Photonic Integrated Circuits and Mid Infrared Sensors in Marine Applications

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Photonics4BlueGrowth
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Santiago de Compostela
The European Commission identifies photonics as one of the key enabling technology, fundamental for the industrial development of Europe.

**EPIC AS DISSEMINATION PARTNER IN EUROPEAN PROJECTS**

A Pilot Line produces small series of prototypes allowing the companies to test the technology before the mass-production.

**Pilot Lines in PHOTONICS**

Maintain the production of photonic technologies in Europe.

**TERABOARD:** High density scalable optically interconnected Tb/s Board

**Pics4All:** Photonic Integrated circuit Accessible to Everyone
1. Marine environmental monitoring
2. PIXAPP Pilot Line
3. The Braavoo Project
4. MIRPHAB Pilot Line
5. Conclusion
Actual detection techniques (such as HPLC) are slow, require sampling and are not real-time. New tools able to detect contaminants in the sea are required.

**ADVANTAGES OF USING PHOTONICS**

- Simplicity
- Fast Analysis
- Low cost
- Small Size
- Ideal candidates to be integrated into existing equipment
- On-Line detection
Overcoming the existing bottleneck in packaging for developing photonic based devices

https://www.pixapp.eu/
The objective is to set-up a pilot line for the assembly and packaging of integrated photonic components. The pilot line should offer generic solutions for a wide class of PICs (Photonic Integrated Circuits)

“A credible strategy to future full-scale manufacturing is expected”
European Packaging Pilot Line (linking the ecosystem)

PIC Applications (Users)

Design

Materials

Devices

Packaging

Equipment

Applications

Medium Volume Manufacturing
Photonic Integrated Circuits
(Si, InP, Si$_3$N$_4$)

Communications
Healthcare
Sensors

PICs for Mass Markets
3 Pillars of PIXAPP

1. Custom Solutions through **Standard Packaging** Technologies

2. **Training & Educating** the Future Workforce

3. **Linking** the PIC Ecosystem through Standards and Roadmaps
• PIC Design for Packaging
• PIC Fabrication Fundamentals (lab-based training)
• PIC Packaging Processes (lab-based training)
• Application Examples (telecom, medical, sensors)
PHOTONICS INTEGRATED CIRCUITS FOR THE OCEAN

BRAAVOO aims to develop innovative solutions for real-time in-situ measurement of high impact and difficult to measure marine pollutants.

The concept of BRAAVOO is based on a unique combination of three types of biosensors, which will enable the detection of both a number of specific marine priority pollutants and also general biological effects that can be used for early warning.

See you in London at Oceanology International?
4 Mar 2016
Are you interested in the latest in marine science and ocean technology? The 48th edition of the Oceanology International Conference is happening in London in

Successful DIY Biosensor Course!
6 Feb 2016
The BRAAVOO Workshop and Creative Design Course, put on in collaboration with BioDesign for the Real World, is already done, and was a resounding success! About 20 biologi...

BRAAVOO Workshop and Creative Design Course!
2 Feb 2016
The BRAAVOO Workshop and Creative Design Course, run in collaboration with BioDesign for the Real World, at the University of Lausanne, is already into its second

The research leading to these results has received funding from the European Community’s Seventh Framework Programme under grant agreement No. 614010 (Project BRAAVOO).

OUR OUTCOMES
Click here to show the public outcomes of the BRAAVOO Project

Biosensors to detect marine algal toxins, pesticides and more
Mid-IR sensors and Applications

Mid Infrared (MIR) light interacts strongly with molecular vibrations. In MIR, each molecule gives a unique adsorption spectrum providing a simple solution for sensing
Monitoring the quality of gas or oil during the extraction process.

On-line warning detection systems for leaks in gas distribution networks.

Protecting transport systems require new sensing tools to detect explosives or drugs.

More stringent environmental regulations will require cost efficient detection tools.

The future of diagnosis; non-invasive blood test, breath analysis and in-vivo imaging.

Vehicle embedded sensors will effectively control engine emissions.
Objectives of MIRPHAB

To be a single-access platform for the prototyping and production of Mid-IR devices in Europe.

To deploy new products swiftly in the market and achieve prompt take up in the environmental and chemical sensing areas.

The final objective is become a sustainable source of key components for MIR sensors.
The MIR Sensor System proposed by MIRPHAB consist of **light sources, passive components** and **IR detectors**.

The wavelength at which the molecule to detect is absorbing will define the source, the PIC and the detection to be integrated in the sensor system.
Training for Platform users

• Why is training important?
  • Bringing the developed processes and tools to a wider audience
  • Improve pick-up of project outcome by 3rd parties
  • Lowering access barriers for novice designers / users of the technology

• What training is needed?
  • Introduction for interested engineers, engineering managers (2 day)
  • “How to use” course for interested engineers (3 day)
  • In depth training for experienced engineers (5 day)
Leading European industrial suppliers of MIR photonics components and first-class European R&D institutes with processing facilities capable of carrying out pilot line production.

### LASER TECH
- Design
- Fabrication
- Test of MIR sources: ICL, QCL in EC or DFB configuration.

### PIC CIRCUITS
- Design
- Fabrication
- Test of passive photonics components on Si, including integration of ICL and QCL sources.

### DETECTORS
Development of novel generations of uncooled III-V based high performance detectors.

### DISSEMINATION AND TRAINING
The whole prototyping and fabrication activity is supported by dissemination and training actions.

### HIGH LEVEL DESIGN
PDK tools for automated design of novel system concepts

### DEMONSTRATION ACTIONS
Demonstration actions are carried out by industrial partners and driven by end-users’s needs. Its functions is to validate the effectiveness of the full fabrication and supply chain.

### BUSSINES DEVELOPMENT
Coordination of the exploitation activities of the project.
## Impact of the MIRPHAB Project

### Economic impacts
- Accelerating the **deployment of MIR-based technologies** along the entire value chain
- Increasing the **competitiveness of European industry** in this field
- Opening a set of **new applications** bringing a response to the user requirements
- Helping MIR sensors to become a **mass market technology** by the miniaturization at chip/device level

### Social impacts
- Design of medical “Points of Care” **systems for non-invasive analysis** of blood, breath...
- Analyzers enabling **safety and quality of food** assessment from farms to consumers
- **Environmental monitoring:** greenhouse gases, air quality and water quality
- Meet the increasing demand for **security** of people, properties, infrastructures and goods
How MIRPHAB works?

Full info at www.mirphab.eu

You can apply for matching funding to develop your prototype
Open Access to MIRPHAB Services

**Full access procedure available on** [www.MIRPHAB.eu](http://www.MIRPHAB.eu)

- Catalogue of the Technologies offered
- Access to “Expression of Interest”
- Access to Templates & guidelines
- Electronic submission

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Submit a Proposal

Single Access Point

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MIRPHAB Market Positioning

The MIRPHAB Model:

• The Role of MIRPHAB is to:
  ➢ Promote MIR applications development
  ➢ Provide FastTrack access to novel devices development
  ➢ Establish the leadership of EU Industry in MIR Sensing
  ➢ Generate New Business Opportunities for European Industry

• Added value of MIRPHAB:
  • High level of miniaturization
  • Standardization
  • Full Supply Chain

Market Evolution

Today

Technology Offer

Tomorrow

Application Driven
Executing a Project

**MIRPHAB**

*Project Activity Record*

**Partial support of MIRPHAB**
- Prototyping
- 10-50%/90-50% ratio

**Fully funded by the customer**
- Prototyping
- 100% Budget from the customer

**Internal Projects**
- Technology Test Vehicles;
- Technology Transfer;
- Prototyping
- 100% MIRPHAB Budget
CONCLUSION

We have presented the PIXAPP and MIRPHAB Pilot Lines as single-access points in Europe for PIC packaging and MID-IR Sensor development respectively. These Pilot Lines open the door for photonics sensor to enter the market addressing different applications such as marine environmental monitoring.
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3. The MIR Sensor System: LASERS

Laser Sources for the 3 - 12 µm wavelength range

**QCL based sources**
- Single DFB emitters
- DFB arrays
- Devices for extended tuning
- Gain chips for µ-EC modules

**ICL based sources**
- Laterally coupled DFB emitters
- Mode matched Devices for integration
- Gain chips for µ-EC modules
- Monolithic DFB arrays
3. The MIR Sensor System: PICs

Integrated photonics based on:

- **SOI waveguide platform** (between 2 and 4.5 µm)
- **SiGe/Si waveguide platform** (between 3.5 and 7.4 µm)
- **Ge/SiGe waveguide platform** (between 7.4 and 11 µm)

Including functionalities like:
- wavelength multiplexers
- spectrometers
- wavelength locker
- on-chip gas cell
- optical interfaces for laser / detector
Detector Structures for the 3 - 12 μm wavelength range
Various concepts based on

**InAsSb Detectors**

**Type-II Superlattice (T2SL) Detectors**

**Quantum Cascade Detectors (QCD)**

- uncooled / TE cooled operation
- packaging and integration routes
  e.g. direct combination of QCD / QCL
- optically immersion

Of general importance for all MIRPHAB components:

- Industrialization of fabrication
- Packaging and integration challenges of laser and detector chips
- μ-assembly of optical components
- Reliability testing in standardized fashion