



**UNIVERSITI PUTRA MALAYSIA**

***INFLUENCE OF PLATINUM ON STRUCTURAL THICK FILM GAS  
SENSOR BASED ON LANTHANUM OXIDE-DOPED TIN (IV) OXIDE FOR  
CARBON DIOXIDE DETECTION***

**MARYAM EHSANI**

**FK 2014 60**



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CARBON DIOXIDE DETECTION**

**By**

**MARYAM EHSANI**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
in Fulfillment of the Requirements for the Degree of Master of Science**

**January 2014**

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## DEDICATION

*This master thesis is dedicated to my dear parents and sisters  
for their endless love, support, and encouragement*



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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SENSOR BASED ON LANTHANUM OXIDE-DOPED TIN (IV) OXIDE FOR  
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By

**MARYAM EHSANI**

**January 2014**

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**Faculty: Engineering**

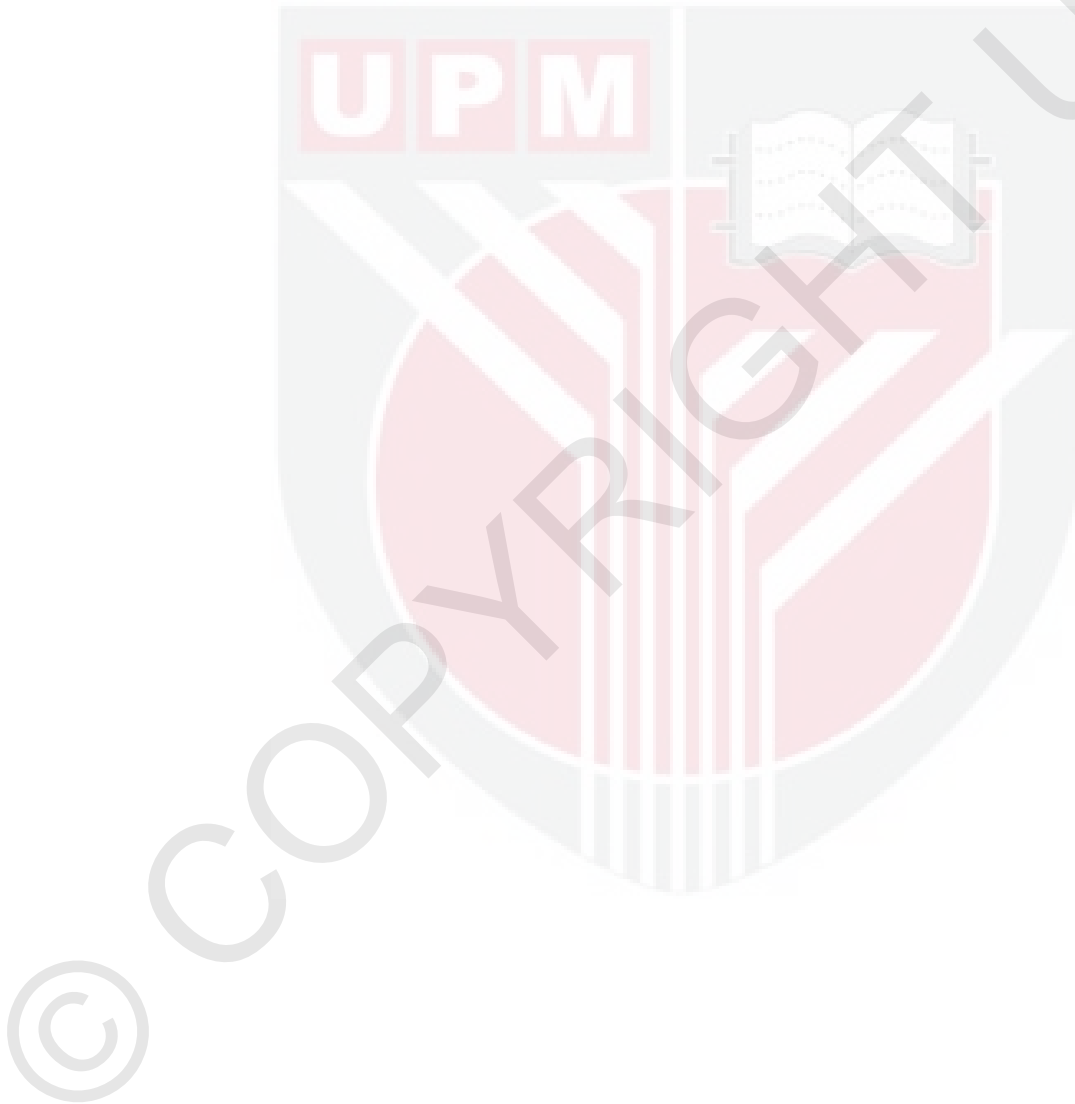
Industrialization in societies has increased the needs of gas sensor technology for natural reservation and cover numerous kinds of toxic gases and chemical compounds. The carbon dioxide gas, one of the primary greenhouse gases in the earth's atmosphere, which is increasing with the revolution of the industry and human activities such as combustion of fossil fuels and deforestation. Although carbon dioxide gas is one of the odorless greenhouse gases, it is harmful for animal life and human health in high concentration. Different kinds of detectors are used to detect the carbon dioxide gas, but they have disadvantages such as high cost, needs of maintenance and regular overhaul.

There are different types of solid-state gas sensors, with several fabrication methods. The thick film technique was proven as a promising and low cost fabrication method because of the controllable film thickness, thermal and electrical properties of thick-film substrate, integration of printed elements, and structure resolutions. These devices have high-power consumption and unsuitable sensing properties. Different metal oxides and noble metals were typically used to improve the sensing properties of sensors.

The main goal of this study is to fabricate a gas sensor, based on mixed metal oxide material using thick film technology and improve the sensor sensitivity to carbon dioxide gas by adding of platinum (Pt). Choosing platinum between other noble metals such as Ag is because of its high thermal conductivity and non-corrosive property in faced with carbon dioxide gas.

The process of fabrication consists of three main elements that include the heater, electrode, and a sensing layer which are printed over an alumina substrate. Pt paste was used for the heater and electrode layers, and  $\text{La}_2\text{O}_3/\text{SnO}_2$  was utilized as a sensitive paste. Modification of sensing properties of the sensor and film morphology was carried out using Pt Nano-powder. The thermal treatment process was applied for all printed layers in order to dry the solvents and stabilize the sensitive layer over alumina substrate. Finally, sensitivity of the fabricated sensor was measured in presence of different carbon dioxide gas concentration.

Crystalline size of sensitive material were analyzed by X-ray diffraction (XRD) analysis. The results showed that the particles size and phase shift of sensitive material were less than 30 nm and 20 nm, respectively. Sensing properties of all fabricated sensors were measured and compared to TGS 813 commercial gas sensor. The results showed that  $\text{La}_2\text{O}_3/\text{SnO}_2/3 \text{ wt. \% Pt}$  had better sensitivity up to 4.38 to carbon dioxide gas compared with sensitivity of 0.64, 0.32, and 0.005 for TGS 813,  $\text{La}_2\text{O}_3/\text{SnO}_2/1 \text{ wt. \% Pt}$  and pure  $\text{La}_2\text{O}_3/\text{SnO}_2$  gas sensors, respectively.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

**PENGARUH PLATINUM MENGENAI STRUKTUR TEBAL FILEM GAS  
SENSOR BERDASARKAN LANTANUM OKSIDA DIDOPKAN TIN (IV)  
OKSIDA KARBON DIOKSIDA PENGESANAN**

Oleh

**MARYAM EHSANI**

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Perindustrian masyarakat, meningkatkan keperluan pembangunan teknologi sensor gas kepada tempahan alam sekitar dan meliputi pelbagai jenis gas toksik dan bahan kimia. Gas karbon dioksida, salah satu daripada gas-gas rumah hijau utama di dalam atmosfera bumi, telah meningkat dengan revolusi industri dan aktiviti manusia seperti pembakaran bahan api fosil dan pembasmian hutan. Walaupun gas karbon dioksida yang dikenali sebagai gas rumah hijau tidak berbau, ia adalah berbahaya untuk haiwan dan kesihatan manusia dalam kepekatan yang tinggi. Pelbagai jenis pengesan digunakan untuk mengesan gas karbon dioksida, tetapi mereka mengalami kelemahan seperti kos dan keperluan penyelenggaraan dan baik pulih tetap tinggi.

Terdapat sensor gas keadaan pepejal yang berbeza yang diberikan secara fabrikasi yang berbeza. Teknik filem tebal telah membuktikan sebagai kaedah fabrikasi kos rendah dan rendah kerana ketebalan dikawal filem, sifat haba dan elektrik filem substrat tebal, integrasi elemen bercetak, dan resolusi struktur. Alat-alat ini mengalami penggunaan kuasa yang tinggi dan sifat sensing yang tidak sesuai. Oksida logam yang berbeza dan logam mulia digunakan untuk memperbaiki sifat-sifat penderiaan sensor.

Matlamat utama kajian ini adalah fabrikasi sensor gas berasaskan logam bahan oksida campuran menggunakan teknologi filem tebal dan pembaikan sensor sensitiviti kepada gas karbon dioksida dengan penambahan platinum (Pt). Memilih antara platinum logam mulia lain seperti Ag adalah kerana kekonduksian haba yang tinggi dan harta menghakis bukan daripada Pt dalam berhadapan dengan gas karbon dioksida.

Yang direka sensor gas oksida logam terdiri daripada tiga elemen utama yang termasuk pemanas, elektrod dan lapisan sensing dicetak ke atas substrat alumina. Pes Platinum digunakan untuk unsur-unsur pemanas dan elektrod dan  $\text{La}_2\text{O}_3$  /  $\text{SnO}_2$  telah digunakan sebagai oksida logam asas untuk paste sensitif dan Pt telah ditambah sebagai bahan tambahan logam mulia untuk mengubah suai morfologi filem dan sensitiviti. Selepas percetakan bagi setiap lapisan, proses rawatan haba telah digunakan untuk kering dan api filem. Akhir sekali, gas karbon dioksida telah digunakan untuk sensor untuk ukuran

Saiz kristal bahan sensitif dianalisis oleh pembelauan sinar-X (XRD) analisis menunjukkan zarah saiz kurang daripada 30 nm dan juga anjakan fasa 20 nm untuk oksida logam dan bahan tambahan masing-masing . Penderiaan sifat semua sensor direka diukur dan dibandingkan dengan bersama-sama dan juga dengan TGS 813 sensor gas komersial. Keputusan menunjukkan bahawa  $\text{La}_2\text{O}_3 / \text{SnO}_2 / 3$  berat . % Pt mempunyai sensitiviti yang lebih baik sehingga 4.38 kepada gas karbon dioksida berbanding sensitiviti 0.64, 0.32, dan 0.005 untuk TGS 813,  $\text{La}_2\text{O}_3 / \text{SnO}_2 / 1$ wt. % Pt dan sensor gas  $\text{La}_2\text{O}_3 / \text{SnO}_2$  tulen, masing-masing.





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## APPROVAL SHEET

I certify that a Thesis Examination Committee has met on 10<sup>th</sup> January 2014 to conduct the final examination of Maryam Ehsani on her thesis entitled "Influence Of Platinum On Structural Thick Film Gas Sensor Based On Lanthanum Oxide-Doped TIN (IV) Oxide for Carbon Dioxide Detection" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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