COPY

REPORT DOCUMENTATION PAGE

AFRL-SR-AR-TR-03-

0283

1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
10-07-2003	Final Technical Report	May 99 - Oct 02 Final

4. TITLE AND SUBTITLE

WideGap Semiconductor III-Nitride Research

5a. CONTRACT NUMBER

F49620-99-1-0267

5b. GRANT NUMBER

F49620-99-1-0267

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Dr. Nicholas Kotov

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Oklahoma State University
College of Arts & Science
210 Life Science East
Stillwater, OK 74078-3015

8. PERFORMING ORGANIZATION REPORT NUMBER

CAGE Code OU784

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Grants and Contracts, Financial Administration
Oklahoma State University
402 Whitehurst
Stillwater, OK 74078

10. SPONSOR/MONITOR'S ACRONYM(S)

OSU

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

See enclosed abstract

20030731 111

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Dr. Nicholas Kotov
					19b. TELEPHONE NUMBER (Include area code) 405-744-5920

Title: WideGap Semiconductor III-Nitride Research
PI/Co-PI: J.J. Song, N. Kotov
Institution: Oklahoma State University
Contract number: F49620-99-1-0267

Objectives:
1. Investigation of the mechanism of light emission in widegap III-Nitride semiconductors
2. Investigation of the nanoscale morphology of the semiconductors.
3. Preparation of light-emitting diodes from II-Nitride semiconductors.
4. Extension of the regularities observed for III-nitride semiconductors to other semiconductor and nanoscale systems.

Status of Effort

By the onset of the project many aspects of optical properties of InGaN semiconductrs were unknown. From the literature publications, it was known that they strongly depend on the micro-and nanostructure of the semiconductor. S This need of further investigation was spurred by the across-the-board advances in the preparation of the high-brightness light-emitting devices in the blue region of the spectrum, which was difficult to obtain by other means. Over 3 years of the project we made new advances in the investigation of the mechanism of the light emission in InGaN. As expected, it was identified that the emission mechanism in InGaN is the recombination of electrons and holes. InGaN was made by two methods: molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD). Substantial problem was found in the correlation of the emission parameters of InGaN and method of their preparation, however eventually it was largely sorted out with the help of atomic force microscopy. It was firmly established that the traps on inhomogeneities act as centers for light emission and the LED activity should be attributed to this feature of the semiconductor. Strong evidence of the participation of nanoscale In quantum dots in the light-emmitting process was the major objective of this 3-year project.

Accomplishments/New Findings

Extensive AFM investigation of the InGaN slabs of different composition made under various growth conditions showed round nanoscale inclusions in polished InGaN films deposited on sapphire wafers. Additionally the terraces of the crystal lattice planes were revealed The integrated 1/T dependence demonstrated that the charge carriers are trapped in shallow traps. By correlating the surface morphology and optical characteristics of the alloys, it was established that the emission centers are likely located at the boundary of the two phases. In the first halfe of the project period, the importance of localized band tail states in InGanN epilayer by the temperature-, excitation energy-, excitation density-, and excitation length dependence of their emission properties was demonstrated. The band tail states originate from large In alloy inhomogeneity, layer thickness variations, and/or defects. The photoluminescence peak has an S-shape temperature dependence (red-shift, blueshift, and then redshift) with increasing temperature. Initially with increasing temperature above 10 K the char5ge carrier decay

time increases, indicating the dominance of radiative recombination. This gives the carriers more opportunity to relax to lower energy band tail states before radiatively recombining, and this causes the initial redshift. With further temperature increases, the decay time decreases due to non-radiative process, and this causes the blueshift. Then with further temperature increases, the regular bandgap shrinkage causes a redshift, which is not as great as it would be without the band filling.

During the second half of the project, it was demonstarated that the S-shaped temperature dependence of the PL peak cannot be explained in terms of internal electrical field created by piezoelectric polarization, although this has been a competitive theory to that of carrier localization. Even up to RT, the relative blueshift of the spontaneous emission peak is seen for InGaN/GaN and the emission peak energy is still lower than the mobility edge determined by energy-dependent PL and SE. This is evidence that the carrier localization is important for the RT operation of InGanN/GaN devices.

Optically pumped alloys were studied over a temperature range of 175-575 K, and the spontaneous emission threshold was found to have a characteristic temperature of 162 K. Strong evidence that spontaneous emission in InGaN quantum wells is caused by recombination of localized carriers rather than recombination in an electron-hole plasma is (1) the spontaneous emission FWHM is narrow and temperature invariant over 175-575 K, (II) the SE threshold density is extremely low, and the (III) spontaneous emission threshold has rather weak temperature dependenceThese factors make these materials very attractive for the preparation of the light emitting devices.

Interestingly enough, the processes observed in InGaN quantum wells can be found in the CdSe and CdS semiconductor nanoparticles. These species are also considered also as the major element for the future light-emitting devices. The effects of the surface, temperature and composition can be directly correlated with the similar effects seen in metalcomplex-modified nanoparticles of CdSe.

PERSONNEL SUPPORTED:

Prof. J. J. Song
Prof. N. Kotov
Gordon Gainer
Tong Ni,
Dattatri Nagesha,
John Ostrander

PUBLICATIONS:

Bibliographic Information

Exceptionally slow rise in differential reflectivity spectra of excitons in GaN: effect of excitation-induced dephasing. Jho, Y. D.; Kim, D. S.; Fischer, A. J.; Song, J. J.; Kenrow, J.; El Sayed, K.; Stanton, C. J. Department of Physics, Seoul National University, Seoul, S. Korea. Los Alamos National Laboratory, Preprint Archive, Condensed Matter (2003), 1-16, arXiv:cond-mat/0302280. CODEN: LNCMFR http://xxx.lanl.gov/pdf/cond-mat/0302280 Preprint written in English. CAN 138:376000 AN 2003:130943 CAPLUS (Copyright 2003 ACS)

Abstract

Femtosecond pump-probe (PP) differential reflectivity spectroscopy (DRS) and 4-wave mixing (FWM) expts. were performed simultaneously to study the initial temporal dynamics of the exciton line-shapes in GaN epilayers. Beats between the A-B excitons were found only for pos. time delay in both PP and FWM expts. The rise time at neg. time delay for the differential reflection spectra was much slower than the FWM signal or PP differential transmission spectroscopy (DTS) at the exciton resonance. A numerical soln. of a 6 band semiconductor Bloch equation model including nonlinearities at the Hartree-Fock level shows that this slow rise in C. the DRS results from excitation induced dephasing (EID), i.e., the strong d. dependence of the dephasing time which changes with the laser excitation energy.

Bibliographic Information

Polarization dependence of the excitonic optical Stark effect in GaN. Choi, C. K.; Lam, J. B.; Gainer, G. H.; Shee, S. K.; Krasinski, J. S.; Song, J. J.; Chang, Yia-Chung. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2002), 65(15), 155206/1-155206/7. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 136:392592 AN 2002:309467 CAPLUS (Copyright 2003 ACS)

Abstract

The dynamic Stark effect of excitons in GaN was studied using femtosecond pump-probe spectroscopy with various polarization configurations and pump detunings at 10 K. In contrast to 2-dimensional GaAs/AlGaAs quantum wells which have Bloch eigenstates similar to those of GaN and a large spin-orbit coupling, the Stark effect in GaN is strongly dependent on pump and probe relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of A and B valence bands induced by a linearly polarized pump. Using 2 different circular polarization configurations, splitting of degenerate excitons was obsd. because of different optical Stark shifts. The exptl. results are explained by a simple theor. model.

Bibliographic Information

The excitonic optical Stark effect in GaN. Choi, C. K.; Chang, Yia-Chung; Lam, J. B.; Gainer, G. H.; Shee, S. K.; Krasinski, J. S.; Song, J. J.. Center for Laser and Photonics Research, Oklahoma State University, Stillwater, OK, USA. Physica Status Solidi A: Applied Research (2002), 190(1), 99-105. CODEN: PSSABA ISSN: 0031-8965. Journal written in English. CAN 136:392588 AN 2002:290162 CAPLUS (Copyright 2003 ACS)

Abstract

The dynamic Stark effect of excitons in GaN at 10 K with excitation well below the excitonic resonances was studied using nondegenerate femtosecond pump-probe spectroscopy with co- and cross-linear polarization configurations. In contrast to 2-dimensional GaAs/AlGaAs quantum wells, which have Bloch eigenstates similar to those of GaN and a large spin-orbit coupling, the Stark effect in GaN is strongly dependent on the pump and probe relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of the A and B valence bands induced by a linearly polarized pump.

Bibliographic Information

Optical properties of highly excited (Al,In) GaN epilayers and heterostructures. Bidnyk, Sergiy; Schmidt, Theodore J.; Song, Jin-Joo. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Editor(s): Nalwa, Hari Singh. Handbook of Thin Film Materials (2002), 4 117-186. Publisher: Academic Press, San Diego, Calif CODEN:

69CKYX Conference; General Review written in English. CAN 136:361052 AN 2002:263715 CAPLUS (Copyright 2003 ACS)

Abstract

A review. After a summation of the fundamental optical properties of IIIA nitrides, degenerate and nondegenerate nanosecond and femtosecond optical-pump-probe expts. of GaN thin films are described. Then, the gain mechanisms in nitride lasing structures are treated, such as GaN films, AlGaN epilayers, and GaN/AlGaN sep.-confinement heterostructures. The optical properties of InGaN-based thin films and quantum well structures are addressed. The presented exptl. results support the theory that carrier localization is the origin of spontaneous and stimulated emission in this material system. The optical characterization of GaN epilayers and InGaN/GaN multiple quantum wells is given for temps. ≤700°. The stimulated-emission and lasing properties of GaN epilayers are illustrated taking into account the presence of self- and intentionally formed microcavities, scattering defects, and dislocations. Finally, imaging techniques for wide-band gap semiconductors are presented, including a new technique to measure the optical confinement in GaN-based lasing structures. (c) 2002 Academic Press.

Bibliographic Information

Effect of the number of wells on optical and structural properties in InGaN quantum well structures grown by metalorganic chemical vapor deposition. Yuh, H.-K.; Yoon, E.; Shee, S. K.; Lam, J. B.; Choi, C. K.; Gainer, G. H.; Park, G. H.; Hwang, S. J.; Song, J. J.. School of Materials Science and Engineering, Seoul National University, Seoul, S. Korea. Journal of Applied Physics (2002), 91(5), 3483-3485. CODEN: JAPIAU ISSN: 0021-8979. Journal written in English. CAN 137:69869 AN 2002:162334 CAPLUS (Copyright 2003 ACS)

Abstract

High-quality InGaN quantum well (QW) structures with 1, 2, 3, 5, and 7 wells were grown by metalorg. CVD. The effect of the no. of InGaN QWs on the structural and optical properties was studied by high-resoln. x-ray diffraction (HRXRD), at. force microscopy, low excitation d. photoluminescence (PL), high excitation d. pulsed PL, and PL excitation (PLE). The 10 K PLE band edge of all the samples is almost same, but the 10 K PL peaks of the InGaN QWs initially blueshifts, and then red shifts as the no. of wells increases. HRXRD reciprocal space mapping and high excitation pulsed PL show that this anomalous peak shift is due mainly to potential fluctuations, rather than the piezoelec. field. The degree of potential fluctuations varies with dislocation d., which could be affected by growth interruption, the deposition of strained layers, and the accumulated strain energy in InGaN QW structures.

Bibliographic Information

Spatially resolved cathodoluminescence of laterally overgrown GaN pyramids on (111) silicon substrate: Strong correlation between structural and optical properties. Cho, Yong-Hoon; Kim, H. M.; Kang, T. W.; Song, J. J.; Yang, W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Applied Physics Letters (2002), 80(7), 1141-1143. CODEN: APPLAB ISSN: 0003-6951. Journal written in English. CAN 136:347541 AN 2002:130138 CAPLUS (Copyright 2003 ACS)

Abstract

Spatially resolved optical emission properties of laterally overgrown GaN hexagonal pyramids on (111) Si substrates are studied by cathodoluminescence (CL) spectroscopy and mapping techniques. The results are compared with structural properties obtained by scanning and transmission electron microscopic techniques. To clarify the origin of the band edge and yellow-band emissions from the GaN pyramids, wavelength-resolved CL properties of normal and cleaved GaN pyramids are studied in top and/or cross-

sectional view configurations. The cross-sectional view CL images for cleaved GaN pyramid samples show significant differences between the overgrown areas on top of the mask and the coherently grown regions over the windows. Precise reverse (identical) contrast between the band-edge (yellow-band) emission intensity and threading dislocation d. is obsd. by comparing the cross-sectional view CL and transmission electron microscopic images. A strong correlation exists between structural defects and optical properties in laterally overgrown GaN hexagonal pyramids.

Absorption, emission, and carrier dynamics study of MOCVD-grown AlxGa1-xN alloys. Cho, Yong-Hoon; Gainer, G. H.; Lam, J. B.; Song, J. J.; Yang, W.; Kang, T. W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Journal of the Korean Physical Society (2001), 39(Suppl. Issue), S189-S192. CODEN: JKPSDV ISSN: 0374-4884. Journal written in English. CAN 136:271155 AN 2002:89696 CAPLUS (Copyright 2003 ACS)

Abstract

Optical absorption, emission, and carrier recombination characteristics of AlxGa1-xN epilayers (x = 0.17 and 0.33) were systematically studied by transmission, photoluminescence (PL), and time-resolved PL spectroscopy, resp. A typical energy-gap shrinkage behavior with temp. was obsd. for both AlxGa1-xN epilayers by absorption measurements, but an anomalous PL temp. dependence was obsd.: (i) a decrease-increase-decrease behavior of the PL peak energy and (ii) an increase-decrease-increase behavior of the spectral width with increasing temp. The effective lifetime was enhanced in the temp. region showing the anomalous temp.-induced emission behavior, reflecting superior luminescence efficiency by suppressing nonradiative processes. The anomalous temp.-induced emission shift is attributed to energy tail states due to alloy potential inhomogeneities in the AlxGa1-xN epilayers with large Al content.

Bibliographic Information

Temperature dependence of transmission and emission spectra in MOCVD-grown AlGaN ternary alloys. Cho, Yong-Hoon; Gainer, G. H.; Lam, J. B.; Song, J. J.; Yang, W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Physica Status Solidi A: Applied Research (2001), 188(2), 815-819. CODEN: PSSABA ISSN: 0031-8965. Journal written in English. CAN 136:158009 AN 2001:937148 CAPLUS (Copyright 2003 ACS)

Abstract

Optical absorption, emission, and carrier recombination characteristics of AlxGa1-xN epilayers (x = 0.17, 0.26, and 0.33) were systematically studied by transmission, photoluminescence (PL), and time-resolved PL spectroscopy, resp. A typical energy-gap shrinkage behavior with temp. was confirmed for all the AlxGa1-xN epilayers by transmission measurements. However, the authors obsd. anomalous PL temp. dependences such as a decrease-increase-decrease behavior of the PL peak energy shift and an increase-decrease-increase behavior of the spectral width broadening with increasing temp. The anomalous temp.-induced emission shift is attributed to energy tail states due to alloy potential inhomogeneities in the AlxGa1-xN epilayers with large Al content.

Bibliographic Information

Growth of submicron AlGaN/GaN/AlGaN heterostructures by hydride vapor phase epitaxy (HVPE). Tsvetkov, D.; Melnik, Yu.; Davydov, A.; Shapiro, A.; Kovalenkov, O.; Lam, J. B.; Song, J. J.; Dmitriev, V. Technologies and Devices International, Inc., Gaithersburg, MD, USA. Physica Status Solidi A: Applied Research (2001), 188(1), 429-432. CODEN: PSSABA ISSN: 0031-8965. Journal written in English. CAN 136:207876 AN 2001:933552 CAPLUS (Copyright 2003 ACS)

Abstract

Multilayer AlGaN/GaN epitaxial structures were grown on SiC by HVPE method. Characterization of the grown structures was performed using SEM, SIMS, mercury probe, electroluminescence, and photoluminescence techniques. Thicknesses of nitride layers in nanometer range were achieved. Stimulated emission from double confined heterostructure grown by HVPE was detected at room temp. under optical pumping. Short wave UV electroluminescence ($\lambda max \approx 340$-350 nm) was measured for p-AlGaN/n-AlGaN structures having $\leq$38 mol% and 9 mol% of AlN in p-AlGaN carrier emitter layers and n-AlGaN light emitting layers, resp.

Bibliographic Information

Time-resolved photoluminescence of InxGa1-xN/GaN multiple quantum well structures: Effect of Si doping in the barriers. Choi, C. K.; Kwon, Y. H.; Little, B. D.; Gainer, G. H.; Song, J. J.; Chang, Y. C.; Keller, S.; Mishra, U. K.; DenBaars, S. P. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2001), 64(24), 245339/1-245339/7. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 136:174769 AN 2001:911715 CAPLUS (Copyright 2003 ACS)

Abstract

The carrier recombination dynamics in InxGa1-xN/GaN multiple quantum wells, nominally identical apart from different Si doping concns. in the GaN barriers, were studied by time-resolved photoluminescence (PL) with excitation densities ranging from 220 nJ/cm2 to 28 μJ/cm2 at 10 K and 300 K At early time delays and with excitation densities >5 μJ/cm2, at which the strain-induced piezoelec. field is screened by both photogenerated carriers and electrons from the GaN barriers, the authors observe a strong InxGa1-xN PL peak initially located .apprx.60 meV below the absorption edge and well above an effective mobility edge. This peak decays quickly with an effective lifetime <70 ps and disappears into the extended states while it gradually red shifts. The amt. of this PL peak red shift decreases with increasing Si doping in the GaN barriers, suggesting that the peak is due to radiative recombination of free excitons in the screened piezoelec. field.

Bibliographic Information

In2S3 Nanocolloids with Excitonic Emission: In2S3 vs. CdS Comparative Study of Optical and Structural Characteristics. Nagesha, Dattatri K.; Liang, Xiaorong; Mamedov, Arif A.; Gainer, Gordon; Eastman, Margaret A.; Giersig, Michael; Song, Jin-Joo; Ni, Tong; Kotov, Nicholas A. Department of Chemistry, Oklahoma State University, Stillwater, OK, USA. Journal of Physical Chemistry B (2001), 105(31), 7490-7498. CODEN: JPCBFK ISSN: 1089-5647. Journal written in English. CAN 135:248894 AN 2001:508124 CAPLUS (Copyright 2003 ACS)

Abstract

Stable aq. colloids of 2-3 nm In2S3 nanocrystals were prepd. by using the classical method of nanoparticle stabilization by low mol. wt. thiols. TEM crystal lattice spacing, x-ray diffraction, EDAX data, and electron diffraction indicate that the nanoparticles are predominantly in β-In2S3 form. They exhibit relatively strong excitonic emission at 360-380 nm with a quantum yield of 1.5%. The excitonic radiative lifetime is 350 ns, which indicates that a direct allowed electronic transition is responsible for this emission. The NMR lines of the stabilizer are strongly broadened and shifted as a result of deshielding induced by electron withdrawing by pos. charged metal ions. This effect quickly wears off as the C chain becomes longer and the sepn. between the H atoms of the stabilizer and the semiconductor surface increases. The broadening is attributed to the reduced mobility of the stabilizer in the nanoparticle shell. For CdS nanoparticles of the same size, this effect is substantially stronger than for In2S3. The lower d. of metal centers in In2S3 than in CdS, which serve as anchor points for the stabilizer, promotes greater mobility of the stabilizer moieties.

Bibliographic Information

Well-thickness dependence of emission from GaN/AlGaN separate confinement heterostructures. Gainer, G. H.; Kwon, Y. H.; Lam, J. B.; Bidnyk, S.; Kalashyan, A.; Song, J. J.; Choi, S. C.; Yang, G. M. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Applied Physics Letters (2001), 78(24), 3890-3892. CODEN: APPLAB ISSN: 0003-6951. Journal written in English. CAN 135:187100 AN 2001:421843 CAPLUS (Copyright 2003 ACS)

Abstract

The authors studied the effects of well thickness on spontaneous and stimulated emission (SE) in GaN/AlGaN sep. confinement heterostructures (SCHs), grown by low-pressure metalorg. CVD. The SCH wells are unstrained and lattice-matched to a GaN buffer layer. Series of SCHs had GaN well thicknesses of 3, 5, 9, and 15 nm. The authors explain the spontaneous emission peak energy positions of the SCHs in terms of spontaneous and strain-induced piezoelec. polarizations. At 10 K, the carrier lifetime is lowest for a 3. nm well, and the SE threshold was lowest for a 5. nm well. The screening of the piezoelec. field and the electron-hole sepn. are strongly dependent on the well thickness and have a profound effect on the optical properties of the GaN/AlGaN SCHs. The implications of this study on the development of near- and deep-UV light emitters are discussed.

Bibliographic Information

Femtosecond pump-probe spectroscopy and time-resolved photoluminescence of an InxGa1-xN/GaN double heterostructure. Choi, C. K.; Little, B. D.; Kwon, Y. H.; Lam, J. B.; Song, J. J.; Chang, Y. C.; Keller, S.; Mishra, U. K.; DenBaars, S. P. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2001), 63(19), 195302/1-195302/7. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 135:159541 AN 2001:328863 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report a study of the carrier dynamics in an In0.18Ga0.82N thin film photoexcited well above the band gap using nondegenerate pump-probe spectroscopy and time-resolved photoluminescence (TRPL) for carrier densities ranging from 1017 to 1019 cm-3 at 10 K. At carrier densities >4* 1018 cm-3, optical gain occurs across the entire band tail region after .apprx.2.5 ps time delay, when the hot carriers completely fill these states. From TRPL measurements performed in the surface emission geometry, the authors obsd. stimulated emission (SE) with a .apprx. 28 ps decay time. Since this SE has a threshold d. of 1* 1018 cm-3, which is larger than the total d. of localized states, and the SE spectra at early time delays are quite different from the spontaneous emission spectra, the authors attribute the SE to the recombination of an electron-hole plasma from renormalized band-to-band transitions.

Bibliographic Information

Ultrafast carrier dynamics in a highly excited GaN epilayer. Choi, C. K.; Kwon, Y. H.; Krasinski, J. S.; Park, G. H.; Setlur, G.; Song, J. J.; Chang, Y. C. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2001), 63(11), 115315/1-115315/6. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 134:373482 AN 2001:171247 CAPLUS (Copyright 2003 ACS)

Abstract

Femtosecond pump-probe transmission spectroscopy was performed at 10 K to study the nonequil. carrier dynamics in a GaN thin film for carrier densities ranging from 4 × 1017 to 1019 cm-3. Spectral hole burning was initially peaked roughly at the excitation energy for an estd. carrier d. of 4 × 1018 cm-3 and gradually red-shifted during the excitation. Because of hot phonon effects, a very slow energy relaxation of the hot carriers at these densities was obsd. The hot carriers were strongly confined in a nonthermal distribution and they relaxed collectively to the band edge for .apprx.1 ps. The authors obsd. remarkable persistence of the excitonic resonances in GaN at carrier densities well above the Mott d. at early time delays, indicating that the excitons do not strongly couple to the nonthermal electron-hole plasma.

Bibliographic Information

Efficient gene transfer of VSV-G pseudotyped retroviral vector to human brain tumor. Lee, H.; Song, J. J.; Kim, E.; Yun, C-O.; Choi, J.; Lee, B.; Kim, J.; Chang, J. W.; Kim, J-H. Department of Microbiology, University of Ulsan College of Medicine, Seoul, S. Korea. Gene Therapy (2001), 8(4), 268-273. CODEN: GETHEC ISSN: 0969-7128. Journal written in English. CAN 135:206095 AN 2001:166497 CAPLUS (Copyright 2003 ACS)

Abstract

A retroviral vector constructed from the murine leukemia virus (MLV) can only express transgenes in cells undergoing mitosis, indicating its suitability as a delivery vehicle for cancer gene therapy. However, the transduction efficiency (TE) of retroviruses embedding endogenous envelope proteins in human cancer cells was found to be unsatisfactory. Recently, several research groups have demonstrated the feasibility of a retroviral vector pseudotyped with a vesicular stomatitis virus G (VSV-G) protein. In this study, the potential of VSV-G pseudotyped MLV-based retrovirus was examd. as a delivery vehicle in a variety of human cancer cells including brain tumor cells in vitro and in vivo. The transduction efficiency of the 293T/G/GP/LacZ retrovirus in cell culture was superior in most cancer cells, particularly in brain tumor cells, compared with that of other retroviruses, such as PA317- or PG13-derived. The relative growth rate and phosphatidylserine expression level on the plasma membrane of target cells mainly influenced the transduction efficiency of VSV-G pseudotyped retrovirus, which suggested that both the relative growth rate and phosphatidylserine expression level were major determinants of TE. Furthermore, 293T/G/GP/LacZ could efficiently transduce human cancer cells regardless of the presence of chem. additives, whereas in other retroviruses, cationic chem. additives such as polybrene or liposomes were essential during virus infection. Finally, an av. of 10% gene expression was routinely obtained exclusively in the tumor mass when 293T/G/GP/LacZ concd. by simple ultracentrifugation was directly administrated to pre-established brain tumors in animal models (U251-N nu/nu mice or C6 Wistar rats). All told, the present study suggests that the VSV-G pseudotyped retrovirus is a suitable vector for brain tumor gene therapy.

Bibliographic Information

Optical properties and lasing in (In, Al)GaN structures. Bidnyk, S.; Gainer, G. H.; Shee, S. K.; Lam, J. B.; Little, B. D.; Sugahara, T.; Krasinski, J.; Kwon, Y. H.; Park, G. H.; Hwang, S. J.; Song, J. J.; Bulman, G. E.; Kong, H. S. Zenastra Photonics, Inc., Ottawa, ON, Can. Physica Status Solidi A: Applied Research (2001), 183(1), 105-109. CODEN: PSSABA ISSN: 0031-8965. Journal written in English. CAN 134:258882 AN 2001:99766 CAPLUS (Copyright 2003 ACS)

Abstract

The authors achieved low-threshold UV lasing in optically pumped GaN/AlGaN sep. confinement heterostructures over a wide temp. range. Lasing modes of a single microcavity were examd. from 20 to 300 K and gain mechanisms were compared to those of a thick GaN epilayer. The authors have also systematically studied InGaN/(In)GaN multiple quantum wells as a function of well and barrier thickness. The stimulated emission threshold and photoluminescence (PL) decay time are strongly dependent on the well and barrier thickness. The exptl. results indicate that the enhanced optical quality of samples with

larger barrier thicknesses can be readily applied to the fabrication of InGaN/(In)GaN laser diodes.

Bibliographic Information

Geographical variations of trace elements in sediments of the major rivers in eastern China. Chen, J. S.; Wang, F. Y.; Li, X. D.; Song, J. J.. Department of Urban and Environmental Sciences, Peking University, Beijing, Peop. Rep. China. Environmental Geology (Berlin) (2000), 39(12), 1334-1340. CODEN: ENGOE9 ISSN: 1073-9106. Journal written in English. CAN 134:120328 AN 2000:903417 CAPLUS (Copyright 2003 ACS)

Abstract

A total of 26 geog. and hydrol. diverse sediment samples were collected from 12 major rivers in eastern China. The <63-μm fraction of the sediments was analyzed for both total concns. of Cu, Zn, Pb, and Cd, and their assocns. with various geochem. phases. The geog. variations of sediment-bound trace metals can be related to the bedrock types and weathering processes in the corresponding river basins. The rivers in southern China had notably higher concns. of trace metals in sediments because of abundant non-ferrous mineral deposits and stronger weathering process in the region. A large proportion of trace metals in these sediments was assocd. with Fe and Mn oxides and org. matter. Relative low levels of trace metals were found in river sediments in northern China, and a significant proportion of the metals was bound to org. matter, carbonates, and the residual fraction. The sediments in the Yellow River, originating from special loess, had the lowest concns. of trace metals. Most of the trace metals were assocd. with the carbonates, and residual phases.

Bibliographic Information

MOCVD growth, stimulated emission and time-resolved PL studies of InGaN/(In)GaN MQWs: well and barrier thickness dependence. Shee, S. K.; Kwon, Y. H.; Lam, J. B.; Gainer, G. H.; Park, G. H.; Hwang, S. J.; Little, B. D.; Song, J. J.. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Journal of Crystal Growth (2000), 221 373-377. CODEN: JCRGAE ISSN: 0022-0248. Journal written in English. CAN 134:244843 AN 2000:893410 CAPLUS (Copyright 2003 ACS)

Abstract

Optically pumped stimulated emission (SE) and time-resolved photoluminescence (TRPL) of InGaN/(In)GaN multiple quantum wells (MQWs) grown by low-pressure metalorg. CVD (MOCVD) were systemically studied as a function of well and barrier thickness. The SE threshold pumping d. and photoluminescence (PL) decay time are strongly dependent on the well and barrier thickness. As the barrier thickness increases, the PL efficiencies and room temp. PL decay time significantly increase, which can be attributed to the improved structural quality, as seen by the reciprocal lattice mapping results. The lowest SE threshold d. of 58 kW/cm2 was obtained for the 3.0 nm well and 15.0 nm barrier sample. The exptl. results indicate that the enhanced optical quality of samples with larger barrier thicknesses can be readily applied to the fabrication of InGaN/(In)GaN LDs.

Bibliographic Information

Study of gain mechanisms in AlGaN in the temperature range of 30-300 K. Lam, J. B.; Bidnyk, S.; Gainer, G. H.; Little, B. D.; Song, J. J.; Yang, W. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Applied Physics Letters (2000), 77(25), 4101-4103. CODEN: APPLAB ISSN: 0003-6951. Journal written in English. CAN 134:154900 AN 2000:886181 CAPLUS (Copyright 2003 ACS)

Abstract

We report the results of an exptl. study of the stimulated emission (SE) properties of AlGaN epilayers

grown by MOCVD under high optical excitation conditions at 30-300 K. The band gap and energy position of spontaneous and SE peaks were measured over the entire temp. range studied. Through an anal. of the temp. dependence of the relative energy positions and the SE threshold, combined with absorption and time-resolved photoluminescence measurements, we estd. the carrier d. at threshold to be ≈1019 cm-3 throughout the temp. range studied. Such a high carrier d. indicates that an electron-hole plasma is responsible for the generation of gain in this material system from 30-300 K. Issues related to the development of short-wavelength AlGaN-based light emitting devices are discussed.

Bibliographic Information

Ultrafast Phenomena in Semiconductors. IV. (Proceedings held 27-28 January 2000, in San Jose, California.) [In: Proc. SPIE-Int. Soc. Opt. Eng., 2000; 3940]. Tsen, Kong Thon; Song, Jin-Joo; Editors. USA. (2000), 288 pp. Publisher: (SPIE, Bellingham, Wash.) Book written in English. CAN 133:158511 AN 2000:578088 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Crystallization and preliminary X-ray crystallographic studies of HslU mutant in Escherichia coli. Song, Ji-Joon; Lee, Cheol Soon; Kim, Yun Sik; Kim, Jung Jin; Im, Young-Jun; Kim, Hyun Hee; Yoo, Soon Ji; Seong, Ihn Sik; Chung, Chin Ha; Eom, Soo Hyun. Department of Life Science, Kwangju Institute of Science and Technology, Kwangju, S. Korea. Bulletin of the Korean Chemical Society (2000), 21(7), 747-748. CODEN: BKCSDE ISSN: 0253-2964. Journal written in English. CAN 133:277997 AN 2000:566266 CAPLUS (Copyright 2003 ACS)

Abstract

HslVU is an ATP-dependent protease in E. coli which is composed of 2 multimeric components: the 19 kDa HslV and the 50 kDa HslU protein. In the presence of ATP, the HslUs form hexameric or heptameric rings. HslU contains 2 Cys residues, Cys261 and Cys287. It was suggested that Cys261 is involved in the oligomerization and Cys287 is related to the ATPase function (Yoo, 1997). To reveal the 3D structure and the mechanism of oligomerization between HslUs and between HSlU and HSlV, the HslUC261V was crystd. and studied by x-ray crystallog. Two crystal forms of HslUC261V were grown at room temp. using the hanging-drop vapor diffusion method. One form is orthorhombic, space group P21212 or P212121, a = 80.0, b = 138.1, c = 175.0 .ANG., V = 1933400 .ANG.3, and Z = 3. The other form is hexagonal, space group P61 or P64, a = 81.0, c = 174.6 .ANG., and Z = 1. For the orthorhombic and hexagonal crystals a Vm value of 3.25 and 3.33 .ANG.3 D-1 was calcd. resulting in a solvent content of 62.2 and 63.1%, resp.

Bibliographic Information

Linear and nonlinear optical properties of InxGa1-xN/GaN heterostructures. Cho, Yong-Hoon; Schmidt, T. J.; Bidnyk, S.; Gainer, G. H.; Song, J. J.; Keller, S.; Mishra, U. K.; DenBaars, S. P. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2000), 61(11), 7571-7588. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 132:229180 AN 2000:180054 CAPLUS (Copyright 2003 ACS)

Abstract

The spontaneous and stimulated emission properties in blue-light-emitting InxGa1-xN/GaN multiple quantum well structures were studied using various linear and nonlinear optical techniques. The exptl. observations are consistently understandable in the context of localization of carriers assocd. with large potential fluctuations in the InxGa1-xN active regions and at heterointerfaces. The studies were done as a function of excitation power d., excitation photon energy, excitation length, and temp. The results show carrier localization features for spontaneous emission and demonstrate potential fluctuations in the InxGa1-

xN active region of the InxGa1-xN/GaN structures and its predominant role in spontaneous emission. The stimulated emission has the same microscopic origin as spontaneous emission, i.e., radiative recombination of localized states. Therefore, carriers localized at potential fluctuations in InxGa1-xN active layers and interfaces can play a key role in not only spontaneous but also stimulated emission of state-of-the-art blue-light-emitting InxGa1-xN/GaN quantum structures.

Bibliographic Information

Dynamics of anomalous optical transitions in AlxGa1-xN alloys. Cho, Yong-Hoon; Gainer, G. H.; Lam, J. B.; Song, J. J.; Yang, W.; Jhe, W. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2000), 61(11), 7203-7206. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 132:228819 AN 2000:179879 CAPLUS (Copyright 2003 ACS)

Abstract

The authors present a comprehensive study of the optical characteristics of AlxGa1-xN epilayers ($0 \leq x \leq 0.6$) by photoluminescence (PL), PL excitation, and time-resolved PL spectroscopy. For AlxGa1-xN with large Al content, the authors obsd. an anomalous PL temp. dependence: (i) an S-shaped PL peak energy shift (decrease-increase-decrease) and (ii) an inverted S-shaped spectral width broadening (increase-decrease-increase) with increasing temp. The thermal decrease in integrated PL intensity was suppressed and the effective lifetime was enhanced in the temp. region showing the anomalous temp.-induced emission behavior, reflecting superior luminescence efficiency by suppressing nonradiative processes. All these features were enhanced as the Al mole fraction was increased. The anomalous temp.-induced emission shift is attributed to energy tail states due to alloy potential inhomogeneities in the AlxGa1-xN epilayers with large Al content.

Bibliographic Information

Time-resolved study of yellow and blue luminescence in Si- and Mg-doped GaN. Kwon, Yong-Hwan; Shee, S. K.; Gainer, G. H.; Park, G. H.; Hwang, S. J.; Song, J. J.. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Applied Physics Letters (2000), 76(7), 840-842. CODEN: APPLAB ISSN: 0003-6951. Journal written in English. CAN 132:200522 AN 2000:89034 CAPLUS (Copyright 2003 ACS)

Abstract

Time-resolved luminescence was employed to study the donor-acceptor pair recombination kinetics of the yellow (.apprx.2.3 eV) and blue (.apprx.2.8 eV) luminescence bands in Si- and Mg-doped GaN layers, resp. As the Si doping concn. in Si-doped GaN increases, the lifetime $\tau 1/e$ of the yellow luminescence decreases, indicating that a shallow Si donor is the origin of the yellow luminescence. The blue luminescence is most likely due to a shallow Mg acceptor and a deep donor composed of a Mg acceptor-N vacancy complex, as seen by the independence of $\tau 1/e$ on the Mg concn. measured by secondary ion mass spectroscopy in the range (2.5-6.0) × 1019 cm-3. As the temp. is increased from 10 to 300 K, the lifetimes for the yellow and blue luminescence remain nearly const., indicating that the distribution of electrons and holes bound to donors and acceptors does not change much with increasing temp.

Ni, T.; Nagesha, D. K.; Robles, J.; Materer, N.; Müssig, S.; Kotov, N. A.; CdS Nanoparticles Modified To Chalcogen Sites: New Supramolecular Complexes, Butterfly Bridging, And Related Optical Effects, *J. Am. Chem. Soc.* **2002**, 124(15), 3980-3992.

Westenhoff, S.; Nicholas A. Kotov, N. A.Quantum Dot On A Rope, *J. Am. Chem. Soc.* **2002,** 124(11), 2448-2449.

Bibliographic Information

Nonlinear optical properties of highly excited III-nitrides. Schmidt, T. J.; Song, J.-J.. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Optoelectronic Properties of Semiconductors and Superlattices (2002), 14(III-Nitride Semiconductors: Optical Properties, II), 3-72. CODEN: OPSSF2 ISSN: 1023-6619. Journal written in English. AN 2003:458085 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Structural and optical characteristics of laterally overgrown GaN pyramids on (111) Si substrate. Cho, Yong-Hoon; Kim, H. M.; Kang, T. W.; Song, J. J.; Yang, W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Materials Research Society Symposium Proceedings (2002), 693(GaN and Related Alloys--2001), 93-98. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 137:301559 AN 2002:603092 CAPLUS (Copyright 2003 ACS)

Abstract

Structural and optical characteristics of laterally overgrown GaN pyramids on a (111) Si substrate were studied by SEM, TEM, and cathodoluminescence (CL) microscopy and spectroscopy. Cross-sectional TEM images revealed that the threading dislocation d. over the window openings is very high, but gradually decreases with increasing GaN thickness, and that dislocations obsd. over the mask are parallel to the mask interface. Cross-sectional-view CL images taken at different emission wavelengths clearly showed significant differences between the overgrown areas on top of the mask and the coherently grown regions over the windows. A clear reverse contrast in the cross-sectional CL images of band-edge (identical contrast in case of yellow-band) emission was obsd. by comparing the defect d. obsd. in cross-sectional TEM images. The CL peak intensity ratio of band-edge-emission to yellow luminescence was also studied as a function of position in the GaN pyramid cross section. There exists a strong correlation between structural defects and optical properties in laterally overgrown GaN pyramids on (111) Si substrate.

Bibliographic Information

Polarization dependence of the excitonic optical Stark effect in GaN. Choi, C. K.; Lam, J. B.; Gainer, G. H.; Shee, S. K.; Krasinski, J. S.; Song, J. J.; Chang, Yia-Chung. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Physical Review B: Condensed Matter and Materials Physics (2002), 65(15), 155206/1-155206/7. CODEN: PRBMDO ISSN: 0163-1829. Journal written in English. CAN 136:392592 AN 2002:309467 CAPLUS (Copyright 2003 ACS)

Abstract

The dynamic Stark effect of excitons in GaN was studied using femtosecond pump-probe spectroscopy with various polarization configurations and pump detunings at 10 K. In contrast to 2-dimensional GaAs/AlGaAs quantum wells which have Bloch eigenstates similar to those of GaN and a large spin-orbit coupling, the Stark effect in GaN is strongly dependent on pump and probe relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of A and B valence bands induced by a linearly polarized pump. Using 2 different circular polarization configurations, splitting of degenerate excitons was obsd. because of different optical Stark shifts. The exptl. results are explained by a simple theor. model.

Bibliographic Information

The excitonic optical Stark effect in GaN. Choi, C. K.; Chang, Yia-Chung; Lam, J. B.; Gainer, G. H.; Shee, S. K.; Krasinski, J. S.; Song, J. J.. Center for Laser and Photonics Research, Oklahoma State University, Stillwater, OK, USA. Physica Status Solidi A: Applied Research (2002), 190(1), 99-105. CODEN: PSSABA ISSN: 0031-8965. Journal written in English. CAN 136:392588 AN 2002:290162 CAPLUS (Copyright 2003 ACS)

Abstract

The dynamic Stark effect of excitons in GaN at 10 K with excitation well below the excitonic resonances was studied using nondegenerate femtosecond pump-probe spectroscopy with co- and cross-linear polarization configurations. In contrast to 2-dimensional GaAs/AlGaAs quantum wells, which have Bloch eigenstates similar to those of GaN and a large spin-orbit coupling, the Stark effect in GaN is strongly dependent on the pump and probe relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of the A and B valence bands induced by a linearly polarized pump.

Bibliographic Information

Optical properties of highly excited (Al,In) GaN epilayers and heterostructures. Bidnyk, Sergiy; Schmidt, Theodore J.; Song, Jin-Joo. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Editor(s): Nalwa, Hari Singh. Handbook of Thin Film Materials (2002), 4 117-186. Publisher: Academic Press, San Diego, Calif CODEN: 69CKYX Conference; General Review written in English. CAN 136:361052 AN 2002:263715 CAPLUS (Copyright 2003 ACS)

Abstract

A review. After a summation of the fundamental optical properties of IIIA nitrides, degenerate and nondegenerate nanosecond and femtosecond optical-pump-probe expts. of GaN thin films are described. Then, the gain mechanisms in nitride lasing structures are treated, such as GaN films, AlGaN epilayers, and GaN/AlGaN sep.-confinement heterostructures. The optical properties of InGaN-based thin films and quantum well structures are addressed. The presented exptl. results support the theory that carrier localization is the origin of spontaneous and stimulated emission in this material system. The optical characterization of GaN epilayers and InGaN/GaN multiple quantum wells is given for temps. ≤700°. The stimulated-emission and lasing properties of GaN epilayers are illustrated taking into account the presence of self- and intentionally formed microcavities, scattering defects, and dislocations. Finally, imaging techniques for wide-band gap semiconductors are presented, including a new technique to measure the optical confinement in GaN-based lasing structures. (c) 2002 Academic Press.

Bibliographic Information

Comparative study of HVPE- and MOCVD-grown nitride structures for UV lasing application. Lam, J. B.; Gainer, G. H.; Bidnyk, S.; Elgawadi, Amal; Park, G. H.; Krasinski, J.; Song, J. J.; Tsvetkov, D. V.; Dmitriev, V. A. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Materials Research Society Symposium Proceedings (2001), 639(GaN and Related Alloys--2000), G6.4/1-G6.4/6. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 136:347820 AN 2002:261068 CAPLUS (Copyright 2003 ACS)

Abstract

The authors studied and compared the emission properties of optically excited (Al)GaN structures grown by two different techniques: hydride VPE (HVPE) and metalorg. CVD (MOCVD). The authors successfully achieved stimulated emission (SE) in an HVPE-grown GaN epilayer and a GaN/AlGaN double heterostructure at 10 K and room temp. The SE threshold and photoluminescence efficiency of the HVPE-grown samples are similar to those of high-quality MOCVD-grown structures. Photoluminescence

measurements from 10 to 300 K show that the HVPE GaN has a high d. of nonradiative recombination channels, esp. those activated <100 K. This study represents the 1st demonstration of SE in HVPE-grown (Al)GaN heterostructures.

Bibliographic Information

Effect of the number of wells on optical and structural properties in InGaN quantum well structures grown by metalorganic chemical vapor deposition. Yuh, H.-K.; Yoon, E.; Shee, S. K.; Lam, J. B.; Choi, C. K.; Gainer, G. H.; Park, G. H.; Hwang, S. J.; Song, J. J.. School of Materials Science and Engineering, Seoul National University, Seoul, S. Korea. Journal of Applied Physics (2002), 91(5), 3483-3485. CODEN: JAPIAU ISSN: 0021-8979. Journal written in English. CAN 137:69869 AN 2002:162334 CAPLUS (Copyright 2003 ACS)

Abstract

High-quality InGaN quantum well (QW) structures with 1, 2, 3, 5, and 7 wells were grown by metalorg. CVD. The effect of the no. of InGaN QWs on the structural and optical properties was studied by high-resoln. x-ray diffraction (HRXRD), at. force microscopy, low excitation d. photoluminescence (PL), high excitation d. pulsed PL, and PL excitation (PLE). The 10 K PLE band edge of all the samples is almost same, but the 10 K PL peaks of the InGaN QWs initially blueshifts, and then red shifts as the no. of wells increases. HRXRD reciprocal space mapping and high excitation pulsed PL show that this anomalous peak shift is due mainly to potential fluctuations, rather than the piezoelec. field. The degree of potential fluctuations varies with dislocation d., which could be affected by growth interruption, the deposition of strained layers, and the accumulated strain energy in InGaN QW structures.

Bibliographic Information

Spatially resolved cathodoluminescence of laterally overgrown GaN pyramids on (111) silicon substrate: Strong correlation between structural and optical properties. Cho, Yong-Hoon; Kim, H. M.; Kang, T. W.; Song, J. J.; Yang, W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Applied Physics Letters (2002), 80(7), 1141-1143. CODEN: APPLAB ISSN: 0003-6951. Journal written in English. CAN 136:347541 AN 2002:130138 CAPLUS (Copyright 2003 ACS)

Abstract

Spatially resolved optical emission properties of laterally overgrown GaN hexagonal pyramids on (111) Si substrates are studied by cathodoluminescence (CL) spectroscopy and mapping techniques. The results are compared with structural properties obtained by scanning and transmission electron microscopic techniques. To clarify the origin of the band edge and yellow-band emissions from the GaN pyramids, wavelength-resolved CL properties of normal and cleaved GaN pyramids are studied in top and/or cross-sectional view configurations. The cross-sectional view CL images for cleaved GaN pyramid samples show significant differences between the overgrown areas on top of the mask and the coherently grown regions over the windows. Precise reverse (identical) contrast between the band-edge (yellow-band) emission intensity and threading dislocation d. is obsd. by comparing the cross-sectional view CL and transmission electron microscopic images. A strong correlation exists between structural defects and optical properties in laterally overgrown GaN hexagonal pyramids.

Bibliographic Information

Multicolor Luminescence Patterning by Photoactivation of Semiconductor Nanoparticle Films. Wang, Ying; Tang, Zhiyong; Correa-Duarte, Miguel A.; Liz-Marzan, Luis M.; Kotov, Nicholas A.. Department of Chemistry, Oklahoma State University, Stillwater, OK, USA. Journal of the American Chemical Society (2003), 125(10), 2830-2831. CODEN: JACSAT ISSN: 0002-7863. Journal written in English. CAN 138:294800 AN 2003:113727 CAPLUS (Copyright 2003 ACS)

Abstract

Indiscriminate adsorption of nanoparticles (NPs) significantly complicates the prepn. of mesoscale NP patterns considered as enabling technol. for many devices and processes. Instead of selected chem. functionalization of the substrate surface prior to the assembly of nanocolloids, the required optical properties - in our case, high quantum yield luminescence - are imparted to the layer-by-layer assembled films by spatially selected photoactivation. The films are made by sequential adsorption of a pos. charged polyelectrolyte and a neg. charged CdSe/CdS aq. dispersion with an initial quantum yield of 0.5-2%. The photoactivation process takes place in the presence of oxygen and may be accompanied by photoetching. A 50-500-fold increase in the luminescence intensity of CdSe/CdS citrate-stabilized particles (quantum yield 25-45%) after visible light illumination provides excellent pattern contrast. Micron scale luminescence patterns were produced from NPs of various CdSe core diams. with red, yellow, and green emission. It was also demonstrated that different emission colors such as orange and green can be combined in one image by taking advantage of spatially selective photoetching. The presented optical patterning technique significantly simplifies the prepn. of luminescence patterns as compared to conventional methods. The high signal-to-noise ratio assocd. with it is essential for optical devices, information processing, and biophotonics. The most immediate use of this approach is expected in cryptog. and cell monitoring.

Bibliographic Information

CdS Nanoparticles Modified to Chalcogen Sites: New Supramolecular Complexes, Butterfly Bridging, and Related Optical Effects. Ni, Tong; Nagesha, Dattatri K.; Robles, Juvencio; Materer, Nicholas F.; Muessig, Stefan; Kotov, Nicholas A.. Chemistry Department, Oklahoma State University, Stillwater, OK, USA. Journal of the American Chemical Society (2002), 124(15), 3980-3992. CODEN: JACSAT ISSN: 0002-7863. Journal written in English. CAN 136:379042 AN 2002:215153 CAPLUS (Copyright 2003 ACS)

Abstract

All present approaches to surface modification of nanoparticles (NPs) with org. ligands exploit metal (Cd) sites as anchor points. To obtain efficient interaction of NP surface with p-orbitals of org. chromophores, the authors use the chalcogen (S) sites on the NP surface. These sites present several advantages stemming from a stronger interaction of their AOs with both modifier and NP core. The chalcogen modification of CdS was achieved by using a mixed ligand aqua(2,2'-bipyridyl-N,N')(malonato-O,O')copper(II) complex. The weak monodentate ligands (water) are replaced by a Cu-S bond during the modification reaction. The structure of the product was studied by optical spectroscopy, ESR, and NMR. The modified NP can be described as a few tens (<40) of (2,2'-bipyridyl-N,N')(malonato-O,O')copper units attached to the CdS core. Steady-state and time-resolved luminescence measurements, MO calcns., and UPS data indicate that delocalized surface states enveloping the surface chalcogen atoms of NP, transition metal, and p-orbitals of the bipyridine ligand are present in the synthesized species. The delocalized states are made possible due to the bridging of p-levels of S and π-orbitals of bipyridine by butterfly d-orbitals of the transition metal atom placed between them. Chalcogen-modified NP can be considered as a new member of the family of supramol. compds. based on transition metal complexes. Both NP and metal complex parts of the prepd. supramols. are very versatile structural units, and new mol. constructs of similar design, in which quantum effects of NPs are combined with optical properties of transition metal complexes, can be obtained with different NPs and metal complexes.

Bibliographic Information

Quantum Dot on a Rope. Westenhoff, Sebastian; Kotov, Nicholas A.. Chemistry Department, Oklahoma State University, Stillwater, OK, USA. Journal of the American Chemical Society (2002),

124(11), 2448-2449. CODEN: JACSAT ISSN: 0002-7863. Journal written in English. CAN 136:326099 AN 2002:145011 CAPLUS (Copyright 2003 ACS)

Abstract

The conjugation of nanoparticles (NPs) typically yields supramol. materials which are fairly rigid, and the electronic coupling between the NP and other structural units of these compds. is fixed by covalent bonds. Here, we report on a novel bichromophore system constructed from a quantum dot tethered to a semiconducting polymer, which demonstrates the possibility of the dynamic inter-unit coupling in the NP supramols. The NP bichromophoric system was made on the basis of the layer-by-layer assembled (LBL) films of an anionic polyelectrolyte with poly(p-phenylene ethynylene) backbone, aPPE, and poly(allylamine hydrochloride) PAH polycation. To conjugate CdTe NPs to the (aPPE/PAH)m LBL film, we took advantage of the reactive groups of NP stabilizer, i.e., -COOH, and the amino groups on PAH. Tethering of CdTe was accomplished by using poly(ethylene glycol), PEG, chains with two reactive terminals such as t-BOC-NH-PEG-COO-NHS. The evidence for successful conjugation of NPs to the LBL films can be seen both in AFM images and in optical data. The latter also indicate that the light quanta emitted by the NPs originate from the light absorption of the polymer film, which proves the presence of the aPPE → NP energy-transfer process. The av. sepn. distance between the NPs tethered to the LBL films can be changed by altering the dielec. properties of the solvent affecting PEG tether coiling (water/alc. mixt.). The reduced emission intensity of aPPE was found to follow the extension of the PEG tether. The quenching of aPPE is reversible when the original compn. of the solvent mixt. is restored. Thus, CdTe-PEG-aPPE is an example of an organized NP system with tunable optical coupling. Variable electronic coupling offers a convenient structural platform for new nanotechnol. devices for which spatial control translates into a higher level of sophistication. PEG mols. afford a wide variety of polymer chain configurations with different reactive terminals, which makes possible the prepn. of diverse NP superstructures.

Bibliographic Information

Crystal field, phonon coupling and emission shift of Mn2+ in ZnS:Mn nanoparticles. Chen, Wei; Sammynaiken, Ramaswami; Huang, Yining; Malm, Jan-Olle; Wallenberg, Reine; Bovin, Jan-Olov; Zwiller, Valery; Kotov, Nicholas A.. Department of Chemistry, University of Western Ontario, London, ON, Can. Journal of Applied Physics (2001), 89(2), 1120-1129. CODEN: JAPIAU ISSN: 0021-8979. Journal written in English. CAN 134:214231 AN 2001:6900 CAPLUS (Copyright 2003 ACS)

Abstract

The Mn2+ emission wavelengths are at 591, 588, 581 and 570 nm, resp., for the .apprx.10, .apprx.4.5, .apprx.3.5 nm sized nanoparticles and the ZnS:Mn nanoparticles formed in an ultrastable zeolite-Y. To reveal the cause for the shift, the crystal field and phonon coupling were studied. The results show that the predominant factor for the shift is the phonon coupling, whose strength is size dependent and is detd. by both the size confinement and the surface modification of the nanoparticles. Although the crystal field strength decreases with the decreasing of the particle size, its change has little contribution to the emission shift of Mn2+ in ZnS:Mn nanoparticles.

INTERACTIONS TRANSITIONS

a. Presentations

Bibliographic Information

Comparative study of HVPE- and MOCVD-grown nitride structures for UV lasing application. Lam, J. B.; Gainer, G. H.; Bidnyk, S.; Elgawadi, Amal; Park, G. H.; Krasinski, J.; Song, J. J.; Tsvetkov, D. V.; Dmitriev, V. A. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Materials Research Society Symposium Proceedings (2001),

639(GaN and Related Alloys--2000), G6.4/1-G6.4/6. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 136:347820 AN 2002:261068 CAPLUS (Copyright 2003 ACS)

Abstract

The authors studied and compared the emission properties of optically excited (Al)GaN structures grown by two different techniques: hydride VPE (HVPE) and metalorg. CVD (MOCVD). The authors successfully achieved stimulated emission (SE) in an HVPE-grown GaN epilayer and a GaN/AlGaN double heterostructure at 10 K and room temp. The SE threshold and photoluminescence efficiency of the HVPE-grown samples are similar to those of high-quality MOCVD-grown structures. Photoluminescence measurements from 10 to 300 K show that the HVPE GaN has a high d. of nonradiative recombination channels, esp. those activated <100 K. This study represents the 1st demonstration of SE in HVPE-grown (Al)GaN heterostructures.

Structural and optical characteristics of laterally overgrown GaN pyramids on (111) Si substrate. Cho, Yong-Hoon; Kim, H. M.; Kang, T. W.; Song, J. J.; Yang, W. Department of Physics, Chungbuk National University, Cheongju, S. Korea. Materials Research Society Symposium Proceedings (2002), 693(GaN and Related Alloys--2001), 93-98. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 137:301559 AN 2002:603092 CAPLUS (Copyright 2003 ACS)

Abstract

Structural and optical characteristics of laterally overgrown GaN pyramids on a (111) Si substrate were studied by SEM, TEM, and cathodoluminescence (CL) microscopy and spectroscopy. Cross-sectional TEM images revealed that the threading dislocation d. over the window openings is very high, but gradually decreases with increasing GaN thickness, and that dislocations obsd. over the mask are parallel to the mask interface. Cross-sectional-view CL images taken at different emission wavelengths clearly showed significant differences between the overgrown areas on top of the mask and the coherently grown regions over the windows. A clear reverse contrast in the cross-sectional CL images of band-edge (identical contrast in case of yellow-band) emission was obsd. by comparing the defect d. obsd. in cross-sectional TEM images. The CL peak intensity ratio of band-edge-emission to yellow luminescence was also studied as a function of position in the GaN pyramid cross section. There exists a strong correlation between structural defects and optical properties in laterally overgrown GaN pyramids on (111) Si substrate.

Bibliographic Information

Ultrafast Phenomena in Semiconductors VI. (Symposium held 21, 24-25 January 2002, in San Jose, California.) [In: Proc. SPIE-Int. Soc. Opt. Eng., 2002; 4643]. Tsen, Kong-Thon F.; Song, Jin-Joo; Jiang, Hongxing; Editors. USA. (2002), 276 pp. Publisher: (SPIE, Bellingham, Wash.) Book written in English. CAN 138:81677 AN 2002:780259 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Excitonic optical Stark effect in GaN. Choi, Chan-Kyung; Chang, Yia-Chung; Lam, Jack Biu; Shee, Sang-Kee; Krasinski, Jerzy S.; Song, Jin-Joo. Center Laser and Photonics Res., Oklahoma State Univ., Stillwater, OK, USA. Proceedings of SPIE-The International Society for Optical Engineering (2002), 4643(Ultrafast Phenomena in Semiconductors VI), 139-147. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 137:390496 AN 2002:671372 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report exptl. and theor. studies of the excitonic optical Stark effect in GaN photoexcited below the excitonic resonances with various polarization configurations and pump detunings, using nondegenerate pump-probe spectroscopy at 10 K. The Stark effect in GaN is strongly dependent on pump and probe

relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of A and B valence bands induced by a linearly polarized pump. Using two different circular polarization configurations, the authors also obsd. splitting of degenerate excitons because of different optical Stark shifts. The authors' exptl. results are explained by a simple theor. model.

Bibliographic Information

Nonlinear optical properties of highly excited III-nitrides. Schmidt, T. J.; Song, J.-J.. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Optoelectronic Properties of Semiconductors and Superlattices (2002), 14(III-Nitride Semiconductors: Optical Properties, II), 3-72. CODEN: OPSSF2 ISSN: 1023-6619. Journal written in English. AN 2003:458085 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Optical properties of InGaN-based III-nitride heterostructures. Cho, Y.-H.; Song, J.-J.. Center for Laser and Photonics Research, Stillwater, OK, USA. Optoelectronic Properties of Semiconductors and Superlattices (2002), 13(III-Nitride Semiconductors: Optical Properties, I), 135-196. CODEN: OPSSF2 ISSN: 1023-6619. Journal written in English. AN 2003:458079 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Layer-by-Layer Assembly of Indium Sulfide-Based Nanoparticles. Liang, Xiaorong; Kotov, Nicholas A.. Department of Chemistry, Oklahoma State University, Stillwater, OK, USA. Abstracts of Papers, 223rd ACS National Meeting, Orlando, FL, United States, April 7-11, 2002 (2002), COLL-275. Publisher: American Chemical Society, Washington, D. C CODEN: 69CKQP Conference; Meeting Abstract written in English. AN 2002:188193 CAPLUS (Copyright 2003 ACS)

Abstract

Highly luminescent thin films have been prepd. by means of layer-by-layer assembly (LBL) from a novel class of nanoparticles based on In2S3 doped with different metals. Unlike II-VI semiconductors, these particles have sheet-like morphol. that makes their LBL assembly particularly facile. The morphol. of the In2S3 and CuInS2 LBL films was investigated by AFM. The bang-gaps of individual nanoparticles were studied by STM and found to be strongly dependent on the compn. of the parent material and particle dimensions. Compared to other nanoparticle LBL films, In2S3-based multilayers revealed strong emission in the UV part of the spectrum, previously unaccessible for such materials.

Bibliographic Information

Protein-CdTe nanoparticle bioconjugates: Preparation, structure, and resonance energy-transfer. Mamedova, Nataliya N.; Wang, Shaopeng; Kotov, Nicholas A.. Department of Chemistry, Oklahoma State University, Stillwater, OK, USA. Abstracts of Papers, 224th ACS National Meeting, Boston, MA, United States, August 18-22, 2002 (2002), PHYS-253. Publisher: American Chemical Society, Washington, D. C CODEN: 69CZPZ Conference; Meeting Abstract written in English. AN 2002:776593 CAPLUS (Copyright 2003 ACS)

Abstract

CdTe nanoparticles bioconjugates of bovine serum albumin (BSA) and anti-BSA and CdTe nanoparticles have been synthesized using glutaric dialdehyde and EDC/sulfo-NHS crosslinking procedure. Specific binding of bioconjugates based on BSA and anti-BSA and luminescent CdTe quantum dots of different

sizes resulted in the formation of immunocomplex. The enhanced luminescence of red-emitting nanoparticles conjugated to BSA was caused by fluorescence resonance energy transfer (FRET) from the green-emitting nanoparticles conjugated to anti-BSA. The luminescence recovered when the immunocomplex was exposed to an unlabeled antigen. This effect can be put in the foundation of a new immunoassay protocol taking advantage of competitive inhibition of FRET. In addn., the immunocomplexes can be considered as a prototype of NP superstructures based on biospecific ligands.

Bibliographic Information

Synthesis and characterization of copper indium sulfide nanoparticles. Liang, Xiaorong; Kotov, Nicholas A.. Department of Chemistry, Oklahoma State University, Stillwater, OK, USA. Abstracts of Papers, 224th ACS National Meeting, Boston, MA, United States, August 18-22, 2002 (2002), PHYS-260. Publisher: American Chemical Society, Washington, D. C CODEN: 69CZPZ Conference; Meeting Abstract written in English. AN 2002:776600 CAPLUS (Copyright 2003 ACS)

Abstract

Copper indium sulfide nanoparticles(NP) have been successfully prepd. in the aq. soln. stabilized by L-cysteine. Both TEM micrographs and AFM spectra indicate that copper indium sulfide NPs have the av. size of 3-5nm, which is responsible for the strong quantum confinement effect. They display high luminescence quantum yield increasing with the amt. of Cu doped into the indium sulfide lattice. The scanning tunneling microscopy was used to det. the energy gap of these semiconductor NPs and it was found energy gap decreases with the amt. of Cu, which correlated very well with the UV-vis absorption data and XPS band edge energy measurements.

Optical properties of InGaN-based III-nitride heterostructures. Cho, Y.-H.; Song, J.-J.. Center for Laser and Photonics Research, Stillwater, OK, USA. Optoelectronic Properties of Semiconductors and Superlattices (2002), 13(III-Nitride Semiconductors: Optical Properties, I), 135-196. CODEN: OPSSF2 ISSN: 1023-6619. Journal written in English. AN 2003:458079 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Exceptionally slow rise in differential reflectivity spectra of excitons in GaN: effect of excitation-induced dephasing. Jho, Y. D.; Kim, D. S.; Fischer, A. J.; Song, J. J.; Kenrow, J.; El Sayed, K.; Stanton, C. J. Department of Physics, Seoul National University, Seoul, S. Korea. Los Alamos National Laboratory, Preprint Archive, Condensed Matter (2003), 1-16, arXiv:cond-mat/0302280. CODEN: LNCMFR http://xxx.lanl.gov/pdf/cond-mat/0302280 Preprint written in English. CAN 138:376000 AN 2003:130943 CAPLUS (Copyright 2003 ACS)

Abstract

Femtosecond pump-probe (PP) differential reflectivity spectroscopy (DRS) and 4-wave mixing (FWM) expts. were performed simultaneously to study the initial temporal dynamics of the exciton line-shapes in GaN epilayers. Beats between the A-B excitons were found only for pos. time delay in both PP and FWM expts. The rise time at neg. time delay for the differential reflection spectra was much slower than the FWM signal or PP differential transmission spectroscopy (DTS) at the exciton resonance. A numerical soln. of a 6 band semiconductor Bloch equation model including nonlinearities at the Hartree-Fock level shows that this slow rise in C. the DRS results from excitation induced dephasing (EID), i.e., the strong d. dependence of the dephasing time which changes with the laser excitation energy.

Bibliographic Information

Ultrafast Phenomena in Semiconductors VI. (Symposium held 21, 24-25 January 2002, in San Jose, California.) [In: Proc. SPIE-Int. Soc. Opt. Eng., 2002; 4643]. Tsen, Kong-Thon F.; Song, Jin-Joo; Jiang, Hongxing; Editors. USA. (2002), 276 pp. Publisher: (SPIE, Bellingham, Wash.) Book written in English. CAN 138:81677 AN 2002:780259 CAPLUS (Copyright 2003

ACS)**Bibliographic Information**

Excitonic optical Stark effect in GaN. Choi, Chan-Kyung; Chang, Yia-Chung; Lam, Jack Biu; Shee, Sang-Kee; Krasinski, Jerzy S.; Song, Jin-Joo. Center Laser and Photonics Res., Oklahoma State Univ., Stillwater, OK, USA. Proceedings of SPIE-The International Society for Optical Engineering (2002), 4643(Ultrafast Phenomena in Semiconductors VI), 139-147. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 137:390496 AN 2002:671372 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report exptl. and theor. studies of the excitonic optical Stark effect in GaN photoexcited below the excitonic resonances with various polarization configurations and pump detunings, using nondegenerate pump-probe spectroscopy at 10 K. The Stark effect in GaN is strongly dependent on pump and probe relative linear polarizations. This dependence results from the small spin-orbit splitting in GaN and a mixing of A and B valence bands induced by a linearly polarized pump. Using two different circular polarization configurations, the authors also obsd. splitting of degenerate excitons because of different optical Stark shifts. The authors' exptl. results are explained by a simple theor. model.

Bibliographic Information

Femtosecond pump-probe and four-wave mixing studies of excitons in GaN. Jho, Young-Dahl; Kim, Dai-sik; Fischer, Art J.; Song, Jin-Joo; Kenrow, J.; El Sayed, K.; Stanton, Christopher J. Dep. Phys., Seoul National Univ., Seoul, S. Korea. Proceedings of SPIE-The International Society for Optical Engineering (2000), 3940(Ultrafast Phenomena in Semiconductors IV), 279-286. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 133:65673 AN 2000:334101 CAPLUS (Copyright 2003 ACS)

Abstract

Femtosecond pump-probe (P-P) and 4-wave mixing (FWM) expts. were performed simultaneously at 11 K on Ga nitride epilayers to study the initial temporal line-shapes of the exciton. A-B exciton beats were found in both P-P and FWM expts. near the exciton resonance. However, the differential reflection spectra showed a much slower rise time that persisted at longer neg. time delay than the FWM signal or differential transition spectra at the exciton resonance. A numerical soln. of a 6. band semiconductor Bloch equation model including all Hartree Fock nonlinearities shows that this slow rise results from excitation induced dephasing, i.e., the strong d. dependence of the dephasing time which changes with the laser excitation energy.

Comparative study of near-threshold gain mechanisms in GaN epilayers and GaN/AlGaN separate confinement heterostructures. Bidnyk, Sergiy; Lam, Jack Biu; Little, Brian D.; Gainer, Gordon H.; Kwon, Yong Hwang; Song, Jin-Joo; Bulman, Gary E.; Kong, Hua-Shuang. Laser and Photonic Research Ctr., Dep. Phys., Oklahoma State Univ., Stillwater, OK, USA. Proceedings of SPIE-The International Society for Optical Engineering (2000), 3947(In-Plane Semiconductor Lasers IV), 165-173. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 133:65680 AN 2000:334149 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report the results of an exptl. study on near- threshold gain mechanism in optically pumped GaN epilayers and GaN/AlGaN sep. confinement heterostructures (SCHs) at 10-300 K. In GaN epilayers the near-threshold gain mechanism is inelastic exciton-exciton scattering for temps. .ltorsim.150 K, whereas at elevated temps. an electron-hole plasma is the dominant gain mechanism. An anal. of the relative shift between the spontaneous emission and lasing peaks in SCH samples, combined with the temp. dependence of the lasing threshold, reveals that exciton-exciton scattering is the dominant gain mechanism leading to low-threshold UV lasing in the GaN/AlGaN SCH over the entire temp. range studied. Strongly polarized (TE:TM > 300:1) lasing peaks were obsd. in a wavelength range of 358-367 nm. High finesse

lasing modes originated from self-formed microcavities in the AlGaN and GaN layers. The lasing threshold is ≥15 kW/cm2 at 10 K and 105 kW/cm2 at room temp. Based on results the authors suggest ways for the realization of GaN-active-medium UV laser diodes.

Bibliographic Information

Comparison study of structural and optical properties of InxGa1-xN/GaN quantum wells with different In compositions. Kwon, Yong-Hwan; Gainer, G. H.; Bidnyk, S.; Cho, Y. H.; Song, J. J.; Hansen, M.; DenBaars, S. P. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Materials Research Society Symposium Proceedings (2000), 595(GaN and Related Alloys--1999), W12.7.1-W12.7.6. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 133:10540 AN 2000:373465 CAPLUS (Copyright 2003 ACS)

Abstract

The effect of In on the structural and optical properties of InxGa1-xN(x = 0.088, 0.12, 0.133)/GaN multiple quantum wells (MQWs) was studied. These were 5-period MQWs grown on sapphire by metalorg. CVD. Increasing the In compn. caused broadening of the high-resoln. x-ray diffraction superlattice satellite peak and the luminescence-excitation band-edge. The higher In content degrades the interface quality because of nonuniform In incorporation into the GaN layer. The samples with higher In compns. have lower room temp. (RT) stimulated (SE) threshold densities and lower nonradiative recombination rates. The lower RT SE threshold densities of the higher In samples show that the suppression of nonradiative recombination by In overcomes the drawback of greater interface imperfection.

Bibliographic Information

Microstructure-based lasing in GaN/AlGaN separate confinement heterostructures. Bidnyk, S.; Lam, J. B.; Little, B. D.; Gainer, G. H.; Kwon, Y. H.; Song, J. J.; Bulman, G. E.; Kong, H. S. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Materials Research Society Symposium Proceedings (2000), 595(GaN and Related Alloys--1999), W11.22.1-W11.22.6. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 133:10712 AN 2000:373414 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report on an exptl. study of microstructure-based lasing in an optically pumped GaN/AlGaN sep. confinement heterostructure (SCH). The authors achieved low-threshold UV lasing in optically pumped GaN/AlGaN sep. confinement heterostructures over a wide temp. range. The spacing, directionality, and far-field patterns of the lasing modes are the result of microcavities that were naturally formed in the structures due to strain relaxation. The temp. sensitivity of the lasing wavelength is twice as low as that of bulk-like GaN films. Based on these results, the authors discuss possibilities for the development of UV laser diodes with increased temp. stability of the emission wavelength.

Bibliographic Information

Microstructure-based lasing in GaN/AlGaN separate confinement heterostructures. Bidnyk, S.; Lam, J. B.; Little, B. D.; Gainer, G. H.; Kwon, Y. H.; Song, J. J.; Bulman, G. E.; Kong, H. S. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. MRS Internet Journal of Nitride Semiconductor Research [Electronic Publication] (2000), 5S1 No pp. given. CODEN: MIJNF7 ISSN: 1092-5783. http://nsr.mij.mrs.org/5sl/w11.22/article.pdf Journal; Online Computer File written in English. CAN 133:200507 AN 2000:463129 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report on an exptl. study of microstructure-based lasing in an optically pumped GaN/AlGaN sep. confinement heterostructure (SCH). The authors achieved low-threshold UV lasing in optically pumped GaN/AlGaN sep. confinement heterostructures over a wide temp. range. The spacing, directionality, and far-field patterns of the lasing modes are the result of microcavities that were naturally formed in the structures due to strain relaxation. The temp. sensitivity of the lasing wavelength is twice as low as that of bulk-like GaN films. Based on these results, the authors discuss possibilities for the development of UV laser diodes with increased temp. stability of the emission wavelength.

Bibliographic Information

Dynamics of anomalous temperature-induced emission shift in MOCVD-grown (Al,In)GaN thin films. Cho, Yong-Hoon; Gainer, G. H.; Lam, J. B.; Song, J. J.; Yang, W.; Jhe, W. Center for Laser and Photonics Research and Department of Physics Oklahoma State University, Stillwater, OK, USA. MRS Internet Journal of Nitride Semiconductor Research [Electronic Publication] (2000), 5S1 No pp. given. CODEN: MIJNF7 ISSN: 1092-5783. http://nsr.mij.mrs.org/5sl/w11.57/article.pdf Journal; Online Computer File written in English. CAN 133:200316 AN 2000:463469 CAPLUS (Copyright 2003 ACS)

Abstract

The authors present a comprehensive study of the optical characteristics of (Al, In) GaN epilayers measured by photoluminescence (PL), integrated PL intensity, and time-resolved PL spectroscopy. For not only InGaN, but also AlGaN epilayers with large Al content, the authors obsd. an anomalous PL temp. dependence: (i) an S-shaped PL peak energy shift (decrease-increase-decrease) and (ii) an inverted S-shaped full width at half max. (FWHM) change (increase-decrease-increase) with increasing temp. Based on time-resolved PL, the S shape (inverted S shape) of the PL peak position (FWHM) as a function of temp., and the much smaller PL intensity decrease in the temp. range showing the anomalous emission behavior, strong localization of carriers occurs in InGaN and even in AlGaN with rather high Al content. The following increase with increasing Al content in AlGaN epilayers: (i) a Stokes shift between the PL peak energy and the absorption edge, (ii) a red shift of the emission with decay time, (iii) the deviations of the PL peak energy, FWHM, and PL intensity from their typical temp. dependence, and (iv) the corresponding temp. range of the anomalous emission behavior. The band-gap fluctuation responsible for these characteristics is due to energy tail states caused by nonrandom inhomogeneous alloy potential variations enhanced with increasing Al content.

Bibliographic Information

Comparison study of structural and optical properties of InxGa1-xN/GaN quantum wells with different in compositions. Kwon, Yong-Hwan; Gainer, G. H.; Bidnyk, S.; Cho, Y. H.; Song, J. J.; Hansen, M.; DenBaars, S. P. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. MRS Internet Journal of Nitride Semiconductor Research [Electronic Publication] (2000), 5S1 No pp. given. CODEN: MIJNF7 ISSN: 1092-5783. http://nsr.mij.mrs.org/5sl/w12.7/article.pdf Journal; Online Computer File written in English. CAN 133:229757 AN 2000:464305 CAPLUS (Copyright 2003 ACS)

Abstract

The effect of In on the structural and optical properties of InxGa1-xN/GaN multiple quantum wells (MQWs) was studied. These were 5-period MQWS grown on sapphire by metalorg. CVD. Increasing the In compn. caused broadening of the high-resoln. x-ray diffraction superlattice satellite peak and the photoluminescence-excitation bandedge. This indicates that the higher In content degrades the interface quality because of nonuniform In incorporation into the GaN layer. However, the samples with higher In compns. have lower room temp. (RT) stimulated (SE) threshold densities and lower nonradiative recombination rates. The lower RT SE threshold densities of the higher In samples show that the suppression of nonradiative recombination by In overcomes the drawback of greater interface imperfection.

Stimulated emission and pump-probe studies of wide-gap nitrides for UV-blue photonic applications. Song, Jin-Joo; Bidnyk, Sergiy; Schmidt, Theodore J. CLPR, Dep. Phys., Oklahoma State Univ., Stillwater, OK, USA. Proceedings of SPIE-The International Society for Optical Engineering (1999), 3896(Design, Fabrication, and Characterization of Photonic Devices), 72-85. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 133:302812 AN 2000:496803 CAPLUS (Copyright 2003 ACS)

Abstract

Stimulated Emission and Pump-Probe studies were performed in GaN, InGaN, and AlGaN epilayers as well as GaN/AlGaN sep. confinement heterostructures. In GaN epilayers the near-threshold gain mechanism is inelastic exciton-exciton scattering for temps. .ltorsim.150 K, whereas at elevated temps. electron-hole plasma is the dominant gain mechanism. An anal. of the relative shift between the spontaneous emission and lasing peaks in SCH samples, combined with the temp. dependence of the lasing threshold, reveals that exciton-exciton scattering is the dominant gain mechanisms leading to low-threshold UV lasing in the GaN/AlGaN SCH over the entire temp. range studied. The authors further performed optical pumping of AlGaN epilayers at different temps. Stimulated emission was obsd. in AlxGa1-xN thin films for Al concns. as high as x is 0.26, with a resultant stimulated emission wavelength ≥328 nm at room temp. This result indicated that AlGaN-based structures are suitable not only for use in deep-UV detectors, but also as a potential source of deep-UV laser radiation. The interband optical transitions in GaN and InGaN also were studied at 10 K and room temp. using nondegenerate nanosecond optical pump-probe techniques. At low temps., strong, well- resolved features were seen in the absorption and reflection spectra corresponding to the 1s A and B exciton transitions. Broadening and decrease in intensity of these features were studied as the function of excitation pump d. Values of induced transparency and induced absorption are extremely large in GaN epilayers. The pump-probe results in GaN epilayers were directly compared to ones obtained from InGaN films. Significant differences in near-bandedge absorption changes were clearly obsd. between the two materials.

Bibliographic Information

Optical properties of (Al)GaN-based structures for near- and deep-ultraviolet emitters. Bidnyk, S.; Lam, J. B.; Little, B. D.; Gainer, G. H.; Kwon, Y. H.; Song, J. J.; Bulman, G. E.; Kong, H. S. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. IPAP Conference Series (2000), 1(Proceedings of International Workshop on Nitride Semiconductors, 2000), 567-569. CODEN: ICSPF6 Journal written in English. CAN 134:317960 AN 2001:164503 CAPLUS (Copyright 2003 ACS)

Abstract

GaN and AlGaN epilayers and GaN/AlGaN sep. confinement heterostructures (SCH) were studied using photoluminescence (PL), PL excitation (PLE), time-resolved PL (TRPL), and optical pumping expts. at 10-300 K. Efficient stimulated emission (SE) was achieved in all samples in the wavelength region of 350-373 nm. An order of magnitude redn. in the lasing threshold of the GaN/AlGaN SCH compared to GaN and AlGaN epilayers was obsd. over the entire temp. range studied. Through TRPL and PLE measurements the carriers in the active region of the SCH are generated through both carrier capture and diffusion from the waveguide region. Optimization of carrier and optical confinement in GaN/AlGaN-based heterostructures is the crit. parameter leading to a dramatic lowering of the lasing threshold and substantial improvements in the emission intensity of near- and deep-UV emitters.

Bibliographic Information

A comparative study of AlGaN- and GaN-based lasing structures for near- and deep-UV applications. Bidnyk, Sergiy; Lam, Jack B.; Gainer, Gordon G.; Little, Brian D.; Kwon, Yong-Hwan; Song, Jin-Joo; Bulman, Gary E.; Kong, Hua-Shuang. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Materials Research Society

Symposium Proceedings (2001), 622(Wide-Bandgap Electronic Devices), T3.8.1-T3.8.6. CODEN: MRSPDH ISSN: 0272-9172. Journal written in English. CAN 135:113782 AN 2001:342986 CAPLUS (Copyright 2003 ACS)

Abstract

The authors report a comprehensive study on the optical properties of GaN- and AlGaN-based lasing structures at high-levels of optical excitation (carrier densities of 1017-1020 cm-3) and identify crit. issues necessary for the development of near- and deep-UV light emitting devices. Room temp. stimulated emission (SE) with emission wavelengths ranging from 351 nm to 373 nm was achieved in a variety of samples. Through an anal. of the temp.-dependent lasing characteristics, combined with absorption and time-resolved photoluminescence measurements, the carrier d. required to achieve the SE threshold in GaN epilayers was estd. In AlGaN epilayers, the onset of SE (.apprx.1019 cm-3) occurs at carrier densities 1 order of magnitude higher than in thick GaN epilayers, indicating that an electron-hole plasma is the dominant gain mechanism over the entire temp. range studied (10-300 K). A remarkably low lasing threshold was obsd. in GaN/AlGaN heterostructures over the temp. range of 10-300 K. The results indicate that GaN/AlGaN heterostructures could be used to efficiently generate laser emission with wavelengths shorter than 373 nm. The implications of this study on the development of UV laser diodes is discussed.

Bibliographic Information

Theoretical modeling of femtosecond pump-probe spectroscopy in GaN systems. Chang, Yia-Chung; Choi, Chan-Kyung; Song, Jin-Joo. Department of Physics and Materials Research Laboratory, University of Illinois at Urbana-Champaign, Urbana, IL, USA. Proceedings of SPIE-The International Society for Optical Engineering (2001), 4280(Ultrafast Phenomena in Semiconductors V), 58-69. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 135:377924 AN 2001:687572 CAPLUS (Copyright 2003 ACS)

Abstract

The authors present theor. simulation of the fs pump-probe spectroscopy in GaN systems for photoexcitation both far below and far above the band gap. Semiconductor Bloch equations for carrier distribution and exciton polarization are solved numerically. The simulation results are compared with expt. The expt. for both cases was performed at 10 K to study the nonequil. carrier dynamics in bulk GaN. For pump below the band gap, prominent a.c. Stark effects are obsd., and the theor. simulation gives line-shapes of the differential absorption spectra in qual. agreement with expt. If the carrier screening and band renormalized effects are properly scaled, then good quant. agreement between theory and expt. can be obtained for various pump intensities and detuning energies. For pump far above band gap, the theor. simulation shows a fast carrier relaxation due to LO phonon emission and carrier-carrier scattering with scattering time .apprx.10-100 fs, while exptl., the hot carriers are strongly confined in a nonthermal distribution and they relaxed collectively to the band edge at a surprisingly slow rate (with relaxation time around 1 ps).

Bibliographic Information

Ultrafast Phenomena in Semiconductors V. (Proceedings of a Symposium held 25-26 January 2001, in San Jose, California.) [In: Proc. SPIE-Int. Soc. Opt. Eng., 2001; 4280]. Jiang, Hongxing; Tsen, Kong Thon; Song, Jin-Joo; Editors. USA. (2001), 226 pp. Publisher: (SPIE, Bellingham, Wash.) Book written in English. CAN 135:280162 AN 2001:733681 CAPLUS (Copyright 2003 ACS)

Bibliographic Information

Femtosecond pump-probe spectroscopy of a highly excited GaN epilayer. Choi, Chan-Kyung; Kwon, Yong Hwang; Krasinski, Jerzy S.; Park, Gil-Han; Setlur, Girish; Song, Jin-Joo; Chang, Yia-Chung. Center for Laser and Photonics Research and Department of Physics, Oklahoma State University, Stillwater, OK, USA. Proceedings of SPIE-The International Society for Optical Engineering (2001),

4280(Ultrafast Phenomena in Semiconductors V), 89-95. CODEN: PSISDG ISSN: 0277-786X. Journal written in English. CAN 135:378360 AN 2001:687575 CAPLUS (Copyright 2003 ACS)

Abstract

The nonequil. carrier dynamics in GaN epilayer for carrier densities ranging from 4 *1017 to 1019 cm-3 at 10 K was studied by femtosecond pump-probe transmission spectroscopy. Spectral hole burning was initially peaked roughly at the excitation energy for an estd. carrier d. of 4 *1018 cm-3 and gradually red-shifted during the excitation. Because of reduced carrier-carrier and carrier-phonon scattering, a very slow energy relaxation of the hot carriers at these densities were obsd. The hot carriers were strongly confined in a nonthermal distribution and they relaxed collectively to the band edge.

b. Consulting
Sciperio Inc. Nomadics, Inc

c. Transitions
none

NEW DISCOVERIES/ PATENT DISCLOSURES
none

HONORS AWARDS
OSU Junior Faculty Scholarly Excellence Award.