



ELENA AIMS TO ESTABLISH

- the first European LNOI-based open-access PIC foundry through the creation of a **Process Design Kit (PDK)** library of standard **Building Blocks (BBs)** for the LNOI PIC platform to enable a large variety of PIC designs, accessible through monolithic integration and combination of BBs;
- a **fully European supply chain for the LNOI PIC foundry** from wafer manufacturing, PIC design and simulations to characterisation and packaging.

OBJECTIVE #01

Develop and mature key passive and active BBs for the LNOI PIC platform as well as a reliable and reproducible BB fabrication process.

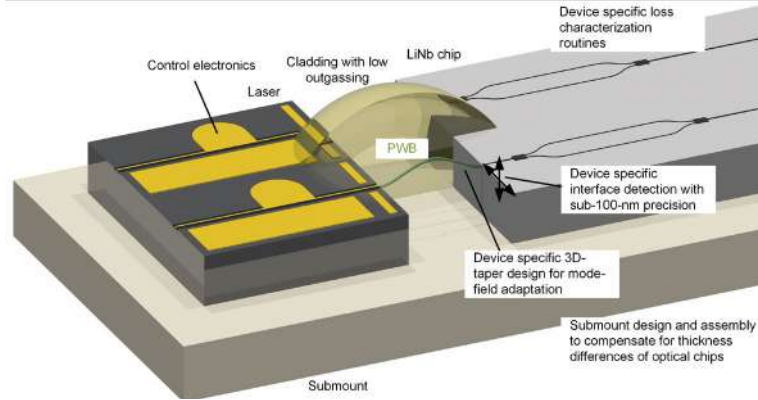
OBJECTIVE #02

Expand the foundry capabilities by integrating indium phosphide (InP) BBs (for light emission and detection) with a flexible and automatic assembly process.

OBJECTIVE #03

Develop a **commercialization strategy** including the key aspects of a supply chain:

- establishing the processes to produce **150 mm diameter optical-grade LNOI wafers** on an industrial scale;
- developing a reliable and flexible method for **packaging LNOI chips and interfacing them with other PIC platforms** such as InP using **3D-printed Photonic Wirebonds (PWB)** for low-cost hybrid integration.



OBJECTIVE #04

Produce **four PIC prototypes** for the end-user partners in the project consortium to demonstrate the **monolithic integration** of the newly developed BBs.

OBJECTIVE #05

Create an **end-user group** and a **strong network of stakeholders** to promote ELENA's LNOI-integrated photonics.

ELENA: TECHNOLOGY DRIVER FOR NEXT-DECADE PICS

HIGH BANDWIDTH

- Exponential expansion of the internet (beyond 400 Gbit/s)
- Next-generation communication technologies (5G/6G)
- New bandwidth-demanding applications (AR, VR, IoT, etc.)
- Cloud computing

LARGE-SCALE INTEGRATION

- Low-loss and compact footprint
- Heterogeneous integration
- Photonic-electronics co-integration
- Programmable PICs

WIDE WAVELENGTH RANGE OPERATION

- Availability of new bands / expansion of optical data link (L-band, S-band, etc.)
- Demand for PICs in new wavelength ranges such as visible and near infrared:
 - quantum computing
 - biosensing
 - Raman spectroscopy

LOW POWER CONSUMPTION

- Fewer joules per bit
- Cost-effective integrated systems
- Versatile packaging
- Low thermal parasitic effects
- Low-loss waveguide

NEW FUNCTIONALITIES

- On-chip nonlinear wavelength conversion
- Optical isolators and circulators
- Acousto-optical modulators
- Narrow linewidth, fast tunable lasers
- Ultra-fast photodetectors
- Entangled/single-photon sources

LNOI – A VERSATILE PIC PLATFORM FOR THE FUTURE



Intrinsic EO coefficient

- Fast (≥ 100 GHz) and low V_{π} (< 1 V) modulators
- Addressing the need for a wider bandwidth
- CMOS-level voltage operation
- Ultra-low insertion loss modulators



Integration and scalability

- Low-loss waveguides (< 0.1 dB/cm)
- Small bending radii ($\sim 30\mu\text{m}$)
- Compact circuit footprint
- Low-power building blocks
- Programmable photonics
- High-port-count switches



Wide bandgap

- LiNbO₃ bandgap = 4.9 eV
- High optical power handling
- Low optical loss
- No parasitic two-photon absorption



Large 2nd and 3rd order optical nonlinearities

- Non-linear photonics and metrology
- Wavelength conversion, 2nd harmonic generation, DFG, and SFG
- Optical frequency combs and supercontinuum generation
- Entangled photon pair generation



Piezoelectric effect

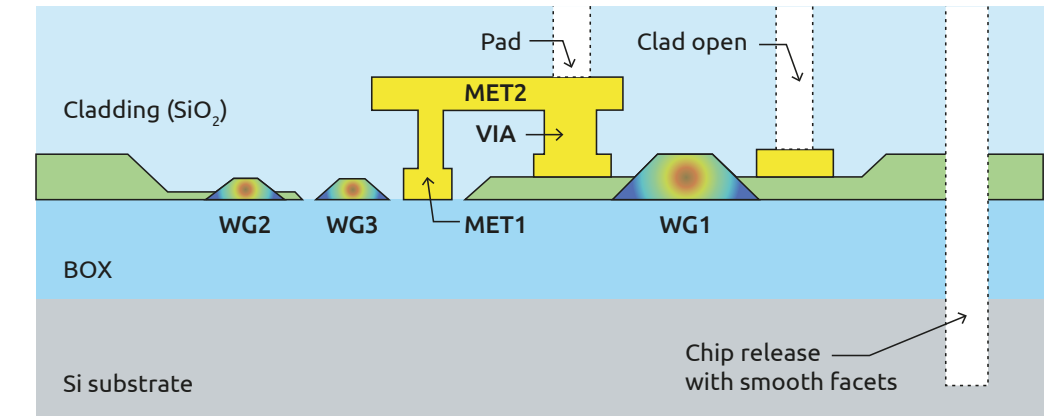
- Acousto-optical modulators (AOM)
- Optical MEMS integration
- Gyros and pressure sensors



Wide transparency window

- LiNbO₃ is transparent for 350 nm to 5.5 μm wavelength span
- Availability of new bands / expansion of optical data link
- Electro-optical light control below μm wavelength (the range in which Si or InP are not transparent)

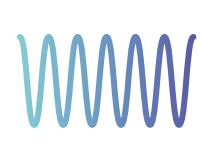
CSEM'S LNOI PIC PLATFORM



Property	Value
Wafer cut	X
Refractive index (ordinary)	2.21 (@ 1550 nm)
Refractive index (ex-ordinary)	2.13 (@ 1550 nm)
Bandgap	4.9eV
Transparency window	350nm - 5.5 μm
EO coefficient	$r_{33} = 31$ pm/V
$\chi^{(2)}$ nonlinearity	3×10^{-11} m/V
$\chi^{(3)}$ nonlinearity	1.6×10^{-21} m ² V ⁻²
Piezoelectric coefficient	$d_{33} = 6.0 \times 10^{-12}$ C/N

APPLICATIONS

Thanks to the unique properties of lithium niobate, an LNOI PIC platform could serve many applications ranging from **telecom** (e.g. supporting ultra-high-speed transceivers beyond 100 GHz), **LIDAR** (e.g. ideal for FMCW LIDAR engines and OPAs) and **space applications** (compatibilities with harsh environments and wide transparency range), to **nonlinear photonics** (e.g. new functionalities such as on-chip wavelength conversion), **optical signal processing** and **optical computing** (e.g. neuromorphic computing), **sensing & spectroscopy** (e.g. on-chip bio sensing at visible and NIR and mid-IR gas sensing), as well as **quantum computing** (e.g. continuous variables, photonics drivers of atomic systems and QKD).



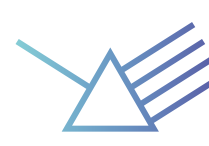
Signal processing



LIDAR



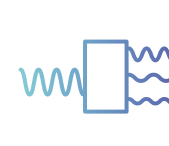
Telecom



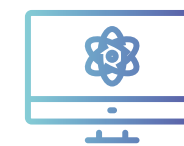
Sensing & spectroscopy



Space

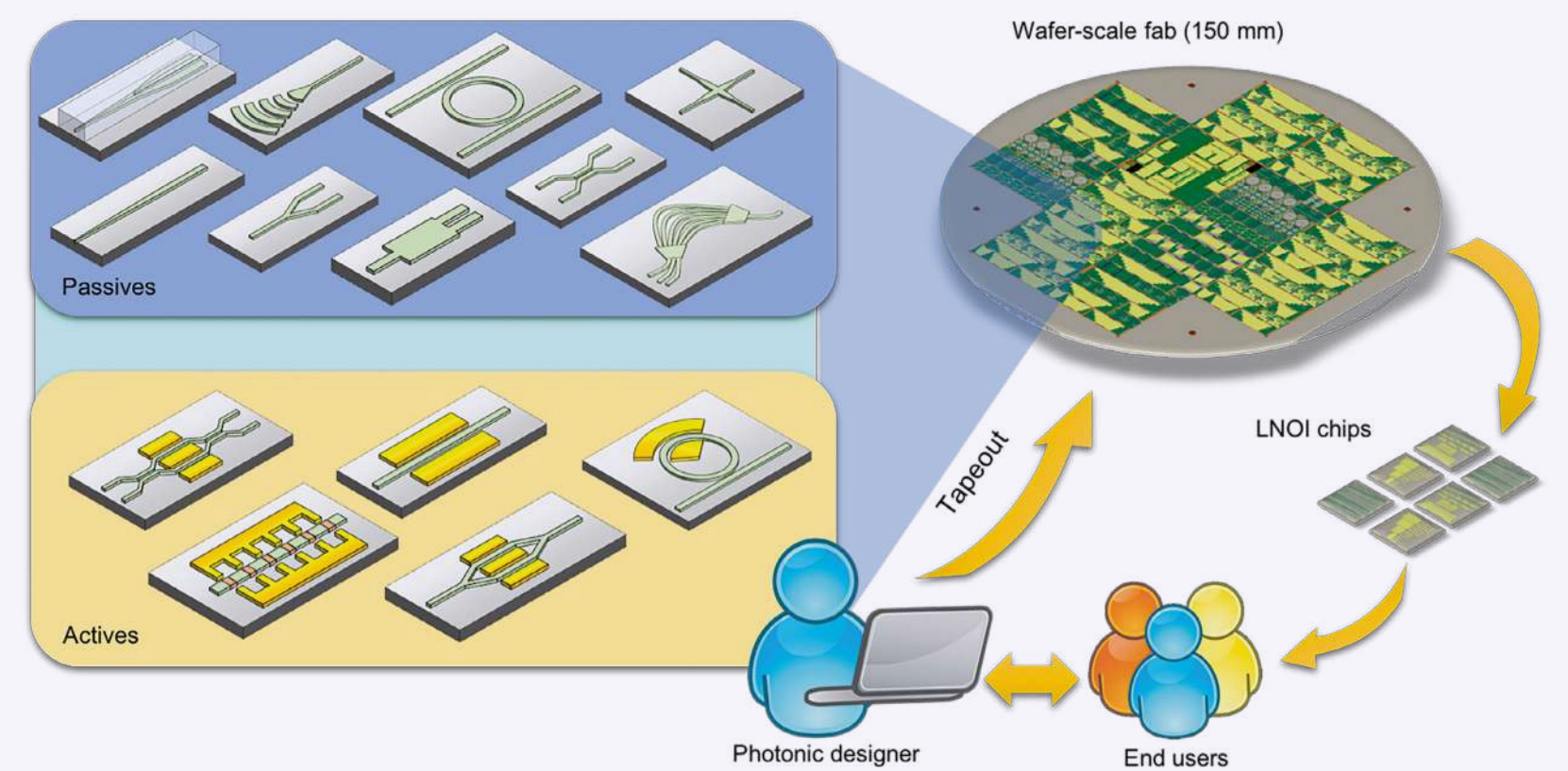


Nonlinear optics



Quantum computing

ELENA'S ENVISIONED LIBRARY OF STANDARDISED BUILDING BLOCKS: TOWARDS THE FIRST LNOI PHOTONICS PROCESS DESIGN KIT (PDK)



CONSORTIUM



IN A NUTSHELL

42 months, starting date: 1/1/2022,
10 partners, EC grant: 5 M€

COORDINATOR

Dr Hamed Sattari, CSEM

FOLLOW US ON

www.project-elena.eu
ZENODO / ELENA community

