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MatEl: PZT and Graphene MATerials innovations for advanced opto-Electronic applications in AR and biosensing

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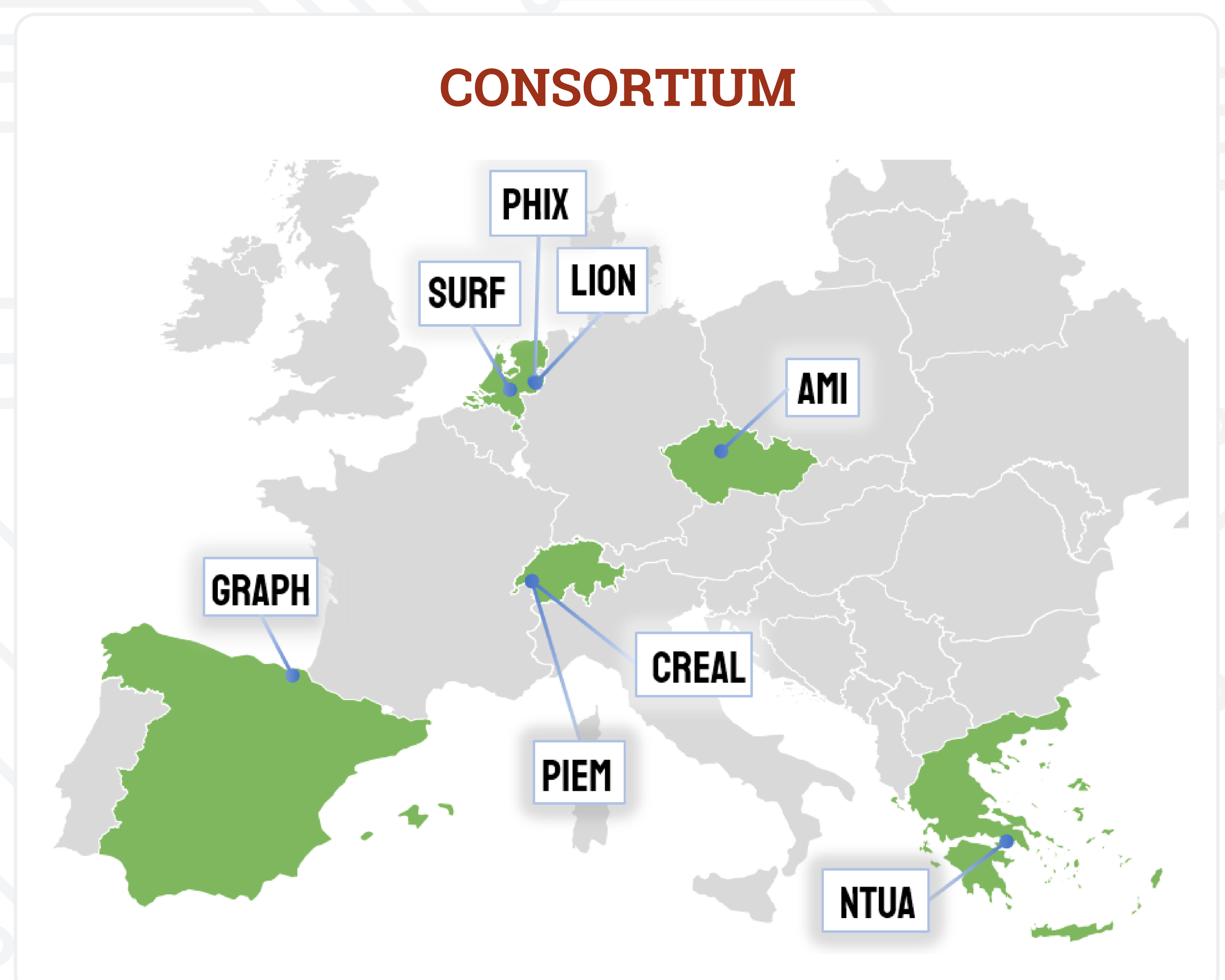
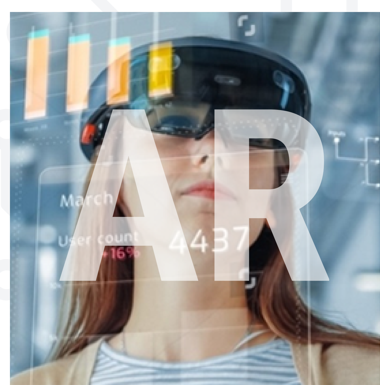
CONSORTIUM



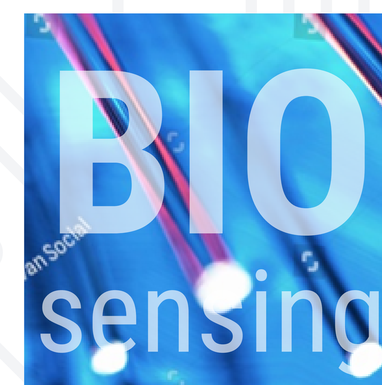
Europe's leading position in photonics and electronics can only be secured by adapting to the next generation of optoelectronic devices requirements: high performance, multi-functionality and cost efficiency in miniaturized footprint. These can only be achieved if novel schemes for on-chip integration emerge. **Silicon nitride** (Si3N4) is a promising candidate for optoelectronics applications; next to silicon photonics and indium phosphide, Si3N4 photonic integrated circuits have broad spectral coverage and low propagation losses. Still, Si3N4 itself has no active effect (except thermal tuning) and active functionality can be demonstrated either by integrating active components or active materials. The on-chip integration of III-V and II-VI semiconductors on Si3N4 is complicated and costly.

The EU-funded project "MatEl" introduces a novel, on-chip integration scheme enabling accurate and fast alignment and bonding of any type of chip package on Si3N4. MatEl will combine **laser transfer** (LIFT) and **laser soldering** processes to demonstrate next-gen applications, which will accelerate the industrial adoption of hybrid **optoelectronic integrated circuits** (OEICs) - offering high-performance, multi-functionality and cost efficiency in a miniaturized footprint. MatEl's innovative solution, enhanced by the monolithic integration of advanced materials – graphene and high-quality PZT, will thus be demonstrated for two selected next-gen devices at TRL5:

APPLICATIONS



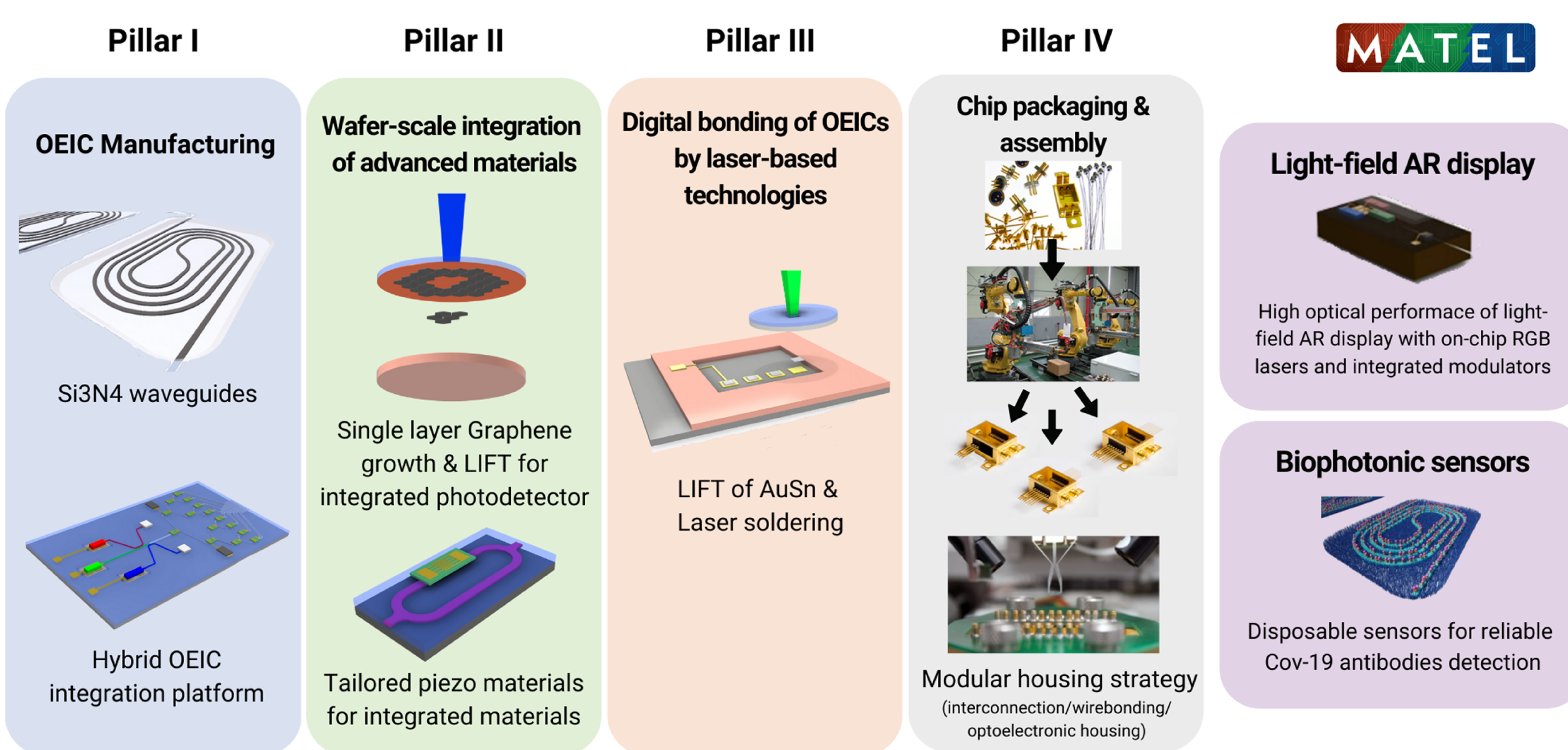
AR display featuring a 2D light source for light-field with on-chip RGB lasers and OEIC-based demultiplexer.

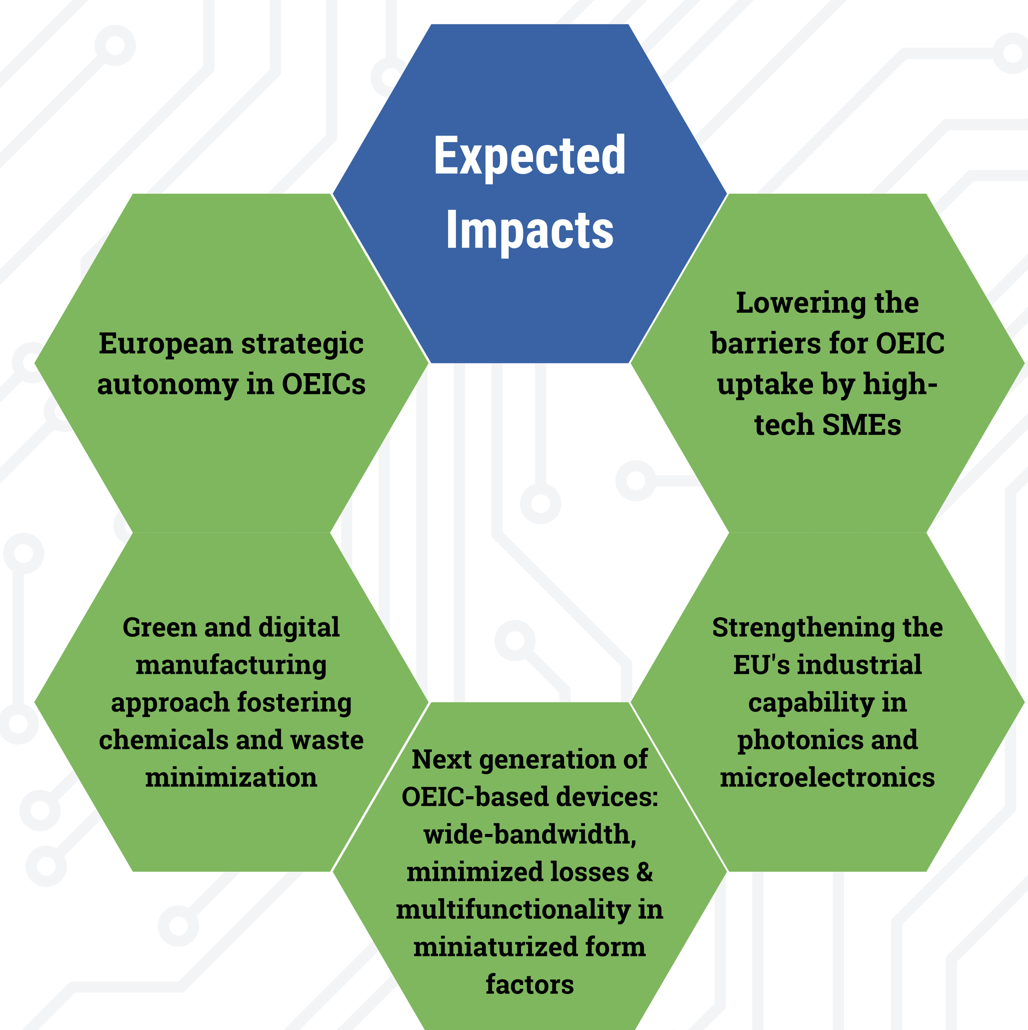


Bio-photonic sensors for reliable and low-cost detection of Covid-19 featuring integrated on-chip VCSEL at 850 nm and Graphene-based photodetector.

TECHNICAL OBJECTIVES

The EU-funded project "MatEl" consists of **four pillars** encompassing new integration schemes for (i) chip manufacturing (**WP2**), (ii) advanced materials integration on OEIC (**WP3**), (iii) Hybrid integration of advanced materials using laser based technologies (**WP4**) and (iv) PIC & IC packaging and assembly technologies in order to enable the development of two use applications (**WP5**). This will be achieved by consistently pursuing the following objectives:





OBJECTIVE 1.

Wafer – scale integration of high-quality and defect-free advanced materials

PZT/ AlScN and graphene integration for on-chip high-speed (GHz) demultiplexers and ultra-sensitive photodetectors (responsivity of 0.36 A/W and response time down to 10 ps), respectively.

OBJECTIVE 2.

To develop a novel Si3N4 wafer platform featuring etched pockets compatible with heterogeneous active components (III-V, II-V chips and electronic chips).

The first Si3N4 platform featuring integrated active and passive components (PZT modulators, graphene-based photodetectors) and hosting active photonic and electronic chips bonded within etched pockets with form factors compatible with III-V and II-VI semiconductor chips.

OBJECTIVE 3.

To introduce the first fully digital, laser-based approach for the bonding of heterogeneous active components on – chip, within predesignated etched pockets.

Laser transfer and laser soldering will be combined offering a high-resolution < 100 µm pitch; < 10 µm height) high-throughput (>100,000 pads /s) and low temperature (<80 oC).

OBJECTIVE 4.

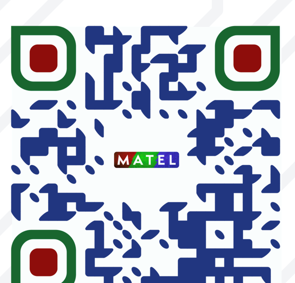
To Design and develop a generic housing for hybrid OEICs with different functionalities

The individual chips' form factors and integrated components will enable the housing into a package ready to be assembled and wire-bonded. The modular concept will have major impact on production systems regarding hardware- and software- tools.

OBJECTIVE 5.

To demonstrate and validate at TRL5 advanced OEICs for two applications:

i) **Display & Recreation**: AR display featuring a 2D light source
ii) **Health**: Biophotonic sensors.



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