

Review of the dissertation entitled:

“Preparation and characterisation of nanostructured materials for electronic gas sensor devices”,
submitted for defence at the University of Tomáš Bata, Centre of Polymer Systems by
Mr. David John Dmonte, M.Sc.

The report is based on the submitted copy of the dissertation and is delivered in paper version back to the address of the Centre of Polymer System, Tomáš Bata 5678, 760 01 Zlín and also in electronic form to the e-mail address studeny@utb.cz.

Finally, I declare that I am not interested in this matter.

The topic of the dissertation

The present dissertation, examines three main areas of research in sensing, focusing on zinc oxide, bismuth ferrite and chromium vanadate.

In the first part, zinc oxide sensors were investigated using material printing to create sensor layers on different substrates. These layers contained ZnO nanostructures prepared by hydrothermal growth. The research focused on optimizing the length of the nanostructures and minimizing agglomeration, which was achieved using polyethyleneimine. The sensing properties were subsequently studied after coating the nanostructures with PTMSDPA and testing the response to ethanol vapor.

The second part dealt with bismuth ferrite sensors, where the nanomaterial was prepared by sol-gel method and applied to the sensor platforms. The material properties for gas analysis were analysed, with emphasis on selectivity, sensitivity and repeatability of the response to NO₂. The third part focused on chromium vanadate sensors, where the nanomaterial was prepared by coprecipitation method and tested on sensor platforms. A similar analysis to the previous section was performed, but this time with an emphasis on the response to NH₃.

Overall, the work focused on the development of gas sensors using original nanostructured materials. These sensors achieved reasonable sensitivity, selectivity and repeatability of response to the gases under investigation without the need for precious metals. The results indicate the potential of these sensors in industrial applications.

Method of processing the topic

The dissertation is clear, written in English in a well understandable language and at a very high level in all aspects. The thesis is conceived in a clear and logical way. After a brief introduction to the subject in Chapter 1, the author briefly introduces the issue of sensors and gas response measurements in the following chapters (Chapter 2), then in Chapter 3 he introduces metal oxides that are suitable for sensing applications and the introductory discussion is rounded off with Chapter 4, where the basic coating techniques are introduced with a focus on material printing, which is further discussed in the practical part of the dissertation.

In Chapter 5, the author sets out the aims of the thesis in detail, followed by Chapter 6, which contains a general description of the list of experimental work, materials, setup and sites at which the research was carried out. The results from each of the 3 areas that the author listed at the beginning of his thesis are very well covered in Chapters 7 (zinc oxide-based sensors), 8 (bismuth ferrite-based sensors) and 9 (chromium vanadate-based sensors). These are summarized by Chapter 10, where partial results and outlook for future research are presented. I also very much welcome and commend Chapter 11, which discusses the contribution of this thesis to the field and thus places it in the context of current knowledge.

Formally, the lack of page numbering of the thesis, which ends with acknowledgements on (the last numbered) page 4 and is missing until page 154, can be criticised. As regards the figures, they are in many cases not sufficiently well differentiated and do not have a uniform style (e.g. different font of the captions). Other criticisms of a typographical nature are rather minor, such as the small and hard-to-read peak labels in Figure 8.5 or the use of the asterisk symbol instead of the dot symbol in equations 2.1, 2.2, 3.1 and 3.2.

Summary and contribution of partial results of the dissertation

In this thesis, the results of three parts of research focused on sensing of different substances using nanostructures were presented. The first part was devoted to the study of zinc oxide, where ZnO-based nanotubes and a new method for the fabrication of gas sensors were successfully developed. Although the desired level of sensitivity could not be achieved without high-temperature operation, the work opened the door for future improvements including the integration of UV sources.

The second part of the results obtained focused on the study of bismuth ferrite, where sensors with high relative response to NO₂ were synthesized. Sr doping led to lower operating temperature and higher response, indicating the potential for low-cost and stable NO₂ sensors. In the third part, chrome-vanadium nanostructures were investigated as NH₃ gas sensors. These showed promising response and detection limits, with the sensors operating without noble elements. Proposed improvements include structural modifications and further testing under realistic conditions.

Overall, the work provided interesting insights and opened the door for further research in the development of gas sensors with higher sensitivity, lower operating temperature and stable performance.

Final opinion

In the present thesis, PhD student David John Dmonte has demonstrated that he has fully mastered the methodology of scientific work, has studied numerous literature on the topic and has produced results in his work that represent an unquestionable contribution to his field, both in the field of theoretical and, above all, experimental work. We should not omit to mention the author's publications to date, where two thematic publications with an impact factor, in one of which he is also the first author and in the other case a co-author, are particularly valuable. It can therefore be assumed that David John Dmonte has thus mastered the presentation at an international forum not only in the form of posters, but also in the form of lectures in English, among other things because his entire work is in English.

Based on the results presented in his dissertation, I believe that the PhD student David John Dmonte has demonstrated the skills and professional qualities necessary to be awarded the Ph. I consider the dissertation a success and strongly recommend it for defence, and I also recommend the award of the Ph.D. degree and recommend the following questions:

During the thesis defence, I recommend asking the following questions:

1. You use the drop-casting method in your work; explain the physical principle of this method.
2. Explain the mechanism (for the BSFO sensor) by which the strontium dopant as a catalyst reduces the output work required for the reversible process and allows for additional binding sites.
3. What effect does temperature have on the response of the sensor and how might a change in temperature affect it?

Brno, April 15, 2024

doc. Ing. Alexandr Knápek, Ph.D.

