

**UNIVERSITI TEKNOLOGI MARA**

**SYNTHESIS OF GOLD  
NANOPARTICLES EMBEDDED  
GRAPHENE OXIDE FOR FIBRE  
OPTIC GAS SENSOR  
APPLICATIONS**

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Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**  
**(Mechanical Engineering)**

**College of Engineering**

**October 2022**

## ABSTRACT

In this work, graphene oxide (GO) was successfully synthesized with the optimization formulation obtained using 1g of graphite, 3g of potassium permanganate ( $\text{KMnO}_4$ ), 25 mL of sulfuric acid ( $\text{H}_2\text{SO}_4$ ), 5 mL of hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) with  $20^\circ\text{C}$  of reaction temperatures and 3 hours of reaction time. The AuNPs were successfully synthesized with the optimum condition using 0.254 mM of gold chloride ( $\text{HAuCl}_4$ ) and 40 mM of trisodium citrate (NaCt). The composite structure of AuNPs embedded to GO (GO-AuNPs) was performed by direct mixing of GO solution to AuNPs solution at various volume ratios (1:05, 1:1, 1:2.5, 1:5, 1:7.5, 1:10 and 1:15). Then, fabrication of GO, AuNPs, and composite GO-AuNPs (at various volume ratios) encapsulated optical fibre probes was performed via dipping process for 24 hours with the aid of vortex mixing. The detection using indoor air exposed the highest light intensity signal on the fibre optic sensor generated from the GO-AuNPs-based sensor at a volume ratio of 1:5 and 1:10. For spectral analysis, the highest  $\text{CO}_2$  detection was detected by fibre optic sensors with GO-AuNPs (1:5) as a coating material with 62.7% signal improvement from uncoated sensor probe, 26.4% higher than the signal from GO-coated and 33.9% better than AuNPs-coated sensor. The highest  $\text{N}_2$  detection was obtained by the sensor fabricated of GO-AuNPs (1:10) with the signal enhancement of 59.8% from uncoated probe sensors. In the sensitivity analysis which represents the ratio of a change in output intensity to a change in gas concentration, the results of GO-AuNPs (1:5)-based sensor demonstrated excellent sensitivity enhancement to  $\text{CO}_2$  detection (28.02% at 25 L/min) and GO-AuNPs (1:10)-based sensor demonstrated high sensitivity to  $\text{N}_2$  (12.4% at 25 L/min). The signal also proved that the composite (GO-AuNPs) coating probe provides 6 times higher signal than single-element coating (GO or AuNPs). Based on the stability analysis, GO-AuNPs (1:5) sensors, and GO-AuNPs (1:10) sensors were found to be very stable against  $\text{CO}_2$  and  $\text{N}_2$ . From the selectivity analysis, the results show that GO-AuNPs (1:5), GO-AuNPs (1:10) and AuNPs-based sensors have a high selectivity for  $\text{CO}_2$ . Meanwhile, GO-based sensors are the most sensitive to  $\text{N}_2$  gas, which is supported by the results of selectivity analysis. In summary, the  $\text{CO}_2$  and  $\text{N}_2$  detection signal from the uncoated probe was really low while all coated probes generated a higher signal, hence proving that the composite (GO-AuNPs) coating materials are very useful in enhancing the signal of the gas detection. This newly integrated configuration of the sensing platform should help in developing versatile optical fibre-based sensors, thus creating enormous sensor application possibilities, especially for gas sensor applications.

## ACKNOWLEDGEMENT

Firstly, I wish to thank Allah SWT for providing me with the opportunity to embark on my Master's degree and for completing this long and challenging journey successfully. My gratitude and thanks to my supervisor Dr. Siti Rabizah Makhsin, my co-supervisors; Prof. Ir. Dr. Hj. Muhammad Azmi Ayub, Prof. Ts. Dr. Nor Hayati Saad and Prof. Dr. Mohammed Zourob.

I am greatly appreciative and thankful for all technical staff and postgraduate students, Micro-Nano Electromechanical System Laboratory (MiNEMs), School of Mechanical Engineering, Nano-Electronic (NET) Research Group, School of Electrical, Centre for Functional Materials & Nanotechnology (CFMN), Institute of Science (IOS), Photonics And Materials Research Group, Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Selangor, Analytical Unit, Faculty of Pharmacy, Universiti Teknologi MARA, Puncak Alam, Centre For Research And Instrumentation Management (CRIM), Universiti Kebangsaan Malaysia and Institute for Research in Molecular Medicine (INFORMM), Universiti Sains Malaysia, Pulau Penang. This work is financially supported by the fundamental research grant scheme; FRGS grant 600-IRMI/FRGS 5/3(341/2019), Ministry of Higher Education Malaysia. This project wouldn't have been possible without the help of my supervisor, friends and colleagues.

Finally, this thesis is dedicated to the loving memory of my wife and mother for the vision and determination to educate me. This piece of victory is dedicated to both of you. Alhamdulillah.

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