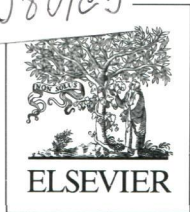


NU  
J80/e5

Volume 370

1 May 2013

ISSN 0022-0248



**JOURNAL OF** **CRYSTAL**  
**GROWTH**

Editors: T.F. KUECH (Principal Editor)  
R.S. FEIGELSON, R. KERN,  
K. NAKAJIMA, G.B. STRINGFELLOW

**16th International Conference on Metalorganic  
Vapor Phase Epitaxy**

*Guest Editors*

Jong Kyu Kim  
Thomas F. Kuech  
Catherine Caneau  
Joan M. Redwing  
Armin Dadgar

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

**SciVerse ScienceDirect**

## Contents

### 16th International Conference on Metalorganic Vapor Phase Epitaxy

Preface	1
<b>Nitrides: Growth and characterization</b>	
MOVPE growth, optical and electrical characterization of thick Mg-doped InGa <sub>N</sub> layers Ö. Tuna, H. Hahn, H. Kalisch, C. Giesen, A. Vescan, M.V. Rzhetski, V.N. Pavlovskii, E.V. Lutsenko, G.P. Yablonskii and M. Heuken	2
Fast AlGa <sub>N</sub> growth in a whole composition range in planetary reactor W.V. Lundin, A.E. Nikolaev, M.M. Rozhavskaia, E.E. Zavarin, A.V. Sakharov, S.I. Troshkov, M.A. Yagovkina and A.F. Tsatsulnikov	7
Suppression of crack generation in AlGa <sub>N</sub> /Ga <sub>N</sub> distributed Bragg reflectors grown by MOVPE T. Moudakir, S. Gautier, S. Suresh, M. Abid, Y. El Gmili, G. Patriarche, K. Pantzas, D. Troadec, J. Jacquet, F. Genty, P. Voss and A. Ougazzaden	12
AlN/air distributed Bragg reflector by Ga <sub>N</sub> sublimation from microcracks of AlN T. Mitsunari, T. Tanikawa, Y. Honda, M. Yamaguchi and H. Amano	16
Influence of initial growth pressure on the optical properties of Si-doped nonpolar <i>a</i> -plane Ga <sub>N</sub> grown with different doping levels K. Man Song, J. Min Kim, C. Soo Shin, C. Gi Ko, H. Koun Cho, D. Ho Yoon, S. Min Hwang and H. Kim	22
Defect reduction in (11–22) semipolar Ga <sub>N</sub> with embedded InN islands on m-plane sapphire C. Jung, J. Jang, J. Hwang, J. Jeong, J. Kim, k. Lee and O. Nam	26
HCl-assisted growth of Ga <sub>N</sub> and AlN D. Fahle, D. Brien, M. Dauelsberg, G. Strauch, H. Kalisch, M. Heuken and A. Vescan	30
<i>In situ</i> X-ray measurements of MOVPE growth of In <sub><i>x</i></sub> Ga <sub>1–<i>x</i></sub> N single quantum wells G. Ju, S. Fuchi, M. Tabuchi and Y. Takeda	36
Fabrication of Ga <sub>N</sub> structures with embedded network of voids using pillar patterned Ga <sub>N</sub> templates O. Svensk, M. Ali, L. Riuttanen, P.T. Törmä, S. Sintonen, S. Suihkonen, M. Sopanen and H. Lipsanen	42
Photoluminescence properties of InGaAsN films on Ge(001) vicinal substrates K. Uesugi, S. Kuboya, S. Sanorpim and K. Onabe	46
High resolution synchrotron X-ray studies of phase separation phenomena and the scaling law for the threading dislocation densities reduction in high quality AlGa <sub>N</sub> heterostructure S. Lazarev, S. Bauer, K. Forghani, M. Barchuk, F. Scholz and T. Baumbach	51
Semibulk InGa <sub>N</sub> : A novel approach for thick, single phase, epitaxial InGa <sub>N</sub> layers grown by MOVPE K. Pantzas, Y. El Gmili, J. Dickerson, S. Gautier, L. Largeau, O. Mauguin, G. Patriarche, S. Suresh, T. Moudakir, C. Bishop, A. Ahaitouf, T. Rivera, C. Tanguy, P.L. Voss and A. Ougazzaden	57
Structural and compositional characterization of MOVPE Ga <sub>N</sub> thin films transferred from sapphire to glass substrates using chemical lift-off and room temperature direct wafer bonding and Ga <sub>N</sub> wafer scale MOVPE growth on ZnO-buffered sapphire S. Gautier, T. Moudakir, G. Patriarche, D.J. Rogers, V.E. Sandana, F. Hosseini Téherani, P. Bove, Y. El Gmili, K. Pantzas, S. Sundaram, D. Troadec, P.L. Voss, M. Razeghi and A. Ougazzaden	63

Nitride based heterostructures with Ga- and N-polarity for sensing applications M. Fandrich, T. Mehrrens, T. Aschenbrenner, T. Klein, M. Gebbe, S. Figge, C. Kruse, A. Rosenauer and D. Hommel	68
Effects of Si doping in high-quality AlN grown by MOVPE on trench-patterned template G. Nishio, S. Yang, H. Miyake and K. Hiramatsu	74
Defect states of <i>a</i> -plane GaN grown on <i>r</i> -plane sapphire by controlled integration of silica nano-spheres S.W. Pak, D.U. Lee, E.K. Kim, S.H. Park, K. Joo and E. Yoon	78
Growth of strain-compensated InGaN/AlN multiple quantum wells on GaN by MOVPE K. Anazawa, S. Hassanet, K. Fujii, Y. Nakano and M. Sugiyama	82
In-situ growth monitoring of AlInN/AlGaN distributed Bragg reflectors for the UV-spectral range C. Berger, A. Dadgar, J. Bläsing and A. Krost	87
Growth of thick GaN layer on ZnAl <sub>2</sub> O <sub>4</sub> spinel layer by HVPE J. Yoo, S. Choi, S. Jung, Y. Cho, J. Lee, S. Lee, W. Lee, H. Lee, S. Kim, J. Chang	92
<b>Nitrides: Devices</b>	
InGaN-based solar cells with a tapered GaN structure C.-F. Lin, K.-T. Chen, S.-H. Chen, C.-C. Yang, W.-C. Huang and T.-H. Hsieh	97
GaN based LEDs with semipolar QWs employing embedded sub-micrometer sized selectively grown 3D structures R.A.R. Leute, D. Heinz, J. Wang, F. Lipski, T. Meisch, K. Thonke, J. Thalmeier, J. Zweck and F. Scholz	101
Optimizing the growth process of the active zone in GaN based laser structures for the long wavelength region U. Rossow, A. Kruse, H. Jönen, L. Hoffmann, F. Ketzer, T. Langer, R. Buss, H. Bremers, A. Hangleiter, T. Mehrrens, M. Schowalter and A. Rosenauer	105
Manipulation on the optical properties of InGaN/GaN light emitting diodes by adopting InN layer J. Hwang, K. Lee, J.S. Kim, C.-R. Lee, I.-H. Lee, K. Lee, J.H. Lee, J.-Y. Leem, J.S. Kim, J.-H. Ryou and R.D. Dupuis	109
Improved performance of semi-polar (11-22) GaN-based light-emitting diodes grown on SiN <sub>x</sub> interlayer J. Jeong, J. Jang, J. Hwang, C. Jung, J. Kim, K. Lee, H. Lim and O. Nam	114
INGAN/GAN based semipolar green converters J. Wang, D. Zhang, R.A.R. Leute, T. Meisch, D. Heinz, I. Tischer, M. Hocker, K. Thonke and F. Scholz	120
Enhanced emission efficiency of green InGaN/GaN multiple quantum wells by surface plasmon of Au nanoparticles M.-K. Kwon, J.-Y. Kim and S.-J. Park	124
<b>Arsenides, Phosphides, and Antimonides: Growth and characterization</b>	
Micro-characterization and three dimensional modeling of very large waveguide arrays by selective area growth for photonic integrated circuits R. Guillamet, N. Lagay, C. Mocuta, P.-Y. Lagrée, G. Carbone and J. Décobert	128
Growth of GaInAs/InP MQW using MOVPE on directly-bonded InP/Si substrate K. Matsumoto, T. Makino, K. Kimura and K. Shimomura	133
Characterization of partially ordered GaInP/GaAs heterointerfaces by the quantum Hall effect K. Uchida, K. Satoh, K. Asano, A. Koizumi and S. Nozaki	136
From conformal overgrowth to lateral growth of indium arsenide nano structures on silicon substrates by MOVPE K. Sladek, F. Haas, M. Heidelmann, D. Park, J. Barthel, F. Dorn, T.E. Weirich, D. Grützmacher and H. Hardtdegen	141

Site-controlled growth of InP/GaInP islands on periodic hole patterns in GaAs substrates produced by microsphere photolithography E. Koroknay, U. Rengstl, M. Bommer, M. Jetter and P. Michler	146
MOVPE-grown $\text{Al}_x\text{Ga}_{1-x}\text{As}_y\text{P}_{1-y}$ strain compensating layers on GaAs A. Maassdorf, U. Zeimer and M. Weyers	150
Structural characterization of selectively grown multilayers with new high angular resolution and sub-millimeter spot-size x-ray diffractometer J. Décobert, R. Guillamet, C. Mocuta, G. Carbone and H. Guerault	154
Optimized interfacial management for InGaAs/GaAsP strain-compensated superlattice structure S. Ma, Y. Wang, H. Sodabanlu, K. Watanabe, M. Sugiyama and Y. Nakano	157
Characteristics of bulk InGaAsSbN/GaAs grown by metalorganic vapor phase epitaxy (MOVPE) T.W. Kim, T.J. Garrod, L.J. Mawst, T.F. Kuech, S.D. LaLumondiere, Y. Sin, W.T. Lotshaw and S.C. Moss	163
Characterization of deep levels in GaInP on Ge and Ge-on-Si substrates by photoluminescence and cathodoluminescence C. Yang, S. Lee, K.-W. Shin, S. Oh, D. Moon, S.-D. Kim, Y.-W. Kim, C.-Z. Kim, W.-k. Park, W.J. Choi, J. Park and E. Yoon	168
<i>In situ</i> study of Ge(100) surfaces with tertiarybutylphosphine supply in vapor phase epitaxy ambient E. Barrigón, S. Brückner, O. Supplie, H. Döscher, I. Rey-Stolle and T. Hannappel	173
AP-MOVPE GaInSb: Influence of V/III ratio on quality and indium incorporation S.S. Miya, V. Wagener and J.R. Botha	177
Optical characterization of a GaAsSb/GaAs/GaAsP strain-compensated quantum well structure grown by metal-organic vapor phase epitaxy C.T. Huang, J.D. Wu, C.F. Liu, Y.S. Huang, C.T. Wan, Y.K. Su and K.K. Tiong	182
MOVPE growth of Ga(AsBi)/GaAs multi quantum well structures P. Ludewig, N. Knaub, W. Stolz and K. Volz	186
Growth of (BGa)As, (BGa)P, (BGa)(AsP) and (BGaIn)P by MOVPE N. Sommer, R. Buss, J. Ohlmann, T. Wegele, C. Jurecka, S. Liebich, B. Kunert, W. Stolz and K. Volz	191
Highly p-typed superlattices consist of undoped InAs and carbon-doped GaAs layers K. Uchida, H. Kanaya, H. Imanishi, A. Koizumi and S. Nozaki	197
Optical study of GaAsN/GaAs and InGaAsN/GaAs T-shaped quantum wires grown by MOVPE P. Klangtakai, S. Sanorpim and K. Onabe	200
Effect of compressive strain relaxation on surface morphology in GaAsP growth on GaP substrate X. Jin, S. Fuchi and Y. Takeda	204
<b>Arsenides, Phosphides, and Antimonides: Devices</b>	
Strain compensation techniques for red AlGaInP-VECSELs: Performance comparison of epitaxial designs T. Schwarzbäck, H. Kahle, M. Jetter and P. Michler	208
High power (>5 W) $\lambda \sim 9.6 \mu\text{m}$ tapered quantum cascade lasers grown by OMVPE C.A. Wang, A.K. Goyal, S. Menzel, D.R. Calawa, M. Spencer, M.K. Connors, D. McNulty, A. Sanchez, G.W. Turner and F. Capasso	212
AlGaInAsPSb-based high-speed short-cavity VCSEL with single-mode emission at 1.3 $\mu\text{m}$ grown by MOVPE on InP substrate C. Grasse, M. Mueller, T. Gruendl, G. Boehm, E. Roenneberg, P. Wiecha, J. Roskopf, M. Ortsiefer, R. Meyer and M.-C. Amann	217

MOVPE growth of $\text{Al}_{0.85}\text{Ga}_{0.15}\text{As}$ for high power laser diodes emitting at 808 nm F. Bugge, C. Netzel and M. Weyers	221
In-situ etching of patterned GaAs/InGaP surfaces for highly efficient 975 nm DFB-BA diode lasers A. Maaßdorf, C.M. Schultz, O. Brox, H. Wenzel, P. Crump, F. Bugge, A. Mogilatenko, G. Erbert, M. Weyers and G. Tränkle	226
InGaAs/AlInAs strain-compensated Superlattices grown on metamorphic buffer layers for low-strain, 3.6- emitting quantum-cascade-laser active regions L.J. Mawst, J.D. Kirch, C.-C. Chang, T. Kim, T. Garrod, D. Botez, S. Ruder, T.F. Kuech, T. Earles, R. Tatavarti, N. Pan and A. Wibowo	230
1-eV InGaAsN/GaAs quantum well structure for high efficiency solar application grown by MOVPE T.H. Wu, Y.K. Su, R.W. Chuang, C.Y. Huang, H.J. Wu and Y.C. Lin	236
GaInAs/GaAsSb-based type-II micro-cavity LED with 2–3 $\mu\text{m}$ light emission grown on InP substrate C. Grasse, T. Gruendl, S. Sprengel, P. Wiecha, K. Vizbaras, R. Meyer and M.-C. Amann	240
Improved optical absorption and photocurrent of GaAs solar cells with hexagonal micro-hole array surface texturing N.D. Lam, Y. Kim, K. Kim, K. Jung, H.K. Kang and J. Lee	244
<b>III-Vs on Si, Ge, or SiC</b>	
Epitaxy of GaN on Si(111) substrate by the hydride vapor phase epitaxy method J. Wang, H.-B. Ryu, M.-S. Park, W.-J. Lee, Y.-J. Choi and H.-Y. Lee	249
Study on the effects of AlN interlayer in thick GaN grown on 3C-SiC/Si substrates H. Fang, Y. Takaya, H. Miyake, K. Hiramatsu, H. Asamura, K. Kawamura and H. Oku	254
GaN growth on Si pillar arrays by metalorganic chemical vapor deposition D. Won, X. Weng, Y.A. Yuwen, Y. Ke, C. Kendrick, H. Shen, T.S. Mayer and J.M. Redwing	259
Improved GaN-based LED grown on silicon (111) substrates using stress/dislocation-engineered interlayers J. Ma, X. Zhu, K.M. Wong, X. Zou and K.M. Lau	265
High-growth-rate AlGaIn buffer layers and atmospheric-pressure growth of low-carbon GaN for AlGaIn/GaN HEMT on the 6-in.-diameter Si substrate metal-organic vapor phase epitaxy system A. Ubukata, Y. Yano, H. Shimamura, A. Yamaguchi, T. Tabuchi and K. Matsumoto	269
The effect of a temperature-varying sandwich buffer layer structure on GaN epitaxial layer grown on Si substrate J.-H. Lin, S.-J. Huang, Y.-K. Su and C.-W. Hsu	273
Anisotropic bow and plastic deformation of GaN on silicon A. Dadgar, S. Fritze, O. Schulz, J. Hennig, J. Bläsing, H. Witte, A. Diez, U. Heinle, M. Kunze, I. Daumiller, K. Haberland and A. Krost	278
Impact of the substrate and of the nucleation layer on the properties of AlGaIn/GaN HEMTs on SiC P. Gamarra, C. Lacam, M. Tordjman and M.-A. di Forte-Poisson	282
MOVPE growth of semi-polar GaN light-emitting diode structures on planar Si(112) and Si(113) substrates R. Ravash, A. Dadgar, F. Bertram, A. Dempewolf, S. Metzner, T. Hempel, J. Christen and A. Krost	288
<b>Quantum dots and nano structures</b>	
Metalorganic vapor phase growth of quantum well structures on thick metamorphic buffer layers grown by hydride vapor phase epitaxy K.L. Schulte, T.J. Garrod, T. Wan Kim, J. Kirch, S. Ruder, L.J. Mawst and T.F. Kuech	293

Formation and optical properties of multi-stack InGaAs quantum dots embedded in GaAs nanowires by selective metalorganic chemical vapor deposition J. Tatebayashi, Y. Ota, S. Ishida, M. Nishioka, S. Iwamoto and Y. Arakawa	299
Graded GaAsSb strain reducing layers covering InAs/GaAs quantum dots A. Hospodková, M. Zíková, J. Pangrác, J. Oswald, K. Kuldová, J. Vyskočil and E. Hulicius	303
Carrier dynamics and activation energy of CdTe/ZnTe nanostructures with different CdTe thicknesses W.I. Han, J.H. Lee, J.C. Choi and H.S. Lee	307
MOCVD growth of vertically aligned InGaN nanowires H.C. Kuo, T. Su Oh and P.-C. Ku	311
Ultraviolet light emitting diode based on p-NiO/n-ZnO nanowire heterojunction B.O. Jung, Y.H. Kwon, D.J. Seo, D.S. Lee and H.K. Cho	314
Coaxial InGaN epitaxy around GaN micro-tubes: Tracing the signs M. Fikry, Z. Ren, M. Madel, I. Tischer, K. Thonke and F. Scholz	319
Au-catalyzed synthesis and characterisation of phase change Ge-doped Sb-Te nanowires by MOCVD M. Longo, T. Stoycheva, R. Fallica, C. Wiemer, L. Lazzarini and E. Rotunno	323
Site-controlled growth of single GaN quantum dots in nanowires by MOCVD K. Choi, M. Arita, S. Kako and Y. Arakawa	328
Fabrication and characterization of high efficiency green nanopillar LED J.-W. Ju, J. Hyeob Baek, S.-J. Lee, D.-W. Jeon, J.-W. Park, J.-H. Choi, L.-W. Jang and I.-H. Lee	332
Site-controlled growth of indium nitride based nanostructures using metalorganic vapour phase epitaxy A. Winden, M. Mikulics, T. Stoica, M. von der Ahe, G. Mussler, A. Haab, D. Grützmacher and H. Hardtdegen	336
<b>II-Vs</b>	
Effects of annealing treatment upon electrical and photoluminescence properties of phosphorus-doped ZnMgTe epilayers grown by metalorganic vapor phase epitaxy M. Nishio, K. Kai, R. Fujiki, K. Saito, T. Tanaka and Q. Guo	342
Surface morphologies and photoluminescence properties of undoped and P-doped ZnTe layers grown by metalorganic vapor phase epitaxy M. Nishio, Y. Hayashida, K. Saito, T. Tanaka and Q. Guo	348