Review on PhD thesis

„Plasma-assisted Deposition of Functional Bioactive Nanostructured Films“

submitted by Mgr. Petr Sezemsky

The thesis submitted by Petr Sezemsky is a part of the research on plasma surface interaction for bioactive nanostructured thin films that has been going on in the group of Doc. RNDr. Vit Stranak. The research has been performed in the frame of several international and national co-operations. Study of plasma-surface interaction is very important for the understanding and optimization of process plasmas for treatment of novel and advanced materials, in particular, for biomedical use.

Nanostructured coatings have a bright perspective for present and potential applications as biosensors. In this context, the PhD thesis is related to the development of electro-chemically and optically active sensors for the detection of biomolecules and pathogens. Mr. Sezemsky can demonstrate in his study that the deposition of tailored, nanostructured, and functionalized thin films on optical fibers results in active transducer properties for electro-chemical and optical detection of the related species. For this purpose, for example, he employed and studied ITO films which have been deposited by low-temperature plasma processes. Tailoring of the ITO thin film properties determines the properties necessary for sensitive detection.

Doubtless, the submitted work by Petr Sezemsky is, for my opinion, an important and interesting piece in experimental investigation of plasma-assisted deposition of biosensing films. The results obtained during his research project and described in the frame of this thesis will be highly appreciated by the community. Most of the investigations made by Mr. Sezemsky during the last years have been already published in an amazing number of papers in peer-reviewed journals of plasma research and thin film technology for biomedical applications. The results have also been presented in related conferences, where he was author or co-author, respectively.

The Ph D thesis is divided into three main parts. After a motivating preface describing shortly the background for the need of biosensors and plasma processing, the author provides in the first part information on nanostructured surfaces for biosensing applications and non-thermal plasma-assisted deposition of functional films (“Theoretical Section”). In the second part (“Research Section”) he describes the sensor fabrication for LMR fibers as an active substrate for multi-domain sensors. Finally, in the third part (“Appendices”) related publications for (i) the technology and procedure of sensor fabrication, (ii) the combined electrochemical and lossy-mode resonance interrogation of liquids as well as for (iii) bioactivation of sensors for selective

detection are presented. Hence, the thesis is an extensive cumulative work. The papers of the third part have already undergone a review process during their submission before publication.

At the beginning of the "Theoretical Section" Mr. Sezemsky provides an overview on nanostructured surfaces and their application in biosciences. In particular, he discusses the detection by an optical fiber coated with functionalized nanostructured coating. What about the role of defects which may be induced by high energetic charge carriers during plasma treatment? In the next section, the author discusses carefully the peculiarities of non-thermal plasma-assisted thin film deposition where he mentioned rf-discharges and magnetron sputtering. Although Mr. Sezemsky used mainly low-pressure discharges for his experimental investigations, it would be also interesting to inform about possibilities for biodetector modification by atmospheric pressure plasma sources. Additional information on the diagnostics and measurement of typical internal plasma parameters (carrier densities, electron temperature, potentials etc.) of the used plasma sources would also be useful. However, the basics of the employed gas discharges are clearly presented. Finally, in this theoretical part the author introduces the fundamental phenomena which are essential for biosensing applications in his thesis as, for example, surface plasmon resonance and lossy-mode resonance. For the latter he also discusses in detail the advantages and properties of the electrochemistry of ITO films as analytical tool for the investigation of liquids.

The following "Research Section" is devoted to the most important results of Mr. Sezemsky's experimental investigations. They are impressively illustrated by the various papers listed in the "Appendices". For the demonstration of bioactivation of the fabricated detection sensors the candidate has chosen an exemplary organism (*Borrelia burgdorferi*).

Carefully he describes the technology and procedure of sensor fabrication by magnetron discharges and characteristic dependences of surface roughness, resistivity and lattice parameter of the films on macroscopic plasma parameters (gas mixture, pressure). Is there any effect of negative oxygen ions which are accelerated at almost the total discharge voltage on the thin film properties? The combination of electrochemistry and LMR for sensing of bioactive liquids is presented by several examples. Finally, the possibility for selective detection of different species is given in detail at the end of this section where CV measurements and LMR sensograms are provided.

The presentation of the experiments concerning the preparation of nanostructured biosensing films as well as their application as multi-domain sensors for diagnostics is stringent and quite convincing. The findings obtained show clearly that magnetron sputtering is a promising method for deposition of related (fiber) coatings for biomedical sensing application. Furthermore, very interesting and valuable insight in the interplay between discharge properties, film

composition, morphology, and conductivity and prospective utilization has been obtained in the frame of the submitted thesis. Doubtless, the results can stimulate additional investigations on this interesting subject.

Summarizing, it can be stated that Petr Sezemsky submitted a very good thesis which combines aspects of discharge physics with material science and biomedical sensing. The thesis is well written and the presentation of the achieved results is quite clear. The related literature has been cited and was extensively taken into account by the author. Based on the above stated I can say that Mr. Sezemsky possess both: excellent experimental skills and very good theoretical background.

Definitely, the submitted study is of very high quality, I clearly recommend the PhD thesis of Petr Sezemsky to be defended.

Prof. Dr. Holger Kersten