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14. ABSTRACT
The investigators have undertaken several efforts underlying the enhancement of the performance of Ill-nitride and related wurtzite quantum-dot-based optoelectronic devices. These include: carrier scattering by optical phonons; spontaneous polarization in wurtzites; the use of colloidal quantum dots as optoelectronic elements; strain- and confinement-induced shifts in the phonon frequencies in GaN quantum dots; two-phonon processes in photon absorption; phonon effects on carrier transport in nanowires, including wurtzite-based nanowires; and the design of photodetectors using wurtzite-based quantum dots and initial efforts on self-assembly of quantum dots into networks for optoelectronic applications. Eighteen refereed publication (with more in press) and resulted form this program as well as twenty-seven presentations, including seven invited presentations, have resulted form this program to date.

15. SUBJECT TERMS Ill-nitrides; Wurtzites; Quantum-dot-based Devices; Optoelectronic Devices; Spontaneous Polarization; Carrier Transport

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"III-nitride and Related Wurtzite Quantum-dot-based Optoelectronic Devices with Enhanced Performance"

(1) Introduction

The investigators have undertaken several efforts underlying the enhancement of the performance of III-nitride and related wurtzite quantum-dot-based optoelectronic devices. These include: carrier scattering by optical phonons; spontaneous polarization in wurtzites; the use of colloidal quantum dots as optoelectronic elements; strain- and confinement-induced shifts in the phonon frequencies in GaN quantum dots; two-phonon processes in photon absorption; phonon effects on carrier transport in nanowires, including wurtzite-based nanowires; and the design of photodetectors using wurtzite-based quantum dots and initial efforts on self-assembly of quantum dots into networks for optoelectronic applications. Eighteen refereed publication (with more in press) and resulted from this program as well as twenty-seven presentations, including seven invited presentations, have resulted from this program to date.

(2) List of Appendixes --- N/A

(3) Statement of Problem Studied

The problem addressed in this AFOSR effort on high-performance III-nitride quantum-dot-based devices is to design and characterize optically III-nitride laser heterostructures through the application of the quantum-engineering techniques. The investigators studies mechanisms, phenomena, and interactions --- strain-induced shifts in the phonon frequencies in GaN quantum dots, confinement-induced shifts in the phonon frequencies in GaN quantum dots, carrier transport in heterostructure lasers, spontaneous-polarization effects in III-nitride quantum dots, radiation absorption due to two-phonon effects --- having potential for enhancing the performance III-nitride and related wurtzite quantum-dot-based optoelectronic devices.

(4) Summary of Most Important Results

The most important results obtained during this period of this effort include: electrical and optical studies of components of devices and systems of III-nitride and related wurtzite quantum-dot-based optoelectronic devices; electronic and optical properties of quantum dots in ensembles; models of heterostructure-based and nanowire-based devices; models and measurements of strain-induced shifts in the phonon frequencies in GaN quantum dots; models and measurements of confinement-induced shifts in the phonon frequencies in GaN quantum dots; the characterization of quantum dots in chemically-assembled optoelectronic structures; formulating a theory of the spontaneous polarization of the nanoscale wurtzite structures; formulating models for conductance in nanowires components for optoelectronic devices and systems; and designing photodetectors using wurtzite-based quantum dots.

(5) List of Publications and Technical Reports

PAPERS PUBLISHED


PAPERS IN PRESS


PRESENTATIONS


• Michael A. Stroscio and Mitra Dutta, "Phonon Lifetimes and Phonon Confinement Effects in Semiconductor Heterostructures: Central Role of the Klemens Channel," Symposium in Honor of Paul Klemens as part of World Year of Physics/Einstein Centennial Lecture Series, University of Connecticut, Storrs, CT, October 21, 2005. (Invited) Other invited speakers in the Lecture Series were Randy Hulet, Ron Mallett, Patricia Rife, Frank Wilczek, Dan Kleppner, Francis Everitt, Alan Guth, Marlan Scully, Georgi Dvali, John Donoghue, and Alain Aspect.


• Ke Sun, Mitra Dutta, and Michael A. Stroscio, Transmission Coefficients for Minibands Formed in Quantum Dot Arrays under Bias, 12th International Workshop on Computational Electronics, Amherst, MA, October 2007.


• Michael A. Stroscio, Mitra Dutta, Takayuki Yamanaka, Jianyong Yang, and Chen Chen, Challenges Facing GaN and ZnO: Frohlich Interaction and Spontaneous Polarization, at Workshop on Challenges Facing GaN and ZnO, hosted by Virginia Commonwealth University, Richmond, VA, 18-19 Oct 2007. (Invited)


• Sun Ke, Milana Vasudev, Hye-Son Jung, Jianyong Yang, Yang Li, Kitt Reinhardt, Michael A. Stroscio, and Mitra Dutta, "Applications of Colloidal Quantum Dots," Workshop on Recent Advances on Low Dimensional Structures, University of Nottingham, England, April 7-9, 2008. (Invited)


(6) List of All Participating Scientific Personnel

Michael A. Stroscio, PI
Mitra Dutta, Co-PI
Ke Sun
Takayuki Yamanaka; received PhD, now at Northwestern University. Thesis results are all described in published articles listed previously.
Amit Raichura

(7) Honors and Awards

The PI was:

named the Richard and Loan Hill Professor in September 2006;
selected for the Technical Leadership Award a for the Nano-DDS Conference in July 2008;
appointed to the Editorial Board of the IEEE Proceedings in Fall 2007;
appointed as a member of the National Research Council (NRC) Board on Army Science and Technology (BAST) in January 2008.

(8) Report of Inventions: None