# Master 2/3rd year Engineer internship topic (2023)

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## "Fano resonances in silicon photonics"

## Research project description:

**Silicon photonics** is a key field that has developed considerably in recent years [1]. This strong index core/cladding waveguiding platform allows for extremely narrow waveguides: the cross-section of optical waveguides needs to be reduced to around 450nm×220nm to allow single-mode propagation in the near infra-red (e.g. around 1.55µm light wavelength). This raises the need for specific light injection and extraction techniques like optimized grating couplers but provides the strong interest to also reinforce light-matter interactions due to the extremely large electromagnetic density in optical waveguides. A simple rectangular waveguide capped with a 2D material monolayer or few monolayers of active biomolecules can thus present extremely large optical nonlinearities or sensing sensitivity, respectively. Things are even more reinforced in optical dielectric resonators that can be easily realized through different means including micro-ring resonators (folded waveguides wrapped on themselves) or photonic crystal cavities.

In the vast majority of cases, classical resonators are implemented, i.e. they then present Lorentzian-like resonances.

The **proposed internship topic** will **explore** on the contrary the design and realization of **Fano resonators** in the silicon photonics platform. Such resonances occur from the interference between the coupling of the fields decaying from a narrow resonance and a continuum (a spectrally wide resonance is often enough). They can provide extremely asymmetric transmission and reflection spectra which are very useful for a wide range of applications. Additionally, they can be engineered in-plane or out-of-plane with respect to a semiconductor substrate.

The challenge of the internship is to design Fano cavities bypassing the present state-of-the-art in terms on-demand control of resonance frequencies, large quality factors, control of the far-field patterns.

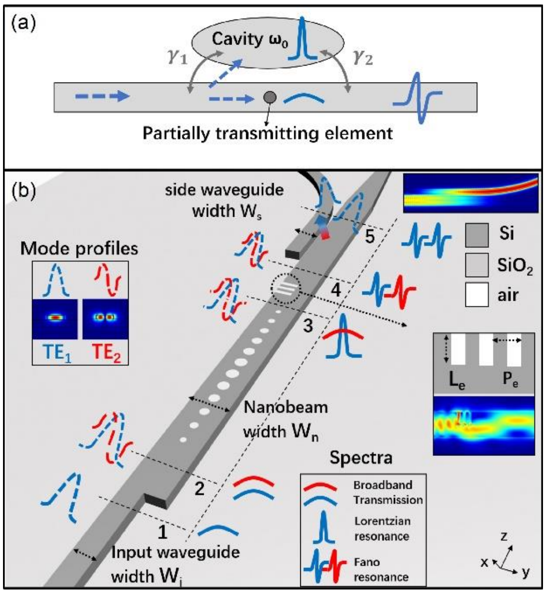


**Fig. 1: Folded Fano cavity in a Si waveguide [3]**

https://minaphot.c2n.universite-paris-saclay.fr

## References:

[1] **"Roadmap on silicon photonics"**, David Thomson, Aaron Zilkie, John E Bowers, Tin Komljenovic, Graham T Reed, Laurent Vivien, Delphine Marris-Morini, Eric Cassan, Léopold Virot, Jean-Marc Fédéli, et al., Journal of Optics, vol. 18 (7), 73003 (2016)

[2] **"Progress in 2D photonic crystal Fano resonance photonics"**
W. Zhou et al., Progress in Quantum Electronics 38 (2014) 1–74

[3] **"Generating Fano Resonances in a single-waveguide silicon nanobeam cavity for efficient electro-optical modulation",** J. Zhang, X. Leroux, E. Durán-Valdeiglesias, C. Alonso-Ramos, D. Marris-Morini, L. Vivien, S. He, E. Cassan, ACS Photonics 2018, 5, 4229.