PhD position in NanoPhotonics

Nanostructure-waveguide optical interaction: application to nearfield optical microscopy and photonic integrated circuits

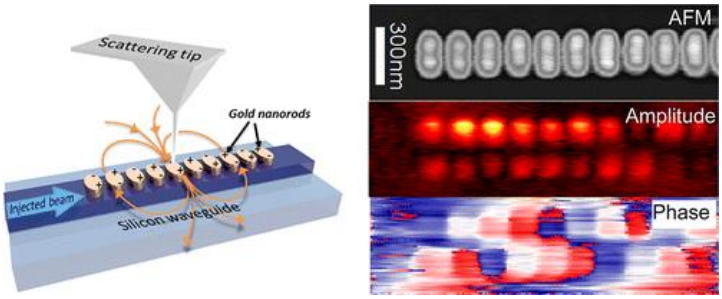

Figure 1: Nearfield optical imaging of a nanostructured integrated pghotonic waveguide. Left: AFM topography and experimental cartography of the complex optical nearfield [4].

The last two decades have seen the development of several revolutionary methods that have allowed access to optical information exceeding the diffraction limit, reaching previously inaccessible scales of the order of some ten nanometers. These technics include near-field optical microscopy (SNOM) and advances in fluorescence microscopy, which were rewarded by the Nobel Prize in Chemistry in 2014 [1].

Beyond the applications of these imaging techniques in the field of biology, they promise many breakthroughs in other fields such as materials physics and photonics at the nanoscale. Indeed, these methods open a way to the measurement of the local density of optical states (LDOS), which represents a major milestone for the full understanding and control of the optical energy transfer processes and more generally the understanding of the light-matter coupling at nanoscale. So far, several experimental and theoretical tracks in this aim have been explored with varying degrees of success.

Recently we studied new experimental approaches where we used the local phase to access to the LDOS [2,3] but also simple SNOM apparatus like the well-known scattering mode [4] and all-fiber transmission or reflection modes [5,6]. However, the experimental rigorous demonstration that quantitative measurements are achievable with these technics still remains to be evaluated. In this thesis, a first stage will be, in collaboration with the experimental team at UTT and in the Institute of Physics in Beijing (Pr. Wei Ding), to explore the different SNOM experimental configurations, both theoretically and experimentally. This work will be carried out in the framework of the FDTD (Lumerical software) and home-made calculation methods (Fourie modal methods) and in interaction with collaborators in charge of the manufacturing and characterization tasks on the NanoMat platform [http://www.nanomat.eu] and also in Beijing.

On the application side, the manufacturing techniques accessible on the NanoMat platform makes it possible to control the energy transfer at the nanoscale and thus to engineer the

energy transfer between a photonic integrated waveguide of for instance some plasmonic nanoantennas, quantum dots, molecules, or a single molecule.

One of the goals that we want to address in the thesis, is the good comprehension of the image formation process in the so-called transmission and reflection modes SNOM configurations [5-6]. This step is essential for a quantitative experimental evaluation of nanostructured integrated optical circuits like the waveguide coupled nanoantenna structure that can provide the desired energy transfer between far field and near field [7-8] or between a single quantum emitter and a waveguide [9].

The Laboratory of Nanotechnology, Instrumentation and Optics (LNIO) is tasked with the development of nano-optics, which addresses a number of technological, scientific and socio-economic challenges. Researchers at LNIO are working on new concepts and approaches, developing both innovative instrumentation and nanocharacterization and nanomanufacturing methods.

Collaboration with China [5-6]:
Dr. Wei Ding, Associate Professor, Laboratory of Optical Physics, Institute of Physics, Chinese Academy of Science, Beijing, China

Skills: For this project, good knowledge in Electromagnetism and Optics are mandatory, with experience in experimental development *and/or* numerical simulation *and/or* knowledge in programming language such as fortran, python and Matlab. A taste for Physics and theory is required, together with good communication skills.

Contact : Sylvain Blaize sylvain.blaize@utt.fr Rémi VINCENT : rémi.vincent@utt.fr;

Key-Words : **Fluorescence, plasmonics, LDOS, phase, Simulation, energy transfer at nanoscale.**

Bibliography:

[1] **2014 Nobel Prize in Chemistry** to Eric Betzig, Stefan Hell and William E. Moerner for their pioneering work in "super-resolution" fluorescence microscopy corroborates its promise for many investigations in physics, chemistry, materials science and life.

[2] E. Castanie, **R. Vincent**, R. Pierrat, and R. Carminati. Absorption by an optical dipole antenna in a structured environment, Intern. J. of Opt. 2012, 452047 (2012).

[3] R. Prasad, and **R. Vincent**, 'Resolving phase information of the local optical density of state (LDOS) with scattering near-field probes', Phys. Rev. B **94**, 165440 (2016).

[4] *Observation of near-field dipolar interactions involved in a metal nanoparticle chain waveguide* Apuzzo, A., Février, M., Salas-Montiel, R., Bruyant, A., Chelnokov, A., Lérondel, G., Dagens, B., **Blaize, S.** Nano Letters, **13** (3), pp. 1000-1006. (2013)

[5] *Imaging of guided waves using an all-fiber reflection-based NSOM with self-compensation of a phase drift*
Sun, Yi-Zhi; Wang, Bin-Bin; Salas-Montiel, Rafael; **Blaize, Sylvain**; Bachelot, Renaud; Feng, Li-Shuang; Ding, Wei, Optics letters,43,20,4863-4866,2018,Optical Society of America

[6] *Standing-wave spectrometry in silicon nano-waveguides using reflection-based near-field scanning optical microscopy*
Sun, Yi-Zhi; Ding, Wei; Wang, Bin-Bin; Salas-Montiel, Rafael; **Blaize, Sylvain**; Bachelot, Renaud; Fan, Zhong-Wei; Feng, Li-Shuang, Chinese Physics B, 28, 1, 010702, 2019

[7] *On-chip hybrid photonic–plasmonic light concentrator for nanofocusing in an integrated silicon photonics platform*,
Luo, Ye; Chamanzar, Maysamreza; Apuzzo, Aniello; Salas-Montiel, Rafael; Nguyen, Kim Ngoc; **Blaize, Sylvain**; Adibi, Ali; Nano letters, 15, 2, 849-856, 2015

[8] *Vector beam generation via micrometer-scale photonic integrated circuits and plasmonic nano-antennae*,
Sun, Yi-Zhi; Bachelot, Renaud; Blaize, Sylvain; Li, Zhi-Yuan; Ding, Wei; *JOSA B,33,3,360-366,2016,Optical Society of America*

[9] *Towards a new platform for quantum photonics applications* ,
Couteau, Christophe; Nahra, Mackrine; Muhammad, Muhammad H; Pierini, Stefano; Xu, Xiaolun; Broussier, Aurélie; Bachelot, Renaud; **Blaize, Sylvain**; *(Conference Presentation),"Advances in Photonics of Quantum*