

Opponent's review on the dissertation

Name and Surname: Ing. Martin Hruška

Title of the thesis:

Utilisation of nanostructured and nanoporous materials for chemical sensors

Opponent: Prof. Sabrina Grassini

The thesis deals with the investigation of the possible application of nanoporous black metals as sensitive layers for chemical gas sensors for air quality monitoring. In particular, the work is focused on QCM sensors and chemiresistors which are deeply investigated by means of a systematic and rigorous methodological approach. From the material point of view, a comprehensive and complete morphological and microstructural characterisation of the black metals layers has been performed by SEM, AFM and XRD, while UV-VIS spectroscopy has been employed for light absorbance and reflectance measurements. Surface temperature treatments and laser direct writing have been also investigated to improve the sensing properties, while functionalisation by SAMs is investigated to add additional receptors.

In-situ impedance measurements during evaporation of black metals thin films is the main technique employed for assessing QCM sensors sensitivity and to investigate the viscoelastic properties of the sensitive layer; DC resistance measurements carried out by means of a specifically designed setup have been performed for chemiresistor measurements.

The main novelty of the research work is the investigation of black metals prepared by evaporation for sensing applications, coupled with the possibility to perform in-situ measurements, following the film growth. Main contributions are seen in the understanding of black metal preparation by evaporation and in providing important insights into sensing capability and viscoelastic properties. The topic is of undouble interest and the obtained results are very promising and constitute a truly important contribution in gas sensing, from both scientific and application point of view.

The thesis is divided in 7 chapters. The first two chapters provide a comprehensive review of the state of the art and introduce the main concepts and advancements in chemical sensors being a strong background for the motivation of the presented work, which is clearly stated; the main research goals are described in chapter 3; chapter 4 and 5 describes the equipment, the methodologies and the software developed and employed; a detailed and clear discussion of the experimental results, together with a summary of main conclusions, are described in chapter 6 and 7; the latter suggests possible future developments, too.

The thesis is well written, in clear language, and well organized; links between the theoretical part and the discussion of the results, as well as among motivation, objectives and achievements, help the reader to follow the research program carried out by the candidate.

It is interesting to highlight that the research program has been modified during the work on the basis of the experimental results obtained, allowing the candidate to expand his knowledge by addressing new challenges and enriching the impact of his research.

The candidate has carried out a noticeable experimental work and the dissertation clearly shows his contribution in the experimental activities, data processing and discussion of the results. The research has been also focused on the optimisation of the evaporation system and the development of software for data acquisition and measurements, further highlighting the candidate's multidisciplinary abilities.

The research work was mainly carried out at the Department of Physics and Measurements of the University of Chemistry and Technology in Prague. During his doctorate the candidate had also spent three research periods in Japan, Estonia and France, which provided him the opportunity to gain experience in networking and research activities at international level.

The main achievements of the thesis have been published in two scientific papers and one recently submitted.

Questions

1. The films deposited via evaporation often present adhesion and robustness problems, also depending on the thickness. Could you please comment this issue? Do you investigate any possible solution?
2. In your work, several black metals have been investigated. Could you please state as a conclusion of your work which is the best solution for the different kind of sensors?
3. The preparation of black metals by evaporation, as you discussed in your dissertation, is a difficult process. Which are, according to your opinion, the main advantages of this production technology respect to the others?

Conclusions

I state that I have carefully studied the dissertation work of Martin Hruška and I have come to the unambiguous conclusion that the work contains original scientific knowledge and demonstrate the excellent author's aptitude for independent creative activity.

Therefore, I recommend the thesis for defence.