

Olga V. Shapoval

SCIENTIFIC REPORT

on the short-visit travel grant of the ESF Research and Networking Programme “Plasmon-Bionanosense”

28 February - 14 March 2013

for the visit from the Institute of Radio-Physics and Electronics NASU, Kharkiv, Ukraine
to the Institute of Photonics and Electronics AS CR, v.v.i., Prague, Czech Republic

TOPIC: “MODELING OF OPTICAL NANOANTENNAS SHAPED AS COMB-LIKE METAL STRIP GRATINGS: INTERPLAY OF SURFACE PLASMON RESONANCES AND PERIODICITY-INDUCED GRATING RESONANCES”

PURPOSE OF THE VISIT

By agreement with the hosts, my work goal was an accurate modeling of 2-D electromagnetic wave scattering and absorption by optical nanoantennas shaped as comb-like metal strip gratings. The proposed Nystrom-type numerical analysis is based on the median-line integral equations obtained using with the generalized boundary conditions and also on the quadrature formulas of interpolation type. Proposed algorithm is numerically efficient and guarantees fast convergence and controlled accuracy of computations. It allows simulating fairly rapidly the scatterers consisting even of hundreds of nanosize noble-metal strips. In particular, in the framework of this short visit I have investigated the interplay between the surface plasmon resonances and the grating or lattice resonances in the vicinities of the wavelengths of Rayleigh anomalies, i.e. caused only by the periodicity and dependent on the number of strips in the grating.

Besides, I have had intensive discussions with the heads and researchers of the host laboratories, the Department of Guided-Wave Photonics and the Department of Optical Sensors of IPE ASCR. We have come to agreement about problems of joint interest in the context of the biosensor application based on the localized surface plasmons and the grating resonances of finite gratings of many gold strips surrounded with the oil or water. Now we plan to carry out a set of the experiments on the plasmon and the periodicity-induced grating resonance properties of the mentioned gold strip gratings in the optical band. Here, the proper parameters of the nanostructures that could be fabricated, measured and modeled theoretically have been discussed in detail.

DESCRIPTION OF THE WORK CARRIED OUT DURING MY SHORT VISIT

During my visit from 28th of February to 14th March 2013 I have done the following:

- studied the surface plasmon resonances emergence on the optical nanoantennas shaped as comb-like metal strip gratings in the optical band in the case of H-polarization versus the incidence angle of the incident plane electromagnetic wave and strip characteristics, such as strip thickness and width and gap size between the strips; both near-field and far-field properties of the associated surface plasmon resonances and especially local field enhancement or focusing effects have been computed;
- analyzed in details the periodicity-induced properties such as the grating resonances, and also combined co-existence of the surface plasmon resonances and grating resonances; characterized their interplay in dependence on the grating parameters;
- presented preliminary results at the joint internal meeting in the Department of Guided-Wave Photonics and Department of Optical Sensors, IPE ASCR;
- wrote a conference paper draft for Proceedings of SPIE: Optics and Optoelectronics (to be submitted in April 2013);
- discussed and came to agreement about the proper parameters of the nanostructures of joint interest that could be both fabricated and measured, from the one side, and modeled theoretically, from the other side, in the context of the possible application of surface plasmons and grating resonances in biosensors.

Thus, the main goal of the short visit has been achieved. It gave me an opportunity to study new area of the biosensor applications of my on-going studies into the surface plasmon resonance and periodicity-induced grating resonances. This was thanks to the expertise of and the collaboration with my hosts at IPE ASCR: Profs. J. Ctyroky and J. Homola. I hope that my work on the project will lead to more permanent research interaction between my home R&D laboratory and host laboratories at IPE ASCR.

Planned publications based on the project work:

O. V. Shapoval, J. Ctyroky, A. I. Nosich, “Resonance effects in the optical antennas shaped as finite comb-like gratings of noble-metal nanostrips,” *SPIE Optics and Optoelectronics.*, to be submitted in April 2013.