テラヘルツ量子素子研究チーム ／ Terahertz Quantum Device Research Team

（１）原著論文（accept を含む） ／ Original Papers

1. M. A. Khan, R. Takeda, Y. Yamada, N. Maeda, M. Jo, and H. Hirayama, “Beyond 53% internal quantum efficiency in a AlGaN quantum well at 326 nm UVA emission and single-peak operation of UVA LED” , Optics Letters, Vol. 45, No. 2, pp. 495-498, January 15, (2020). (10.1364/OL.376894).
2. M. A. Khan, E. Matsuura, Y. Kashima and H. Hirayama, “Overcoming the current injection issue in the 310 nm band AlGaN UVB light-emitting diode” , Japanese Journal of Applied Physics, Vol. 59, No. SA, pp. SAAD01-7, January 1, (2020).(10.7567/1347-4065/ab460b)
3. J. Yun, D. P. Han, and H. Hirayama, “Random electric field induced by interface roughness in GaN/AlxGa1-xN multiple quantum wells” , Applied Physics Express, Vol. 12, No. 12, pp. 124005-1-6, November 21, (2019). (10.7567/1882-0786/ab548a).
4. M. A. Khan, E. Matsuura, Y. Kashima, and H. Hirayama, “Influence of undoped-AlGaN final barrier of MQWs on the performance of lateral-type UVB LEDs” , Physica Status Solidi A, Vol. 216, No. 18, p. 1900185, September 18, (2019). (10.1002/pssa.201970059)
5. L. Wang, T. T. Lin, K. Wang, and H. Hirayama, “Parasitic transport paths in two-well scattering-assisted terahertz quantum cascade lasers” , Applied Physics Express, Vol. 12, No. 8, pp. 082003-1-5, July 9, (2019). (10.7567/1882-0786/ab2b56)
6. L. Wang, T. T. Lin, K. Wang, T. Grange, S. Birner and H. Hirayama, “Short-period scattering-assisted terahertz quantum cascade lasers operating at high temperatures” , Scientific Reports, Vol. 9, No. 9446, July 1, (2019). (10.1038/s41598-019-45957-8)
7. M. I. Hossain, Y. Itokazu, S. Kuwaba, N. Kamata, N. Maeda, and H. Hirayama, “Nonradiative recombination centers in deep UV-wavelength AlGaN quantum wells detected by below-gap excitation light” , Japanese Journal of Applied Physics, Vol. 58, No. SC, pp. SCCB37-1-7, May 29, (2019). (10.7567/1347-4065/ab1069)
8. Y. Itokazu, S. Kuwaba, M. Jo, N. Kamata, and H. Hirayama, “Influence of the nucleation conditions on the quality of AlN layers with hightemperature annealing and regrowth processes” , Japanese Journal of Applied Physics, Vol. 58, No. SC, pp. SC1056-1-5, May 28, (2019). (10.7567/1347-4065/ab1126)
9. M. Jo, Y. Itokazu, S. Kuwaba, and H. Hirayama, “Controlled crystal orientations of semipolar AlN grown on an m-plane sapphire by MOCVD” , Japanese Journal of Applied Physics, Vol. 58, No. SC, pp. SC1031-3, May 17, (2019). (10.7567/1347-4065/ab0f1c)
10. Y. Mogami, S. Motegi, A. Osawa, K. Osaki, Y. Tanioka. A. Maeoka, M. Jo, N. Maeda, H. Yaguchi, and H. Hirayama, “Evolution of morphology and crystalline quality of DC-sputtered AlN films with high-temperature annealing” , Japanese Journal of Applied

Physics, Vol. 58, No. SC, pp. SC1029-1-4, May 17, (2019). (10.7567/1347-4065/ab1066)

11. 平山秀樹，前田哲利，M. A. Khan，只友一行，岡田成仁，山田陽一：“AlGaN 深紫外LD の実現へ向けた最近の進展”，レーザー研究，第47 巻，第4 号，pp. 196-203，4 月20 日，(2019). (ISSN 0387-0200)

（２）著書・解説など／ Book Editions, Review Papers

1. 平山秀樹：“AlGaN 深紫外LED の最近の進展”，Photonics Division フォトニクスニュース（応用物理学会フォトニクス分科会出版），第5 巻，第3 号，pp. 133-138，9 月10 日，(2019). ISSN: 2189-6496
   https://annex.jsap.or.jp/photonics/publication/latest
2. 平山秀樹：“殺菌用・深紫外LED の最近の進展”，クリーンテクノロジー（日本工業出版），第29 巻，第4 号，pp. 1-5，4 月10 日，(2019). ISSN: 0917-1819
   https://www.nikko-pb.co.jp/products/detail.php?product_id=4550

（３）招待講演 ／ Invited Talks

1. M. Jo, N. Maeda and H. Hirayama, “Progress in AlGaN UVC LEDs by improving light extraction efficiency” , SPIE Photonics West, The Moscone Center, San Francisco, USA, February 6, (2020).
2. A. Khan, N. Maeda, M. Jo, Y. Kashima and H. Hirayama, “High performances of AlGaN-based UVC and UVB LEDs with relaxed buffer layer as well as using p-type graded multi-quantum-barrier electron-blocking layer” , SPIE Photonics West, The Moscone Center,San Francisco, USA, February 6, (2020).
3. K. Matsumoto, Y. Tomita, A. Mishima, Y. Yamaoka, S. Koseki, Y. Yano, H. Miyake and H. Hirayama, “Challenge and opportunity for mass production of UVC LED by MOVPE on high temperature annealed AlN template” , Material Research Meeting 2019, Yokohama Symposia, December 11, (2019).
4. 【Keynote】H. Hirayama, “Problems and latest achievements in AlGaN-based deep-UV LEDs” , 4th International Workshop on Ultraviolet Materials and Devices (IWUMD4), Saint Petersburg, Russia, September 10, (2019).
5. H. Hirayama, N. Maeda and M. Jo, “Recent progress of high-efficiency AlGaN deep-UV LEDs” , SPIE Optics + Photonics, San Diego, USA, August 11, (2019).
6. T. G. Kim, T. H. Lee, H. Hirayama, T. H. Park, K. R. Son, “Simultaneous improvements in EQE and WPE of AlGaN UV-C LEDs with Ni:AlN/Al Ohmic reflectors” , UV and Higher Energy Photonics: From Materials to Applications, SPIE Optics + Photonics, San Diego, USA, August 11, (2019).
7. H. Hirayama, “Recent progress and future prospects of AlGaN deep-UV LEDs” , 48th

International School & Conference on the Physics of Semiconductors (Jaszowiec 2019), Szczyrk, Poland, June 11, (2019).

8. H. Hirayama, Y. Kashima, Y. Watanabe, T. Shibata, N. Maeda, M. Jo, E. Matsuura, T. Iwai, M. Kokubo, T. Tashiro, K. Furuta, R. Kamimura, Y. Osada, H. Takagi, Y. Kurashima, Y. Iwaisako and T. Nagano, "LEE enhancement in AlGaN UVC LED using photonic crystal reflector" , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 8, (2019).
9. 平山秀樹，林宗澤，王科，王利："GaAs 系およびGaN 系テラヘルツ量子カスケードレーザーの進展"，レーザー学会学術講演会第40 回年次大会講演会，仙台国際センター，1 月21 日，(2020).
10. 定昌史，平山秀樹，"深紫外LED の開発最前線"，モノづくりフェア2019，マンメッセ福岡，10 月18 日，(2019).
11. 平山秀樹："AlGaN 系深紫外LED の最近の進展"，徳島大学ポストLED フォトニクス研究所開所記念式典，キックオフセミナー，徳島大学常三島キャンパス，10 月16 日，(2019).
12. K. Wang, L. Wang, T. T. Lin, K. Fukuda and H. Hirayama, "Recent progress and future of GaN and GaAs-based THz-QCL" , 第80 回応用物理学会秋季学術講演会，北海道大学，9 月18 日，(2019).
13. 平山秀樹，"深紫外LED の国内外の最新技術と今後の展望"，特許庁技術研修，特許庁六本木仮庁舎，5 月29 日，(2019).
14. 平山秀樹："殺菌用紫外LED の開発と今後の展望"，OPIE' 19 紫外線応用技術セミナー，パシフィコ横浜アネックスホール，4 月26 日，(2019).

（4）会議、シンポジウム、セミナー主催 ／ Meeting, Symposiums and Seminars

1. M. A. Khan, N. Maeda, M. Jo, E. Matsuura, Y. Kashima, Y. Yamada, H. Hirayama, "AlGaN UVB LEDs at 310nm emission with high efficiency and light power using partially relaxed n-AlGaN buffer layer" , ISPlasma2020/IC-PLANTS2020, Nagoya University, March 11, (2020).
2. K. Wang, T. T. Lin, L. Wang and H. Hirayama, "Recent progress in GaAs THz-QCLs and towards realizing GaN based QCLs" , SPIE Photonics West, The Moscone Center, San Francisco, USA, February 6, (2020).
3. K. Wang, L. Wang, T. T. Lin, K. Fukuda, R. Zhang, and H. Hirayama, "Simulation and growth of GaN/AlGaN based terahertz quantum cascade structures" , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 13, (2019).
4. H. Murotani, H. Miyoshi, R. Takeda, M. A. Khan, N. Maeda, M. Jo, H. Hirayama, and Y.

Yamada, “Radiative and nonradiative recombination rates of excitons and their effects on internal quantum efficiency of AlGaN-based UV-B MQWs” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 13, (2019).

5. M. A. Khan, N. Maeda, M. Jo, S. Fujikawa, Y. Yamada, and H. Hirayama, “42mW light power from AlGaN-based 302nm-band UVB LEDs: a way forward for UVB LDs” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 12, (2019).
6. M.A. Khan, R. Takeda, H. Miyoshi, Y. Yamada, S. Fujikawa, N. Maeda, M. Jo and H. Hirayama, “Achievement of internal quantum efficiency up to 53% at 326nm-UVA emission from AlGaN QWs with engineering of highly relaxed buffer layer” , 4th International Workshop on Ultraviolet Materials and Devices (IWUMD4), Saint Petersburg, Russia, September 13, (2019).
7. K. Wang, N. Maeda, M. A. Khan, Z. Li, Y. Wu, T. Tao, B. Liu, R. Zhang and H. Hirayama, “MBE grown p-type AlGaN and deep ultraviolet light emitting diodes” , 4th International Workshop on Ultraviolet Materials and Devices (IWUMD4), Saint Petersburg, Russia,September 12, (2019).
8. M. A. Khan, N. Maeda, M. Jo, S. Fujikawa, E. Matsuura, Y. Kashima, Y. Yamada and H. Hirayama, “Realization of high light output power in AlGaN-based UVB LED at 310±2nm emission using highly relaxed (50%) n-AlGaN electron injection layer” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 10, (2019).
9. M. A. Khan and H, Hirayama, “Current status and future directions of high power AlGaN-based UVB LEDs with emission of 280nm-320nm” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 10, (2019).
10. H. Murotani, K. Hisanaga, R. Tanabe, A. Hamada, N. Maeda, M. Jo, H. Hirayama and Y. Yamada, “Optically pumped stimulated emission from AlGaN-based UV-C multiple quantum wells with high internal quantum efficiency of 16 % at 750 K” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 9, (2019).
11. H. Murotani, H. Miyoshi, R. Takeda, M. A. Khan, N. Maeda, M. Jo, H. Hirayama and Y. Yamada, “Role of exciton recombination processes on internal quantum efficiency in AlGaN-based UV-B multiple quantum wells” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 9, (2019).

12. N. Okada, F. Kim, T. Saito, S. Fujikawa, N. Maeda, H. Hirayama and K. Tadatomo, “Epitaxial lateral overgrowth of AlN with partially non-dislocation-region on vicinal AlN template” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 9, (2019).
13. M. A. Khan, N. Maeda, M. Jo, Y. Yamada and H. Hirayama, “Current challenges and future direction for AlGaN based UV-B LEDs grown by LP-MOVPE” , European Materials Research Society Spring Meeting 2019 (E-MRS), Acropolis Congress Center, Nice, France, May 31, (2019).
14. E. Hase, T. Yasui, H. Hirayama and K. Nagamatsu, “The improving resolution for dislocation analysis in GaN by three-photon microscopy” , SPIE Photonics West, The Moscone Center, San Francisco, USA, February 5, (2020).
15. Y. Tomita, A. Mishima, Y. Yamaoka, T. Arimura, S. Koseki, Y. Yano, K. Matsumoto, and H. Hirayama, “Optimization of p-cladding layer for improvement of deep ultraviolet light emitting diode performance” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 14, (2019).
16. Y. Itokazu, S. Kuwaba, M. Jo, N. Kamata, and H. Hirayama, “Investigation of AlGaN/AlN interface structure and annealing effect for control of strain re- laxation” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan,November 14, (2019).
17. Y. Mogami, A. Osawa, K. Osaki, Y. Tanioka, A. Maeoka, Y. Itokazu, S. Kuwaba, M. Jo, N. Maeda, H. Yaguchi, and H. Hirayama, “Fabrication of UVC AlGaN LEDs on DC-sputtered AlN templates with high-temperature an- nealing” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 11, (2019).
18. M. I. Hossain, Y. Itokazu, S. Kuwaba, N. Kamata, N. Maeda, and H. Hirayama, “Nonradiative recombination centers in UVB AlGaN quantum well and their temperature dependence revealed by below-gap excitation light” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 11, (2019).
19. J. Yun and H. Hirayama, “Influence of dipole scattering to level broadening and carrier transport in AlGaN-based superlattice structures” , The 9th Asia-Pacific Workshop on Widegap Semiconductors (APWS2019), OIST, Onna-son, Japan, November 11, (2019).
20. J. Yun and H. Hirayama, “Level broadening by dipole scattering in AlGaN/ AlGaN superlattice structures” , Infrared Terahertz Quantum Workshop (ITQW 2019), Ojai, USA, September 17, (2019).
21. L. Wang, T. T. Lin, K. Wang, T. Grange and H. Hirayama, “Experimental and theoretical study of piezoelectric polarization in GaN/AlGaN terahertz quantum cascade lasers” ,

Infrared Terahertz Quantum Workshop (ITQW 2019), Ojai, USA, September 17, (2019).

22. T. T. Ln, K. Wang, L. Wang and H. Hirayama, “Optimization of THz QCLs by suppressing A leakage current via high energy states” ,44th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz 2019), Paris, France, September 3, (2019).
23. M. Jo, Y. Itokazu, S. Kuwaba and H. Hirayama, “Improved simulation of MOCVD growth of AlN by using data assimilation” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 9, (2019).
24. M. C. D. Figueira, A. Trellakis, S. Birner, M. A. Khan and H, Hirayama, “Optimizing AlGaN-based UVB LEDs using experimental device data in the nextnano software” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue,Bellevue, Washington, July 9, (2019).
25. S. Kuwaba, Y. Itokazu, S. Motegi, Y. Mogami, A. Osawa, K. Osaki, Y. Tamioka, A. Maeoka, M. Jo, N. Kamata and H. Hirayama, “AlGaN UVC LEDs directly grown on DC-sputtered and high temperature annealed AlN templates” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 8, (2019).
26. Y. Mogami, S. Motegi, A. Osawa, K. Osaki, Y. Tomioka, A. Maeoka, Y. Itokazu, S. Kuwaba, M. Jo, N. Maeda, H. Yagichi and H. Hirayama, “Enhanced strain relaxation in AlGaN layers grown on sputter-based AlN templates” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 8, (2019).
27. Y. Itokazu, Y. Mogami, S. Kuwaba, S. Motegi, A. Osawa, K. Osaki, Y. Tamioka, M. Jo, N. Kamata and H. Hirayama, “Influence of the strain relaxation on the optical property of AlGaN quantum wells” , 13th International Conference on Nitride Semiconductors (ICNS-13), Hyatt Regency Bellevue, Bellevue, Washington, July 8, (2019).
28. 室谷英彰，三好博之，武田椋平，中生拓希，倉井聡，M. A. Khan，前田哲利，定昌史，平山秀樹，山田陽一：“AlGaN系多重量子 井戸構造における励起子レート方程式モデルによる効率Droop 現象の解析”，第67 回応用物理学会春季学術講演会，上智大学四谷キャンパス，3 月15 日，(2020).
29. 三好博之，武田椋平，中生拓希，倉井聡，室谷英彰，M. A. Khan，前田哲利，定昌史，平山秀樹，山田陽一：“AlGaN 系多重量子井戸構造における励起子の輻射・非輻射再結合レートの励起強度依存性”，第67 回応用物理学会春季学術講演会，上智大学四谷キャンパス，3 月15 日，(2020).
30. 斉藤貴大，金輝俊，岡田成仁，前田哲利，定昌史，平山秀樹，只友一行：“ELO-

AlN テンプレートの作製とMQW の評価”，第67回応用物理学会春季学術講演会，上智大学四谷キャンパス，3 月12 日，(2020)．

31. T. T. Lin, K. Wang, L. Wang and H. Hirayama, “Progress on high output power THz QCLs developed by reducing horizontal parasitic current leakage”， 電子情報通信学会電子デバイス研究会，東北大学電気通信研究所，12 月23 日，(2019)．
32. L. Wang, T. T. Lin, K. Wang and H. Hirayama, “Near- and far-infrared quantum cascade lasers based on GaAs and GaN materials: devices design and MBE growth”，電子情報通信学会　電子デバイス研究会，東北大学電気通信研究所，12 月23 日，(2019)．
33. T. T. Lin, L. Wang, K. Wang and H. Hirayama, “Recent progress of high output power THz QCLs by reducing parasitic leakage current”，理研シンポジウム第7 回「光量子工学研究」，和光地区，12 月10 日，(2019)．
34. 最上耀介，大澤篤史，尾崎一人，谷岡千丈，前岡淳史，糸数雄吏，定昌史，前田哲利，矢口裕之，平山秀樹：“DC スパッタAlNテンプレートを用いたUVCLEDの進展”，電子情報通信学会レーザ・エレクトロニクス研究会，静岡大学浜松キャンパス，11 月22 日，(2019)．
35. 中村励志，藤川紗千恵，前田哲利，遠藤聡，藤代博記，平山秀樹，“電子ブロック層の最適化による250nm AlGaN UVC-LED の出力改善”，第80 回応用物理学会秋季学術講演会，北海道大学，9 月20 日，(2019)．
36. 斉藤貴大，中村亮太，藤川紗千恵，金輝俊，前田哲利，岡田成仁，平山秀樹，只友一行，“微傾斜サファイア基板上AlN の選択横方向成長”，第80 回応用物理学会秋季学術講演会，北海道大学，9 月20 日，(2019)．
37. T. T. Lin, L. Wang and H. Hirayama, “0.44 watt power GaAs/AlGaAs THz QCL developed by reducing horizontal current leakage”，第80 回応用物理学会秋季学術講演会，北海道大学，9 月19 日，(2019)．
38. 室谷英彰，三好博之，武田椋平，中生拓希，倉井聡，M. A. Khan，前田哲利，定昌史，平山秀樹，山田陽一, “AlGaN 系多重量子井戸構造における励起子レート方程式モデルによる効率曲線の解析(2)”，第80 回応用物理学会秋季学術講演会，北海道大学，9月19 日，(2019)．
39. 田邉凌平，久永桂典，濱田晟，別府寛太，倉井聡，室谷英彰，前田哲利，定昌文，平山秀樹，山田陽一，“AlGaN 量子井戸構造における深紫外誘導放出の温度依存性”，第80 回応用物理学会秋季学術講演会，北海道大学，9 月19 日，(2019)．
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北海道大学，9 月19 日，(2019).

41. M. A. Khan, J. P. Bermudo, Y. Ishikawa, H. Ikenoue, S. Fujikawa, N. Maeda, M. Jo and H. Hirayama, “The influence of both Mg-concentration and excimer laser annealing (ELA) on p-AlGaN cladding layer for the application of AlGaN-based UVB Laser Diodes”, 第80 回応用物理学会秋季学術講演会，北海道大学，9 月18 日，(2019).
42. 最上耀介，大澤篤史，尾崎一人，谷岡千丈，前岡淳史，糸数雄吏，桑葉俊輔，定昌史，前田哲利，矢口裕之，平山秀樹，“DC スパッタAlN を用いたAlGaN 層格子緩和の促進”，第80 回応用物理学会秋季学術講演会，北海道大学，9 月18 日，(2019).
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44. 平山秀樹：“特異構造の特性を生かした新機能発光デバイスの研究”，新学術領域研究第4 回領域全体会議，ホテル＆リゾーツ長浜，4 月19 日，(2019).
45. 白井草汰，千代田夏樹，鎌田憲彦，糸数雄吏，山初駿太，平山秀樹：“電流注入と光励起を用いたUV-LED 内の欠陥準位の検出”，第67 回応用物理学会春季学術講演会，上智大学四谷キャンパス，3 月14 日，(2020).
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（５）特筆すべき事項・トピックス／ Topics

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