Post-doctoral position:
On chip frequency combs in the mid-IR wavelength range

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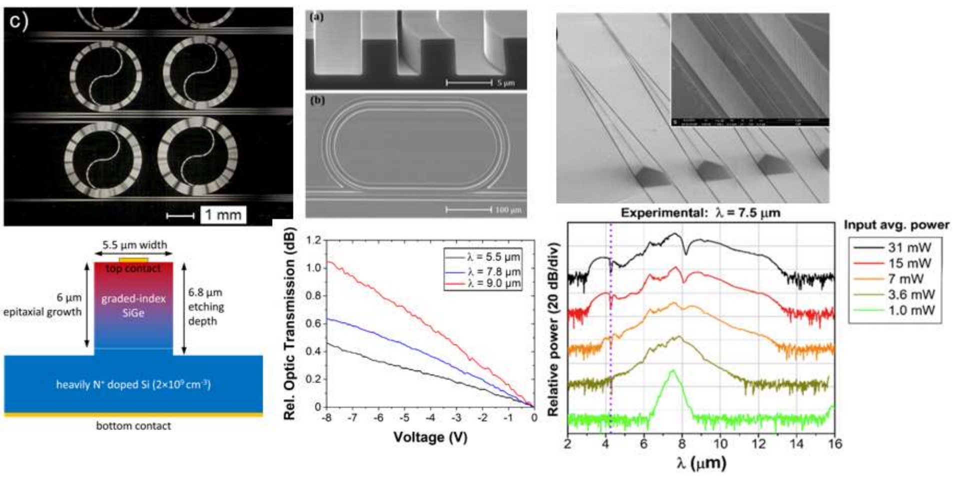
Mid-infrared (mid-IR) spectroscopy is a nearly universal way to identify chemical and biological substances and to perform non-intrusive diagnostics. Indeed, the mid-IR spectral range contains the so-called "fingerprint" region (wavelength from 6 to 15 µm) in which most molecules have vibrational and 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.



Examples of SiGe mid IR photonics circuits (SEM view, schematic view and experimental results)

In this context, the goal of the post-doctoral position is to develop **for the first time on chip mid-IR frequency comb in SiGe photonic integrated circuits based on Kerr effect in integrated resonators. As a main objective, frequency combs will be generated above 6µm wavelength, with typical optical bandwidth of 500cm^{-1}.**

Potential applications are related with dual comb spectroscopy which has been shown to be a unique tool that allows to scan the optical spectrum with high frequency resolution, obviating any step-by-step measurement in the frequency domain.

The research activity will include:

- **Modeling of the dynamics of the frequency comb** generation in integrated SiGe high Q resonators.
- Design and fabrication of the devices in in-house clean room in collaboration with the group members.
- **Experimental characterizations** of the devices, using a mid-IR optical bench already developed in the group

Profil of the candidate

Design, fabrication, and linear characterization of SiGe photonics circuits in the mid-IR are well developed in the group. We are thus looking for a candidate with a complementary experience in the propagation of Kerr soliton in non-linear resonators, including the modeling of the dynamics in the resonator and the experimental characterization.

The work is done in the framework of ERC Electrophot project (2023-2028), in collaboration with L-Ness lab (Politecnico di Milano)

References

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