Nano-structure devices: simulations – fabrication & characterization

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Head of laboratory: Prof. Hans Peter HERZIG
Responsible: Matthieu ROUSSEY

The OPT Lab is investigating the interaction of light with structures where the important length scale is from a few hundred nanometers down to just a few nanometers. The study of nano-optics requires knowledge from various areas: theoretical studies are needed to predict and understand the behavior of light in such environments, highly sensitive and precise equipment has to be designed and built to test the theoretical predictions, and cutting-edge technologies are required for the fabrication of the tiny structures used for this research. The present research fields include photonic crystals, engineered local fields, nano-particles and optical memory.

Simulation of the behavior of light in subwavelength structures (Vincent PAEDER, Qing TAN)

Simulations are at the beginning of each study in the domain of nano-structures. The prediction of behavior of light in such devices is not obvious and requires other techniques than analytical method. In the OPT Lab, different methods are used, from homemade codes or commercial software such as FDTD (finite difference time domain), RCWA (rigorous coupled wave analysis) or PWE (plane wave expansion) for example.

The principal goal of our studies is to design sensors with the highest sensitivity and the smallest size.

Structure materials at the nano-scale (Armando COSENTINO, Yu Chi Chang)

The fabrication of nano-structures is performed in clean room thanks to different high and precise techniques and equipment such as electron beam lithography, lift-off, reactive ion etching in the clean room of the OPT Lab and partially in the CMI (Center of MicroNano Technology / EPFL) also.

Measure of transmission and reflection

Measuring variation of intensity in transmission or reflection or distinguish displacement of a spotlight of few micrometers is generally the methods used to characterize the nano-photonic samples. The main application for our devices is the sensing and this project is linked with bio-photonic projects.
Simulation of nano-structure for solar cell optimization (Ali Naqavi in collaboration with PVLAB)

As the demand for energy grows during time, solar cell technology attracts more attention as a major candidate to provide green power generation. Advancing a viable market for photovoltaic solar energy requests for making a balance between the efficiency of solar cells and their cost. Thin-film photovoltaic cells which use much less raw material compared to wafer-based solar cells can lead to a significant price cut; however, they need light trapping techniques to exhibit acceptable performance. Our aim, here, is semi-analytical or numerical simulation of light-matter interaction in thin film solar cells to optimize their structure using periodic or random interfaces.

Figure 4. Simulation of field enhancement in a grating for a solar cell.

Actual Projects in this field:

- SNF project ELF ‘Engineered Local Field’ n°200021-117930
- SNF project ‘Interface texturing for light trapping in solar cells’
- SNF project NIPP ‘Nano-Imaging with Phase and Polarization: Using multi-heterodyne scanning near-field optical microscopy (SNOM) for nanostructure characterization’, n° 200020-105354

Reference