Master 2/3rd year Engineer internship topic (2020)

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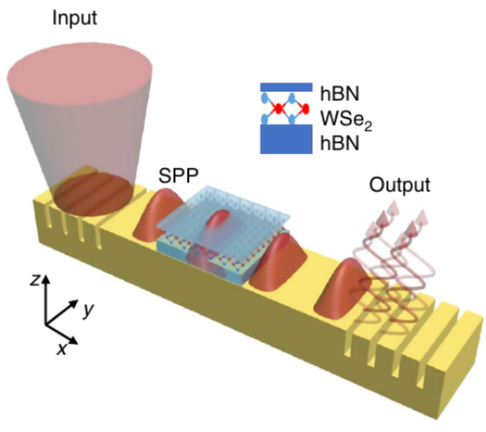
"Nonlinear plasmonic composite waveguides embedding 2D materials"

Research project description:

Integrated photonics is a platform of choice for the realization of various experiments in physics and rich in numerous applications. Among these, one of its branches, **silicon photonics**, has developed considerably in recent years, specializing in the development of optoelectronic and optical components for integration with silicon microelectronics. In recent years, there has been a trend towards a **strong diversification of silicon photonics to various fields** such as quantum optics on a chip, metrology or spectroscopy on a chip at mid infra-red wavelengths (2µm-20µm), and the development of all-optical signal processing functions through the exploitation of second or third order non-linear optical effects. The use of nonlinear effects, particularly of the third order, indeed opens up a whole range of possibilities from the realization of optical sources based on the supercontinuum generation effect to Kerr frequency comb generation, or the ultra-fast switching of signals without conversion to electrical signals. However, **several challenges** remain to be solved in order to achieve the desired functions. The first is that silicon, itself a material with a strong Kerr effect in the near infrared (1.3-1.6µm), also has an important limitation related to the phenomenon of two-photon absorption. In addition, the dimensions of the components, in particular the lengths of the waveguides required to observe significant effects, are often at least a few hundred microns, which limits the possibilities of integration of the structures.

To overcome these difficulties, one possible approach consists in playing on two levers simultaneously: i) Shrink the dimensions of the structures in a very substantial way by using plasmonic effects and devices, ii) Combine this approach by using 2D materials (typically Transition metal dichalcogenide monolayers: TMD) whose optical nonlinear properties can be much superior to those of silicon.

The proposed internship topic is about exploring this issue. The aim will be to inventory the integrated structures with hybrid silicon/TMD plasmonic composite waveguides, to study their properties using optical modelling (solver of modes and extraction of effective parameters, resolution of the non-linear propagation equation, electrical polarization of the structures), in order to identify the best ones and optimize them. A second step will be to design GDSII mask sets for the fabrication of these structures in a clean room (electron beam lithography, etching, etc). Depending on the samples available during the internship period, the recruited student will participate in optical characterization experiments (linear and/or nonlinear) with the team's doctoral candidates.



Courtesy from: (2019)10:3264:
https://doi.org/10.1038/s41467-019-11186-w
| www.nature.com/naturecommunications

BIBLIOGRAPHY:

1) "**Silicon–Organic and Plasmonic–Organic Hybrid Photonics**", Wolfgang Heni et al., **ACS Photonics** 2017, 4, 7, 1576-1590, June 12, 2017.
2) "**Photonics and optoelectronics of 2D semiconductor transition metal dichalcogenide**s", Kin Fai Mak & Jie Shan, **Nature Photonics** volume 10, pages216–226(2016)

Send an email to eric.cassan@u-psud.fr if you are interested in these papers.

We expect from you:

- **Enthusiasm and involvement**
- **Taste for electromagnetism&optics + Taste for simulation (python, electromagnetic commercial softwares) and optical experiments**
- **Ability to communicate and work in a group (4 researchers/teacher-researchers, and around 10 post-doc fellows and doctoral candidates)**