Partners

The **CIRCULIGHT** consortium consists of 7 research institutions and 2 industrial partners from 6 countries:

France

université PARIS-SACLAY

Université Jean Monnet Saint-Étienne

cnrs

Italy

Politecnico di Bari

Czech Republic

VSB TECHNICAL UNIVERSITY OF OSTRAVA

Germany

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United Kingdom

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The Netherlands

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SMART PHOTONICS Bringing your innovation to life

PHOTONFIRST

The **CIRCULIGHT** is a research project aimed at the development of highly functional, miniaturized, and energy-efficient PICs

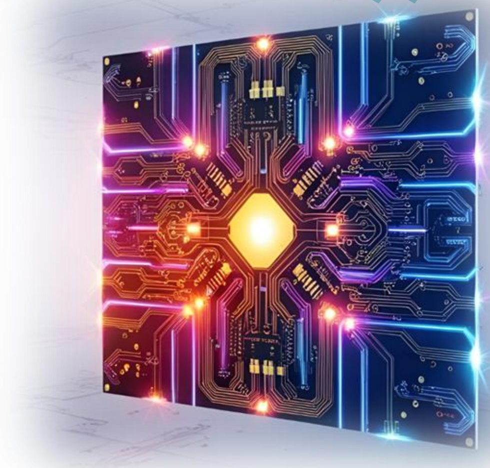
Coordinator:
Dr. **Beatrice DAGENS** (PhD)
University Paris Saclay and CNRS
Centre for Nanoscience and Nanotechnology (C2N)
10 Boulevard Thomas Gobert 91120 Palaiseau, France
Beatrice.Dagens@c2n.upsaclay.fr

Administrative Coordinator:
Mouad EZZAHIR
mouad.ezzahir@cnrs.fr

www.circulight.eu

CIRCULIGHT

CIRCULATING LIGHT ON ANY PHOTONIC PLATFORM



The **CIRCULIGHT** project has received funding from the **Horizon Europe** research and innovation programme.

- **Project Call**: HORIZON-EIC-023-PATHFINDEROPEN-01
- Proposal number:**101129645**
- Duration : 42 months
- Start date : 1/04/2024
- End date : 30/09/2027

European Innovation Council

Aims of the CIRCULIGHT project

The **CIRCULIGHT** project aims to develop highly functional, miniaturized, and energy-efficient Photonics Integrated Circuits (PICs), which are also easy to manufacture and cost-effective.

The focus is on creating an integrated optical circulator, an essential component for the protection, distribution, and integration of optical functions in various PIC architectures. The key will be an approach based on magneto-optical nanoparticle-composite sol-gel material and on the Magneto-BiPlasmonic (MBP) effect, enabling the optical circulator to be integrated monolithically into any photonic platform.

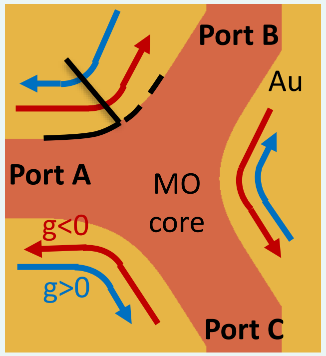
Operational Principle MBP Circulator

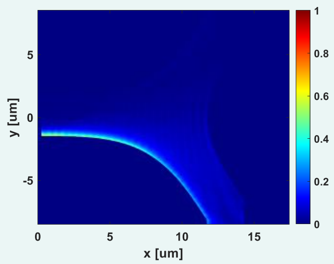
Optical circulator is a nonreciprocal 3-port device that routes light directionally:

- **Port A → Port B, Port B → Port C, Port C → Port A**

This design achieves nonreciprocity via the perturbation of plasmonic mode coupling by the Transverse Magneto-Optical Kerr (Effect (TMOKE).

- **Circulator core**: Central region filled with MO sol-gel composite, containing magnetic nanoparticles.
- **Plasmonic layers**: Metal cladding (e.g., gold) forms the Metal-Insulator-Metal (MIM) slot waveguide supporting Long-Range Surface Plasmon Polaritons (LRSPPs).



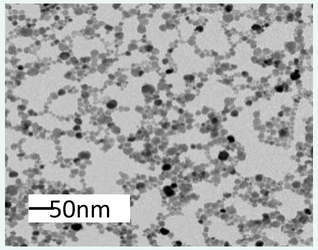


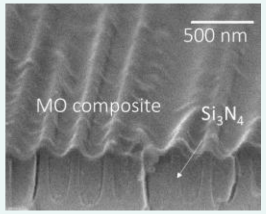
Compact, High-Performance Circulator Design

The circulator will be designed to achieve high mode asymmetry in the core, enabling high isolation ratios. The structure will be compact, with a footprint optimized for telecom integration. Performance will be tuned by adjusting gyrotropy, slot geometry, and material properties, ensuring reliable one-way light routing for practical photonic systems.

Magneto-Optical Sol-Gel Material Development

The project develops a novel magneto-optical (MO) composite using sol-gel technology, allowing liquid-phase deposition and solidification independent of substrate properties. Embedded MO garnet or Co-Fe nanoparticles enable tunable magneto-optical response and refractive index.

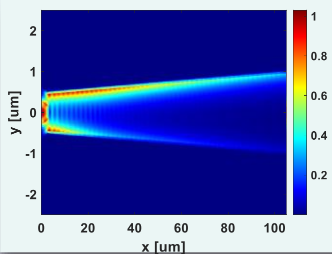


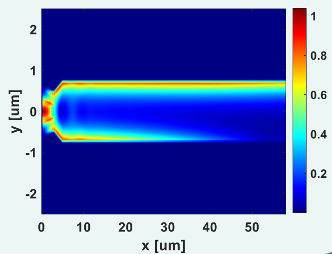


The material supports integration into narrow slits, is compatible with lithography, and maintains optical transparency at telecom wavelengths (1.3 µm and 1.5 µm).

Low-Loss Integration with Photonic Circuits

Efficient integration with photonic integrated circuits (PICs) is a core objective. The project develops tapered transitions between silicon waveguides and magneto-plasmonic slots, using both butt-joint and evanescent coupling. Simulations (FDTD/FEM) and optimization techniques will ensure minimal insertion loss and robust mode matching in the adiabatic (left) and tapered transition (right) with mode-beating principle of asymetrization.



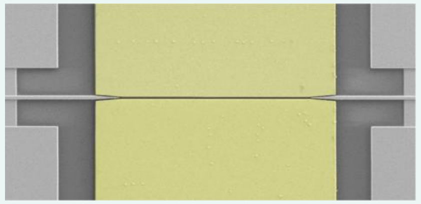


Demonstration of the Magneto Bi-Plasmonic Effect

The project aims to experimentally validate the Magneto-BiPlasmonic (MBP) effect, previously only shown in simulations. This involves generating strong mode asymmetry in plasmonic slot waveguides filled with MO material. The physical effect will be achieved by controlling nanoparticle properties, material magnetization, and waveguide geometry, enabling nonreciprocal light propagation essential for integrated optical circulators.

Monolithic Integration and Proof-of-Concept

To validate real-world functionality, the circulator will be monolithically integrated with a laser and a photodetector on two PIC platform. The system will support applications in sensing, data communication, and telecom. Polarization-independent operation will be addressed through polarization-diversity schemes. This proof-of-concept will demonstrate the circulator's feasibility for compact, low-power, high-performance optical systems.



Societal Impact and Sustainability

We ensure that the **CIRCULIGHT** project is shaped by real-world needs through early and ongoing collaboration with a broad range of industrial and societal stakeholders.

Together, we co-create a circulator technology roadmap, exploring use cases, and identify barriers and enablers for sustainable implementation of the circulator. As part of this process, we study how and when societal impact can be addressed in the development of enabling technologies, ensuring it is meaningfully embedded from the very beginning