Review Report on PhD Thesis

Faculty: **Central European Institute of Technology**
Brno University of Technology in Brno

Academic year: **2018/2019**

Student: **Ing. Filip Ligmajer**

Doctoral study program: **Advanced Materials and Nanosciences**

Field of study: **Advanced nanotechnologies and microtechnologies**

Supervisor: **prof. RNDr. Tomáš Šikola, CSc.**

Reviewer: **Dr. Martin Bauch**

PhD thesis title: Advanced plasmonic materials for metasurfaces and photochemistry

The thesis titled "Advanced plasmonic materials for metasurfaces and photochemistry" by Filip Ligmajer presents work in the research field of plasmonics. The thesis is structured into 5 chapters. Chapters 1 and 2 give an overview to the field of plasmonics, while in chapters 3 to 5 original research is presented.

Chapter 1 gives an introduction to the basic theory of plasmonics and the dispersion relations of surface plasmon polaritons and localized surface plasmons are derived. Chapter 2 reviews the state-of-the-art in plasmonic nanostructure fabrication, plasmonic sensing, metamaterials and metasurfaces for light manipulation and introduces the concept of hot electrons. The exhaustive introduction section (chapter 1 and 2) gives an excellent overview of the basic concepts and state-of-the-art research done in the field of plasmonics and provides the groundwork for the subsequent chapters. The way of presentation is excellent and indicates a deep understanding of the topic by the author.

Chapter 3 covers two topics: plasmonics for polarization control and plasmonics for phase control, which are based on two peer-review papers [published in Light: Science & Applications (IF: 14.098 (2016)) and ACS Photonics IF: 6.880 (2017)], which Filip Ligmajer co-authored. An introduction of relevant spectroscopic techniques and setups employed is preceding the results. The emission polarization of a lanthanide-doped upconversion nanocrystal attached to a gold nanorod with additional SiO_2-shell was investigated. The emission showed a strong degree of polarization dependent on gold

nanoparticle orientation and polarization of excitation light. Further the emission was significantly enhanced compared to the case without the gold nanorod. In this work Filip Ligmajer contributed by analyzing experimental data and results of numerical simulations, developing model and co-writing the manuscript. The second topic of this chapter is the phase imaging of periodic silver nanodisc arrays with different periods and diameters by coherence-controlled holographic microscopy. Further 3D phase mapping of a plasmonic zone plate was performed. Filip Ligmajer contributed to this work by developing software for spectra analysis, analyzing experimental data and results of numerical simulations as well as co-writing the manuscript.

Chapter 4 deals with tunability in plasmonics and results of two peer-review publications (both published in ACS Photonics IF: 6.880 (2017)]) are presented. In one of the publication Filip Langmajer is the first-author and in the other a co-author. Firstly, vanadium dioxide is introduced as efficient material for tunable metasurfaces exhibiting a metal-insulator transition and is used in two different ways. In the first study, where Filip Ligmajer is a co-author, a thin vanadium dioxide film is used as a substrate material below periodic gold nanodisks. Active tuning of the localized surface plasmon resonance over a wide spectral range is done by external heating and UV-light pulse. Filip Ligmajer contributed to this work by performing experiments, analyzing data and co-writing the manuscript. In the second study, in which Filip Ligmajer is the first-author, a novel fabrication route for tunable metasurfaces without complex nanolithography fabrication is presented. Vanadium dioxide nanobeams are grown by a single-step pulsed laser deposition and are optically characterized at room temperature and at 80°C. The nanobeams show a remarkably strong switching behavior in the near-infrared. The experiments are supported by simulations, in which several nanobeam geometry parameters are varied and the impact on the extinction spectrum is studied. In this study Filip Ligmajer defined the methodology, performed the experiments, analysed the data and wrote the manuscript.

The last chapter comprises still unpublished work concerning the use of plasmonics in electrochemistry. Firstly, the fundamentals of electrochemistry are thoroughly introduced and a state-of-the-art survey of studies combining electrochemistry and plasmonics is given. Finally, hot-electron transport and photochemistry in WS2-Nanotubes decorated with gold nanoparticles are studied.

The presented thesis comprises a wide range of research topics in the field of plasmonics, which are all of current research interest and help in advancing the field. The diction and presentation of research results is excellent. The figures are of high quality, well-structured and allow for fast comprehension of the presented data. A small section describing the research goals of the thesis would have been beneficial.

In summary, the thesis of doctoral candidate – Filip Ligmajer - documents high quality and amount of work in the field of plasmonics. The thesis covers a wide range of original work in this highly multidisciplinary research domain and proves his excellent skills to carry on independent research, to pursue collaborative research projects, and attractively present achieved results.

In my opinion, the reviewed thesis fulfills all requirements posed on theses aimed for obtaining PhD degree. This thesis is ready to be defended orally, in front of respective committee.

In Vienna date 8.10.2018

Dr. Martin Bauch

CEITEC – Středoevropský technologický institut
Vysoké učení technické v Brně
Purkyňova 123, 612 00 Brno, Česká republika
www.ceitec.cz