

# Review Report on PhD Thesis

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

Academic year: **2019/2020**

Student: **Milena Setka M.Sc.**

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

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

Supervisor: **Assoc. Prof. Ing. Jana Drbohlavova, Ph.D.**

Reviewer: **Assoc. Prof. Gemma García Mandayo**

PhD thesis title: **Nanoscaled polypyrrole for sensing gaseous analytes and volatile organic compounds**

## Topicality of doctoral thesis:

The scientific relevance of developing nanostructured materials that can be applied to gas and vapour sensing is beyond any doubt. Among them, the study of organic materials (Conductive Polymers among them) shows great interest because of their ability to sense the gas at lower temperature than the commonly used semiconductor sensors, decreasing power consumption and opening the door to a wider number of applications (food quality/safety assessment, environmental pollution or disease detection through breath analysis). Despite there are already commercial conductometric sensors, the interest of researching alternative transducing methods, such as the Surface Acoustic Wave principle is highly interesting in order to improve the performance of this type of devices and get a more reliable and accurate detection.

## Meeting the goals set:

The goals set for the thesis work have been successfully achieved:

1. Nanoscaled materials have been synthesized through chemical and electrochemical routes in a repeatable way.
2. The PPy material composition has been thoroughly studied using the pertinent microscopy techniques and also analyses in the presence of different vapours to check their performance as sensing gas.

3. The PPy has been modified with catalytic metals and metal oxide quantum dots and the composition of the resulting materials has been carefully analyzed.
4. The performance of all the aforementioned materials has been researched in the presence of several toxic gases and vapours of high interest in the sensor field in two sensing configurations: conductometric sensor and surface acoustic wave sensor.

#### **Problem solving and dissertation results:**

Low cost toxic gas sensors are being widely researched in the for several applications field, such as the detection of disease markers in the exhaled breath, pollution measurement and food spoilage and/or safety measurement, among others. The novelty of this work focuses on the use of organic materials, namely PPy (a polymeric conductive material), combined with nanostructured or quantum dot forms of metals and metal oxides, and the use of the less researched SAW transduction method, together with the most known conductometric principle.

The thesis shows a high-level research work, with great application potential. First, the most relevant scientific aspects have been covered in the literature review. Then the properties of PPy based materials and their performance as gas sensors for different VOCs has been thoroughly researched. On the whole, five different PPy forms have been synthesized and characterized in depth using microscopy and spectroscopy techniques, even using Raman and XPS for the in-situ gas-surface characterization, with a high scientific interest in order to understand the underlying sensing mechanisms. But the work also covers more applied aspects and low-cost synthesis and fabrication techniques are developed to get chemoresistive and L-SAW structures.

The problems that have arisen have been critically analyzed and proper decisions have been taken in order to solve them and carry on with the research.

#### **Importance for practice or development of the discipline:**

The contribution of this thesis to the knowledge in the discipline is sound. As stated before, the research opens the door to low-cost and high performance toxic gas sensors based in new materials. The results obtained regarding sensitivity and limit of detection of the devices, show the feasibility of using the developed sensors in a wide number of different applications. Moreover, the impact of this work in the scientific field is supported by the journal publications and presentations in international conferences of relevance in the field.

#### **Formal adjustment of the thesis and language level:**

Methodology and exposition are high level. The chapter structure of the thesis is clear and follows the steps taken to carry out the work. The redaction is easy to follow. Only a small number of minor mistakes have been found.

The review chapter covers all the relevant aspects in a synthetic and clear way. The data presentation and analysis has been very thoroughly carried out. The graphs are clear and well explained within the text. The discussions about the target of the research and the means to reach it are extensive. The bibliography is updated and pertinent in all the chapters.

**Whether the dissertation meets the conditions specified in § 47 paragraph 4 of the Act below:**

(4) The study is duly completed by a state doctoral examination and the defense of a dissertation, which proves the ability and readiness for independent activity in research or development or for independent theoretical and creative artistic activity. The dissertation must include original and published results or results accepted for publication.

I can state that the study is duly completed for a doctoral examination and the defense of a dissertation. The ability and readiness for independent activity in research or development has been proven. The dissertation includes original and published results..

**Questions and comments:**

As stated before, the thesis shows a material research and application-oriented scope. The main achievement is the successful development of PPy based L-SAW sensor with a remarkable performance for VOC sensing. The topic is both scientific and application-oriented, with all the relevant aspects properly covered with the depth expected in a high-standard thesis work.

**Conclusion:**

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 San Sebastián, date 23<sup>rd</sup> of June 2020

Assoc. Prof. Gemma García Mandayo