Driven by the impressive development in the nanofabrication technologies and the nanoscale engineering, silicon photonics has rapidly become the platform of choice for on-chip integration of high performing photonic devices. At the beginning, these photonic circuits mainly targeted the realization of ultra-wideband transceivers for datacom applications, e.g. in big datacenters. However, this enormous technology development has opened new opportunities for Si photonics beyond datacom, with a growing interest in sensing [1], microwave photonics [2] and quantum photonics [3] applications. Aiming to meet the requirements of these envisioned applications, Si photonics is expanding its frontiers by exploring wider wavelength ranges and new physical phenomena. On the one hand, a great effort is being devoted to increase the operation wavelength from the near-infrared towards the mid-infrared, thus covering the full Si transparency window, between 1.1 μm and 8 μm wavelengths [4]. This new wavelength range holds the promise to create exciting new opportunities, e.g. in absorption spectroscopy and nonlinear photonics. On the other hand, light-sound (photon-phonon) interactions in Si waveguides is raising a growing interest [5,6]. Specifically, stimulated Brillouin scattering is being investigated, targeting key functionalities in all-optical circuits and microwave photonics signal processing.

In this context of new applications, new wavelength ranges and new physical phenomena, researches in subwavelength engineering of Si structures can play a key role. Patterning Si with features smaller than half of the wavelength (well within the capabilities of standard large volume fabrication processes) has proven to be a simple and powerful tool to tailor material properties [6]. This innovative approach releases new degrees of freedom in the design of light-matter interactions, chromatic dispersion and light propagation in general. Indeed, sub-wavelength engineering has already been used to demonstrate state-of-the-art performance in several key devices, including low loss waveguides and crossings, micro-resonators, fiber-to-chip grating couplers and power splitters (see Fig. 1).

![Examples of key building blocks based on sub-wavelength engineering, with performances and functionalities that go far beyond what is possible with standard approaches.](images)

**Fig. 1:** Examples of key building blocks based on sub-wavelength engineering, with performances and functionalities that go far beyond what is possible with standard approaches.

The goal of this PhD is to develop new types of sub-wavelength nanostructured silicon photonics devices, targeting ultra-wideband operation and enhanced light-matter interactions.

This work will be done in the framework of the ANR project MIR-Spec, in close collaboration with ST-Microelectronics (www.st.com) and start-up mirSense (www.mirsense.com)

The research activity will include:
- Theoretical study of sub-wavelength engineered devices (using commercial software) extract main relationships between geometrical parameters and properties of the waveguide.
- Fabrication of nano-structured Si photonics devices in our clean-room facilities.
- Experimental characterization of linear and nonlinear properties of developed devices.
VALUED QUALITIES IN THE STUDENT

- 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.

BIBLIOGRAPHY RELATED TO THE TOPIC


