PhD position

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Dispersion management and non linear dynamics in SiGe photonics circuits operating in the mid-IR spectral range

Mid-infrared (mid-IR) spectroscopy is a nearly universal way to identify chemical and biological substances and to perform non-intrusive diagnostics. Indeed, the mid-IR spectral range contains the so-called "fingerprint" region (wavelength from 6 to 15 µm) in which most molecules have vibrational and rotational resonances. This wavelength range can, hence, be exploited to detect small traces of environmentally hazardous and toxic substances for a variety of applications including defense, security and industrial monitoring. **A challenging task is to make mid-IR** spectroscopy **accessible in remote areas, driving the development of compact and cost-effective solutions to replace table-top systems**.

The development of mid-IR photonics circuits thus benefited from a burst of research activity in the recent years. Different solutions are explored for the development of an integrated mid-IR sensing platform. Among them **silicon (Si) photonics can have a major impact for the development of mid-IR photonics by leveraging the reliable and high-volume fabrication technologies already developed for microelectronic integrated circuits**. As a key point for optical spectroscopy and molecular sensing, the optical functions that will be developed using Si photonics circuits **should offer the capability of retrieving the spectrum of a light beam after interaction with the substance to be analyzed**, to detect the presence and quantify the concentration of the molecular compounds.

Ge-rich SiGe photonics has been developed in our group in the recent years, in strong collaboration with Politecnico Di Milano. It has been demonstrated that **graded index SiGe waveguide can be used in a large wavelength range in the mid-IR, and a large range of passive building bloc including Mach Zehnder interferometers [1] or integrated resonators have been obtained [2]**. Then, the demonstration of large bandwidth optical source on chip based on non-linear optical effects of SiGe waveguides[3], and the realization of optoelectronic devices (modulator and photodetector) [4,5] complete the photonics platform.

In this context, the goal of the PhD project is to demonstrate advanced optical function on chip, relying on the possibility to finely tune the dispersion and non linear optical properties of SiGe waveguides. Examples of optical function on chip that will be targeted are :

- On chip mid-IR **frequency combs** that have not been demonstrated so far, relying on Kerr effect in integrated resonators, exploiting either normal or anomalous dispersion
- **Pulse generation and compression** exploiting dispersion controlled SiGe photonic devices
- Coupling of light from **monolithically integrated QCL source** to SiGe photonics circuits.

The research activity will include:

-**Modeling of the photonics devices** (optical, electro-optical simulation using commercially available software and developing code interfaces (python/matlab)
- **Design and fabrication** of the devices in in-house clean room
- **Experimental characterizations** of the devices, using mid-IR optical benches

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References

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