ISETC2025

UNIVERSITI TEKNOLOGI MARA

ISETC2025

2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM

THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:

三重大学
MIE UNIVERSITY

2nd International Science, Engineering and Technology Colloquium

(ISETC 2025)

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025
Publication date: 9th September 2025

Proceedings of Extended Abstracts

EDITORS

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

e-ISBN: 978-629-97630-5-5

Published by Faculty of Applied Sciences, Universiti Teknologi MARA,
Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

BAND-ENGINEERING ANALYSIS FOR HIGH CARRIER CONFINEMENT OF ALUMINIUM GALLIUM NITRIDE-BASED DEEP-ULTRAVIOLET LIGHT-EMITTING DIODE

Nur Luqman Hakim Zaini[1,2], Ahmad Fakhrurrazi Ahmad Noorden[1,2*], Mohammad Amirul Hairol Aman[1,2]

[1]*Centre for Advanced Optoelectronics Research (CAPTOR), Department of Physics, Kulliyyah of Science, International Islamic University Malaysia, 25200, Kuantan, Malaysia*
[2]*IIUM Photonics and Quantum Centre (IPQC), Kulliyyah of Science, International Islamic University Malaysia, 25200, Kuantan, Pahang, Malaysia*

**Corresponding author: fakhrurrazi@iium.edu.my*

Abstract: This research focuses on the numerical design and simulation of Aluminium Gallium Nitride (AlGaN)-based deep-ultraviolet light-emitting diodes (DUV-LEDs) using a multiple quantum well (MQW) structure. Five DUV-LED models were developed with varying aluminium (Al) compositions in the quantum barrier (QB) layers to investigate their effects on carrier confinement and device performance. The efficiency droop commonly observed in DUV-LEDs is often attributed to factors such as strong polarization fields, electron leakage, and poor hole injection. The analysis demonstrates that optimizing the Al content in the barrier layers significantly improves carrier confinement, reduces polarization-induced electric fields, and enhances the radiative recombination rate. These improvements are critical for achieving higher internal quantum efficiency (IQE) in AlGaN-based DUV-LEDs.

Keywords: *AlGaN, quantum barrier, internal quantum efficiency, numerical simulation*

INTRODUCTION

Numerous strategies have been explored to enhance the performance DUV-LEDs, including the optimization of quantum well structures and the engineering of electron and hole injection layers. Among these, improving carrier confinement in the active region remains a key approach to mitigating efficiency droop and enhancing IQE. In this work, a theoretical study is conducted on AlGaN-based DUV-LEDs incorporating MQW structures, with a focus on analyzing the effect of varying Al-composition in the QB layers. Five DUV-LED structures were designed with identical QWs (Al-composition of 70%) but with QB Al-compositions ranging from 0.75 to 0.85. The goal is to investigate how differences in QB Al-composition influence internal electric fields, carrier distribution, band alignment, and radiative recombination rates. The epilayer structures were simulated using a one-dimensional Poisson, drift-diffusion, and Schrödinger solver (1D-DDCC) (Amirul, Aman, Azim, et al., n.d.; Amirul, Aman, Azrisham, et al., n.d.).

MATERIALS AND METHODS

The simulation of AlGaN-based DUV-LEDs was conducted using a multi quantum well (MQW) structure. Five different LED models, which is LED A to LED E were designed with identical QW compositions but varying Al-composition in the QBs. Each structure begins with a 10,000 nm thick aluminium nitride (AlN) substrate followed by a series of AlGaN buffer layers, with Al-composition decreasing from 0.98 to 0.82. In addition, an n-type AlGaN electron injection layer with Al-composition of 0.800 and a thickness of 100 nm was used, doped at 1.50×1018 cm^{-3}. The active region consists of five pairs of Al0.70Ga0.30N of QWs, each 30 nm thick, and 120 nm thick AlGaN quantum barriers QBs. In LED A, the QBs have an Al-composition of 0.85, while the other LEDs use lower compositions from 0.825 to 0.75 with decreasing of 0.025. The layer of QWs and QBs were arranged alternately to form a region of MQW called as an active region where the recombination of carrier happened (Amirul, Aman, Azrisham, et al., n.d.). The p-type side consists of a 200 nm thick AlN electron blocking layer (EBL) (Guowen et al., 2024), a 600 nm thick Al0.65Ga0.35N hole injection layer, and a 600 nm thick p-GaN contact layer, doped at 2.00×1020 cm^{-3}.

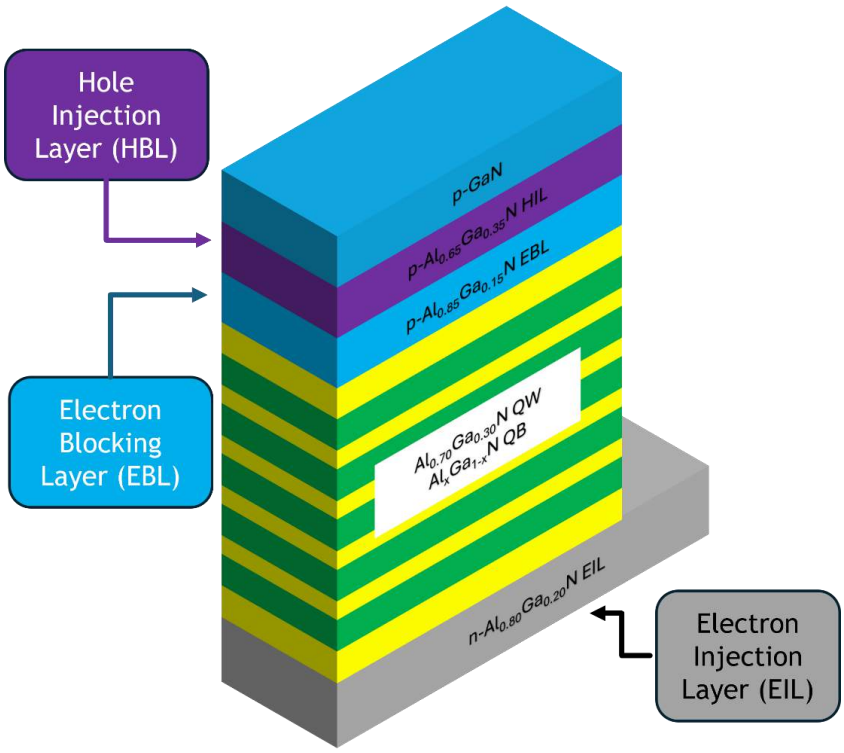

Figure 1. The heterostructure of DUV-LED

RESULTS AND DISCUSSION

Figure 2 shows that the energy band of LED A with 85% Al-composition in the QBs is strongly tilted due to high polarization, causing poor carrier confinement and low device performance. As the Al- composition in the barriers is reduced from LED B to LED D, the energy band becomes more balanced, leading to better overlap between electrons and holes, improving carrier confinement and radiative recombination. LED D (77.5% Al) shows the best energy band alignment with minimal electric field, indicating strong carrier confinement and high efficiency. However, in LED E (75% Al), the conduction band becomes too shallow, allowing electrons to leak and reducing performance. This shows that too much reduction in Al-composition weakens the polarization control and harms the device efficiency.

Figure 3 shows that LED D achieves the highest IQE, reaching a peak value of 34.5%. The performance decreases in the order of LED D, LED E, LED C, LED B, and finally LED A. While LED E has the lowest Al-composition in the quantum barriers, its efficiency is slightly lower than LED D, indicating that a lower Al-composition alone does not guarantee better performance. LED D shows a more stable IQE under increasing current density, suggesting it has the most favourable conditions for efficient carrier recombination.

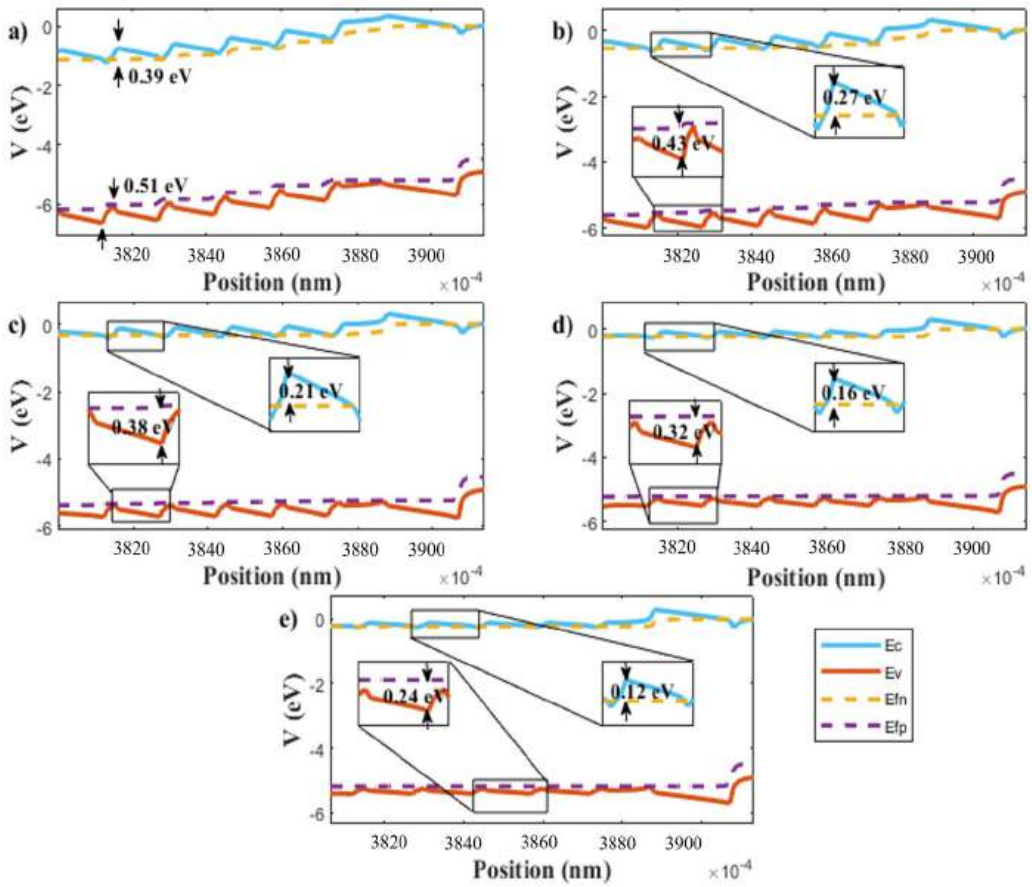

Figure 2. (a) The EBD of LED A. (b) The EBD of LED B. (c) The EBD of LED C. (d) The EBD of LED D. (e) The EBD of LED E.

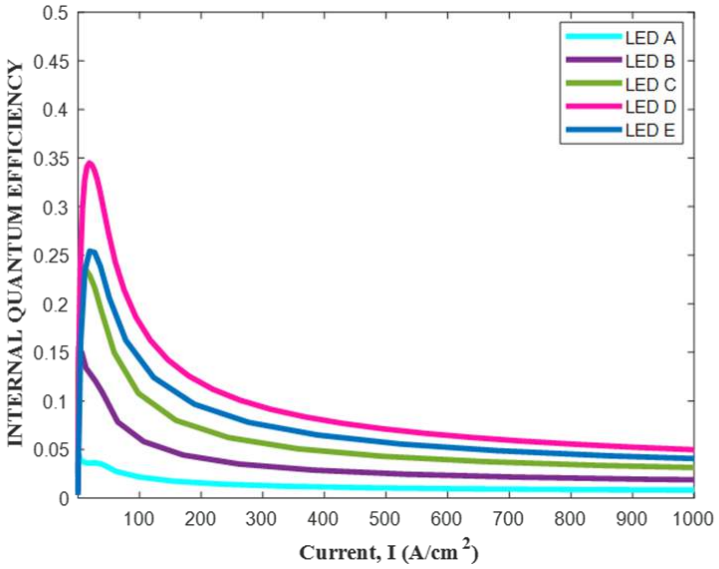

Figure 3. The Internal Quantum Efficiency (IQE) resulted using 1D-DDCC of each LED

CONCLUSIONS

An AlGaN-based DUV-LED employing MQW configurations has been analyzed through numerical simulation to study the impact of Al-composition in the QBs on carrier confinement and IQE. In conclusion, the LED structure with 77.5% Al in the barriers (LED D) demonstrates the most balanced performance, showing improved carrier confinement, reduced polarization effects, and the highest IQE among the five designs.

REFERENCES

Amirul, M., Aman, H., Azim, F., Fajri, A., Fakhrurrazi, A., Noorden, A., Daud, S., Zamzuri, M., Kadir, A., Malaysia, T., & Bahru, J. (n.d.). *High Photoluminescence Intensity of Heterostructure AlGaN-based DUV-LED through Uniform Carrier Distribution*.

Amirul, M., Aman, H., Azrisham, N. F., Fakhrurrazi, A., Noorden, A., Danial, W. H., Zamzuri, M., & Kadir, A. (n.d.). *High-Performances AlGaN-based DUV-LED via Under-Level Multiple Quantum Well Configuration*.

Guowen, S., Lin, L., Fujun, X., Chen, L., Wengen, G., & Guangzhen, D. (2024). AlGaN-based deep ultraviolet light-emitting diodes on separated multiple quantum barrier electron blocking layer. *Chinese Journal of Luminescence, 45*(7), 1156–1162. https://doi.org/10.37188/CJL.20240045

Pejabat Perpustakaan
Library Office

Universiti Teknologi MARA
Cawangan Perak
Kampus Seri Iskandar
32610 Bandar Baru Seri Iskandar,
Perak Darul Ridzuan, MALAYSIA
Tel: (+605) 374 2093/2453 Faks: (+605) 374 2299

UNIVERSITI TEKNOLOGI MARA

Surat kami : 700-KPK (PRP.UP.1/20/1)
Tarikh : 20 Januari 2023

Prof. Madya Dr. Nur Hisham Ibrahim
Rektor
Universiti Teknologi MARA
Cawangan Perak

Tuan,

PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK MELALUI REPOSITORI INSTITUSI UiTM (IR)

Perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Setuju.

27.1.2023

PROF. MADYA DR. NUR HISHAM IBRAHIM
REKTOR
UNIVERSITI TEKNOLOGI MARA
CAWANGAN PERAK
KAMPUS SERI ISKANDAR

Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

nar