# Shuji Nakamura, Ph.D.

Professor of Materials Department
University of California, Santa Barbara
Santa Barbara, CA 93106-5050


## EDUCATION

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|---|---|
| 1994 | University of Tokushima, Japan<br>Doctor of Engineering |
| 1979 | University of Tokushima, Japan<br>Master of Electronic Engineering |
| 1977 | University of Tokushima, Japan<br>Bachelor of Electronic Engineering |

## ACADEMIC APPOINTMENTS

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| 1999 – Present | University of California, Santa Barbara<br>Professor, Materials Department |
| 1993 – 1999 | Nichia Chemical Ind., Ltd.<br>Senior Researcher, Department of Research and Development (R&D) |
| 1989 – 1993 | Nichia Chemical Ind., Ltd.<br>Group Head, Research and Development 2nd Section |
| 1988 – 1989 | University of Florida<br>Visiting Research Associate, Electronic Engineering |
| 1985 – 1988 | Nichia Chemical Ind., Ltd.<br>Group Head, Research and Development 1st Section |
| 1979 – 1984 | Nichia Chemical Ind., Ltd.<br>Research and Development |

## HONORS & AWARDS

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|---|---|
| 1994, 1996 | Nikkei BP Engineering Award |
| 1994, 1997 | Best Paper Award of Japanese Applied Physics Society |

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| 1995 | Sakurai Award |
| 1996 | Nishina Memorial Award |
| 1996 | IEEE Lasers and Electro-Optics Society Engineering Achievement Award |
| 1996 | Society for Information Display (SID) Special Recognition Award |
| 1997 | Okochi Memorial Award |
| 1997 | Materials Research Society (MRS) Medal Award |
| 1998 | Innovation in Real Materials (IRM) Award |
| 1998 | C&C Award |
| 1998 | IEEE Jack A. Morton Award |
| 1998 | British Rank Prize |
| 1999 | Julius-Springer Prize for Applied Physics |
| 2000 | Takayanagi Award |
| 2000 | Carl Zeiss Research Award |
| 2000 | Honda Award |
| 2000 | Crystal Growth and Crystal Technology Award |
| 2001 | Asahi Award |
| 2001 | Cree Professor in Solid State Lighting and Display Endowed Chair |
| 2001 | OSA Nick Holonyak Award |
| 2001 | LEOS Distinguished Lecturer Award |
| 2002 | IEEE/LEOS Quantum Electronics Award |
| 2002 | Recipient of the Franklin Institute's 2002 Benjamin Franklin Medal in Engineering |
| 2002 | Takeda Award |
| 2002 | The Economist Innovation Award 2002 "No Boundaries" |
| 2002 | World Technology Award |
| 2003 | CompoundSemi Pioneer Award |
| 2003 | National Academy of Engineering Fellow |
| 2003 | Blue Spectrum Pioneer Awards |
| 2004 | The Society for Information Display Karl Ferdinand Braun Prize |
| 2006 | Global Innovation Leader Award, Optical Media Global Industry Awards |
| 2006 | Millennium Technology Prize |
| 2007 | Santa Barbara Region Chamber of Commerce Innovator of the Year Award |
| 2007 | Czochralski Award |

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| 2008 | Japanese Science of Applied Physics (JSAP) Outstanding Paper Award for the "Demonstration of Nonpolar m-Plane InGaN/GaN Laser Diode" |
| 2008 | The Prince of Asturias Award for Technical Scientific Research (The Prince of Asturias Foundation) |
| 2009 | Harvey Prize |
| 2011 | Technology and Engineering Emmy Award |
| 2012 | Inventor of the Year Award by Silicon Valley Intellectual Property Law Association |
| 2013 | LED Pioneer Awards |
| 2013 | LUX Awards "LUX person of the Year in association with One-LUX" |
| 2013 | Awards of Outstanding Achievement for Global SSL Development by ISA (International SSL Alliances) |
| 2014 | Nobel Prize in Physics |
| 2014 | Order of Culture Award, Japan |
| 2014 | National Academy of Inventors (NAI) Member |
| 2014 | Goleta's Finest – Special Recognition by the Goleta Chamber of Commerce |
| 2015 | Charles Stark Draper Prize for Engineering |
| 2015 | National Academy of Inventors Fellow |
| 2015 | Japanese Science of Applied Physics (JSAP) Honorary Member |
| 2015 | National Inventors Hall of Fame |
| 2015 | Physical Society of Japan Honorary Member |
| 2015 | Pioneer Award, 21st annual South Coast Business & Technology Awards |
| 2015 | Global Energy Prize |
| 2015 | Asia Game Changer |
| 2015 | Eagle on the World |
| 2015 | Japanese Illuminating Engineering Institute Honorary Member |
| 2015 | Japanese Institute of Electronics and information Honorary Member |
| 2015 | Japanese Institute of Electrical and Electronic Engineering Honorary Member |
| 2015 | AAEOY Distinguished Science and Technology Award in Los Angeles |
| 2015 | Doctor Honoris Cause from Wroclaw University in Poland |
| 2016 | The Asian Award/Outstanding Achievement in Science & Technology, London, England |
| 2016 | The Nelson W. Taylor Keynote Award, The Pennsylvania State University |
| 2016 | Asian & Pacific Islander American (APIA) Heritage Award, Sacramento, CA |
| 2016 | Ordine dei Santi Mauizio e Lazzaro |
| 2017 | Academia Sinica Fellow, Taiwan |

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| 2017 | Mountbatten Medal Achievement Award, Institute of Engineering and Technology, England |
| 2017 | Asia Pacific Brands Foundation Awards: Legendary Award |
| 2017 | Doctor Honoris Causa from University of Warsaw in Poland |
| 2017 | Honorary Fellowship Awards from Hong Kong Baptist University ACKM |
| 2017 | Doctor Honoris Causa from Universidad International Menendez Pelayo in Spain |
| 2018 | Zayed Future Energy Prize Lifetime Achievement, United Arab Emirates |
| 2018 | Honorary Doctorate Degree from University of Massachusetts Lowell |
| 2018 | $10^{th}$ Iwaki Award in Japan |
| 2018 | Degree of Doctor of Science in Engineering (Honoris cause) for distinction in engineering from Queen's University Belfast |
| 2019 | Honorary Doctorate of Science, Universiti Sains Malaysia |
| 2020 | National Academy of Science (NAS) Award for the Industrial Application of Science |

## PROFESSIONAL ACTIVITIES

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| 1995 | Developed the first group-III nitride-based blue/green LEDs |
| 1995 | Developed the first group-III nitride-based violet laser diodes (LDs) |
| 1998 – 2000 | Editorial Board, Applied Physics Society |
| 2000 – 2007 | Research Director, Solid State Lighting and Display Center, UCSB |
| 2007 – 2013 | Research Director, Solid State Lighting and Energy Center, UCSB |
| 2014 – Present | Research Director, Solid State Lighting and Energy Electronics Center, UCSB |
| 2000 – Present | Editorial Board, Compound Semiconductor Magazine |
| 2001 – Present | Editor, Materials Research Society Conference Proceedings |
| 2001 – 2007 | Director, Exploratory Research for Advanced Technology (ERATO), UCSB |
| 2002 – Present | Guest Professor, Shinshu University (Japan) |
| 2004 – Present | Guest Professor, Tottori University (Japan) |
| 2004 – Present | Honorary Professor, Universtät Bremen (Germany) |
| 2004 – Present | Guest Professor, University of Tokushima (Japan) |
| 2005 – 10/2020 | Honorary Professor, Wuhan University (China) |
| 2007 – 10/2020 | Visiting Honorary Professor, Hong Kong University of Science & Technology |
| 2008 – Present | Honorary Graduates: Doctor of Engineering honoris causa, Hong Kong University of Science and Technology |
| 2007 – Present | Guest Professor, University of Ehime (Japan) |
| 2009 – 10/2020 | Advisor, Shanghai Research Center of Engineering and Technology for Solid-State Lighting (China) |

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| 2009 – 10/2020 | Advisory Professor, Fudan University (China) |
| 2015 – Present | Distinguished Professor, Tokyo University of Agriculture and Technology(Japan) |
| 2015 | Doctor Honoris Causa, University of Wroclaw, Poland |
| 2016 | University of Michigan Dow Lectureship |
| 2016 | GLOBALFOUNDRIES Fab8 |
| 2016 | Honorary Degree, McGill University, Montreal, Canada |
| 2016 | Cohen Distinguished Lecturer, Northwestern University |
| 2016 | Gurevitch Lecture, Portland State University, OR |
| 2016 | Keynote, International Conference on Physics, New Orleans, LA |
| 2016 | Keynote, ICEM2016 Conference, Singapore |
| 2016 | Keynote, 2016 QMS symposium, NY |
| 2016 | 2016 CPS (Chinese Physical Society), Beijing University of Technology, China |
| 2016 | LpS 2016 venue, St. Petersburg, Russia |
| 2016 | DLS, University of Wisconsin-La Crosse |
| 2016 | CeOPP (Center of Optoelectronics and Photonics Paderborn), University of Paderborn, Germany |
| 2016 | Nelson W. Taylor Lecturer at Penn State's University Park |
| 2016 | Honorary Professor of China University of Mining and Technology |
| 2017 | Honorary Academician, Academia Sinica, Taiwan |
| 2017 | Doctorado Honoris Causa, Universidad Internacional Menéndez Pelayo (UIMP), Spain |
| 2017 | Honorary Fellowship Awards from Hong Kong Baptist University ACKM |
| 2017 | The Doctorate Honoris, University of Warsaw (Poland) |
| 2017 | Invited Speaker, Military University of Technology (aka Wojskowa Akademia Techniczna), Warsaw, Poland |
| 2018 | Honorary Degree, University of Massachusetts Lowell |
| 2019 | Leigh Ann Conn Prize for Renewable Energy |
| 2019 | Honorary Degree of Doctor of Science from the Universiti Sains Malaysia |
| 2019 | 2019 Consumer Technology (CT) Hall of Fame |
| 2019 | Royal Academy of Engineering Member |
| 2020 | National Academy of Science (NAS) Award for the Industrial Application of Science |

**PUBLICATIONS: 691 as of 2/6/19**

| No. | Year | Authors and Title | Publisher | Category |
|---|---|---|---|---|
| 1. | 1989 | S. Nakamura, S. Sakai, S.S. Chang, R.V. Ramaswamy, J.-H. Kim, G. Radhakrishnan, J.K. Liu, J. Katz **"Transient-mode liquid phase epitaxial growth of GaAs on GaAs-coated Si substrates prepared by migration-enhanced molecular beam epitaxy"** | *J. Cryst. Growth*, Vol. 97, pp. 303-309 | Journal |
| 2. | 1990 | S. Nakamura, H. Takagi **"High-power and high-efficiency P-GaAlAs/N-GaAs: Si single herterostucture infrared emitting diodes"** | *Jpn. J. Appl. Phys.,* Vol. 29 No. 12, pp. 2694-2697 | Journal |
| 3. | 1991 | S. Nakamura, Y. Harada, M. Senoh **"Novel metalorganic chemical vapor deposition system for GaN growth"** | *Appl. Phys. Lett.,* Vol. 58 No. 18, pp. 2021-2023 | Journal |
| 4. | 1991 | S. Nakamura **"Analysis of real-time monitoring using interference effects"** | *Jpn. J. Appl. Phys.,* Vol. 30 No. 7, pp.1348-1353 | Journal |
| 5. | 1991 | S. Nakamura **"*In situ* monitoring of GaN growth using interference effects"** | *Jpn. J. Appl. Phys.,* Vol. 30 No. 8, pp. 1620-1628 | Journal |
| 6. | 1991 | S. Nakamura **"GaN growth using GaN buffer layer"** | *Jpn. J. Appl. Phys.,* Vol. 30 No. 10A, pp. L1705-L1707 | Journal |
| 7. | 1991 | S. Nakamura, M. Senoh, T. Mukai **"Highly P-typed Mg-doped GaN films grown with GaN buffer layers"** | *Jpn. J. Appl. Phys.,* Vol. 30 No. 10A, pp.L1708-L1711 | Journal |
| 8. | 1991 | S. Nakamura, T. Mukai, M. Senoh **"High-power GaN P-N junction blue-light-emitting diodes"** | *Jpn. J. Appl. Phys.,* Vol. 30 No. 12A, pp. L1998-L2001 | Journal |

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| 9. | 1992 | S. Nakamura, T. Mukai, M. Senoh, N. Iwasa **"Thermal annealing effects on P-type Mg-doped GaN films"** | *Jpn. J. Appl. Phys.,* Vol. 31 No. 2B, pp. L139-L142 | Journal |
| 10. | 1992 | S. Nakamura, N. Iwasa, M. Senoh, T. Mukai **"Hole compensation mechanism of P-type GaN films"** | *Jpn. J. Appl. Phys.,* Vol. 31 No. 5A, pp. 1258-1266 | Journal |
| 11. | 1992 | S. Nakamura, T. Mukai, M. Senoh **"*In situ* monitoring and hall measurements of GaN growth with GaN buffer layers"** | *J. Appl. Phys.,* Vol. 71, No. 11, pp. 5543-5549 | Journal |
| 12. | 1992 | S. Nakamura, T. Mukai, M. Senoh **"Si- and Ge-doped GaN films grown with GaN buffer layers"** | *Jpn. J. Appl. Phys.,* Vol. 31 No. 9A, pp. 2883-2888 | Journal |
| 13. | 1992 | S. Nakamura, T. Mukai **"High-quality InGaN films grown on GaN films"** | *Jpn. J. Appl. Phys.,* Vol. 31 No. 10B, pp. L1457-L1459 | Journal |
| 14. | 1993 | S. Nakamura, M. Senoh, T. Mukai **"p-GaN/N-InGaN/N-GaN double-heterostructure blue-light-emitting diodes"** | *Jpn. J. Appl. Phys.,* Vol. 32 No. 1A/B. pp. L8-L11 | Journal |
| 15. | 1993 | S. Nakamura, T. Mukai, M. Senoh **"Si-doped InGaN films grown on GaN films"** | *Jpn. J. Appl. Phys.,* Vol. 32 No. 1A/B, pp. L16-L19 | Journal |
| 16. | 1993 | S. Nakamura, N. Iwasa, S. Nagahama **"Cd-doped InGaN films grown on GaN films"** | *Jpn. J. Appl. Phys.,* Vol. 32 No. 3A, pp. L338-L341 | Journal |
| 17. | 1993 | S. Nakamura, M. Senoh, T. Mukai **"High-power InGaN/GaN double-heterostructure violet light-emitting diodes"** | *Appl. Phys. Lett.,* Vol. 62 No. 19, pp. 2390-2392 | Journal |

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| 18. | 1993 | S. Nakamura **"InGaN blue-light-emitting diodes"** | *Journal of the Institute of Electronics, Information and Communication Engineers,* Vol. 76 No. 9, pp. 3911-3915 | Journal |
| 19. | 1993 | S. Nakamura, T. Mukai, M. Senoh, S. Nagahama, N. Iwasa **"In/sub x-Ga/sub (1-x)-N/In/sub y-Ga/sub (1-y)-N superlattices grown on GaN films"** | *J. Appl. Phys.,* Vol. 74 No. 6, pp. 3911-3915 | Journal |
| 20. | 1994 | S. Nakamura **"Blue LEDs, realization of LCD by double-heterostructure"** | No. 602, pp. 93-102 | |
| 21. | 1994 | S. Nakamura, T. Mukai, M. Senoh **"Candela-class high-brightness InGaN/AlGaN double-heterostructure blue-light-emitting diodes"** | *Appl. Phys. Lett.,* Vol. 64 No. 13, pp. 1687-1689 | Journal |
| 22 | 1994 | S. Nakamura **"Nichia's 1cd blue LED paves way for full-color display"** | *Nikkei Electronics Asia*, June 1994 | Magazine |
| 23. | 1994 | S. Nakamura **"InGaN/AlGaN double-heterostructure light-emitting diodes"** | *Extended Abstracts of the 1994 International Conference on Solid State Devices and Materials*, JSAP, pp. 81-83 | Conference Proceeding |
| 24. | 1994 | S. Nakamura **"Realized high bright blue laser-emitting diodes"** | *Scientific American,* October 1994 | Magazine |
| 25. | 1994 | S. Nakamura **"Growth of In/sub x-Ga/sub (1-x)-N compound semiconductors and high-power InGaN/AlGaN double heterostructure violet-light-emitting-diodes"** | *Microelectronics Journal,* Vol. 25, pp. 651-659 | Journal |
| 26. | 1994 | S. Nakamura **"Zn-doped InGaN growth and InGaN/AlGaN double-heterostructure blue-light-emitting diodes"** | *J. Cryst. Growth,* Vol. 145, pp. 911-917 | Journal |

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| 27. | 1994 | S. Nakamura **"InGaN/AlGaN double-heterostructure blue LEDs"** | *Mat. Res. Symp. Proc.,* Vol. 339, pp. 173-178 | Journal |
| 28. | 1994 | S. Nakamura, T. Mukai, M. Senoh **"High-brightness InGaN/AlGaN double heterostructure blue-green-light-emitting diodes"** | *J. Appl. Phys.*, Vol. 76, pp. 8189-8191 | Journal |
| 29. | 1995 | S. Chichibu, T. Azhata, T. Sota, S. Nakamura **"Excitonic emissions from hexagonal GaN epitaxial layers"** | *J. Appl. Phys.,* Vol. 79 No. 5, pp. 2784-2786 | Journal |
| 30. | 1995 | S. Nakamura **"Highly luminous III-V nitride-based devices head for the highway, color displays"** | *IEEE*, May 1995 | Journal |
| 31. | 1995 | S. Nakamura **"InGaN/AlGaN blue-light-emitting diodes"** | *J. Vac. Sci. & Tech. A,* Vol. 13 No. 3, pp. 705-710 | Journal |
| 32. | 1995 | S. Nakamura, M. Senoh, N. Iwasa, S. Nagahama **"High-brightness InGaN blue, green, and yellow light-emitting diodes with quantum well structures"** | *Jpn. J. Appl. Phys.,* Vol. 34 No. 7A, pp. L797-L799 | Journal |
| 33. | 1995 | S. Nakamura **"LED full color display"** | *IEICE*, Vol. 78, No. 7, pp. 683-688 | Journal |
| 34. | 1995 | S. Nakamura **"InGaN light-emitting diodes with quantum well structures"** | *Extended Abstracts of the 1995 International Conference on Solid State Devices and Materials* 08/21-24/95, Osaka, Japan (JSAP) | Conference Proceeding |

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| 35. | 1995 | S. Nakamura, M. Senoh, N. Iwasa, S. Nagahama, Y. Yamada, T. Mukai **"Superbright green InGaN single-quantum-well structure light-emitting diodes"** | *Jpn. J. Appl. Phys.,* Vol. 34 No. 10B, pp. L1332-L1335 | Journal |
| 36. | 1995 | S. Nakamura, M. Senoh, N. Iwasa, S. Nagahama **"High-power InGaN single-quantum-well-structure blue and violet light-emitting diodes'** | *Appl. Phys. Lett.,* Vol. 67 No. 13, pp. 1868-1870 | Journal |
| 37. | 1995 | S. Nakamura **"Laser diodes and progress of InGaN-based IV-V system LED"** | *Optik*, Vol. 24, No. 11, pp. 673-678 | Journal |
| 38. | 1995 | T. Azuhata, T. Soto, K. Suzuki, S. Nakamura **"Polarized Raman Spectra in GaN"** | *J. Phys. Condens. Matter*, Vol. 7 No. 10, pp. L129-L133 | Journal |
| 39. | 1995 | S. Nakamura **"III-V Nitride light-emitting diodes"** | *OSA Proceedings on Advanced Solid-State Lasers,* Vol. 24, pp. 20-24 | Journal |
| 40. | 1995 | W.E. Carlos, E.R. Glaser, T.A. Kennedy, S. Nakamura **"Paramagnetic resonance in GaN-based light emitting diodes"** | *Appl. Phys. Lett.,* Vol. 67 No. 16, pp. 2376-2378 | Journal |
| 41. | 1995 | S. Nakamura **"Recent developments of GaN based LEDs"** | *Proceedings of Topical Workshop on III-V Nitrides*, pp. 11-14 | Conference Proceedings |
| 42. | 1996 | S. Chichibu, T. Azuhata, T. Sota, S. Nakamura **"Contribution of excitons in the photoluminescence spectra of h-GaN epitaxial layers grown on sapphire substrates by TF-MOCVD"** | *International Symposium on Blue Laser and Light Emitting Diodes*, March 5-7, pp. 202-205 | Conference Proceedings |

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| 43. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku, Y. Sugimoto **"InGaN-based multi-quantum-well-structure laser diodes"** | *Jpn. J. Appl. Phys.,* Vol. 35 No. 1B, pp. L74-L76 | Journal |
| 44. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku, Y. Sugimoto **"InGaN multi-quantum-well-structure laser diodes with cleaved mirror cavity facets"** | *Jpn. J. Appl. Phys.,* Vol. 35 No. 2B, pp. L217-L220 | Journal |
| 45. | 1996 | S. Nakamura **"Pulsed operation of violet laser diodes"** | *Electr. Mater.,March issue,* pp. 159-164 | Journal |
| 46. | 1996 | S. Nakamura, N. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku, Y. Sugimoto **"InGaN multi-quantum-well structure laser diodes grown on MgAl(sub 2)O(sub 4) substrates"** | *Appl. Phys. Lett.,* Vol. 68 No. 15, pp. 2105-2107 | Journal |
| 47. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku, Y. Sugimoto **"Characteristics of InGaN multi-quantum-well-structure laser diodes"** | *Appl. Phys. Lett.,* Vol. 68 No. 23, pp. 3269-3271 | Journal |
| 48. | 1996 | S. Chichibu, A. Shikanai, T. Azuhata, T. Sota, A. Kuramata, K. Horino, S. Nakamura **"Effects of biaxial strain on exciton resonance energies of hexagonal GaN heteroepitaxial layers"** | *Appl. Phys. Lett.,* Vo. 68 No. 26, pp. 3766-3768 | Journal |
| 49. | 1996 | S. Nakamura **"InGaN-based blue/green LEDs and laser diodes"** | *Adv. Mater.,* Vol. 8 No. 8, pp. 689-692 | Journal |
| 50. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, H. Kiyoku **"Continuous-wave operation of InGaN multi-quantum-well-structure laser diodes at 233K"** | *Appl. Phys. Lett.,* Vol. 69 No. 20, pp. 3034-3036 | Journal |

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| 51. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushito, Y. Sugimoto, H. Kiyoku **"Room-temperature continuous-wave operation of InGaN multi-quantum-well-structure laser diodes"** | *Appl. Phys. Lett.,* Vol. 69 No. 26, pp. 4056-4058 | Journal |
| 52. | 1996 | S. Chichibu, T. Azuhata, T. Sota, S. Nakamura **"Spontaneous emission of localized excitons in InGaN single and multiquantum well structures"** | *Appl. Phys. Lett.,* Vol. 69 No. 27, pp. 4188-4190 | Journal |
| 53. | 1996 | S. Nakamura **"Present status and future prospects of GaN-based light emitting devices"** | *Jpn. Soc. Appl. Phys.*, Vol. 65 No. 7, pp. 676-685 | Journal |
| 54. | 1996 | T. Azuhata, T. Matsunaga, K. Shimada, K. Yoshida, T. Sota, K. Suzuki, S. Nakamura **"Optical phonons in GaN"** | *Physica B,* Vol. 219-220, pp. 493-495 | Journal |
| 55. | 1996 | S. Nakamura **"Fabrication of blue and green nitride light-emitting diodes"** | *Inst. Phys. Conf. Ser. No. 142,* Chapter 6 | Conference Proceeding |
| 56. | 1996 | S. Nakamura **"III-V nitride-based light-emitting diodes"** | *Diamond and Related Materials,* Vol. 5 Issue 1-3, pp. 496-500 | Journal |
| 57. | 1996 | Y. Kawakami, Z.G. Peng, Y. Narukawa, Sz. Fujita, Sg. Fujita, S. Nakamura **"Recombination dynamics of excitons and biexcitons in hexagonal GaN epitaxial layer"** | *Appl. Phys. Lett.,* Vol. 69 No. 10, pp. 1414-1416 | Journal |
| 58. | 1996 | K. Okada, Y. Yamada, T. Taguchi, F. Sasaki, S. Kobayashi, T. Tani, S. Nakamura, G. Shinomiya **"Biexciton luminescence from GaN epitaxial layers"** | *Jpn. J. Appl. Phys.,* Vol. 35 No. 6B, pp. L787-L789 | Journal |

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| 59. | 1996 | W. E. Carlos, E. R. Glaser, T. A. Kennedy, S. Nakamura **"Magnetic resonance studies of recombination processes in GaN light-emitting diodes"** | *Mat. Res. Soc. Symp. Proc.* 395, pp. 673-678 | Conference Proceedings |
| 60. | 1996 | S. Nakamura **"InGaN light-emitting diodes with quantum-well structures"** | *Mat. Res. Soc. Symp. Proc.* 395, pp. 879-887 | Conference Proceedings |
| 61. | 1996 | S. Nakamura **"High-brightness blue-green LEDs and first III-V nitride-based laser diodes"** | *Proceedings of SPIE,* Vol. 2693, pp. 43-56 | Conference Proceedings |
| 62. | 1996 | T. Taguchi, T. Maeda, Y. Yamada, S. Nakamura, G. Shinomiya **"Band edge emission of InGaN active epilayers in the high-brightness Nichia blue LEDs"** | *International Symposium on Blue Laser and Light Emitting Diodes,* March 5-7, pp. 372-374 | Conference Proceedings |
| 63. | 1996 | S. Nakamura **"First successful III-V nitride based laser diodes"** | *International Symposium on Blue Laser and Light Emitting Diodes,* March 5-7, pp. 119-124 | Conference Proceedings |
| 64. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, H. Kiyoku **"Optical gain and carrier lifetime of InGaN multi-quantum well structure laser diodes"** | *Appl. Phys. Lett.,* Vol. 69 No. 11, pp. 1568-1570 | Journal |
| 65. | 1996 | S. Nakamura **"III-V nitride based blue/green LEDs and LDs"** | *23rd ICPS Proc.*, Berlin, July 21-26, Vol. 1, pp. 11-18 | Conference Proceedings |
| 66. | 1996 | T. Taguchi, Y. Yamada, K. Okada, T. Maeda, F. Sasaki, S. Kobayashi, T. Tani, S. Nakamura, G. Shinomiya **"Time-resolved luminescence spectroscopy of GaN and InGaN epitaxial layers under high density excitation"** | *23rd ICPS Proc.,* Berlin, July 21-26, Vol. 1, pp. 541-544 | Conference Proceedings |

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|---|---|---|---|---|
| 67. | 1996 | W. E. Carlos, E. R. Glaser, T. A. Kennedy, S. Nakamura **"Magnetic resonance studies of recombination processes in GaN-based single-quantum-well light-emitting diodes"** | *23rd ICPS Proc.,* Berlin, July 21-26, Vol. 4, pp. 2921-2924 | Conference Proceedings |
| 68. | 1996 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, H. Kiyoku **"Ridge-geometry InGaN multi-quantum-well-structure laser diodes"** | *Appl. Phys. Lett.*, Vol. 69 No. 10, pp. 1477-1479 | Journal |
| 69. | 1996 | S. Chichibu, T. Azuhata, T. Sota, S. Nakamura **"Excitonic emissions from hexagonal GaN epitaxial layers"** | *J. Appl. Phys.*, Vol. 79 No. 5, pp. 2784-2786 | Journal |
| 70. | 1996 | K. G. Zolina, V. E. Kudryashov, A. N. Turkin, A. E. Yunovich, S. Nakamura **"Luminescence spectra of superbright blue and green InGaN/AlGaN/GaN light-emitting diodes"** | *MRS Internet Journal of Nitride Semiconductor Research*, Vol. 1 | Journal |
| 71. | 1997 | A. Shikanai, T. Azuhata, T. Sota, S. Chichibu, A.Kuramata, K. Horino, S. Nakamura **"Biaxial strain dependence of exciton resonance energies in wurzite GaN"** | *J. Appl. Phys.,* Vol. 81 No. 1, pp. 417-424 | Journal |
| 72. | 1997 | Y. Narukawa, Y. Kawakami, S. Fujita, S. Fujita, S. Nakamura **"Recombination dynamics of localized excitons in In(sub 0.20)Ga(sub 0.80)N-In(sub 0.05)Ga(sub0.95)N multiple quantum wells"** | *Phys. Rev. B*, Vol. 55 No. 4, pp. R1938-R1941 | Journal |
| 73. | 1997 | S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, H. Kiyoku **"Longitudinal mode spectra and ultrashort pulse generation of InGaN multiquantum well structure"** | *Appl. Phys. Lett.,* Vol. 70 No. 5, pp. 616-618 | Journal |

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**PATENTS:** (last updated 1/29/19)

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| 5,290,393 | Crystal growth method for gallium nitride-based compound semiconductor |
| 5,334,277 | Method of vapor-growing semiconductor crystal and apparatus for vapor-growing the same |
| 5,433,169 | Method of depositing a gallium nitride-based III-V group compound semiconductor crystal layer |
| 5,468,678 | Method of manufacturing P-type compound semiconductor |
| 5,563,422 | Gallium nitride-based III-V group compound semiconductor device and method of producing the same |
| 5,578,839 | Light-emitting gallium nitride-based compound semiconductor device |
| 5,652,434 | Gallium nitride-based III-V group compound semiconductor |
| 5,734,182 | Light-emitting gallium nitride-based compound semiconductor device |
| 5,747,832 | Light-emitting gallium nitride-based compound semiconductor device |
| 5,767,581 | Gallium nitride-based III-V group compound semiconductor |
| 5,777,350 | Nitride semiconductor light-emitting device |

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| 5,877,558 | Gallium nitride-based III-V group compound semiconductor |
| 5,880,486 | Light-emitting gallium nitride-based compound semiconductor device |
| 5,959,307 | Nitride semiconductor device |
| 6,078,063 | Light-emitting gallium nitride-based compound semiconductor device |
| 6,093,965 | Gallium nitride-based III-V group compound semiconductor |
| 6,153,010 | Method of growing nitride semiconductors, nitride semiconductor substrate and nitride semiconductor device |
| 6,172,382 | Nitride semiconductor light-emitting and light-receiving devices |
| 6,204,512 | Gallium nitride-based III-V group compound semiconductor device and method of producing the same |
| 6,215,133 | Light-emitting gallium nitride-based compound semiconductor device |
| 6,469,323 | Light-emitting gallium nitride-based compound semiconductor device |
| 6,507,041 | Gallium nitride-based III-V group compound semiconductor |
| 6,580,099 | Nitride semiconductor light-emitting devices |
| 6,610,995 | Gallium nitride-based III-V group compound semiconductor |
| 6,677,619 | Nitride semiconductor device |
| 7,091,514 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| 7,122,844 | Susceptor for MOCVD reactor |
| 7,186,302 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| 7,122,844 | Susceptor for MOCVD reactor |
| 7,208,393 | Growth of planar reduced dislocation density m-plane gallium nitride by hydride vapor phase epitaxy |
| 7,220,324 | Technique for the growth of planar semi-polar gallium nitride |
| 7,220,658 | Growth of reduced dislocation density non-polar gallium nitride by hydride vapor phase epitaxy |
| 7,223,998 | White, single or multi-color light emitting diodes by recycling guided modes |
| 7,332,365 | Method for fabricating group-III nitride devices and devices fabricated using method |
| 7,335,920 | LED with current confinement structure and surface roughening |
| 7,338,828 | Growth of planar non-polar {1 -1 0 0} m-plane gallium nitride with metalorganic chemical vapor deposition (MOCVD) |
| 7,427,555 | Growth of planar, non-polar gallium nitride by hydride vapor phase epitaxy |

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| 7,480,322 | Electrically-pumped (Ga,In,Al)N vertical-cavity surface-emitting laser |
| 7,504,274 | Fabrication of nonpolar indium gallium nitride thin films, heterostructures and devices by metalorganic chemical vapor deposition |
| 7,518,159 | Packaging technique for the fabrication of polarized light emitting diodes |
| 7,550,395 | Control of photoelectrochemical (PEC) etching by modification of the local electrochemical potential of the semiconductor structure relative to the electrolyte |
| 7,575,947 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| 7,687,293 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| 7,687,813 | Standing transparent mirror-less (STML) light emitting diode |
| 7,691,658 | Method for improved growth of semipolar (Al,In,Ga,B)N |
| 7,704,331 | Technique for the growth of planar semi-polar gallium nitride |
| 7,704,763 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| 7,709,284 | Method for deposition of Mg Doped (Al,In,Ga, B)N layers |
| 7,719,020 | (AL, GA, IN)N and ZnO direct wafer bonding structure for optoelectronic applications and its fabrication method |
| 7,723,746 | Packaging technique for the fabrication of polarized light emitting diodes |
| 7,755,172 | Opto-electronic and electronic devices using N-face GaN substrate prepared with ammono thermal growth |
| 7,768,024 | Improved horizontal emitting, vertical emitting, beam shaped, DFB lasers over patterned substrate with multiple overgrowth |
| 7,781,789 | Transparent mirror-less (TML) light emitting diode |
| 7,839,903 | Optimization of laser bar orientation for nonpolar (Ga,Al,In,B)N diode lasers |
| 7,842,527 | MOCVD growth of high performance M-plane GAN optical devices |
| 7,846,757 | Technique for the growth and fabrication of semipolar (Ga,Al,In,B)N thin films, heterostructures, and devices |
| 7,847,280 | Nonpolar III-Nitride light emitting diodes with long wavelength emission |
| 7,847,293 | Growth of reduced dislocation density non-polar gallium nitride by hybrid vapor phaseepitaxy |
| 7,858,996 | Method for growth of semipolar (Al,In,Ga,B) N optoelectronic devices |
| 7,868,341 | Optical designs for high-efficacy white-light emitting diodes |
| 7,956,360 | Growth of planar reduced dislocation density M-plane gallium nitride by hydride vapor phase epitaxy |
| 7,956,371 | High efficiency light emitting diode (LED) |
| 7,982,208 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| 7,994,527 | High light extraction efficiency light emitting diode (LED) |
| 8,022,423 | Standing transparent mirrorless light emitting diode |
| 8,044,383 | Thin P-type gallium nitride and aluminum gallium nitride electron-blocking layer free gallium nitride-based light emitting diode |

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| 8,044,417 | Enhancement of optical polarization of nitride light-emitting diodes by increased indium incorporation |
| 8,053,264 | Photoelectrochemical etching of P-type semiconductor heterostructures |
| 8,080,469 | Method for increasing the area of non-polar and semi-polar nitride substrates |
| 8,084,763 | Optoelectronic device based on non-polar and semi-polar aluminum indium nitride and aluminum indium gallium nitride alloys |
| 8,097,481 | Growth of non-polar M-plane III-nitride film using metalorganic chemical vapor deposition (MOCVD) |
| 8,110,482 | Miscute semipolar optoelectronic device |
| 8,114,698 | High light extraction efficiency nitride based light emitting diode by surface roughening |
| 8,124,991 | Light emitting diodes with high extraction efficiency |
| 8,128,756 | Technique for the growth of planar semi-polar gallium nitride |
| 8,148,244 | Lateral growth method for defect reduction of semipolar nitride films |
| 8,148,713 | Method for fabrication of semipolar-(A1,In,Ga,B)N-based light emitting diodes |
| 8,158,947 | Planar nonpolar m-plane group III nitride films grown on miscute substrates |
| 8,178,373 | MOCVD growth of high performance m-plane GaN optical devices |
| 8,183,557 | (Al, In, Ga, B)N device structures on a patterned substrate |
| 8,188,458 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| 8,193,079 | Method for conductivity control of semipolar (Al,In,Ga,B) N |
| 8,203,159 | Method for growth of semipolar (Al,In,Ga,B) N optoelectronic devices |
| 8,211,723 | AlxGal-x-N-cladding-free nonpolar GaN-Based laser diodes and LED's |
| 8,227,818 | Horizontal emitting, vertical emitting, beam shaped, DFB lasers fabricated by growth over patterned substrate with multiple overgrowth |
| 8,227,819 | Thin P-type GaN and AlGaN electron-blocking layer free GaN-based light emitting diodes |
| 8,227,820 | Semiconductor light-emitting device |
| 8,253,221 | Gallium nitride bulk crystals and their growth method |
| 8,254,423 | (Al, Ga, In) N Diode laser fabricated at reduced temperature |

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| 8,263,424 | Opto-electronic and electronic devices using N-face GaN substrate prepared with ammonothermal growth |
| 8,278,128 | Enhancement of optical polarization of nitride light-emitting diodes by wafer miscute |
| 8,294,166 | Transparent LEDs |
| 8,299,452 | Method for fabrication of semipolar-(A1,In,Ga,B)N-based light emitting diodes |
| 8,357,925 | Optoelectronic Device Based on Non-Polar and Semi-Polr Aluminum Indium Nitride and aluminum Indium Gallium Nitride |
| 8,368,109 | Light emitting diodes with a p-type surface bonded to a transparent submount to increase light extraction efficiency |
| 8,368,179 | Method for improved growth of semipolar (al,in,ga,b)n |
| 8,405,128 | Method for enhancing growth of semipolar (al,in,ga,b)n via metalorganic chemical vapor deposition |
| 8,481,991 | Anisotropic strain control in semipolar nitride quantum wells by partially or fully relaxed aluminum indium gallium nitride |
| 8,502,246 | Fabrication of nonpolar indium gallium nitride thin films, heterostructures and devices by metalorganic chemical vapor |
| 8,524,012 | Technique for the growth of planar semi-polar gallium nitride |
| 8,536,618 | Light emitting diode structure utilizing zinc oxide nanorod arrays on one or more surfaces, and a low cost method of producing |
| 8,541,869 | Cleaved facet (Ga,Al,In)n edge-emitting laser diodes grown on semipolar {11-2n} bulk gan substrates |
| 8,574,525 | Using boron-containing compounds, gasses and fluids during ammonothermal growth of group-III nitride crystals |
| 8,588,260 | Optimization of laser bar orientation for nonpolar (Ga,Al,In,B)n diode lasers |
| 8592802 | (Al,In,Ga,B)n device structures on a patterned substrate |
| 8,624,281 | Optical designs for high-efficacy white-light emitting diodes |
| 8,637,334 | High brightness light emitting diode covered by zinc oxide layers on multiple surfaces grown in low temperature aqueous solute |
| 8,641,823 | Reactor Designs for use in Ammonthermal Growth of Group-III Nitride Crystals |

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| 8,642,993 | Nonpolar III-Nitride Light Emitting Diodes With Long Wavelength Emission |
| 8,647,967 | Hexagonal wurtzite type epitaxial layer possessing a low alkali-metal concentration and method of creating the same |
| 8,653,503 | Optoelectronic Device Based on Non-Polar and Semi-Polr Aluminum Indium Nitride and aluminum Indium Gallium Nitride |
| 8,686,397 | Low Droop Light Emitting Diode Structure On Gallium Nitride Semipolar Substrates |
| 8,686,466 | Technique For The Growth And Fabrication Of Semipolar (Ga,Al,In,B) N Thin Films Heterostructures, And Devices |
| 8,691,671 | Planar Nonpolar M-Plane Group III Nitride Films Grown On Miscut Substrates |
| 8,692,105 | III-V Nitride-Based Thermoelectric Device |
| 8,709,371 | Method For Growing Group Iii-Nitride Crystals In Supercritical Ammonia Using An Autoclave |
| 8,709,925 | Method For Conductivity Control Of Semipolar (Al,In,Ga,B)N |
| 8,729,671 | Method for increasing the area of non-polar and semi-polar gan substrates |
| 8,761,218 | Aluminum gallium nitride barriers and separate confinement heterostructure (SCH) layers for semipolar plane III-nitride |
| 8,766,296 | Highly Efficient Gallim Nitride Based Light Emitting Diodes Via Surface Roughening |
| 8,709,925 | Suppression of inclined defect formation and increase in critical thickness by silicon doping on non-c-plane (Al,Ga,In)N |
| 8,729,671 | (Al,Ga,In)N Diode Laser Fabricated At Reduced Temperature |
| 8,761,218 | Aluminum gallium nitride barriers and separate confinement heterostructure (SCH) layers for semipolar plane III-nitride semiconductor-based light emitting diodes and laser diodes |
| 8,766,296 | Highly efficient gallium nitride based light emitting diodes via surface roughening |
| 8,772,758 | Suppression of inclined defect formation and increase in critical thickness by silicon doping on non-c-plane (Al,Ga,In)N |
| 8,790,943 | (Al,Ga,In)N diode laser fabricated at reduced temperature |
| 8,791,000 | Planar nonpolar group-III nitride films grown on miscut substrates |
| 8,795,430 | Method of improving surface morphology of (Ga,Al,In,B)N thin films and devices grown on nonpolar or semipolar (Ga,Al,In,B)N substrates |
| 8,795,440 | Growth of non-polar M-plane III-nitride film using metalorganic chemical vapor deposition (MOCVD) |
| 8,809,867 | Dislocation reduction in non-polar III-nitride thin films |

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|---|---|
| 8,835,200 | High light extraction efficiency nitride based light emitting diode by surface roughening |
| 8,835,959 | Transparent light emitting diodes |
| 8,841,691 | Light emitting diode structure utilizing zinc oxide nanorod arrays on one or more surfaces, and a low cost method of producing |
| 8,853,669 | Limiting strain relaxation in III-nitride heterostructures by substrate and epitaxial layer patterning |
| 8,860,051 | Textured phosphor conversion layer light emitting diode |
| 8,866,126 | Anisotropic Strain Control In Semipolar Nitride Quantum Wells By Partially Or Fully Relaxed Aluminum Indium Gallium Nitride |
| 8,866,149 | Method For The Reuse Of Gallium Nitride Epitaxial Substrates |
| 8,882,935 | Fabrication of nonpolar indium gallium nitride thin films, heterostructures and devices by metalorganic chemical vapor |
| 8,956,896 | Metalorganic Chemical Vapor Deposition (Mocvd) Growth Of High Performance Non-Polar III-Nitride Optical Devices |
| 9,039,834 | Non-polar gallium nitride thin films grown by metalorganic chemical vapor deposition |
| 9,040,326 | High Light Extraction Efficiency Nitride Based Light Emitting Diode By Surface Roughening |
| 9,040,327 | Alxgal-X-N-Cladding-Free Nonpolar III-Nitride Based Laser Diodes And Light Emitting Diodes |
| 9,054,498 | (Al,Ga,In)N Diode Laser Fabricated At Reduced (Al,Ga,In)N Diode Laser Fabricated At Reduced Temperature |
| 9,077,151 | Semi-Polar III-Nitride Optoelectronic Devices On M-Plane Substrates With Miscuts Less Than +/-15 Degrees In The C-Direction |
| 9,130,119 | Non-Polar And Semi-Polar Light Emitting Devices |
| 9,133,564 | Ammonothermal Growth Of Group-Iii Nitride Crystals On Seeds With At Least Two Surfaces Making An Acute, Right Or Obtuse |
| 9,136,673 | Structure and method for the fabrication of a gallium nitride vertical cavity surface emitting laser |
| 9,147,733 | Method For The Reuse Of Gallium Nitride Epitaxial Substrates |
| 9,159,553 | Semipolar nitride-based devices on partially or fully relaxed alloys with misfit dislocations at the heterointerface |
| 9,219,205 | Optical Designs For High-Efficacy White-Light Emitting Diodes |
| 9,231,376 | Technique For The Growth And Fabrication Of Semipolar (Ga,Al,In,B) N Thin Films Heterostructures, And Devices |
| 9,240,529 | Textured Phosphor Conversion Layer Light Emitting Diode |
| 9,243,344 | Gallium Nitride Bulk Crystals And Their Growth Method |

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|---|---|
| 9,340,899 | Planar Nonpolar Group-III Nitride Films Grown On Miscut Substrates |
| 9,356,431 | High Power Blue-Violet III-Nitride Semipolar Laser Diodes |
| 9,396,943 | Method For The Reuse Of Gallium Nitride Epitaxial Substrates |
| 9,515,240 | Optical Designs For High-Efficacy White-Light Emitting Diodes |
| 9,551,088 | Method For Growing Group Iii-Nitride Crystals In Supercritical Ammonia Using An Autoclave |
| 9,640,947 | Structure and method for the fabrication of a gallium nitride vertical cavity surface emitting laser |
| 9,773,704 | Method for the Reuse of Gallium Nitride Epitaxial Substrates |
| 9,793,435 | Technique for the Growth and Fabrication of Semipolar (Ga, Al, In, B) N Thin Films Heterostructures, and Devices |
| 9,828,695 | Planar Nonpolar Group-III Nitride Films Grown On Miscut Substrates |
| 9,859,464 | Textured Phosphor Conversaion Layer Light Emitting Diode |
| 9,917,422 | Semi-Polar III-Nitride Optoelectronic Devices on M-Plane Substrates with Miscuts Less than +/-15 Degrees in the C-Direction |
| 9,951,912 | Tunable White Light Based on Polarization Sensitive Light-Emitting Diodes |

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| EP00497350B1 | Crystal growth method for gallium nitride-based compound semiconductor |
| EP00497350B2 | Crystal growth method for gallium nitride-based compound semiconductor |
| EP00599224B1 | Light-emitting gallium nitride-based compound semiconductor device |
| EP00541373B1 | Method of manufacturing p-type compound semiconductor |
| EP00541373B2 | Method of manufacturing p-type compound semiconductor |
| EP00622858B1 | Gallium nitride-based III-V group compound semiconductor device and method of producing the same |
| EP1869707 | Technique for the growth of planar semi-polar gallium nitride |
| EP1697983 | Highly Efficient Gallium Nitride Based Light Emitting Diodes Via Surface Roughening |
| EP2087563 | Textured phosphor conversion layer light |
| EP2320482 | emitting diode |
| EP2633103 | 2320482<br>Hightly Efficient Gallium Nitride Based Light Emitting Diodes via Surface Roughening<br>Ammonothermal Growth Of Group-III Nitride Crystals On Seeds With At Least Two Surfaces Making An Acute, Right Or Obtuse Angle With Each Other |

**WORLD PATENTS**

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| WO00048254A1 | Nitride semiconductor device and its manufacturing method |
| WO00052796A1 | Nitride semiconductor laser element |
| WO03029516A1 | Apparatus for inverted CVD |
| WO03098667A1 | Susceptor for MOCVD reactor |
| WO04079043A2 | Susceptor apparatus for inverted type MOCVD reactor |
| WO05117152A1 | Method for fabricating group iii nitride devices and devices fabricated using method |
| WO06080958A1 | Led with current confinement structure and surface roughening |

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| WO07018789A1 | Blue led with roughened high refractive index surface layer for high light extraction |
| WO98031055A1 | Nitride semiconductor device |
| WO98047170A1 | Method of growing nitride semiconductors, nitride semiconductor substrate and nitride semiconductor device |
| WO99005728A1 | Nitride semiconductor device |

**JAPAN PATENTS**

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| 特公平 07-083136 | 窒化ガリウム系化合物半導体発光素子 |
| 特公平 08-008217 | 窒化ガリウム系化合物半導体の結晶成長方法 |
| 特許 2141083 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 2141400 | 窒化ガリウム系化合物半導体の結晶成長方法 |
| 特許 2540791 | ｐ型窒化ガリウム系化合物半導体の製造方法。 |
| 特許 2556211 | 半導体結晶層の成長装置とその成長方法 |
| 特許 2560963 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 2560964 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 2576819 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 2591521 | 窒化ガリウム系化合物半導体素子 |
| 特許 2628404 | 半導体結晶膜の成長方法 |
| 特許 2632239 | 半導体結晶膜の成長方法および装置 |
| 特許 2687742 | 半導体結晶膜の表面状態測定方法 |
| 特許 2697572 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 2713094 | 半導体発光素子およびその製造方法 |
| 特許 2713095 | 半導体発光素子およびその製造方法 |
| 特許 2728190 | 半導体レーザ素子 |

特許 2735057　窒化物半導体発光素子

特許 2748354　窒化ガリウム系化合物半導体チップの製造方法

特許 2748355　窒化ガリウム系化合物半導体チップの製造方法

特許 2748818　窒化ガリウム系化合物半導体発光素子

特許 2751963　窒化インジウムガリウム半導体の成長方法

特許 2751987　窒化インジウムガリウム半導体の成長方法

特許 2770717　窒化ガリウム系化合物半導体発光素子

特許 2770720　窒化ガリウム系化合物半導体発光素子

特許 2778349　窒化ガリウム系化合物半導体の電極

特許 2778405　窒化ガリウム系化合物半導体発光素子

特許 2780618　窒化ガリウム系化合物半導体チップの製造方法

特許 2780691　窒化物半導体発光素子

特許 2783349　ｎ型窒化ガリウム系化合物半導体層の電極及びその形成方法

特許 2785253　窒化ガリウム系化合物半導体のｐ型化方法

特許 2785254　窒化ガリウム系化合物半導体発光素子

特許 2790235　窒化ガリウム系化合物半導体のｐ型化方法

特許 2790237　多色発光素子

特許 2790242　窒化物半導体発光ダイオード

特許 2791448　発光ダイオード

特許 2795294　窒化ガリウムアルミニウム半導体の結晶成長方法。

特許 2800666　窒化ガリウム系化合物半導体レーザ素子

特許 2803741　窒化ガリウム系化合物半導体の電極形成方法

特許 2803742　窒化ガリウム系化合物半導体発光素子及びその電極形成方法

特許 2809045　窒化物半導体発光素子

特許 2812375　窒化ガリウム系化合物半導体の成長方法

特許 2827794　　ｐ型窒化ガリウムの成長方法

特許 2828187　　窒化ガリウム系化合物半導体発光素子

特許 2836685　　ｐ型窒化ガリウム系化合物半導体の製造方法

特許 2836686　　窒化ガリウム系化合物半導体発光素子

特許 2836687　　窒化ガリウム系化合物半導体発光素子

特許 2859478　　発光デバイス用の窒化ガリウム系化合物半導体ウエハーの切断方法

特許 2861991　　窒化ガリウム系化合物半導体チップの製造方法

特許 2868081　　窒化ガリウム系化合物半導体発光素子

特許 2890390　　窒化ガリウム系化合物半導体発光素子

特許 2890392　　ＩＩＩ－Ｖ族窒化物半導体発光素子

特許 2890396　　窒化物半導体発光素子

特許 2891348　　窒化物半導体レーザ素子

特許 2900928　　発光ダイオード

特許 2900990　　窒化物半導体発光素子

特許 2910023　　窒化ガリウム系化合物半導体発光素子

特許 2910811　　窒化ガリウム系化合物半導体ウエハーの切断方法

特許 2914014　　窒化ガリウム系化合物半導体チップの製造方法

特許 2914065　　青色発光素子及びその製造方法

特許 2917742　　窒化ガリウム系化合物半導体発光素子とその製造方法

特許 2918139　　窒化ガリウム系化合物半導体発光素子

特許 2921746　　窒化物半導体レーザ素子

特許 3346735　　窒化物半導体発光素子及びその製造方法

特許 2932467　　窒化ガリウム系化合物半導体発光素子

特許 2932468　　窒化ガリウム系化合物半導体発光素子

特許 2947047　　ＬＥＤチップのリードフレームへのダイボンド方法

特許 2953326　　窒化ガリウム系化合物半導体レーザ素子の製造方法

特許 2956489　　窒化ガリウム系化合物半導体の結晶成長方法

特許 2964822　　発光ダイオードの製造方法

特許 2976951　　窒化物半導体発光ダイオードを備えた表示装置

特許 2982553　　発光デバイスの製造方法

特許 2985908　　窒化ガリウム系化合物半導体の結晶成長方法

特許 2998696　　発光ダイオード

特許 3009091　　青色発光ダイオード

特許 3009095　　窒化物半導体発光素子

特許 3019132　　窒化ガリウム系化合物半導体受光素子

特許 3036465　　発光ダイオードを用いたディスプレイ

特許 3047960　　ｎ型窒化物半導体の電極

特許 3077781　　窒化インジウムガリウムの成長方法

特許 3087829　　窒化物半導体素子の製造方法

特許 3087831　　窒化物半導体素子

特許 3091593　　窒化物半導体発光デバイス用積層体

特許 3101997　　窒化物半導体レーザ素子

特許 3129384　　窒化物半導体レーザ素子

特許 3135041　　窒化物半導体発光素子

特許 3141824　　窒化物半導体発光素子

特許 3152238　　発光ダイオード

特許 3154364　　ｎ型窒化ガリウム系化合物半導体層の電極及びその形成方法

特許 3180710　　窒化ガリウム系化合物半導体発光素子の製造方法

特許 3180871　　窒化ガリウム系化合物半導体発光素子およびその電極形成方法

特許 3187284　ｎ型窒化物半導体層の電極

特許 3203282　発光デバイス用窒化インジウムガリウム半導体

特許 3209233　青色発光ダイオードおよびその製造方法

特許 3212008　窒化ガリウム系化合物半導体レーザ素子

特許 3216118　窒化物半導体素子及びその製造方法

特許 3218595　窒化物半導体レーザ素子及びその製造方法

特許 3216596　窒化ガリウム系化合物半導体発光素子

特許 3218963　窒化物半導体レーザ素子及びその製造方法

特許 3220977　窒化物半導体レーザ素子及び窒化物半導体レーザ素子の製造方法。

特許 3223810　窒化ガリウム系化合物半導体発光素子

特許 3223832　窒化物半導体素子及び半導体レーザダイオード

特許 3224020　窒化物半導体発光素子およびその製造方法

特許 3227287　窒化ガリウム系化合物半導体チップの製造方法と窒化ガリウム系化合物半導体素子

特許 3233258　窒化物半導体の電極

特許 3235440　窒化物半導体レーザ素子とその製造方法

特許 3241250　窒化物半導体レーザ素子

特許 3248564　窒化物半導体レーザダイオード

特許 3255224　窒化ガリウム系化合物半導体素子及びその製造方法

特許 3257344　窒化ガリウム系化合物半導体の結晶成長方法

特許 3257498　窒化ガリウム系化合物半導体の結晶成長方法

特許 3259811　窒化物半導体素子の製造方法及び窒化物半導体素子

特許 3267250　窒化物半導体発光素子

特許 3269070　窒化物半導体発光素子

特許 3271645　窒化物半導体発光ダイオード

特許 3271657　　ｎ型窒化ガリウム系化合物半導体の電極及びその形成方法

特許 3272588　　窒化物半導体レーザ素子

特許 3274907　　窒化インジウムガリウム化合物半導体の成長方法

特許 3275810　　窒化物半導体発光素子

特許 3278108　　窒化物半導体レーザ素の製造方法

特許 3282174　　窒化物半導体発光素子

特許 3282175　　窒化物半導体素子

特許 3292083　　窒化物半導体基板の製造方法及び窒化物半導体素子の製造方法

特許 3298390　　窒化物半導体多色発光素子の製造方法

特許 3298454　　窒化ガリウム系化合物半導体発光素子の製造方法

特許 3301345　　ｐ型窒化ガリウム系化合物半導体層の形成方法

特許 3301601　　窒化物半導体発光素子

特許 3303645　　窒化物半導体発光素子の製造方法

特許 3307218　　窒化物半導体レーザ素子の製造方法

特許 3309953　　窒化物半導体レーザダイオード

特許 3314620　　窒化物半導体発光素子

特許 3314641　　窒化物半導体レーザ素子

特許 3314666　　窒化物半導体素子

特許 3314671　　窒化物半導体素子

特許 3319585　　窒化物半導体レーザ素子の製造方法

特許 3327170　　発光ダイオードの製造方法

特許 3327179　　窒化物半導体レーザ素子の製造方法

特許 3329753　　窒化物半導体レーザ素子

特許 3334624　　窒化物半導体レーザ素子

特許 3336599　　窒化物半導体レーザ素子

特許 3339049　窒化物半導体レーザ素子

特許 3460581　窒化物半導体の成長方法及び窒化物半導体素子

特許 3272588　窒化物半導体レーザ素子

特許 3274907　窒化インジウムガリウム化合物半導体の成長方法

特許 3275810　窒化物半導体発光素子

特許 3278108　窒化物半導体レーザ素の製造方法

特許 3282174　窒化物半導体発光素子

特許 3282175　窒化物半導体素子

特許 3292083　窒化物半導体基板の製造方法及び窒化物半導体素子の製造方法

特許 3298390　窒化物半導体多色発光素子の製造方法

特許 3298454　窒化ガリウム系化合物半導体発光素子の製造方法

特許 3301345　ｐ型窒化ガリウム系化合物半導体層の形成方法

特許 3301601　窒化物半導体発光素子

特許 3303645　窒化物半導体発光素子の製造方法

特許 3307218　窒化物半導体レーザ素子の製造方法

特許 3309953　窒化物半導体レーザダイオード

特許 3314620　窒化物半導体発光素子

特許 3314641　窒化物半導体レーザ素子

特許 3314666　窒化物半導体素子

特許 3314671　窒化物半導体素子

特許 3319585　窒化物半導体レーザ素子の製造方法

特許 3327170　発光ダイオードの製造方法

特許 3327179　窒化物半導体レーザ素子の製造方法

特許 3329753　窒化物半導体レーザ素子

特許 3334624　窒化物半導体レーザ素子

特許 3336599　　窒化物半導体レーザ素子

特許 3339049　　窒化物半導体レーザ素子

特許 3344056　　窒化ガリウム系化合物半導体発光素子及びその製造方法

特許 3344414　　発光ダイオードを用いたディスプレイ

特許 3298390　　窒化物半導体多色発光素子の製造方法

特許 3298454　　窒化ガリウム系化合物半導体発光素子の製造方法

特許 3301345　　ｐ型窒化ガリウム系化合物半導体層の形成方法

特許 3301601　　窒化物半導体発光素子

特許 3303645　　窒化物半導体発光素子の製造方法

特許 3307218　　窒化物半導体レーザ素子の製造方法

特許 3309953　　窒化物半導体レーザダイオード

特許 3314620　　窒化物半導体発光素子

特許 3314641　　窒化物半導体レーザ素子

特許 3314666　　窒化物半導体素子

特許 3314671　　窒化物半導体素子

特許 3319585　　窒化物半導体レーザ素子の製造方法

特許 3327170　　発光ダイオードの製造方法

特許 3327179　　窒化物半導体レーザ素子の製造方法

特許 3329753　　窒化物半導体レーザ素子

特許 3334624　　窒化物半導体レーザ素子

特許 3336599　　窒化物半導体レーザ素子

特許 3339049　　窒化物半導体レーザ素子

特許 3344056　　窒化ガリウム系化合物半導体発光素子及びその製造方法

特許 3344414　　発光ダイオードを用いたディスプレイ

特許 3360812　　窒化物半導体素子

特許 3366188　窒化物半導体素子

特許 3366586　発光ダイオード

特許 3369089　窒化ガリウム系化合物半導体発光素子

特許 3371830　窒化物半導体発光素子

特許 3372226　窒化物半導体レーザ素子

特許 3374737　窒化物半導体素子

特許 3379619　窒化物半導体レーザ素子

特許 3395631　窒化物半導体素子及び窒化物半導体素子の製造方法

特許 3405334　窒化物半導体素子

特許 3424465　窒化物半導体素子及び窒化物半導体の成長方法

特許 3431389　窒化物半導体レーザ素子

特許 3433730　窒化物半導体発光素子

特許 3434162　窒化物半導体素子

特許 3438675　窒化物半導体の成長方法

特許 3441883　窒化物半導体レーザ素子

特許 3448196　窒化物半導体発光素子

特許 3454355　窒化ガリウム系化合物半導体発光素子

特許 3456413　窒化物半導体の成長方法及び窒化物半導体素子

特許 3468082　窒化物半導体素子

特許 3470712　窒化物半導体レーザ素子

特許 3473595　発光デバイス

特許 3476636　窒化物半導体レーザ素子

特許 3478090　窒化物半導体素子

特許 3478287　窒化ガリウム系化合物半導体の結晶成長方法と窒化ガリウム系化合物半導体

特許 3482955　窒化ガリウム系化合物半導体発光素子

特許 3484842　窒化物半導体レーザ素子

特許 3484997　窒化ガリウム系化合物半導体発光素子

特許 3496480　窒化物半導体素子

特許 3496512　窒化物半導体素子

特許 3502527　窒化物半導体レーザ素子

特許 3505167　窒化ガリウム系化合物半導体発光素子の製造方法

特許 3511970　窒化物半導体発光素子

特許 3523700　窒化物半導体レーザ素子

特許 3529286　窒化物半導体レーザ素子の製造方法

特許 3537977　窒化物半導体レーザ素子の製造方法

特許 3537984　窒化物半導体レーザ素子

特許 3538275　窒化物半導体発光素子

特許 3548442　窒化ガリウム系化合物半導体発光素子

特許 3551751　窒化物半導体の成長方法

特許 3557894　窒化物半導体基板および窒化物半導体素子

特許 3562455　窒化物半導体レーザ素子の形成方法

特許 3565202　窒化物半導体レーザ素子

特許 3593952　窒化物半導体レーザ素子

特許 3604205　窒化物半導体の成長方法

特許 3604278　窒化物半導体レーザー素子

特許 3617565　窒化物半導体レーザ素子

特許 3620292　窒化物半導体素子

特許 3622045　窒化物半導体レーザ素子及びその製造方法

特許 3645207　発光ダイオード

特許 3646649　窒化ガリウム系化合物半導体発光素子

特許 3647236　窒化物半導体レーザ素子

特許 3651260　窒化物半導体素子

特許 3656454　窒化物半導体レーザ素子

特許 3657795　発光素子

特許 3658112　窒化物半導体レーザダイオード

特許 3658892　ｐ型窒化物半導体の成長方法及び窒化物半導体素子

特許 3659050　窒化物半導体の成長方法及び窒化物半導体素子

特許 3660446　窒化物半導体素子及びその製造方法

特許 3669848　窒化物半導体レーザ素子

特許 3679626　窒化ガリウム系化合物半導体チップ

特許 3685682　窒化物半導体レーザ素子

特許 3705047　窒化物半導体発光素子

特許 3724490　発光ダイオード

特許 3724498　発光ダイオード

特許 3744211　窒化物半導体素子

特許 3758562　窒化物半導体多色発光素子

特許 3767491　窒化ガリウム系化合物半導体発光素子

特許 3767534　発光デバイス

特許 3770014　窒化物半導体素子

特許 3772651　窒化物半導体レーザ素子

特許 3772807　窒化ガリウム系化合物半導体発光素子

特許 3775259　窒化物半導体レーザ素子

特許 3786000　窒化物半導体レーザダイオードとその製造方法

特許 3794530　窒化物半導体レーザ素子

特許 3800146　窒化物半導体素子の製造方法

特許 3801353　窒化物半導体発光素子

特許 3808892　発光ダイオード

特許 3809749　窒化物半導体発光素子

特許 3835225　窒化物半導体発光素子

特許 3835384　窒化物半導体素子

特許 3835446　窒化物半導体発光素子

特許 3847000　窒化物半導体基板上に活性層を備えた窒化物半導体層を有する窒化物半導体素子及びその成長方法

特許 3857417　窒化物半導体素子

特許 3859356　窒化物半導体素子の製造方法

特許 3867625　窒化物半導体発光素子

特許 3876518　窒化物半導体基板の製造方法および窒化物半導体基板

特許 3884717　窒化ガリウム系化合物半導体の製造方法

特許 3885092　窒化物半導体レーザ素子およびその共振面の作製方法

特許 3888036　ｎ型窒化物半導体の成長方法

特許 3888170　窒化物半導体レーザ素子

特許 3891108　窒化物半導体発光素子

特許 3893614　窒化物半導体レーザ素子のストライプ導波路の側面及び窒化物半導体層の平面に絶縁性の保護膜を形成する方法

特許 3920296　発光ダイオード

特許 3924973　窒化物半導体発光素子の製造方法および窒化物半導体発光素子

特許 3928621　発光素子用ウエハー

特許 3938101　発光素子の製造方法

特許 3941464　窒化物半導体発光素子の製造方法

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|---|---|
| 特許 3951973 | 窒化物半導体素子 |
| 特許 3952079 | 窒化物半導体発光素子の製造方法 |
| 特許 3953077 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 3956753 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 3972943 | 窒化ガリウム系化合物半導体発光素子 |
| 特許 3992027 | 窒化物半導体レーザ素子 |
| 特許 3995011 | 発光ダイオード |
| 特許 4028635 | 窒化物半導体発光素子 |
| 特許 4032836 | 窒化物半導体レーザ素子 |
| 特許 4043087 | 窒化物半導体素子の製造方法及び窒化物半導体素子 |
| 特許 4046114 | 窒化物半導体の成長方法及び窒化物半導体素子 |
| 特許 4053747 | 窒化物半導体レーザ素子 |
| 特許 4072202 | 窒化物半導体レーザ素子 |
| 特許 4109297 | 発光ダイオード |
| 特許 4120698 | 窒化物半導体レーザ素子 |
| 特許 4131101 | 窒化物半導体素子の製造方法 |
| 特許 4197891 | 窒化物半導体レーザ素子 |
| 特許 4239444 | 窒化物半導体レーザダイオード |
| 特許 4254373 | 窒化物半導体素子 |
| 特許 4277283 | 窒化物半導体発光素子 |
| 特許 4285337 | 窒化ガリウム系化合物半導体ウエハーの製造方法 |
| JP 4486506 | Growth of reduced dislocation density non-polar gallium nitride by hydrid vapor phase epitaxy |
| JP 4637503 B2 | Nitride Semiconductor Laser Element |
| JP 4815734 B2 | Nitride Semiconductor Laser Element |
| JP 4816434 B2 | Nitride Semiconductor Device |

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|---|---|
| JP 4825218 | Control of Photoelectrochemical (PEC) Etching by Modification of the Local Electrochemical Potential of the Semiconductor Structure Relative to the Electrolyte |
| JP 5010597 | Method for growing group III-nitride crystals in supercritical ammonia and its source material |
| JP 5043835 | (Al,Ga,In)N and ZnO direct wafer bonding structure for optoelectronic applications and its fabrication method |
| JP 5270348 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| JP 5363996 | AlxGal-x-N-Cladding-Free nonpolar GaN-based laser diodes and LED's |
| JP 5379973 | Technique for the fabrication of nonpolar InGaN thin films, heterostructures, and devices by metalorganic chemical vapor deposition |
| JP 5645887 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| JP 5684455 | Method for conductivity control of semipolar (Al,In,Ga,B)N |
| JP 5702165 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| JP 5706601 | Technique for the growth of planar semi-polar gallium nitride |
| JP 5719493 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| JP 5743127 | Technique for the growth and fabrication of semipolar (Ga,Al,In,B) N thin films, heterostructures, and devices |
| JP 5252465 | Growth Of Planar, Non-Polar A-Plane Gallium Nitride By Hydride Vapor Phase Epitaxy |
| JP 5301988 | Packaging Technique For The Fabrication Of Polarized Light Emitting Diodes |
| JP 5372766 | High Light Extraction Efficiency Sphere Led |
| JP 5461773 | Growth Of Planar Reduced Dislocation Density M-Plane Gallium Nitride By Dydride Vapor Phase Epitaxy |
| JP 5739824 | Devices Grown On Nonpolar Or Semipolar (Ga,Al,In,B)N Substrates |
| JP 5751513 | Gallium Nitride Bulk Crystals And Their Growth Method |
| JP 5774476 | Method Of Creating A Hexagonal Wurtzite Single Crystal And Hexagonal Wurtzite Single Crystal Substrate |
| JP 5838523 | Method For Improved Growth Of Semipolar (Al,In,Ga,B)N |
| JP 5896442 | Method For Improved Growth Of Semipolar (Al,In,Ga,B)N |
| JP 5972798 | Semi-Polar III-Nitride Optoelectronic Devices On M-Plane Substrates With Miscuts Less Than +/-15 Degrees In The C-Direction |

**CHINA PATENTS**

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|---|---|
| CH10052110C | Technique for the highly efficient gallium nitride based LED via surface roughening |
| CH20060076945 | Technique for the growth of planar semi-polar gallium nitride |
| CH0980128483 | (Al,Ga,In)N diode laser fabricated at reduced temperature |
| CHZL200910142642.4 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| CHZL08801177887 | High Light Extraction Efficiency Nitride Based Light Emitting Diode By Surface Roughening |
| CN20118012048 | Semi-polar iii-nitride optoelectronic devices on m-plane substrates with miscuts less than +/-15 degrees in the c-direction |

**FRANCE PATENTS**

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|---|---|
| FR1697983 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| FR1869707 | Technique for the growth of planar semi-polar gallium nitride |
| FR2087563 | Textured phosphor conversion layer light emitting diode |
| FR2633103 | Ammonothermal Growth Of Group-III Nitride Crystals On Seeds With At Least Two Surfaces Making An Acute, Right Or Obtuse Angle With Each Other |

**GERMANY PATENTS**

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|---|---|
| GR60341314.5 | Technique for the highly efficient gallium nitride based LEF via surface roughening |
| GR60200603012 | Technique for the growth of planar semi-polar gallium nitride |
| GR2087563 | Textured phosphor conversion layer light emitting diode |
| GR20070386977 | Textured phosphor conversion layer light emitting diode |
| GR2633103 | Ammonothermal growth of group-III nitride crystals on seeds with at least two surfaces making an acute, right or obtuse angle with each other |

**HONG KONG PATENTS**

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|---|---|
| HK1112109 | Technique for the growth of planar semi-polar gallium nitride |

**ITALY PATENTS**

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|---|---|
| IT1697983 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| IT2087563 | Textured phosphor conversion layer light emitting diode |
| IT2633103 | Ammonothermal Growth Of Group-III Nitride Crystals On Seeds With At Least Two Surfaces Making An Acute, Right Or Obtuse Angle With Each Other |

**NETHERLANDS PATENTS**

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|---|---|
| N1697983 | Technique for the highly efficient gallium nitride based LEF via surface roughening |
| N2087563 | Textured phosphor conversion layer light emitting diode |
| N2633103 | Ammonothermal Growth Of Group-III Nitride Crystals Onseeds With At Least Two Surfaces Making An Acute, Right Or Obtuse Angle With Each Other |

**REPUBLIC OF KOREA PATENTS**

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|---|---|
| ROK10-1086155 | Technique for the growth of planar, non-polar A-plane gallium nitride by hydride vapor phase epitaxy |
| ROK1145755 | Technique for the growth of planar semi-polar gallium nitride |
| ROK1145753 | Technique for the growth of planar semi-polar gallium nitride |
| ROK1154494 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| ROK1156146 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| ROK10-1167590 | Non-polar A-plane gallium nitride thin films grown by metalorganic chemical vapor |
| ROK10-1288489 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| ROK10-1317469 | Non-polar (Al,B,In,Ga)N quantum well and heterostructure materials and devices |
| ROK10-1372698 | Growth of Planar, Non-polar A-Plane Gallium Nitride by Hydride Vapor Phase Epitaxy |
| ROK1347848 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| ROK1351396 | Technique for the growth and fabrication of semipolar (Ga,Al,In,B)N thin films, heterostructures, and devices |
| ROK1365604 | Technique for the fabrication of nonpolar InGaN thin films, heterostructures, and devices by metalorganic chemical vapor deposition |
| ROK1416838 | Method for conductivity control of semipolar (Al,In,Ga,B)N |
| ROK1510461 | Method for improved growth of semipolar (Al,In,Ga,B)N |
| ROK1515058 | Planar nonpolar M-plane group III-Nitride films grown on miscut substrates |
| ROK101251443 | Growth Of Planar Reduced Dislocation Density M-Plane Gallium Nitride By Dydride Vapor Phase Epitaxy |
| ROK1499203 | Growth Of Planar, Non-Polar A-Plane Gallium Nitride By Hydride Vapor Phase Epitaxy |
| ROK10-1537300 | |
| ROK10-1623422 | Growth Of Planar Non-Polar {1-1 00} M-Plane Gallium Nitride With Metalorganic |
| ROK1668385 | Chemical Vapro Deposition(Mocvd) |
| ROK1810613 | Method of Creating a Hexagonal Wurtzite Single Crystal and Hexagonal Wurtzite Single Crystal Substrate |
| | Method of Creating a Hexagonal Wurtzite Single Crystal and Hexagonal Wurtzite Single Crystal Substrate |

**TAIWAN PATIENTS**

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| TI453813 | |
| T1366865 | Planar Nonpolar M-Plane Group III-Nitride Films Grown On Miscut Substrates |
| TI369784 | Optical Designs For High-Efficacy White-Light Emitting Diodes |
| TI377602 | Method Of Creating A Hexagonal Wurtzite Single Crystal And Hexagonal Wurtzite Single Crystal Substrate |
| TI402217 | Technique for the growth of planar semi-polar gallium nitride |
| TI404122 | Growth of reduced dislocation density non-polar gallium nitride by hydride vapor phase epitaxy |
| TI446569 | Technique for the growth of planar, non-polar A-place gallium nitride by hydride vapor phase epitaxy |
| TI452726 | Growth of planar non-polar {1-100} M-plane GaN with metalorganic chemical vapor deposition (MOCVD) |
| TI455181 | Method for growing group III-nitride crystals in supercritical ammonia and its source material |
| TI460881 | Method for enhancing growth of semipolar (Al,In,Ga,B)N via metalorganic chemical vapor deposition |
| TI469186 | Standing transparent mirror-less (STML) light emitting diode |
| TI480435 | High light extraction efficiency nitride based light emitting diode<br>Technique for the growth and fabrication of semipolar (Ga,Al,In,B)N thin films, heterostructures, and devices |
| TI390633 | Transparent LEDS |
| TI397199 | Planar non-polar M-plane group III-nitride films grown on miscut substrates |
| TI433313 | Gallium nitride bulk crystals and their growth method |
| TI445054 | Lateral Growth Method For Defect Reduction Of Semipolar Nitride Films<br>Packaging Technique For The Fabrication Of Polarized Light Emitting Diodes<br>Growth Of Planar, Non-Polar A-Plane Gallium Nitride By Hydride Vapor Phase Epitaxy |
| TI492411 | Growth Of Reduced Dislocation Density Non-Polar Gallium Nitride By Hybrid Vapor Phase Epitaxy |
| TI490918 | Non-Polar And Semi-Polar Light Emitting Devices |
| TI518941 | Method For Improved Growth Of Semipolar (Al,In,Ga,B)N |
| TI560963 | Standing Transparent Mirrorless Light Emitting Diode |
| TI604512 | Semi-polar iii-nitride optoelectronic devices on m-plane substrates with miscuts less than +/-15 degrees in the c-direction<br>Planar non-polar M-plane group III-nitride films grown on miscut substrates |

**UNITED KINGDOM PATIENTS**

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|---|---|
| UK1697983 | |
| UK1869707 | Technique for the highly efficient gallium nitride based LED via surface roughening |
| UK2087563 | Technique for the growth of planar semi-polar gallium nitride |
| UK2633103 | Textured phosphor conversion layer light emitting diode<br>Ammonothermal Growth Of Group-III Nitride Crystals On Seeds With At Least Two Surfaces Making An Acute, Right Or Obtuse Angle With Each Other |