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

COMPARATIVE ANALYSIS OF CARRIER CONCENTRATION AND RADIATIVE RECOMBINATION IN ALGAN-BASED DEEP ULTRAVIOLET LEDS WITH VARYING QUANTUM WELL THICKNESSES

Danish Akalil A. Razak[1], Mohammad Amirul Hairol Aman[2], Ahmad Fakhrurrazi Ahmad Noorden[1*]

[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 study explores the influence of quantum well (QW) and quantum barrier (QB) thickness on carrier concentration and radiative recombination in AlGaN-based deep ultraviolet light-emitting diodes (DUV-LEDs). The main objective is to analyze the carrier transport behavior and recombination dynamics to determine the most efficient QW/QB configuration. Using the 1D-DDCC simulation software, three configurations LED A (QW: 1 nm, QB: 3 nm), LED D (QW: 10 nm, QB: 3 nm), and LED G (QW: 20 nm, QB: 3 nm) were analyzed. Results show that LED A exhibited the most intense and frequent radiative recombination due to strong carrier confinement, albeit with leakage from the narrow QB. LED D displayed optimal balance, achieving the highest peak internal quantum efficiency (IQE) due to enhanced carrier overlap and moderate confinement. In contrast, LED G had broader carrier profiles with reduced recombination efficiency. The findings affirm that precise control of QW/QB ratios is critical to maximizing radiative recombination and overall DUV-LED efficiency (Ishii et al., 2024; Alp et al., 2023).

Keywords**:** *AlGaN, deep ultraviolet LED, carrier concentration, radiative recombination, quantum well, simulation*

INTRODUCTION

Deep ultraviolet LEDs (DUV-LEDs) are crucial for sterilization, disinfection, and biochemical sensing. The efficiency of AlGaN-based DUV-LEDs is often hindered by poor carrier confinement and low internal quantum efficiency (IQE). Optimization of the multi-quantum well (MQW) and quantum barrier (QB) structures plays a pivotal role in enhancing device performance (Wang et al., 2023). This study investigates how varying QW thickness (1 nm, 10 nm, and 20 nm) with a fixed QB thickness of 3 nm affects carrier concentration and radiative recombination.

MATERIALS AND METHODS

The epitaxy layer of the DUV-LED consists of n-GaN with 500 nm thickness, followed by Al0.4Ga0.6N with 500 nm thick. Both layers were doped with 5 x 1018 cm^{-3} Silicon. The device structures comprise five QWs of Al0.3Ga0.7N and six QBs of Al0.4Ga0.6N. LED A has a 1 nm QW, LED D a 10 nm QW, and LED G a 20 nm QW, all with QB thickness of 3 nm. The next layer is a 24 nm p- Al0.5Ga0.5N electron blocking layer with 3 x 1018 cm^{-3} Magnesium (Mg) doping, 250 nm p-Al0.4Ga0.6N with 5 x 1018 cm^{-3} Mg-doped, and lastly, 200 nm p-GaN with 1 x 1020 cm^{-3} Mg doping Devices were simulated at 300 K with a forward bias of 10 V using the 1D-DDCC model, incorporating drift-diffusion and ABC recombination parameters. Carrier concentrations and radiative recombination profiles were evaluated to compare performance (Alp et al., 2023).

RESULTS AND DISCUSSION

Carrier Concentration

LED A exhibited high and sharp carrier concentration peaks due to strong confinement in the narrow QW, but carrier leakage was evident from the thin QB. LED D demonstrated balanced carrier distribution, achieving optimal overlap between electrons and holes, which is essential for recombination. LED G, with the widest QW, showed broad carrier spread and reduced overlap, resulting in poorer confinement and less efficient radiative activity (Ishii et al., 2024).

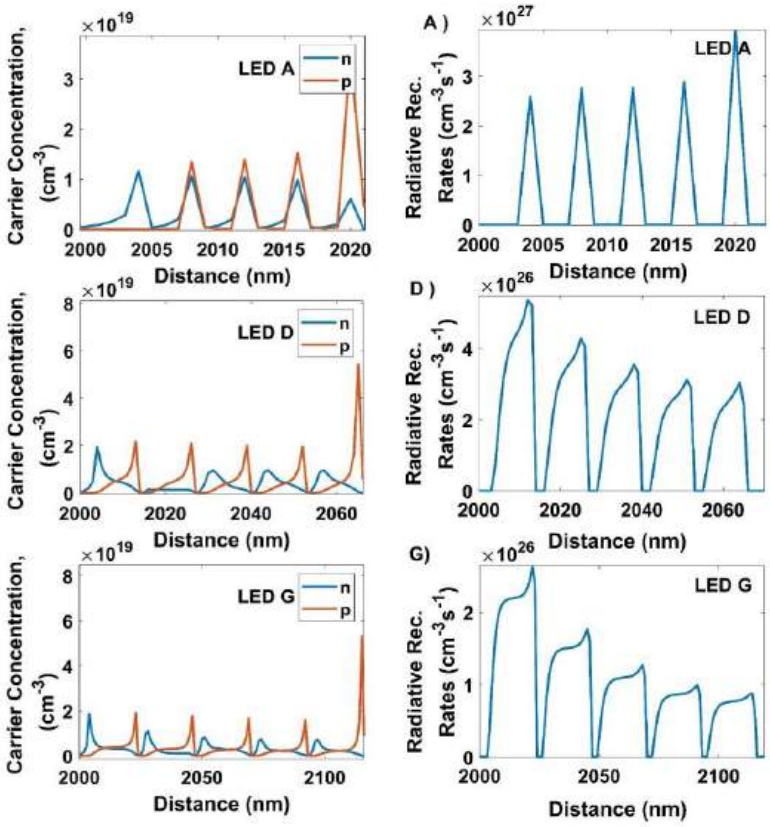

Figure 1. Carrier Concentration and Radiative Recombination for varies QW and fixed QB

Radiative Recombination

LED A's structure promoted frequent and high-intensity radiative recombination events, but leakage limited its effectiveness. LED D produced moderately intense recombination with more stable emission and superior peak IQE (~0.25), attributed to its optimal QW/QB ratio. In LED G, although carrier concentrations remained high, the large QW volume decreased radiative efficiency due to spatial dispersion of carriers and diminished tunneling probability (Jamil et al., 2021).

CONCLUSIONS

This study highlights the importance of optimizing QW and QB thicknesses for DUV-LEDs. Among the three configurations, LED D offered the best performance due to its favorable carrier dynamics and recombination rate. The findings suggest that a QW thickness of 10 nm with a QB of 3 nm achieves a superior balance between confinement

and carrier interaction, vital for efficient light emission. These insights provide a pathway toward developing next-generation high-performance DUV-LEDs.

REFERENCES

Alp, İ., Öner, B. B., & Eroğlu, E. (2023). 285 nm AlGaN-based deep-ultraviolet LED with high internal quantum efficiency: Computational design. *Journal of Scientific Reports-A, 052*, 51–64. https://doi.org/10.59313/jsr-a.1195106

Ishii, R., Tanaka, S., Susilo, N., et al. (2024). Radiative and nonradiative recombination processes in AlGaN quantum wells on epitaxially laterally overgrown AlN/sapphire from 10 to 500 K. *Physica Status Solidi B, 261*(11), 2400018. https://doi.org/10.1002/pssb.202400018

Jamil, T., Usman, M., Jamal, H., & Khan, M. A. (2021). High radiative recombination rate of AlGaN-based deep ultraviolet light-emitting diodes with AlInGaN/AlInN/AlInGaN tunnel electron blocking layer. *Journal of Electronic Materials, 50*(7), 5612–5617. https://doi.org/10.1007/s11664-021-09086-1

Wang, T.-Y., Lai, W.-C., Xie, Q.-J., Yang, S.-H., Chang, S.-P., Kuo, C.-H., & Sheu, J.-K. (2023). The influences of AlGaN barrier epitaxy in multiple quantum wells on the optoelectrical properties of AlGaN-based deep ultraviolet light-emitting diodes. *RSC Advances, 13*, 5437–5443. https://doi.org/10.1039/D2RA07368D

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