FABRICATION OF THICK FILM GAS SENSOR FOR GAS SENSING APPLICATION

MUHAMMAD LUQMAN HAKKIM BIN NOOR

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FABRICATION OF THICK FILM GAS SENSOR FOR GAS SENSING APPLICATION

MUHAMMAD LUQMAN HAKKIM BIN NOOR

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : FABRICATION OF THICK FILM GAS SENSOR FOR GAS SENSING APPLICATION

Sesi Pengajian : 2021/2022

Saya MUHAMMAD LUQMAN HAKKIM BIN NOOR mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐ **TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.)
☑ **TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

Alamat Tetap: 02-6 Blok M,
Jalan Padi
Mahsuri 1, Bandar
Baru Uda, 81200
Johor Bahru,
Johor

DR. SITI AMANIAH BINTI MOHD CHACHULI
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh : 23 Mei 2022

Tarikh : 21 June 2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

UTeM
اونيۏرسيتي تيکنيکل مليسيا ملاك
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DECLARATION

I declare that this report entitled “fabrication of thick film gas sensor for gas sensing application ” is the result of my own work except for quotes as cited in the references.

Signature : ……

Author : MUHAMMAD LUQMAN HAKKIM BIN NOOR

Date : ……21.6.2022……

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : .....

Supervisor Name : Dr. Siti Amaniah binti Mohd Chachuli

Date : 21 June 2022

DEDICATION

For my beloved family, friends, supervisor, and lecturers for helping and supporting me during my studies.

ABSTRACT

A sensor is an analytical equipment made up of a signal transducer and an active sensing substance. It detects changes in its surroundings and transmits the data or signal to other electronic devices for analysis. Gas sensors, on the other hand, have been used to monitor air quality and the environment, as well as to identify dangerous substances. There are many different types of harmful gases, such as volatile organic chemicals (VOC). VOCs are toxic chemicals that are released into the atmosphere as gases from certain solids or liquids, and some of them can cause short- and long-term health problems. VOCs have become commonplace in a wide range of products and materials. The fabrication of a thick film gas sensor for gas detecting applications is discussed in this paper. Graphene is a material with a huge specific surface area and excellent conductivity. These characteristics make it perfect for gas sensor applications. The first objective is to use screen printing and doctor blade techniques to make the thick film gas sensor. The next objective is to assess the constructed gas sensor's performance against VOC gases in terms of sensitivity, response time, and recovery time. The gas sensor will be able to detect three various types of volatile organic compound (VOC) gases at the conclusion of this project, including acetone and ethanol. As the result, the sample of standard graphene paste combination of 95

wt% binder and 5 wt% graphene powder have a good result. Secondly, the sample SK(G)-1 and SG(G0)-1 shown response time of the gas sensor to the targeted gases ethanol shows that the sensor can produce accurate results than on acetone. It is because the sensitivity is 2.00 higher than other samples. Following that, the IV characteristics on the doctor blade's breakdown voltage minimum of 2 volts. However, most the doctor blade sample on standard binder or linseed oil with binder not showing the expected result because the graph can’t have recovery well and the sensitivity less than 1.

ABSTRAK

Penderia ialah peralatan analisis yang terdiri daripada transduser isyarat dan bahan penderiaan aktif. Ia mengesan perubahan dalam persekitarannya dan menghantar data atau isyarat kepada peranti elektronik lain untuk analisis. Sensor gas telah digunakan untuk memantau kualiti udara dan persekitaran, serta untuk mengenal pasti bahan berbahaya. Terdapat pelbagai jenis gas berbahaya, seperti bahan kimia organik meruap (VOC). VOC ialah bahan kimia toksik yang dilepaskan ke atmosfera sebagai gas daripada pepejal atau cecair tertentu, dan sebahagian daripadanya boleh menyebabkan masalah kesihatan untuk jangka masa pendek dan panjang. Gas VOC telah menjadi perkara biasa dalam pelbagai produk dan bahan. Pembuatan penderia gas filem tebal untuk aplikasi pengesan gas dibincangkan dalam kertas ini. Graphene ialah bahan dengan luas permukaan khusus yang besar dan kekonduksian yang sangat baik. Ciri-ciri ini menjadikannya sempurna untuk aplikasi penderia gas. Objektif pertama adalah menggunakan screen printing dan teknik doctor blade untuk membuat sensor gas filem tebal. Objektif seterusnya adalah untuk menilai prestasi sensor gas yang dibina terhadap gas VOC dari segi kepekaan, masa tindak balas dan masa pemulihan. Sensor gas akan dapat mengesan tiga jenis gas sebatian organik meruap (VOC) pada akhir projek ini, termasuk aseton, dan etanol.

Hasilnya, sampel gabungan pes graphene standard bagi pengikat 95% berat dan serbuk grafena 5% berat mempunyai hasil yang baik. Kedua, sampel SK(G)-1 dan SG(G0)-1 menunjukkan tindak balas sensor gas kepada etanol gas menunjukkan bahawa sensor boleh menghasilkan keputusan yang tepat berbanding aseton. Ia adalah kerana sensitiviti adalah 2.00 lebih tinggi daripada sampel lain. Berikutan itu, ciri-ciri IV pada voltan kerosakan bilah doktor minimum 2 volt. Walau bagaimanapun, kebanyakan sampel doctor blade pada pengikat standard atau minyak biji rami dengan pengikat tidak menunjukkan hasil yang diharapkan kerana graf tidak dapat pulih dengan baik dan kepekaan kurang daripada 1.

ACKNOWLEDGEMENTS

Alhamdulillah, thanks to Allah for making me perform this Final Year Project together with my supervisor and finish it. First, I would like to thank my family members for their moral support to complete this project. At this opportunity, I want to thank my parents, Hanisah binti Abdullah. All always gives me advice and criticism while completing this project. They always encourage me to finish this project. I am also wanted to thank those who always supported me and helped my problems during the Final Year project.

Furthermore, I would like to give a very special thank you and respect to Dr Siti Amaniah Binti Mohd Chachuli for supervising me with proper guidance and full cooperation in most of my final year project. Thank you for giving me a lot of guidance and tutoring, which eventually aided us to complete this project perfectly.

Do not forget my friends who always helped me when I faced some problems regarding this project. Thank you for helping and encouraging me. Finally, I would like to extend my thanks to the individual involved directly or indirectly in making this project and this project report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

VOC	:	Volatile Organic Compound
WHO	:	World Health Organization
EPA	:	Environmental Protection Agency
TEAM	:	Total Exposure Assessment Methodology
SnO_2	:	Tin (IV) Oxide
TiO_2	:	Titanium Oxide
ZnO	:	Zinc Oxide
In_2O_3	:	Indium (III) Oxide
LPE	:	Liquid-Phase Exfoliation
MWCNTs	:	Multi-walled carbon nanotubes
SWCNTs	:	Single-walled carbon nanotubes
SE	:	Sensing Electrode
RE	:	Reference Electrode
OCV	:	Open Circuit Voltage
GO	:	Graphene Oxide
CVD	:	Chemical Vapor Deposition
S	:	Sensitivity
FESEM	:	Field Scanning Electron Microscopy

XRD	:	X-ray Diffraction
FTIR	:	Fourier Transform Infrared Spectroscopy

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project background

The purpose of this project is to produce a low-cost, processable graphene-based gas sensor. Graphene is produced using screen-printing and doctor blade processes on glass and Kapton film substrates. Graphene has long been considered as one of the most widely used nanostructures for monitoring and detecting human activity. Second, graphene is the world's strongest material and can be used to strengthen other materials. As a result, it possesses a very high specific surface area and conductivity.

These properties make it ideal for use in gas sensor applications. Capability, being a carbon allotrope with exceptional sensory properties, is ideal for obtaining the highest levels of sensitivity, linearity, responsiveness, and recovery time.

1.2 Problem statement

According to the World Health Organization (WHO) and the United States Environmental Protection Agency (EPA), volatile organic compounds (VOCs) are any carbon compound that takes part in atmospheric photochemical reactions, exception of carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.[1] Paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment like copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials like glues and adhesives, permanent markers, and photographic solutions all contain VOCs gases.[1] The "Total Exposure Assessment Methodology (TEAM) Study" conducted by the EPA's Office of Research and Development discovered levels of VOC gases between 1 and 3 mg/m3 that are harmful to humans. If people are exposed to the gases, it can cause health problems such as irritation of the eyes, nose, and throat. Some organics have been shown to cause cancer in animals, and others have been suspected or shown to cause cancer in humans.[2] The magnitude and character of the health effect, like with other pollutants, will be determined by a variety of parameters, including the quantity of exposure and the time spent exposed.

1.3 Objective

The objectives of the projects are as follows:

i. To fabricate the graphene thick film gas sensor with different substrates using screen printing and doctor blade techniques.
ii. To analyze the performance of the fabricated gas sensor to the Volatile organic compounds (VOC) gases in terms of sensitivity, response time and recovery time.