Proposal of PhD thesis subject

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" Coupled hollow core photonic crystal cavities: a new toolbox in silicon photonics for enhanced light-matter interactions"

Scientific project:

Silicon photonics has raised an increasing interest in the last years due to the foreseen possibility of merging electronics and photonics on the same chips using large scale wafers and well-established technologies. Significant breakthroughs have been demonstrated on optical waveguides and passive optical devices to distribute light, filter optical signals, add-drop individual wavelength around λ=1.5µm, as well as in the field of active structures for light emission, modulation, and detection. The main potential applications of this silicon (on insulator: SOI) photonics technology are optical interconnects within CMOS chips, optical telecommunications, and biophotonics. The main forthcoming challenges are to increase the data bit rates of active components beyond 40Gbits.s^{-1}, significantly reduce their power consumption, reduce the footprint of photonic structures, and improve the sensitivity of SOI-based bio-sensors.

In this view, **we propose in this PhD topic to explore the physics of coupled hollow core waveguide cavities in silicon photonics (Figs. 1 and 2) as a new toolbox for silicon photonics**.

Hollow core cavities (slotted cavities) (see Figs. 3 and 4) are specific resonators with electromagnetic field modes confined in a low index material that can be filled by various active materials (polymers, oxides, etc). Preliminary works achieved in our group have shown that coupled slotted cavities could be described by the tight-binding approach and that arrays of cavities could give rise to a rich physics for application to on-chip nonlinear optics and bisosensing in silicon photonics (see Fig. 4 for the case of two coupled cavities only).

The involved PhD student will enter the Minaphot silicon photonic group of IEF (http://silicon-photonics.ief.u-psud.fr/) and will investigate the properties of slotted coupled cavities. Among the key points that will be explore stems the possible design of Fano resonance cavities and coupled cavities for fast optical switching using electro-optical (plasma dispersion) switching and all-optical switching in silicon photonics. Another direction will be to address the possible use of arrays of coupled slotted cavities to tailor the far-field emission of ensemble of coupled resonators and initiate breakthrough results in their use for sensing.

Additional comments: Our group has already welcome five Chinese PhD students in the last years.

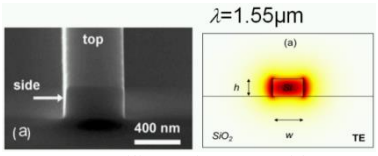


Fig. 1: Silicon wire waveguide

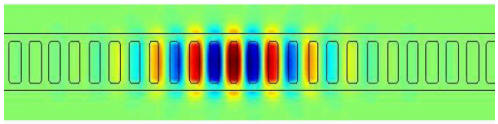


Fig. 2: Nanobeam cavity (waveguide width : 400nm ; λ=1.55µm; shown: electric field of the resonance mode)

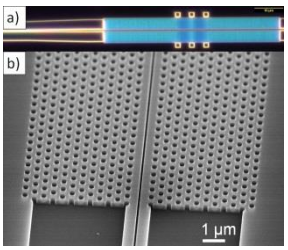
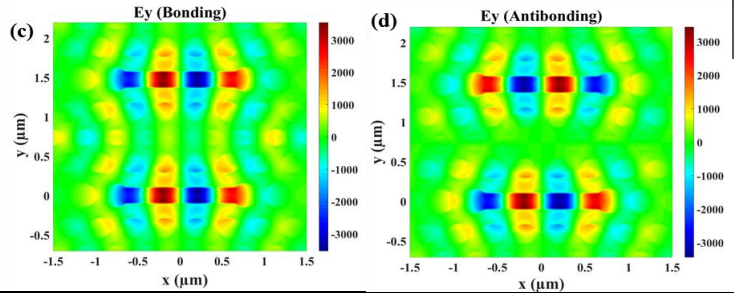


Fig. 3: Heterostructure photonic crystal cavity

Fig. 4: Two coupled slot cavities



If you are interested in this research topic, send an e-mail to eric.cassan@u-psud.fr

This proposal will enter in the frame of a CNRS sino-french research network in Photonics&Optoelectronics gathering 6 French universities and 6 Chinese ones:

PHOTONET: http://www.photonet.cnrs.fr/welcome

Candidate's required skills:
- Taste for electromagnetism, optics, as well as numerical modelling, scientific curiosity
- Hardworking capabilities
- Ability to communicate and work together in a relaxed but studious context
- Very good academic level in your Master program