Internship subject

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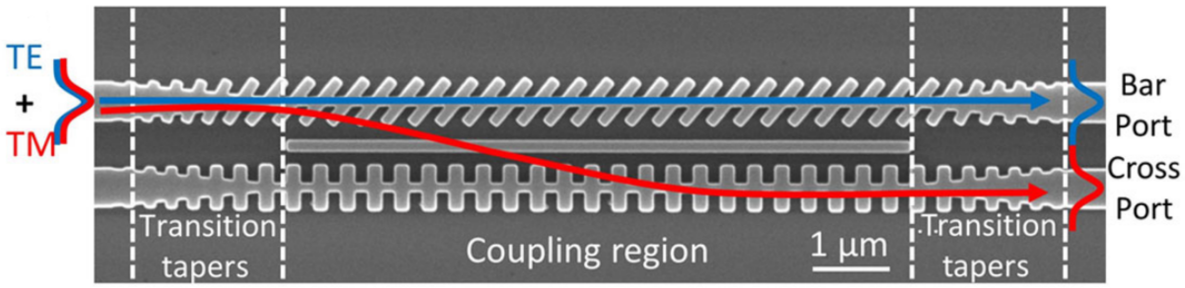
Controlling light polarization with integrated devices

Advances in **nanofabrication technologies** have enabled precise c**ontrol over the behavior of light using nanoscale devices** integrated directly on a chip. **Photonic integrated circuits** offer the potential for ultra-compact devices that can be manufactured at high volumes and low cost. They also provide a unique opportunity to seamlessly integrate photonic and microelectronic functionalities within a single chip.

One of the primary challenges across various applications, such as imaging, optical communication, and both quantum communication [1] and computing [2], lies in the **control and measurement of light's polarization**. Effective polarization management is essential to avoid losses and unintended behaviors, especially in **quantum applications** that use polarization qubits. In these systems, errors cumulate exponentially with the number of qubits, creating a critical obstacle to the scalability of quantum technologies.

While experimental techniques have been developed to precisely control the polarization of light, they are based on classical optical elements (wave plates, lenses, etc.) in free-space optics setups. However, the inherent instability of these systems poses challenges. The integration of polarization control on a chip could overcome these issues, offering significant advantages in terms of compactness, stability, and scalability. Photonic integrated circuits for polarization control show great promise for future quantum applications, combining low optical losses and rapid reconfigurability—essential features for many protocols in quantum communication and quantum computing.



An example of a integrated polarization beam splitter that separates TE and TM polarized light in to two different waveguides

The internship will give the possibility to work on the development of highly performing integrated devices for the control of the polarization of light, e.g., to rotate the polarization state or separate light propagating with different polarizations in different optical waveguides. The main focus will be on passive devices (i.e., whose optical function is fixed during the design) but active components that could be dynamically tuned during operation could be considered as well.

The research activity will be developed within the MINAPHOT (Silicon-based Micro- and Nano-Photonic Devices) and GOSS (Quantum Optics in the Solid State) groups at C2N and it will include, depending on the advancement of the project:

- **Bibliography study** to familiarize with polarization control and measurement and with the fundamental structures that are used in photonics integration for this purpose
- **Design** of selected devices using commercial and in-house software
- Participate in the device **fabrication** in the C2N cleanroom
- **Experimental characterization** of the realized devices to determine their optical response

During the internship, the student will be actively involved in the on-going research activity in the described topic, collaborating with PhD students, postdocs and researchers of different research backgrounds and nationalities. **The research work in this topic can be continued and expanded as a PhD thesis**.

What we expect from you:

- Curiosity for novel research experiences and fields.
- Creativity and pro-activity in the search for innovative solutions and approaches.
- Capability to communicate and share results in a multidisciplinary and multi-nationality environment.

Relevant bibliography

[1] Sören Wengerowsky, et al. 'An entanglement-based wavelength-multiplexed quantum communication network' *Nature* vol. 564, no. 7735, pp. 225-228, 2018.

[2] S. Guerber, et al. 'Broadband Polarization Beam Splitter on a Silicon Nitride Platform for O-Band Operation', *IEEE Photonics Technology Letters*, vol. 30, no. 19, pp. 1679–1682, Oct. 2018.

[3] J. M. Luque-González, et al. 'Polarization splitting directional coupler using tilted subwavelength gratings', *Opt. Lett., OL*, vol. 45, no. 13, pp. 3398–3401, Jul. 2020.