A/W

OBJECTIVES

1. Develop new **advanced PIC building blocks** on an **LNOI platform**, enhance their fabrication quality and yield

2. Develop the **design flow** for the **ultra-high-speed microwave photonic systems**

3. Develop processes for **hybrid integration of InP and Si on top of LNOI** based on
   > **flip-chip bonding** (target specifications: below 1 dB / facet optical insertion losses and < 0.5 dB RF losses)
   > **micro-transfer printing**

4. Develop a **1550 nm LNOI InP fast tunable laser**

5. Realise six **PIC prototypes** for the end-user partners in the PATTERN consortium

6. Develop a platform by **cointegrating BiCMOS electronics with hybrid photonics** to facilitate ultra-high-speed electrical-optical interfacing (FIXME)

Property	InP	On-chip YIG	LNOI	PATTERN Hybrid platform	
Transparency window	0.9 to 2 µm	1.5 to 8 µm	0.3 to 5.5 µm	✓	
Bandgap	1 eV	2.5 to 3 eV	4.9 eV	✓	
Propagation losses	1.5 to 3 dB/cm	3 dB/cm	< 0.1 dB/cm	✓	BiCMOS Integration
Two-photon absorption	High	Very low	Very low	✓	
Electro-optic coefficient	Not intrinsic	No	High (31 pm/v)	✓	
Optical gain	Yes	No	No	✓	
Detectors	Yes	No	No	✓	
Magneto-optics (isolator)	No	Yes	No	✓	
Piezo-electricity (acousto-optics)	No	No	Yes	✓	
Industry status	Ramping up	Academic research	No foundry	✓	

CONSORTIUM

THALES, LUCEDA, phix, Fraunhofer HHI, GHENT UNIVERSITY, imec, cnrs, Microwave Photonics, csem, LP, UCL, University of Cyprus

FOLLOW US

WEBSITE
www.pattern-project.eu

COMMUNITY
in zenodo