Student research lab: Modelling of light absorption in solar cells and other nano- and micro-photonics systems

This page contains a description of a student research lab project. To read more about the student research lab concept, go to the full description.

Introduction

How can you design the perfect solar cell? For solar cells to be profitable and competitive with other electricity sources, thin film solar cells have been developed. Thin film solar cells have lower material costs, though the efficiency of the cells is lower than the traditional solar cells. The absorption properties of solar cells can be strengthened by use of surface structures on nano level, which gives resonance in the energy converting material.

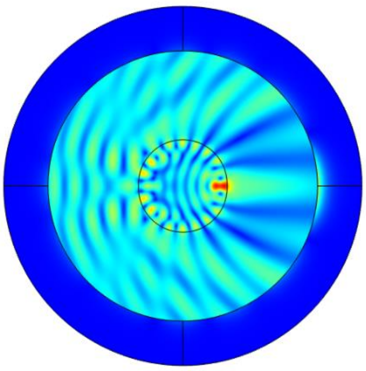

Fig 1: COMSOL-simulations of resonances in a dielectric disc.

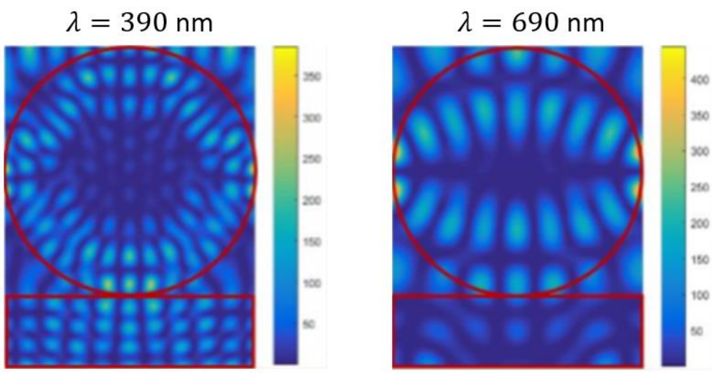

Fig 2: MATLAB-simulations of absorption optimization of a solar cell .

Examples of reseach tasks:

- With the help of the simulation tool COMSOL it is possible to study how physical properties affects scattering and absorption of electromagnetic radiation. The model can be adapted for different use cases, for instance optimization of solar cell design or a fundamental understanding of spectroscopic systems.
- DeepHyperSpec is a project which aims to combine methods in deep learning and multivariate modelling to study scattering and absorption to develop a new paradigm for analysis of hyperspectral imaging. The project is financed by the Research Council of Norway. SRL students can be involved in DeepHyperSpec through simulation of scattering phenomena and development of machine learning tools to characterize hyperspectral imaging.

The research tasks will be finalized in detail with the students.

Tools/methods

The students will through this SRL project get experience with the simulation tool COMSOL, which is based on the finite element method (FEM). The tool comes with the standard package COMSOL multiphysics, and the additional wave optics module is also available. COMSOL is used both in science and industry, for many different purposes, everything from modelling of fluid dynamic to thermal modelling is covered. The students will also get an opportunity to improve their programming skills in Matlab and Python. The BioSpec team has access to two powerful computers (one GPU and one CPU) for expensive computations. In addition, it will be possible to get access to a shared computer facility park at NMBU for even more time-consuming calculations.

Litterature

Articles:

Brandsrud, M. A., Seim, E., Lukacs, R., Kohler, A., Marstein, E. S., Olsen, E., & Blümel, R. (2019). Exact ray theory for the calculation of the optical generation rate in optically thin solar cells. *Physica E: Low-dimensional Systems and Nanostructures*, *105*, 125-138.

Grandidier, J., Callahan, D. M., Munday, J. N., & Atwater, H. A. (2011). Light absorption enhancement in thin-film solar cells using whispering gallery modes in dielectric nanospheres. *Advanced materials*, *23*(10), 1272-1276.

Seim, E., Kohler, A., Lukacs, R., Brandsrud, M. A., Marstein, E. S., Olsen, E., & Blümel, R. (2019, February). Chaos: a new mechanism for enhancing the optical generation rate in optically thin solar cells. In *Physics, Simulation, and Photonic Engineering of Photovoltaic Devices VIII* (Vol. 10913, p. 109131O). International Society for Optics and Photonics.

Ferry, V. E., Polman, A., & Atwater, H. A. (2011). Modeling light trapping in nanostructured solar cells. *ACS nano*, *5*(12), 10055-10064.

Peter Amalathas, A., & Alkaisi, M. M. (2019). Nanostructures for Light Trapping in Thin Film Solar Cells. *Micromachines*, *10*(9), 619.

Master thesis::

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