DR. SETH MARTIN HUBBARD

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EDUCATION

University of Michigan — Ann Arbor, MI
Ph.D. in Electrical Engineering (2005)

Case Western Reserve University — Cleveland, OH
M.S. in Electrical Engineering (1998)

Drexel University — Philadelphia, PA
B.S. in Physics (1995) (*Magna Cum Laude*)

PROFESSIONAL AND ACADEMIC EXPERIENCE

Rochester Institute of Technology — Rochester, NY

2015-Present	***Director, NanoPower Research Laboratory***
2012-Present	***Associate Professor of Physics, Associate Professor of Microsystems Engineering***
2009-Present	*Graduate Faculty, Center for Materials Science and Engineering*
2009-Present	*Graduate Faculty Carlson Center for Imaging Science*
2008-Present	*Graduate Faculty Golisano Institute of Sustainability*
2009-2014	*Photovoltaics Group Lead, NanoPower Research Laboratory*
2006-2011	*Assistant Professor of Physics, Assistant Professor of Microsystems Engineering*

Undergraduate and graduate education and mentoring in areas related to photovoltaics, electronics, solid state physics, materials and semiconductors, and microsystems engineering. Courses taught include Electronics, Introduction to Materials Science and Engineering, Modern Physics I/II, Physics I (mechanics), Physics III (electricity and magnetism), Experimental Physics and Introduction to Micro and Nanostructures. Research focused on quantum photovoltaics devices, materials growth and device design as well as novel sensors using nanostructures.

NASA Glenn Research Center — Cleveland, OH

2005-2006 *National Research Council Postdoctoral Fellowship*
Research related to vapor phase epitaxy (VPE) of photovoltaic devices and nanostructures, nanostructured device design, photovoltaic characterization and testing. First to grown VPE based InAs QD solar cells and demonstrate sub-bandgap absorption process as well a short circuit enhancement.

University of Michigan — Ann Arbor, MI

1998-2005 *Research Assistant*
Research consisted of studying the effects of materials properties and epitaxial device design on high power heterojunction field effect transistors grown using vapor phase epitaxy. Obtained record mobility and sheet charge for VPE grown AlN-GaN MISFET. Achieved record semi-insulating GaN values. Undergraduate Research Opportunity Program (UROP) mentor, 4 years.

Case Western Reserve University

1996-1998 *Research Assistant*
Conduct research at NASA Glenn Research Center on materials for high temperature photovoltaics such as SiC and GaN. Developed a novel EBIC technique for wafer mapping of diffusion length in SiC epitaxial layers.

1996-1998 *Teaching Assistant*
Electronic Circuits, Logic Design and Computer Organization

RESEARCH SUMMARY: 39 Funded projects totaling $8,007,890 as Principle Investigator; 18 funded projects at $6,292,374 as Co-PI. I Currently have 3, $470,667 proposals pending.

FUNDED RESEARCH AS PRINCIPLE INVESTIGATOR

PENDING 11/1/16-10/31/17
DOD Dept of the Air Force/ Dynamic Radiation $114,669
Development & Commercialization of a High Fidelity Proton Defect Simulation for Large Format Focal Plane Arrays
This study is to characterize proton-induced defects in InGaAs diodes required for modeling them as "traps" in TCAD device simulations. The parameters to be determined, as a function of incoming proton energy and fluence, are the dominant defect/trap activation energies (energy levels in the bandgap), electron and hole capture cross sections of particular defects/traps and introduction rates of particular defects/traps.

PENDING 10/1/16-9/30/17
DOD Dept of the Air Force: SVAT/ ATA $80,000
Radiative Coupling Techniques to Enhance End-of-Life Efficiency of Multijunction solar cells
RIT will partner with AFRL to incorporate defect tolerant radiative recombination centers into an InGaP solar cell. In this initial proof-of-concept project we will focus on the more mature QW technology, studying both stained and strained balanced QW structures composed of alloys of InGaP with bandgaps lower than 1.85 eV. Design considerations for the QW include alloy composition, QW thickness, QW location within the top cell, best emission wavelength for efficient coupling to GaAs sub-cells and overall impact on electrical performance of the QW enhanced top cell.

NNX15CC20C 7/27/15-5/26/17
NASA- SBIR/ MicroLink $244,675
High Efficiency, Radiation Hard and Light Weight IMM Solar Cells
This project will incorporate quantum dots (QDs) in the GaAs and InGaAs subcells of an InGaP/GaAs/InGaAs triple-junction solar cell to increase the radiation tolerance and thereby improve the end-of-life performance of the solar cell by >5%. The quantum dot solar cell will be grown in an inverted metamorphic (IMM) format on GaAs and will be compatible with MicroLink's epitaxial lift-off (ELO) process.

1115000233
US Government/ Oak Ridge National Labs 9/1/15-8/31/17
ORNL $34,000 (+1 postdoc salary)
Novel Materials and Device Architectures for Space Photovoltaics
The work proposed in this fellowship will evaluate two paths to reach efficiencies closer to the detail balance limit. The first path is development of solar cells using an interfacial misfit growth that allows the growth of highly mismatched materials with low defect densities. A second research path pursued is the development of an intermediate band solar cell (IBSC) using quantum dots within an InAIAsSb lattice.

DE-EE0007363 7/1/16-6/30/17
DOE EERE/ South Dakota School of Mines $76,618
Aluminum Epilayers for controlled growth and processing of low-cost III-V solar cells

This project aims to demonstrate uses of the earth-abundant and widely available metal Al for 111-V solar cells. Al metal is lattice matched to GalnAs, which can offer maximum S-Q efficiency and is readily partnered with GalnP passivating alloys. The immediate goal is to demonstrate heteroepitaxy of GalnAs on GaAs using Al buffer layers.

D15PC00222 7/15/16-6/30/16
DARPA/ Magnolia Optical Technologies $91,056
Inhibited Radiative Dark Current GaAs-Based Solar Cells
RIT will collaborate with Magnolia in the design, growth, fabrication, and testing of 3 sets of single-junction GaAs-based solar cells. Each experimental set will consist of approximately 3-5 structures. These structures will include multi-step InGaAs-based quantum wells of varying design. Wide band gap heterojunction may also be included for improved low dark current operation.

FA9453-15-C-0404 6/1/2015 - 7/31/2018
AFRL/ MicroLink $433,340
Quantum and Nano-Structure Enhanced Epitaxial Lift-Off (ELO) Solar Cells
This proposes to meet high-efficiency, lightweight and radiation-hard criteria with an innovative, high-efficiency QD enhanced IB solar cells based on ELO technology. The proposed structure will achieve a much higher end-of-life power conversion efficiency, in conjunction with a greatly increased power density, than current state-of-the-art photovoltaic technologies. MicroLink's proprietary epitaxial lift-off (ELO) process will be used to remove the substrate to produce ultra-lightweight, flexible, robust solar cells. Substrate reuse will render this GaAs-based approach cost-effective. With these weight and performance metrics, a specific power >1000 W/kg will be achievable at the solar array level. This technology is also predicted to show higher radiation resistance than complicated and expensive inverted metaporphic solar cells.

NNX15AP53H 8/1/2015 - 7/31/2017
NASA $147,000
NSTRF: Development of InAlAs Top Cell for High Specific Power Multijunction Photovoltaics
This is a fellowship for a graduate student (NSTRF). Funding is for 1 year, renewable up to 5 years. Project is for development of InAlAs to improve upon current space photovoltaics (PV). Ultimately, this technology would increase capability and durability for missions and would also correspond to technology gains for terrestrial concentrator photovoltaic systems.

W911QX09D0016 8/3/2015 - 7/31/2016
EcoPulse/ DoD Army $28,504
Tritium-Based Solid State Power Supplies
This initiative consists of the development of solid state photodiodes optimized for low-light levels to serve as the converter in an indirect conversion radioisotope battery.

EECS-1509468 6/1/2015 - 5/31/2018
NSF/ UCLA $221,225 + $8,000 REU
COLLABORATIVE RESEARCH: Highly mismatched GaSb-GaAs thin film multijuction solar cells for high efficiency.
RIT and UCLA will study the interfacial misfit (IMF) growth technique as applied to highly mismatched, multi-junction (MJ) Sb-based solar cell. The broader goal of this program is to enable low defect density and optimal bandgap multi-junction solar cells, with efficiency near 50% under 500 sun AMI.5 illumination

Contract# Pending 1/1/2015 - 3/31/2016
DOE/ Stanford/ UCLA $124,529
GaSb-GaAs thin film multijuction solar cells
With the University of California Los Angeles (UCLA), propose a highly mismatched, multi-junction (MJ) Sb-based solar cell with low defect density and optimal bandgap subcells, with efficiency near 40% under 500 sun AMI.5 illuminations.

004780-002.1 5/1/2015 - 4/30/2017
DoD/ Dept AF/ Microlink $269,941
STTR: Quantum and Nano-Structure Enhanced Epitaxial Life-Off (ELO) Solar Cells
MicroLink along with the STTR partner RIT propose to achieve a much higher end-of-life power conversion efficiency, in conjunction with a greatly increased power density, than current state-of-the-art photovoltaic technologies. MicroLink's proprietary epitaxial lift-off (ELO) process will be used to remove the substrate to

produce ultra-lightweight, flexible, robust solar cells. Substrate reuse will render this GaAs-based approach cost-effective.

N00173-14-1-G011 10/1/2014 - 9/30/2017
DoD/ Navy $499,576
Transition Of High-Performance III-V Solar Cells To Low Cost Substrates And Growth Methodologies
The Rochester Institute of Technology (RIT), in partnership with Old Dominion University (ODU) propose to radically reduce the cost of high-efficiency III-V solar cells by developing single-junction (SJ), polycrystalline (PX) GaAs and InP thin film solar cells on low cost metal foils. At the end of this three-year program, we will demonstrate thin-film PX-GaAs solar cells on low-cost substrates with efficiencies near 18%-20% grown by low cost, large area deposition techniques.

DE-AR0000335 3/20/13 - 2/29/16
DoE/E-ARPA $945,861
High Efficiency, Lattice-Matched Solar Cells Using Epitaxial Lift-Off
MicroLink Devices, Rochester Institute of Technology (RIT) and the US Naval Research Laboratory (NRL) propose to develop a novel, high-efficiency all-lattice-matched solar cell which can achieve much higher power conversion efficiency and thereby enable a far lower levelized cost of energy than is possible with current concentrator photovoltaic (CPV) technologies. This will be accomplished with a triple-junction InAlAsSb/InGaAsP/InGaAs cell lattice-matched to InP.

HQ0147-12-C-7164 9/1/2012 - 8/1/2015
MDA/CFD Research Corp $307,535
STTR: Radiation Hard Quantum Well Multijunction Solar Cells
Drs. Forbes and Hubbard will support CFDRC by design, epitaxial growth, fabrication and testing of both standard and quantum well enhanced photovoltaic devices.

FA9453-11-C-0253 8/1/2013 - 4/14/2016
AFRL/ Univ. of Toledo $158,498
Quantum Dot Doping Superlattice (nipi) Photovoltaic Devices
This proposal seeks to address challenges and shed light on the technology and device physics leading to an intermediate band solar cell. One thrust will focus on Sb materials systems with improved bandgap and little valence band offset for the intermediate band solar cell (IBSC) application. The other thrust will focus on the doping superlattice nipi devices, which allow for longer carrier lifetime, improved absorption coefficients and high QD (Quantum Dot) doping levels.

MLD#PR0110-1 6/12/2014 - 12/11/2014
NASA/Microlink Devices $36,661
SBIR: High Efficiency, Radiation Hard and Light Weight IMM Solar Cells
In the proposed Phase I project, MicroLink and its collaborator, Rochester Institute of Technology (RIT), will incorporate quantum dots (QDs) in the InGaAs subcell of an InGaP/GaAs/InGaAs triple-junction solar cell to increase the radiation tolerance and thereby improve the end-of-life performance of the solar cell by >5%. By incorporating QD's into the InGaAs third cell, we will also extend the absorption range of InGaAs cell to beyond 1250nm, thereby increasing the current produced in the bottom sub cell.

N00014-14-1-0646 7/1/2014 - 12/31/2015
DoD/ Navy $253,369
Nano-structured Photovoltaics and Optoelectronics
We propose to purchase a toolset to enable research in novel materials systems for both photovoltaics and infrared optoelectronic devices. The toolset will allow RIT the capacity to measure both in-situ and ex-situ the strain, bandgap and material quality of novel materials grown using our newly acquired metal organic vapor phase epitaxy (MOVPE) tool. The toolset will be devoted to development of III-V nanostructured devices and materials for power generation, energy harvesting and adaptive multimodal sensing.

FA9453-14-M-0014 10/1/2013 - 7/31/2014
AFRL/ Microlink Devices $40,844
STTR: Quantum and Nano-Structure Enhanced Epitaxial Life-Off (ELO) Solar Cells
We propose to develop a high-efficiency, single junction, epitaxial lift-off (ELO) GaAs solar cell by incorporating innovative nano-scale features such as quantum-dots (QD) and optically functional textures within the cell structure. The innovative aspect of the proposed work is the use of quantum dots to extend the photon collection

wavelength range and to improve the coupling of light into the cell. We will also include band gap engineering solutions to reduce dark current in the cell.

NY State 4/1/2014 - 7/31/2016
Empire State Development (ESD) $300,000
CFA: Acquisition of Metal Organic Vapor Phase Epitaxy (MOVPE) Reactor for Nanostructured Materials Development
Rochester Institute of Technology intends to purchase of a metal organ vapor phase epitaxy (MOVPE) system for growth of novel materials, thin film crystals and nanostructures. This grant supports the installation and start-up of the MOVPE system.

DMR 1337592 09/01/13 - 12/31/15
National Science Foundation $706,671
MRI: Acquisition of Metal Organic Vapor Phase Epitaxy (MOVPE) Reactor for Nanostructured Materials
RIT will acquire a system for III-V material growth by Metal Organic Vapor Phase Epitaxy (MOVPE). The system will be devoted to growth of III-V nanostructured materials and devices. The requested piece of equipment (Aixtron 3x2" Close Coupled Showerhead MOVPE) has been proven to provide the variety of materials, thickness, composition, and doping control necessary for the various nanomaterials and nanostructures of interest to the PI and co-PIs.

003453-002.1 2/13/2012 - 4/13/2012
USAF/Microlink Devices $11,979
High Efficiency Flexible Photovoltaics
Support Microlink through characterization, measurement and data analysis of Microlink manufactured solar blankets.

003454-002.1 1/16/2012 - 1/15/2013
NRO/Emcore Corp. $251,157
Nanostructured Triple Junction Solar Cells (Phase II)
Continuation of Phase I project with Emcore Photovoltaics.

AN-RIT-0001 Prime: 23641 11/28/2011 - 12/31/2012
NYSERDA/Antek Inc. $46,831
A Low Cost Manufacturing Process for High Efficiency Silicon Hetero-Junc...
RIT will work with Antek to help establish the benefits of a low cost approach to silicon hetero-junction solar technology using a polymer-inorganic hybrid approach.

003488-002.1 1/1/2012 - 12/31/2012
NASA/Microlink Devices $49,997
Advanced Epitaxial Lift-off Quantum Dot Photovoltaic Devices
RIT will demonstrate the advantages of combining both a subtrate removal and Quantum Dot (QD) technology. RIT and Microlink will explore QD advantages using a single junction GaAs epi-liftoff solar cell.

DE-EE00005325 2/1/2012-7/31/2015
DOE/UCLA $300,296
Development of III-Sb Quantum Dot Systems for High Efficiency IBSC
The objective of the proposed work is to identify and develop a III-Sb based quantum dot system suitable for intermediate band solar cells (IBSC) via thorough theoretical and experimental analysis supported by sophisticated band structure modeling.

NNX12AM59H 8/1/2012-7/31/2015
NASA $200,000
Nanostructured Photovoltaics for Space Power (NASA Space Technology Research Fellowship)
Support of PhD student for 3 year period.

DE-FG36-08G018012 02/01/08 - 04/30/12
DOE Next Generation Photovoltaics $843,697
High Efficiency Nanostructured III-V Photovoltaics for Solar Concentrators
The project seeks to provide new photovoltaic cells with very high efficiency, reduced spectral sensitivity and favorable temperature coefficients, for application in concentrator PV systems. The objectives of this project will be

accomplished by combining state-of-the-art solar cell design and fabrication with new functionality afforded by nanostructured materials such as quantum dots (QDs) and quantum wells (QWs).

2010-1042506-000 07/12/10 - 12/31/13
CIA $359,110
IC Postdoctoral Fellowship for Quantum Dot Solar Cells

NRO-000-10-C-0285 09/01/10 - 09/27/11
NRO/Emcore Corp. $253,066
Nanostructured Triple Junction Solar Cell
The overall objective of the proposed program is to incorporate nanotechnology (QD and QW) in state-of-the-art triple junction photovoltaic devices grown by Emcore Photovoltaics Corporation. RIT will support Emcore through design, epitaxial growth, fabrication and testing of both quantum dot and quantum well MJ photovoltaic devices.

HDTRA1-10-C-0075 08/01/10 - 12/31/12
DTRA/CFD Research Corp. $120,000
SBIR Phase II: Characterization and Mitigation of Radiation Effects in QD Based Nanotechnologies
RIT will support CFDRC by design, epitaxial growth, fabrication and testing of both standard and quantum dot enhanced protovoltaic devices for 'rad-hard' operation.

FA9453-08-C-0172 10/04/10 - 10/03/11
USAF/University of Toledo $100,000
Development of Quantum Dot n-i-p-i Photovoltaic Devices
Develop quantum dot nipi devices based on GaAs for enhanced photovoltaic efficiency and radiation hardness.

NNX07AE14G 02/01/07 - 01/31/09
NASA $75,000
Nanostructured Photovoltaics

NNC07CA20C 01/01/07 - 05/29/09
NASA/CFC Research Corp. $75,000
SBIR Phase II: Novel Solar Cell Nanotechnology for Improved Efficiency and Radiation Hardness
RIT will support CFRC to help refine model-to-data with developed CFDRC NanoTCAD software for quantum dot nanostructures and radiation effects in nanotechnology applications.

FA9550-10-C-0063 04/01/10 - 01/31/11
USAF/CFD Research Corp. $49,423
STTR Phase I: Quantum Dot Multi-Photon Photovoltaics Using Nipi Lateral Architecture
Design, epitaxial growth, fabrication and testing of novel nipi type photovoltaic devices.

18810 09/01/10 - 08/31/11
NYSERDA/RNY Solar $48,709
Growth and Characterization of Concentrator Solar Cells

DE-AC36-08GO28308 03/03/10 - 07/22/11
NREL/DOE $39,912
Quantum Dot Enhanced Nipi Based Solar Cells

NNX10AP52H 07/01/10 - 06/30/11
NASA $30,000
Graduate Student Research Program Fellowship

DMR-0840228 05/01/08 - 04/30/11
NSF $31,168
A Study of the Solution-based Synthesis of N-doped ZnO

FUNDED RESEARCH AS CO-PRINCIPLE INVESTIGATOR

Contract# Pending 11/1/2016 – 10/31/2018
NASA $199,749
Demonstration of a Nano-Enabled Space Power System

ECCS-1531320 9/1/2015 – 8/31/2016
NSF $345,000
Acquisition of Direct-Write Laser System for Innovations in Electronic & Photonic Device Design

Contract# Pending 6/22/2015 – 6/30/2020
DoD/ LMI $249,999
American Institute for Manufacturing Integrated Photonics

Contract# Pending 6/22/2015 – 6/30/2020
DoD/ LMI $35,000,000
American Institute for Manufacturing Integrated Photonics

DMR-1461063 5/01/15 - 4/30/18
NSF $353,997
REU Site: Materials, application and development for organic photovoltaic devices

HDTRA1-10-1-0122 10/5/2010 – 10/04/2015
DTRA $1,047,608
Mechanisms of Radiation-Induced Effects in Carbon Nanotubes

NNX11CC58C 7/22/2011 - 7/22/2013
NASA/Firefly Technologies $192,600
Nanowire Photovoltaic Devices

003168-002.2 9/1/2011 - 8/31/2012
NASA/Microlink Devices $50,000
Evaluation of Radiation Hardness of Photovoltaic Devices

FA9453-11-C-0253 12/22/2010 - 6/22/2012
USAF/University of Toledo $147,989
Quantum Dot Enhanced Photovoltaic Devices

DE-FG36-08GO88110 7/1/2008 - 6/30/2010
DOE $984,000
Hyperspectral Polymer Solar Cells

NMA401-02-9-2001 8/31/08 - 9/30/09
NRO $865,829
Nanostructured Space Photovoltaics

NRO000-07-C-0372 10/5/2009 - 8/14/2010
NRO/Lockheed $450,000
Third Generation Based Lithium Ion Battery

W91CRB-09-C-0086 8/24/2009-12/31/2011
Army/AlphaV, Inc. $728,209
Extended-Lifetime Radioisotope Batteries

ECCS-0923298 09/01/09 - 08/31/11
NSF $200,297
MRI: Acquisition of a Scanning Probe Microscopy System

FA9453-08-C-0172 11/1/2009 - 10/31/2010
USAF/University of Toledo $50,000
Quantum Wire III-V Solar Cell

NNX09CA40C 8/4/10 - 5/4/11
NASA/Microlink Devices $50,000
Radiation Hard Photovoltaic Devices

HQ0006-10-c-7386 5/1/10-11/30/10
MDA/CFD Research Corp. $44,948
Radiation Hard Quantum Well Multijunction Solar Cells

ECCS-1625998 9/1/16-8/31/17

NSF/ MRI $332,149
Acquisition of an Inductively Coupled Plasma Reactive-Ion Etching System for Research and Education in Nanophotonics, Nanoelectronics and Nano-Bio Devices

PENDING RESEARCH PROPOSALS

NSF-EAGER 2 year $149,843
E EAGER: TDM solar cells: High Efficiency Perovskite/c-Si Tandem Cells with Wide Bandgap Semiconductor Nanowires (UML and RIT)
The University of Massachusetts Lowell (UML) and Rochester Institute of Technology (RIT) will team up to investigate the high efficiency integration Perovskite and crystalline-silicon (c-Si) tandem cells with semiconductor nanowires, and enable a new class of photovoltaic devices with breakthrough conversion efficiency over 30% under one sun. This approach will draw on the combination of the photovoltaic expertise at RIT and the nanowire and organic solar cell development at UML.

NSF-EAGER 2 year $299,907
EAGER:TDM solar cells; Bifacial III-V nanowire on Si tandem junction solar cells
Propose to explore transformative, bifacial solar cell design that employs arrays of TMD-III-V compound semiconductor nanowires in tandem with a thinned intermediate Si- sub cell.

DOD Dept of Air Force/ nBn Technolgies 1 year $20,686
Fabrication and Characterization of Detectors
RIT will provide and assist with the fabrication and characterization of nBn detectors. This will include the purchase and use of a Keysight LCR meter (or similar) as well as wire bonding and low temperature spectral response using facilities located in SLA-1480.

PHYSICS DEPARTMENT AND COLLEGE OF SCIENCE SERVICE

2016-Present:	***COS Tenure Committee***
2015-Present:	***Physics Faculty Search Committee***
2014-2016:	Trustees Scholarship Award Committee
2014-Present:	***Member, Materials Science Steering Committee***
2013-2014:	Chair, Materials Science Steering Committee
2010-2011:	Faculty Search Committee, 2 positions
2009-2012:	Chair, Colloquia Committee
2009-Present:	***Member, Strategic Vision and Planning Committee***
2009-2010:	Member, Resources, Facilities, and Space Committee
2008-2009:	Member, Colloquia Committee
2007-2009:	Chair, Resources, Facilities, and Space Committee
2007-2008:	Faculty Search Committee, 1 position

MICROSYSTEMS ENGINEERING SERVICE

2015:	Faculty Search Committee
2014:	Faculty Search Committee
2010-2012:	Faculty Search Committee
2009-Present:	***Admissions Committee***
2009-2012:	Bausch & Lomb Chair Search Committee
2008-Present:	***PhD Comprehensive Exams***

PROFESSIONAL SERVICE

2011-Present:	***Editor, IEEE Journal of Photovoltaics***
2020:	***Named as Conference Chair, 47th PVSC***
2017:	***Technical Program Chair, 44th PVSC***
2014-2016:	***Chair of Next Generation Photovoltaics area, 42nd and 43rd PVSC***
2014:	Tutorials Chair, 40th IEEE PVSC
2014:	Publication co-Chair, 6th World Conference on Photovoltaics (WCPEC)
2011-2013:	Publication Chair, 38th and 39th IEEE Photovoltaic Specialists Conference.
2010-2011:	Deputy Publication Chair, 37th IEEE Photovoltaic Specialists Conference
2010-Present:	Chair for Fundamental Conversion Mechanisms sub-area, 37th and 38th IEEE PVSC
2009-2010:	Graduate Student Coordinator, 35th IEEE Photovoltaic Specialists Conference
2009-2010:	Novel Photovoltaic Device Area sub-chair, 35th IEEE PVSC
2007-Present:	Peer reviewer and session chair, IEEE Photovoltaic Specialists Conference
2009:	Rump session panelist for photovoltaics, 2009 IEEE Device Research Conference
2009:	Develop Nanostructured Solar Cell Workshop at the 19th Space Photovoltaics Research and Technology Conference (SPRAT)

OUTREACH ACTIVITIES

2016:	Hands-On Photovoltaic Experience (HOPE), NREL, PV Myth-buster Session
2007-Present:	College and Career Day Presentations on Nanomaterials and Solar Energy
2012-2014:	RIT Middle College (9th Grade) Presentations on Solar Energy
2011-2012:	Presentation on Solar Energy at Rochester Museum and Science Center
2009-2010:	Earth Day Presentations on Solar and Renewable Energy
2006-2007:	Mentor for NASA Educational and Research Internship Program (LERCIP)

PROFESSIONAL AFFILIATIONS

2005-Present:	Member, Institute of Electrical and Electronics Engineers (IEEE)
2004-Present:	Member, Materials Research Society (MRS)
2007-2009:	Society for the Advancement of Material and Process Engineering (SAMPE)
1999-2004:	Student Member, IEEE

HONORS

Trustee Scholarship Award, RIT, 2013
PI Millionaire Award, RIT, 2011
Batting 1000 PI Award, RIT, 2007
National Research Council Research Associate at NASA Glenn Research Center, 2005- 2006
NASA Graduate Student Research Program (GSRP): 1998- 2004
Presidential Scholarship, Drexel University, 1991-1995

ADVISING SUMMARY: Advisor to 6 postdoctoral fellows (3 current, 3 graduates), 9 PhD students (6 current, 3 graduates), 10 MS graduates and 34 undergraduates (3 current, 31 previous). A committee member for 12 PhD candidates (1 current, 11 graduates) and 2 MS graduates.

POSTDOCTORAL ADVISING

2016-Present: **Advisor**, Alessandro Giussani, Postdoctoral Fellow, NanoPower, RIT.

2016-Present: **Advisor**, Hyun Kum, Postdoctoral Fellow, NanoPower, RIT.

2015-Present: **Advisor**, Michael Slocum, IC Postdoctoral Fellow, NanoPower, RIT.

2012-2015: **Advisor**, Staffan Hellstroem, Postdoctoral Fellow, NanoPower, RIT. Status: Independent Solar Cell Simulation Consultant.

2010-2013: **Advisor**, Christopher Kerestes, IC Postdoctoral Fellow, NanoPower, RIT. Status: Emcore Photovoltaics, Inc.

2011-2012: **Advisor**, Kristina Driscoll, Postdoctoral Fellow, NanoPower, RIT. Status: Lecturer RIT School of Physics and Astronomy.

GRADUATE STUDENT ADVISING

Current PhD

2016-Present: **Advisor**, Mitsul Kacharia, PhD Microsystems, RIT, Thesis area:

2014-Present: **Advisor**, Elisabeth McClure, PhD Microsystems, RIT, Thesis area: *Polycrystalline III-V Photovoltaics*.

2013-Present: **Advisor**, George Nelson, PhD Microsystems, RIT. Thesis area: *Characterization of Sb based materials for Photovoltaics*

2013-Present: **Advisor**, Brittany Smith, PhD Microsystems, RIT. Thesis area: *InAlAsSb materials for solar application*

2012-Present: **Advisor**, Yushuai Dai, PhD Microsystems, RIT. Thesis title: *Spectroscopy of quantum dot solar cells*

2011-Present: **Advisor**, Zac Bittner, Ph.D Microsystems Engineering, RIT. Thesis area: *Growth, fabrication and characterization of quantum dots solar cells on InP substrates.*

2013-Present: **Committee Member**, Tarun Mugdal, Thesis topic: *Proposed Investigation on Alternative Semiconductor Materials for Thin-Film Electronics*

Current MS

Graduated PhD

2015: **Advisor**, Steve Polly, Ph.D Microsystems Engineering, RIT. Thesis title: *Design and Implementation of Quantum Dot Enhanced Next Generation Photovoltaic Devices,* Status: IC Postdoctoral Fellowship, RIT.

2015: **Advisor**, Mike Slocum, Ph.D Microsystems Engineering, RIT. Thesis title: *Development and Characterization of a nipi Doping Superlattice Photovoltaic Device*. Status: Postdoctoral Fellow, RIT.

2013: **Co-Advisor**, Chris Bailey, Ph.D Microsystems Engineering, RIT. Thesis title: *Optical and Mechanical Characterization of InAs Quantum Dot Array Embedded Devices.* Status: Assistant Professor, Old Dominion University.

2016: **Committee Member**, Nate Cox, Thesis topic*: Radiation Effects in Single and Multiwall Carbon Nanotubes*

2015: **Committee Member**, Paul Thomas, Thesis topic: *Benchmarking Heterojunction vs. Homojunction Esaki Tunnel Diodes*

2014: **Committee Member**, Meng Zhao, Thesis topic: *Thermal Analysis And Dielectric Spectral Characteristics Of Poly(Ionic Liquids)*

2014: **Committee Member**, Susan Spenser, Thesis title: *Charge Photogeneration Experiments and Theory in Aggregated Squaraine Donor Materials for Improved Organic Solar Cell Efficiencies*

2014: **Committee Member**, Andrew Estroff, Thesis title: *Plasmonic Approach to Deep Ultra Violet Lithography*

2014: **Committee Member**, David Pawlik, Thesis title: *Characterization and Modeling of High Current Density Esaki Diodes for the Optimization of Tunneling-FETs*

2014: **Committee Member**, Abdelsalam Aboketaf, PhD Microsystems, RIT. Thesis title: *High-Speed And Robust Integrated Silicon Nanophotonics For On-Chip Interconnects*

2014: **Committee Member**, Liang Cao, PhD Microsystems, RIT. Thesis title: *Silicon photonics interconnects*

2011-2012: **Committee Member**, Roberta DiLeo, Ph.D Microsystems Engineering, RIT. Thesis title: *High Performance Lithium Ion Battery Anodes through the Development of Nanomaterials.*

2010-2012: **Committee Member**, Ali W. Elshaari, Ph.D Microsystems Engineering, RIT. Thesis title: *Photon Manipulation in silicon based nanophotonic circuits*

2010-2011: **Committee Member**, Karthik Narayanan, Ph.D Microsystems Engineering, RIT. Thesis title: *Hydrogenated-Amorphous-Silicon Photonics*

Graduated MS

2014: **Advisor**, Mitchell Bennett, MS Materials Science/BS Physics, RIT. Thesis: *Flexible QD Solar Cells*, Status: Naval Research Laboratory

2013: **Advisor**, Wyatt Strong, MS Materials Science, RIT. Thesis: *Deep Level Transient Spectroscopy of QD Structures.* Status: Hughes Research Laboratory

2013: **Advisor**, Adam Podell, MS Materials Science, RIT. Thesis: *QD Enhanced Triple Junction Solar Cells.* Status: Photonics Corporation

2012: **Advisor**, Yushuai Dai, MS Materials Science, RIT. Thesis title: *Resonant Spectroscopy of quantum dot solar cells.* Status: PhD in Microsystems

2011: **Advisor**, Zac Bittner, MS Materials Science, RIT. Thesis Title: *Design, Fabrication, and Characterization of Solar Cells for High Temperature and High Radiation Space Applications.* Status: PhD in Microsystems

2011: **Advisor**, Chelsea Mackos, MS Materials Science, RIT. Thesis Title: *Optimization of Concentrator GaAs Photovoltaic Devices with InAs Quantum Dots through Substrate Misorientation and Electroplating.* Status: Emcore Photovoltaics, Inc.

2010: **Advisor**, Joanne Oakvath, MS Electrical Engineering, RIT. Thesis Title: *The Effects of GaAs Substrate Miscut on InAs Quantum Dot Optoelectronic Properties: Examined by Photoreflectance (PR) and Deep Level Transient Spectroscopy (DLTS).* Status: Fairchild Semiconductors.

2010: **Advisor**, Michael Harris, MS Electrical Engineering, RIT. Thesis title: *Design and testing of high concentration quantum dot solar cells.* Status: Imaging Science PhD, RIT.

2009: **Advisor**, Amandeep Saluja, MS Microelectronic Engineering, RIT. Thesis Title: *A Parametric Study of Gas Sensing Response of ZnO Nanostructures and Carbon Nanotubes.* Status: Freescale Semiconductors

2008: **Co-Advisor**, Ryan Aguinaldo, MS Materials Science, RIT. Thesis Title: *Modeling Solutions and Simulations for Advanced III-V Photovoltaics Based on Nanostructures.* Status: PhD University of California San Diego

2008: **Committee**, John DeFranks, MS Materials Science, RIT. Project Title: *Carbon Nanotube Conductive Inks.* Status: IMR Test Labs

2007: **Committee**, Jim McCarty, MS Materials Science, RIT. Project Title: *Polycrystalline III-V Solar Cells on Flexible Metal Films.* Status: Emcore Photovoltaics, Inc.

UNDERGRADUATE MENTORING

Current

2016: **Co-op**, Jeremiah Leit, BS Microelectronic Engineering (2019), RIT. Project: *Epitaxial Liftoff Solar Cells.*

2016: **Co-op**, Htet Kyaw, BS Electrical Engineering (2018), RIT. Project: *Setup for light and voltage biased quantum efficiency measurements of solar cells.*

2016-2017: **Capstone**, George McCurdy, BS Physics (2017), RIT. Project: *Light Trapping for Photovoltaics.*

Past

2015-2016: **Co-op**, Adam Bennett, BS MicroElectronic Engineering (2018), RIT. Project: *Epitaxial Liftoff Solar Cells.*

2016: **Summer Intern**, George McCurdy, BS Physics (2017), RIT. Project: *Light Trapping for Photovoltaics.*

2016: **NSF-REU Intern**, Emily Kessler, BS MicroElectronic Engineering (2018), RIT. Project: *GaSb Solar Cells.*

2016: **NSF-REU Intern**, Ashaki Gumbs, BS Physics (2019), SUNY Geneseo. Project: *Aluminum Induced Recrystallization of Germanium*

2015: **Summer Intern**, Patrick Furrey, BS Physics (2017), RIT. Project: *Aluminum Induced Recrystallization of Germanium.*

2015: **NSF-REU Intern**, Martin Dann, BS Physics (2016), SUNY Oswego. Project: *Epitaxial Liftoff Solar Cells*

2014-2015: **Capstone**, Andrew Sindermann, BS Physics (2015), RIT. Project: *Photoreflectance Spectroscopy*

2012-2013:	**Capstone**, Justin Shellenberger, BS Physics (2013), RIT. Project: *Deep Level Transient Spectroscopy*
2013:	**Summer Intern**, Dannielle Campbell Trost, BS Physics (2015), RIT. Project: Characterization of InAlAs Solar Cells Using Deep Level Transient Spectroscopy.
2012-2013:	**Co-op**, John Hatakeyama, BS Electrical Engineering (2015), RIT. Project: *Fabrication and Analysis of Solar Cells*
2012:	**Summer Intern**, Elisabeth McClure, BS Physics (2014), Emory Univ. Project: *Polishing and Epitaxial Liftoff of GaAs Quantum Dot Solar Cells*.
2011-2013:	**Co-op and Senior Design**, Elias Fernandez, BS Microelectronics Engineering (2013), RIT. Project: *Design, Fabrication, And Characterization Of Ingap Solar Cells*
2011-2012:	**Capstone**, John Howson, BS Physics (2012), RIT. Project: *An exploration in the use of Carbon Nanotubes as Gas Sensors*
2011-2012:	**Co-op**, Hao Shi, BS Physics (2013), RIT. Project: *Development of a Characterization Technique to Measure Dark Series Resistance and Shunt Resistance in Quantum Dot Solar Cells*
2011-2012:	**Intern**, Steven Christopher, BS Physics (2012), RIT. Project: *Characterization of p-Type Zinc Oxide*
2011-2012:	**Intern**, Aymeric Maros, Diploma in Materials Science and Nano-Technology Engineering (2012), Institut National des Sciences Appliquées (INSA), Rennes, France. Project: *Characterizing Spectral Response Performance Of Quantum Dot Solar Cells Across Multiple Tool Platforms*
2010-2011:	**Capstone**, Wyatt Strong, BS Physics (2011), RIT. Project: *Response of Flammable Analytes investigated via Zinc Oxide Gas Sensors*. Status: MS in Materials Science Program
2010-2011:	**Capstone**, Adam Podell, BS Physics (2011), RIT. Project: *Investigation of the Effects of Varying Growth Conditions on Indium-Arsenide Quantum Dots*. Status: MS in Materials Science Program
2009-2010:	**Capstone**, Tim Bald, BS Physics (2010), RIT. Project: *Modeling Concentrator Solar Cells using Detailed Balance and Numerical Approaches*. Status: CFD Research Corporation
2009-2010:	**Senior Design**, Zachary Bittner, BS Microelectronic Engineering (2010), RIT. Project: *Cell Size Effects on Concentrator Photovoltaics*. Status: PhD in Microsystems
2008-2009:	**Capstone**, Eric Albers, BS Physics (2009), RIT. Project: *Characterization of Concentrator Photovoltaics*
2008-2009:	**Senior Design**, Stephan Polly, BS Microelectronic Engineering (2009), RIT. Project: *Front Contact Grid Design for Terrestrial III-V Concentrator Solar Cells.* Status: PhD in Microsystems
2007-2008:	**Capstone**, Elliott Miller, BS Physics (2008), RIT. Project: *Series Resistance measurements of nanostructured solar cells.* Status: PhD in University of California Riverside
2007-2008:	**Capstone**, Matt Szeto, BS Physics (2008), RIT. Project: *ZnO Nanoparticle Gas Sensors*
2010:	**Intern**, Olivier Duigou, Diploma in Materials Science, National Polytechnic Institute of Chemical Engineering and Technology, Toulouse, France. Project: *Calculation of solar cell short-circuit current density using optical spectroscopy*

2010:	**Intern**, Kieran O'Dea, BS Physics (2011), SUNY Geneo. Project: *Analysis Of Statefilling In Quantum Dots Using Pump Intensity Controlled Photoluminescence*
2008-2009:	**Co-op**, Alex Grede, BS Microelectronic Engineering, RIT. Project: *Multijunction Solar Cell Characterization by Electroluminescence Spectroscopy*
2008-2009:	**Co-op**, Michael Kassis, BS Microelectronic Engineering (2011), RIT. Project: *Optimization And Characterization Of The Fabrication Process Of Quantum Dot Enhanced Iii-V Solar Cells* Status: Intel Corp.
2009:	**Co-op**, Michael Brindak, BS Microelectronic Engineering (2010), RIT. Project: *Fabrication And Testing Of Concentrator Photovoltaics Using An Electroplated Grid Design For Terrestrial Applications* Status: Navitar Inc.
2009:	**Co-op**, Brandon Post, BS Microelectronic Engineering, RIT. Project: *Processing Single and Multijunction Photovoltaics for Space Applications*
2007:	**Intern**, Cameron Youngblood, BS Chemistry (2007), RIT. Project: *Differential Scanning Calorimetry*

COLLABORATIONS

Dr. Sheila G. Bailey, Power and On-Board Propulsion, NASA Glenn Research Center
Prof. Alex Balandin, Dept. of Electrical Engineering, Univ. of California-Riverside
Dr. Alex Fedoseyev, CFD Research Corp.
Prof. Alex Freundlich, University of Houston
Prof. Jerry Harris, Department of Chemistry, Northwest Nazarene University
Prof. Diana Huffaker, University of California Los Angeles
Prof. Lei Kerr, Chemical & Paper Engineering, Miami University of Ohio
Dr. Simon Lu, Aerospace Corporation
Prof. Antonio Luque, Director, Instituto de Energía Solar, Ciudad Universitaria, Spain
Prof. Dimitris Pavlidis, Technical University of Darmstadt, Germany
Prof. Ryne Raffaelle, Director, NanoPower Research Labs, Rochester Institute of Technology
Dr. Paul Sharps, Director of Research and Development, Emcore Photovoltaics
David Wilt, Air Force Research Labs, Kirtland Air Force Base
Dr. Robert Walters, Naval Research Laboratory

Graduate Advisors and Postdoctoral Sponsors:

Graduate Advisor: Prof. Dimitris Pavlidis
Graduate Committee: Profs. Jasprit Singh, Johannes Schwank, Amir Mortazawi
Postdoctoral Advisors: Dr. Sheila G. Bailey and David Wilt, NASA Glenn Research Center

RESEARCH SUMMARY: 52 Journal articles, 81 Conference proceedings, 3 Book chapters, 3 Paper in review, 28 Invited talks and 1 Patent filed.

Archival Journal Articles:

S. Polly, C. Baily, A. Grede, S. Hubbard, "Calculation of Strain Compensation Thickness for III-V Semiconductor Quantum Dot Superlattices", *J. Crystal Growth*, accepted for publication Aug. 2016.

S. Sato, K. Schmieder S.M. Hubbard, D. V. Forbes J. Warner, T. Ohshima, and R. J. Walters, " Defect characterization of proton irradiated GaAs pn-junction diodes with layers of InAs quantum dots," *Journal of Applied Physics*, vol. 119 (18), May 2016.

D. G. Sellers, E. Y. Chen, S. J. Polly, S. M. Hubbard, and M. F. Doty, " Effect of doping on room temperature carrier escape mechanisms in InAs/GaAs quantum dot p-i-n junction photovoltaic cells," *Journal of Applied Physics*, vol. 119 (19), p. 194301, May 2016.

N. P. Wells, T. U. Driskell, A. I. Hudson, S. D. LaLumondiere, W. T. Lotshaw, D. V. Forbes, and S. M. Hubbard, "Carrier quenching in InGaP/GaAs double heterostructures," *Journal of Applied Physics*, vol. 118, p. 065703, 2015.

D. G. Sellers, S. J. Polly, Z. Yujun, S. M. Hubbard, J. M. O. Zide, and M. F. Doty, "New Nanostructured Materials for Efficient Photon Upconversion," *Photovoltaics, IEEE Journal of*, vol. 5, pp. 224-228, 2015.

J. S. Hyslop, A. R. Boydstun, T. R. Fereday, J. R. Rusch, J. L. Strunk, C. T. Wall, C. C. Pena, N. L. McKibben, J. D. Harris, A. Thurber, A. Punnoose, J. Brotherton, P. Walker, L. Lowe, B. Rapp, S. Purnell, W. B. Knowlton, S. M. Hubbard, and B. J. Frost, "Synthesis and characterization of [Zn(acetate)2(amine)x] compounds (x=1 or 2) and their use as precursors to ZnO," *Materials Science in Semiconductor Processing*, vol. 38, pp. 278-289, 2015.

Z. S. Bittner, S. Hellstroem, S. J. Polly, R. B. Laghumavarapu, B. Liang, D. L. Huffaker, and S. M. Hubbard, "Investigation of optical transitions in InAs/GaAs(Sb)/AlAsSb quantum dots using modulation spectroscopy," *Applied Physics Letters*, vol. 105, p. 253903, 2014.

C. Kerestes, S. Polly, D. Forbes, C. Bailey, A. Podell, J. Spann, P. Patel, B. Richards, P. Sharps, and S. Hubbard, "Fabrication and analysis of multijunction solar cells with a quantum dot (In)GaAs junction," *Progress in Photovoltaics: Research and Applications*, vol. 22, pp. 1172-1179, 2014.

S. J. Polly, D. V. Forbes, K. Driscoll, S. Hellstrom, and **S. M. Hubbard**, "Delta-Doping Effects on Quantum-Dot Solar Cells," *Photovoltaics, IEEE Journal of*, vol. 4, pp. 1079-1085, 2014.

W. H. Strong, D. V. Forbes, and **S. M. Hubbard**, "Investigation of deep level defects in electron irradiated indium arsenide quantum dots embedded in a gallium arsenide matrix," *Materials Science in Semiconductor Processing*, vol. 25, pp. 76-83, 2014.

D. G. Sellers, S. Polly, **S. M. Hubbard**, and M. F. Doty, "Analyzing carrier escape mechanisms in InAs/GaAs quantum dot p-i-n junction photovoltaic cells," *Applied Physics Letters*, vol. 104, p. 223903, 2014.

K. Driscoll, M. F. Bennett, S. J. Polly, D. V. Forbes, and **S. M. Hubbard**, "Effect of quantum dot position and background doping on the performance of quantum dot enhanced GaAs solar cells," *Applied Physics Letters*, vol. 104, pp. 023119 , 2014.

C. Kerestes, C. D. Cress, B. C. Richards, D. V. Forbes, Y. Lin, Z. Bittner, S. J. Polly, P. Sharps, and **S. M. Hubbard**, "Strain Effects on Radiation Tolerance of Triple-Junction Solar Cells With InAs Quantum Dots in the GaAs Junction," *Photovoltaics, IEEE Journal of*, vol. 4, pp. 224-232, 2014.

M. F. Bennett, Z. S. Bittner, D. V. Forbes, S. Rao Tatavarti, S. Phillip Ahrenkiel, A. Wibowo, N. Pan, K. Chern, and **S. M. Hubbard**, "Epitaxial lift-off of quantum dot enhanced GaAs single junction solar cells," *Applied Physics Letters*, vol. 103, p. 213902, 2013.

Y. Huang, T. W. Kim, S. Xiong, L. J. Mawst, T. F. Kuech, P. F. Nealey, Y. Dai, Z. Wang, W. Guo, D. Forbes, **S. M. Hubbard**, and M. Nesnidal, "InAs Nanowires Grown by Metal–Organic Vapor-Phase Epitaxy (MOVPE) Employing PS/PMMA Diblock Copolymer Nanopatterning," *Nano Letters*, vol. 13, pp. 5979-5984, 2013/12/11 2013.

R. B. Laghumavarapu, B. L. Liang, Z. S. Bittner, T. S. Navruz, **S. M. Hubbard**, A. Norman, and D. L. Huffaker, "GaSb/InGaAs quantum dot–well hybrid structure active regions in solar cells," *Solar Energy Materials and Solar Cells*, vol. 114, pp. 165-171, 2013.

D. V. Forbes, A. M. Podell, M. A. Slocum, S. J. Polly, and **S. M. Hubbard**, "OMVPE of InAs quantum dots on an InGaP surface," *Materials Science in Semiconductor Processing*, vol. 16, pp. 1148-1153, 2013.

S. M. Hubbard, A. Podell, C. Mackos, S. Polly, C. G. Bailey, and D. V. Forbes, "Effect of vicinal substrates on the growth and device performance of quantum dot solar cells," *Solar Energy Materials and Solar Cells*, vol. 108, pp. 256-262, 2013.

M. A. Slocum, D. V. Forbes, and **S. M. Hubbard**, "Subbandgap current collection through the implementation of a doping superlattice solar cell," *Applied Physics Letters*, vol. 101, pp. 073901-4, 2012.

C. G. Bailey, D. V. Forbes, S. J. Polly, Z. S. Bittner, Y. Dai, C. Mackos, R. P. Raffaelle, and **S. M. Hubbard**, "Open-Circuit Voltage Improvement of InAs/GaAs Quantum-Dot Solar Cells Using Reduced InAs Coverage," *Photovoltaics, IEEE Journal of*, vol. 2, pp. 1-7, 2012.

J. E. Rossi, C. D. Cress, A. R. Helenic, C. M. Schauerman, R. A. DiLeo, N. D. Cox, S. R. Messenger, B. D. Weaver, **S. M. Hubbard**, and B. J. Landi, "Ion irradiation of electronic-type-separated single wall carbon nanotubes: A model for radiation effects in nanostructured carbon," *Journal of Applied Physics*, vol. 112, pp. 034314-11, 2012.

C. D. Cress, J. J. McMorrow, J. T. Robinson, B. J. Landi, **S. M. Hubbard**, and S. R. Messenger, "Radiation Effects in Carbon Nanoelectronics," *Electronics*, vol. 1, pp. 23-31, 2012.

C. G. Bailey, D. V. Forbes, R. P. Raffaelle, and **S. M. Hubbard**, "Near 1V open circuit voltage InAs/GaAs quantum dot solar cells," *Appl. Phys. Lett.* **98** (163105) 2011.

C. D. Cress, S. J. Polly, **S. M. Hubbard**, R. P. Raffaelle, and R. J. Walters, "Demonstration of a nipi-diode photovoltaic," *Progress in Photovoltaics: Research and Applications*, 2011.

D. Forbes, **S. Hubbard**, R. Raffaelle, and J. S. McNatt, "Au-catalyst-free epitaxy of InAs nanowires," Journal of Crystal Growth, vol. 312, pp. 1391-1395, 2010.

C. Bailey, **S. M. Hubbard**, D. Forbes, and R. Raffaelle, "Evaluation of strain balancing layer thickness for InAs / GaAs QD arrays using HRXRD and Photoluminescence," *Applied Physics Letters* 95, 203110 (2009).

S. M. Hubbard, C. Bailey, S. Polly, C. Cress, J. Andersen, D. Forbes, and R. Raffaelle, "Nanostructured photovoltaics for space power," *Journal of Nanophotonics* 3, 031880-031816 (2009).

S. M. Hubbard, C. D. Cress, C. G. Bailey, R. P. Raffaelle, "Effect of strain compensation on quantum dot enhanced GaAs solar cells", *Appl. Phys. Lett.* 92, 123512 (2008).

R. Raffaelle, C. Bailey, **S. Hubbard**, S. Polly, D. Forbes, "Quantum Dot Spectral Tuning of Multijunction III-V Solar Cells", *Mater. Res. Soc. Symp. Proc.* 1121E, (2008).

C. Cress, **S.M. Hubbard**, B. Landi, D. Wilt, R. Raffaelle, "Quantum dot solar cell tolerance to alpha-particle irradiation", *Appl. Phys. Lett.* 91, 183108 (2007).

A. Saluja, J. Pan, L. Kerr, E. Cho, and **S. Hubbard**, "Gas Sensing Properties of Porous ZnO Nano-Platelet Films", *Mater. Res. Soc. Symp. Proc.* 1035, L11-07 (2007).

C. Bailey, C. Cress, R. Raffaelle, **S.M. Hubbard**, D. Wilt, W. Maurer, S. Bailey, "Analysis of Strain Compensation in Quantum Dot Embedded GaAs Solar Cells", *Mater. Res. Soc. Symp. Proc.* 1031E, H13-18 (2007).

C. D. Cress, **S. M. Hubbard**, C. Bailey, R. Robinson, B. Landi, R. Raffaelle, "Thermal Dependence of Quantum Dot Solar Cells", *Mater. Res. Soc. Symp. Proc.* 1031H13-19 (2007).

S.M. Hubbard, R. Raffaelle, R. Robinson, C. Bailey, D. Wilt, D. Wolford, W. Maurer, S. Bailey, "Growth and Characterization of InAs Quantum Dot Enhanced Photovoltaic Devices", *Mater. Res. Soc. Symp. Proc.* 1017E, DD13-11 (2007).

E. Cho, D. Pavlidis, G. Zhao, **S.M. Hubbard**, J. Schwank, "Improvement of CO sensitivity in GaN-based gas sensors", *IEICE Transactions on Electronics* E89-C, 1047 (2006).

S.M. Hubbard, G. Zhao, D. Pavlidis, W. Sutton, E. Cho, "High Resistivity GaN Buffer Templates and their Optimization for GaN-Based HFETs", *J. Crystal Growth* 284, 297-305 (2005).

S.M. Hubbard, D. Pavlidis, V. Valiaev, A. Eisenbach, "Metal-Organic Vapor Phase Epitaxy Growth and Characterization of AlN/GaN Heterostructures", *J. Elect. Mat.* 31, 395-401 (2002).

S.M. Hubbard, D. Pavlidis, V. Valiaev, M.A. Stevens-Kalceff, I.M. Tiginyanu, "Electrical characterization and cathodoluminescence microanalysis of AlN/GaN heterostructures", *Mat. Sci. Eng.* B, B91-92, 336-340 (2002).

S.M. Hubbard, M. Tabib-Azar, C.M. Schnabel, S. Bailey, "Mapping of crystal defects and the minority carrier diffusion length in 6H-SiC using a novel electron beam induced current technique", *J. Appl. Phys.* 84, 3986-92 (1998).

G. Zhao and **S.M. Hubbard**, D. Pavlidis, "Yellow Luminescence Centers of GaN", *Jap. J. Appl. Phys.* 43, 2471-2472 (2004).

D. Cui and **S.M. Hubbard**, D. Pavlidis, A. Eisenbach, C. Chelli, "Impact of doping and MOCVD conditions on minority carrier lifetime of zinc- and carbon-doped InGaAs and its applications to zinc- and carbon-doped InP/InGaAs heterostructure bipolar transistors", *Semicond. Sci. Technol.* 17, 503–509 (2002).

S. Mohammadi and **S.M. Hubbard**, C. Chelli, D. Pavlidis, B. Bayraktaroglu, "Photoluminescence and transmission electron microscope studies of low- and high-reliability AlGaAs/GaAs HBTs", *Solid-State-Electronics* 44, 739-46 (2000).

G. Zhao, W. Sutton, D. Pavlidis, E. Piner, J. Schwank, **S. Hubbard**, "A Novel Pt-AlGaN/GaN Heterostructure Schottky Diode Gas Sensor on Si", *IEICE Transactions on Electronics* v E86-C, 2027 (2003).

V. V. Ursaki, I. M. Tiginyanu, V. V. Zalamai, **S. M. Hubbard**, D. Pavlidis, "Optical characterization of AlN/GaN heterostructures", *J. Appl. Phys.* 94, 4813 (2003).

V.V. Ursaki, I.M. Tiginyanu, N.N. Syrbu, V.V. Zalamai, **S. Hubbard**, D. Pavlidis, "Sharp variations in the temperature dependence of optical reflectivity from AlN/GaN heterostructures", S*emicond. Sci. Technol.* 18, L9–L11 (2003).

O. Yilmazoglu, D. Pavlidis, Y.M. Litvin, **S. Hubbard**, I.M. Tiginyanu, K. Mutamba, H.L. Hartnagel, V.G. Litovchenko, A. Evtukh, "Field emission from quantum size GaN structures", *Appl. Surf. Sci.* 220, 46-50 (2003).

I. M. Tiginyanu, V. V. Ursaki, V. V. Zalamai, S. Langa, **S.M. Hubbard**, D. Pavlidis, H. Foll, "Luminescence of GaN nanocolumns obtained by photon-assisted anodic etching", *Appl. Phys. Let.* 83, 1551-1553 (2003).

V. V. Ursaki, I. M. Tiginyanu, P. C. Ricci, A. Anedda, **S.M. Hubbard**, D. Pavlidis, "Persistent photoconductivity and optical quenching of photocurrent in GaN layers under dual excitation", *J. Appl. Phys.* 94, 3875-3882 (2003).

A. Matulionis, J. Liberis, L. Ardaravicius, M. Ramonas, T. Zubkuteÿ, I. Matulionieneÿ, L. F. Eastman, J. R. Shealy, J. Smart, D. Pavlidis, **S.M. Hubbard**, "Fast and Ultrafast Processes in AlGaN/GaN Channels", *phys. stat. sol.* (b) 234, 826–829 (2002).

B. Ferguson, S. Mickan, **S. Hubbard**, D. Pavlidis, D. Abbott, "Investigation of gallium nitride T-ray transmission characteristics", *Proceedings of SPIE* 4591, 210 (2001).

I. M. Tiginyanu, A. Sarua, G. Irmer, J. Monecke, **S. M. Hubbard**, D. Pavlidis, V. Valiaev "Frohlich modes in GaN columnar nanostructures", *Phys. Rev. B* 64, 233317 (2001).

R. Raffaelle, J. Mantovani, R. Friedfeld, S. Bailey, **S. Hubbard**, "Electrodeposited CuInSe2 thin film devices", *Conference Record of the IEEE Photovoltaic Specialists Conference*, p 559-562 (1997).

Papers in Preparation or Under Review:

B. S. Smith, Z. S. Bittner, S. D. Hellstrom, N. M. Hoven, M. A. Slocum, D. V. Forbes, S. M. Hubbard, "InAlAs photovoltaic cell design for high device efficiency", under review for *Progress in Photovoltaic*s

Y. Dai, S. Polly, M. Slocum, Z. Bittner, D. Forbes, S. Hellstroem, P. Roland, R. Ellingson, S. Hubbard, "Effect of electric field on InAs quantum dot enhanced GaAs Solar cells", under review for *Journal of Applied Physics*

M. Slocum, Z. Bittner, R. Tatavarti, S. Hubbard, "Quantum Dot Enhanced Inverted Metamorphic Solar Cells", Invited paper for *SPIE Journal of Photonics for Energy,* Special Edition on Tandem Junction Solar Cells, in preparation for Nov. 15 deadline.

Book Chapters:

S.M. Hubbard, "Basic functional principles of photovoltaics", in *PV from Fundamentals to Applications*, A. Reinders, Ed. Wiley, in-press, 2016.

S. M. Hubbard, "Quantum Dot Solar Cells," in *Nanotechnology for photovoltaics*, L. Tsakalakos, Ed. Boca Raton, FL: CRC Press, Taylor & Francis, 2010.

S. Bailey, **S. Hubbard**, R. Raffaelle, "Self Assemble Quantum Dots for Photovoltaics", in *Handbook of Self Assembled Semiconductor Nanostructures for Novel Devices in Photonics and Electronics*, M. Henini , Ed. Oxford:Elsevier, 2008.

Patents:

Invention disclosure filed with RIT legal affairs office on 11/24/2009. Invention title "Weighted Strain Balancing Procedure for Epitaxial Quantum Dot Growth".

Conference Proceedings:

E. L. McClure, M. A. Slocum, R. K. Hailstone, P. T. Furrey, Z. S. Bittner, C. G. Bailey, S. Maximenko and S. M. Hubbard, "In-Situ Stress Analysis for Aluminum-Induced Crystallization of Germanium as a Function of Anneal Ramp Time," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

B. L. Smith, M. A. Slocum, G. T. Nelson, S. Hellstroem, Y. Dai, Z. S. Bittner and S. M. Hubbard, "Enhanced Absorption in Epitaxial Lift Off (ELO) Quantum Dot Solar Cells by Back Surface Texturing," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

M. A. Slocum, G. T. Nelson, S. Hellstroem, B. L. Smith, A. Wibowo, R. Tatavarti and S. M. Hubbard, "Growth of InAs Quantum Dots in a Metamorphic InGaAs Bottom Cell of an Inverse Metamorphic Solar Cell," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

G. T. Nelson, B. C. Juang, Z. S. Bittner, M. A. Slocum, R. B. Lagumavarapu, D. Huffaker and S. M. Hubbard, "GaSb On GaAs Interfacial Misfit Solar Cells," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

Y. Dai, M. A. Slocum, Z. S. Bittner, S. Hellstroem, D. V. Forbes, and S. M. Hubbard, "Optimization of Wide-Bandgap Quantum Dot Solar Cell," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

Z. S. Bittner, M. A. Slocum, G. T. Nelson, T. Tatavarti and S. M. Hubbard, "Novel InAs/GaAs QD Subcell Design for Radiation Hard 3-J ELO IMM Solar Cell," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 43nd*, Portland, 2016.

C. G. Bailey, D. V. Forbes, M. P. Lumb, R. Hoheisel, M. Gonzalez, S. M. Hubbard, L. C. Hirst, K. Schmeider, M. K. Yakes, P. P. Jenkins, and R. J. Walters, "Investigation of InAlGaAs / InGaAs Quantum Well Solar Cells," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, New Orleans, 2015.

Y. Dai, S. Polly, S. Hellstroem, D. V. Forbes, and S. M. Hubbard, "Carrier Collection in Quantum Dots Solar Cells with Barrier Modification," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

S. Hubbard, S. Hellstroem, Z. Bittner, R. Laghumavarapu, and D. Huffaker, "Intermediate Band Solar Cell Design using InAs quantum dots in AlAsSb Cladding," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

E. L. McClure, Z. S. Bittner, M. A. Slocum, D. V. Forbes, and S. M. Hubbard, "Modeling of Effects of Using Polycrystalline Substrates for Low Cost III-V Photovoltaics," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

S. J. Polly, M. A. Slocum, S. Hellstroem, D. V. Forbes, and S. M. Hubbard, "Investigation of State-Filling and Carrier Collection of Doped InAs QDs through Direct Absorption Measurement," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, New Orleans, 2015.

S.-i. Sato, K. J. Schmieder, S. M. Hubbard, D. V. Forbes, J. H. Warner, T. Ohshima, and R. J. Walters, " Defects in GaAs Solar Cells with InAs Quantum Dots Created by Proton Irradiation," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

K. J. Schmieder, M. P. Lumb, M. K. Yakes, M. Gonzalez, P. D. Cunningham, A. Khachatrian, M. F. Bennett, L. C. Hirst, N. A. Kotulak, Z. Pulwin, C. G. Bailey, S. M. Hubbard, J. S. Melinger, C. W. Ebert, and R. J. Walters, "Analysis of GaAs Photovoltaic Device Losses at High MOCVD Growth Rates," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

B. L. Smith, Z. S. Bittner, S. D. Hellstroem, M. A. Slocum, D. V. Forbes, and S. M. Hubbard, "InAlAs Solar Cells Grown by Alternative MOVPE Precursors," in *Photovoltaic Specialist Conference (PVSC), 2015 IEEE 42nd*, 2015.

M. A. Slocum, D. V. Forbes, and S. M. Hubbard, "Modeling nipi solar cells under concentration accounting for state filling effects," in *Proc. SPIE 9358, Physics, Simulation, and Photonic Engineering of Photovoltaic Devices IV*, 2015, pp. 93580K-1 to 93580K-6.

C. G. Bailey, R. Hoheisel, M. Gonzalez, D. V. Forbes, M. P. Lumb, **S. M. Hubbard**, D. A. Scheiman, L. C. Hirst, K. J. Schmieder, S. R. Messenger, B. D. Weaver, C. D. Cress, J. Warner, M. K. Yakes, P. P. Jenkins, and R. J. Walters, "Radiation Effects on InAlGaAs / InGaAs Quantum Well Solar Cells " in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 2871-2874.

Z. S. Bittner, R. B. Laghumavarapu, S. Hellstroem, D. Huffaker, B. Liang, and **S. M. Hubbard**, "Experimental Examination of an InAs/GaAs(Sb)/AlAsSb Quantum Dot Approach to the Intermediate Band Solar Cell " in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 3488-3491.

Brittany L. Smith, Staffan D. Hellstroem, George T. Nelson, Zachary S. Bittner, Michael A. Slocum, David V. Forbes, and **S. M. Hubbard**, "Characterization of InAlAs Solar Cells Grown by OMVPE," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 3488-3491.

P. S. Ericksen, A. Howard, D. M. Wilt, **S. Hubbard**, and B. Richards, "Thermal Survivability Characterization of Quantum Dot Multi-Junction Photovoltaic Cells," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 3488-3491.

D. V. Forbes, Y. Dai, S. J. Polly, C. G. Bailey, S. D. Hellstroem, and **S.M. Hubbard**, "The Effect of Barrier Composition on Quantum Dot Solar Cell Performance," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 3488-3491.

S. Hellstroem and **S. M. Hubbard**, "Drift-diffusion simulations of InAs/AlAsSb quantum dot intermediate-band solar cells," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 0491-0494.

S. M. Hubbard, S.-i. Sato, K. Schmieder, W. Strong, C. Bailey, D. V. Forbes, R. Hoheisel, and R. Walters, "Impact of Nanostructures and Radiation Environment on Defect Levels in III-V Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 0491-0494.

M. P. Lumb, M. Meitl, J. Wilson, S. Bonafede, S. Burroughs, D. V. Forbes, C. G. Bailey, N. M. Hoven, M. Gonzalez, R. Hoheisel, M. K. Yakes, S. J. Polly, **S. M. Hubbard**, and R. J. Walters, "Development of InGaAs Solar Cells for >44% Efficient Transfer-Printed Multi-junctions," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 0491-0494.

G. T. Nelson, Z. S. Bittner, Brittany Smith, D. F. Forbes, and **S. M. Hubbard**, "Study of deep levels in InAlAsSb grown via MOCVD," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 1168-1173.

S. J. Polly, S. Hellström, D. V. Forbes, and **S. M. Hubbard**, "Effects of Doping on Carrier Confinement in InAs QD Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 1089-1091.

K. J. Schmieder, M. K. Yakes, C. G. Bailey, Z. Pulwin, M. P. Lumb, L. C. Hirst, M. Gonzalez, **S. M. Hubbard**, C. Ebert, and R. J. Walters, "Analysis of GaAs Solar Cells at High MOCVD Growth Rates," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 2130-2133.

M. A. Slocum, D. V. Forbes, A. J. Grede, N. M. Hoven, and **S. M. Hubbard**, "Improving Epitaxial Regrowth Interfaces as a Means of Improving Doping Superlattice Solar Cell Performance," in *Photovoltaic Specialists Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 0102-0106.

Y. Dai, S. Polly, S. Hellstroem, D. V. Forbes, and S. M. Hubbard, "Electric field effect on carrier escape from InAs/GaAs quantum dots solar cells," in *Photovoltaic Specialist Conference (PVSC), 2014 IEEE 40th*, 2014, pp. 3492-3497.

Y. Dai, S. Polly, S. Hellström, K. Driscoll, D. V. Forbes, P. J. Roland, R. J. Ellingson, **S. M. Hubbard** "Effects of electric field on thermal and tunneling carrier escape in InAs/GaAs quantum dot solar cells," in *Proc. SPIE 8981, Physics, Simulation, and Photonic Engineering of Photovoltaic Devices III*, 2014, pp. 898106-6.

M. A. Slocum, D. V. Forbes, and **S. M. Hubbard**, "Enhancement of radiation tolerance with the use of a doping superlattice solar cell," in *Proc. SPIE 8981, Physics, Simulation, and Photonic Engineering of Photovoltaic Devices III*, 2014, pp. 89810V-7.

J. G. J. Adams, V. C. Elarde, G. Hillier, C. Stender, F. Tuminello, A. Wibowo, C. Youtsey, Z. Bittner, **S. M. Hubbard**, E. B. Clark, M. F. Piszczor, and M. Osowski, "Improved radiation resistance of epitaxial lift-off inverted metamorphic solar cells," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 3229-3232.

M. F. Bennett, Z. S. Bittner, D. V. Forbes, R. Tatavarti, A. Wibowo, N. Pan, K. Chern, and **S. M. Hubbard**, "Alpha radiation effects on n-i-p quantum dot epitaxial lift-off solar cells," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 2784-2789.

Z. S. Bittner, S. Spencer, A. Terrinoni, and **S. M. Hubbard**, "A study on hybrid organic/silicon heterojunction solar cells," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 0997-1002.

Y. Dai, S. Hellstroem, S. Polly, J. Hatakeyama, D. Forbes, and **S. Hubbard**, "Optical study of carrier transport in InAs/GaAs quantum dots solar cell," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 0271-0276.

D. V. Forbes, C. Bailey, S. J. Polly, A. Podell, and **S. M. Hubbard**, "The effect of GaAs capping layer thickness on quantum dot solar cell performance," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 3203-3207.

R. B. Laghumavarapu, B. L. Liang, Z. Bittner, T. S. Navruz, **S. M. Hubbard**, A. Norman, and D. L. Huffaker, "GaSb/InGaAs quantum dot-well solar cells," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 0292-0295.

B. C. Richards, L. Yong, P. Patel, D. Chumney, P. R. Sharps, C. Kerestes, D. Forbes, K. Driscoll, A. Podell, and **S. Hubbard**, "Performance and radiation resistance of quantum dot multi-junction solar cells," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 0158-0161.

M. A. Slocum, D. V. Forbes, M. H. Bohra, and **S. M. Hubbard**, "An evaluation of fabrication methods for doping superlattice devices," in *Photovoltaic Specialists Conference (PVSC), 2013 IEEE 39th*, 2013, pp. 1727-1732.

K. Driscoll, M. Bennett, S. Polly, D. V. Forbes, and **S. M. Hubbard**, "Investigation of the design parameters of quantum dot enhanced III-V solar cells," in *Proc. SPIE vol. 8620: Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II*, A. Freundlich and J. F. Guillemoles, Eds., ed, 2013, p. 86200L.

C. Kerestes, D. V. Forbes, C. D. Cress, B. C. Richards, W. T. Lotshaw, S. D. LaLumondiere, E. Fernandez, Y. Lin, P. Sharps, and **S. M. Hubbard**, "Investigation of carrier collection from QD TJSCs," in *Proc. SPIE vol. 8620: Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II*, A. Freundlich and J. F. Guillemoles, Eds., ed, 2013, p. 86200W.

M. A. Slocum, D. V. Forbes, M. H. Bohra, and **S. M. Hubbard**, "Characterization of radiation tolerance in doping superlattice solar cells," in *Proc. SPIE vol. 8620: Physics, Simulation, and Photonic Engineering of Photovoltaic Devices II*, A. Freundlich and J. F. Guillemoles, Eds., ed, 2013, p. 86200Y.

B. C. Richards, L. Yong, P. Pate, D. Chumney, P. R. Sharps, C. Kerestes, D. Forbes, K. Driscoll, A. Podell, and **S. Hubbard**, "Bandgap optimization of lattice matched triple junction solar cells by incorporation of InAs quantum dots," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 002797-002800.

Fedoseyev, T. Bald, M. Turowski, A. Raman, C. Cress, R. Walters, J. Warner, and **S. Hubbard**, "Radiation effect models in solar cells - Comparison of simulations with experimental data," *in Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 002801-002806.

M. A. Slocum, D. V. Forbes, and **S. M. Hubbard**, "Invited: Characterization of a Quantum Dot nipi Photovoltaic Device," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

S. J. Polly, Z. S. Bittner, C. G. Bailey, Y. Dai, D. V. Forbes, and **S. M. Hubbard**, "Low Temperature Analysis of Quantum Dot Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

C. Kerestes, D. V. Forbes, Z. Bittner, S. Polly, Y. Lin, B. Richards, P. Sharps, and **S. Hubbard**, "Strain Effects on Radiation Tolerance of Quantum Dot Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

S. M. Hubbard, A. Podell, M. Bennett, M. Slocum, and D. Forbes, "Optimization of Growth and Device Performance for InAs Quantum Dot Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

D. Forbes, C. G. Bailey, S. Polly, Z. Bittner, C. Kerestes, M. Slocum, and **S. M. Hubbard**, "Correlation Between Quantum Dot Morphology and Photovoltaic Performance," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

K. Driscoll and **S. Hubbard**, "Modeling the optical and electrical response of nanostructured III-V solar cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

Y. Dai, C. G. Bailey, C. Kerestes, D. V. Forbes, and **S. M. Hubbard**, "Investigation of Carrier Escape Mechanism in InAs/GaAs Quantum Dot Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

Z. Bittner, D. V. Forbes, C. G. Bailey, M. A. Slocum, C. Kerestes, and **S. M. Hubbard**, "Characterization of InGaP Heterojunction Emitter Quantum Dot Solar Cells," in *Photovoltaic Specialists Conference (PVSC), 2012 38th IEEE*, 2012, pp. 1-6.

M. A. Slocum, D. V. Forbes, and **S. M. Hubbard**, "Interface quality enhancement of the epitaxial regrowth process for *nipi* photovoltaic devices," in *Physics and Simulation of Optoelectronic Devices XX*, San Francisco, California, USA, 2012, pp. 82561B-8.

S. J. Polly, C. G. Bailey, Z. S. Bittner, Y. Dai, E. G. Fernandez, and **S. M. Hubbard**, "Spectroscopic analysis of InAs quantum dot solar cells," in *Physics and Simulation of Optoelectronic Devices XX*, San Francisco, California, USA, 2012, pp. 825615-6.

C. Kerestes, D. Forbes, C. G. Bailey, J. Spann, B. Richards, P. Sharps, and **S. Hubbard**, "Radiation effects on quantum dot enhanced solar cells," in *Physics and Simulation of Optoelectronic Devices XX*, San Francisco, California, USA, 2012, pp. 82561I-10.

S. J. Polly, Z. Bittner, M. Bennett, R. Raffaelle, and **S. Hubbard**, "Development of a Multi-Source Solar Simulator for Spatial Uniformity and Close Spectral Matching to AM0 and AM1.5," in Photovoltaic Specialists Conference (PVSC), 2011 37th IEEE, 2011, pp. 1-6.

C. Mackos, D. Forbes, C. G. Bailey, S. J. Polly, and **S. Hubbard**, "GaAs Substrate Misorientation and the Effect on InAs Quantum Dot Critical Thickness," in Photovoltaic Specialists Conference (PVSC), 2011 37th IEEE, 2011, pp. 1-6.

C. Kerestes, D. Forbes, P. Sharps, P. Patel, and J. Spann, **S. Hubbard,** " Investigation of Quantum Dot Enhanced Triple Junction Solar Cells," in Photovoltaic Specialists Conference (PVSC), 2011 37th IEEE, 2011, pp. 1-6.

Z. Bittner, D. Forbes, M. Nesnidal, and **S. Hubbard**, "GaP Solar Cells with InGaP Quantum Wells for High Temperature Applications " in Photovoltaic Specialists Conference (PVSC), 2011 37th IEEE, 2011, pp. 1-6.

M. A. Slocum, D. V. Forbes, C. D. Cress, S. Polly, and **S. M. Hubbard**, "Simulation of nipi photovoltaic devices," in *Physics and Simulation of Optoelectronic Devices XIX*, San Francisco, California, USA, 2011, pp. 793305-10.

C. G. Bailey, D. V. Forbes, R. P. Raffaelle, and **S. M. Hubbard**, "Investigation of spectral responsivity of InAs QD-embedded GaAs solar cells," in *Physics and Simulation of Optoelectronic Devices XIX*, San Francisco, California, USA, 2011, pp. 793313-7.

S. J. Polly, M. L. Harris, Z. Bittner, C. R. Plourde, C. G. Bailey, D. V. Forbes, and **S. M. Hubbard**, "Effect of cell size on GaAs concentrators with InAs quantum dots," in *Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE*, 2010, pp. 002057-002061.

S. M. Hubbard, C. Plourde, Z. Bittner, C. G. Bailey, M. Harris, T. Bald, M. Bennett, D. V. Forbes, and R. Raffaelle, "InAs quantum dot enhancement of GaAs solar cells," in *Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE*, 2010, pp. 001217-001222.

D. V. Forbes, **S. M. Hubbard**, C. Bailey, S. Polly, J. Andersen, and R. Raffaelle, "III-V quantum dot enhanced photovoltaic devices," in *Next Generation (Nano) Photonic and Cell Technologies for Solar Energy Conversion*, San Diego, California, USA, 2010, pp. 77720C-10.

D. V. Forbes, C. G. Bailey, S. Polly, C. Plourde, J. Okvath, **S. M. Hubbard**, and R. P. Raffaelle, "Substrate orientation effects on quantum dot enhanced GaAs solar cells," in *Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE, 2010*, pp. 001804-001807.

I. Fedoseyev, M. Turowski, A. Raman, E. W. Taylor, **S. Hubbard**, S. Polly, and A. A. Balandin, "Investigation and modeling of space radiation effects in quantum dot solar cells," in *Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE*, 2010, pp. 002533-002536.

G. Bailey, S. J. Polly, J. Okvath, D. V. Forbes, C. D. Cress, **S. M. Hubbard**, and R. P. Raffaelle, "Temperature dependent photoluminescence spectroscopy of InAs/GaAs solar cells," in *Photovoltaic Specialists Conference (PVSC), 2010 35th IEEE*, 2010, pp. 000364-000369.

I. Fedoseyev, M. Turowski, A. Raman, E. W. Taylor, **S. Hubbard**, S. Polly, Q. Shao, and A. A. Balandin, "Space radiation effects modeling and analysis of quantum dot based photovoltaic cells," in *Nanophotonics and Macrophotonics for Space Environments III*, San Diego, CA, USA, 2009, pp. 746705-10.

Jamie R. Gardner, Eric K. Albers, Chris G. Bailey, **Seth M. Hubbard**, Ryne P. Raffaelle, "Thermal and spectroscopic characterization of quantum dot-enhanced solar cells", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol. 1, pp. 1-6 (2009).

Michael L Harris, **Seth M Hubbard**, Michael S Kassis, Stephen J Polly, Christopher G Bailey, Paul R Jarosz, "Electroplating as Economical Means to Lower Series Resistance in GaAs Concentrator Solar Cells", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol. 1, pp. 1-6 (2009).

David V Forbes, Chris G Bailey, Stephen Polly, **Seth M Hubbard**, Ryne P Raffaelle, William F Maurer, "The Effect of Te as a Surfactant on OMVPE of InAs Quantum Dots", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol. 1, pp. 1-6 (2009).

Cory D. Cress, **Seth M. Hubbard**, Christopher G. Bailey, Ryne P. Raffaelle, Scott R. Messenger, Robert J. Walters, David V. Forbes, "Analysis of Strain Compensated GaAs-based InAs QD Solar Cells", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol. 1, pp. 1-6 (2009).

Christopher G. Bailey, Ryan Aguinaldo, Cory D. Cress, Stephen J. Polly, David V. Forbes, **Seth M. Hubbard**, Ryne P. Raffaelle, "Effect of barrier thickness on InAs QD / GaAs solar cells", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol. 1, pp. 1-6 (2009).

Seth M. Hubbard, Christopher Bailey, Stephen Polly, Ryan Aguinaldo, David Forbes, Ryne Raffaelle, "Characterization of Quantum Dot Enhanced Solar Cells for Concentrator PV", Proc. of 34th IEEE Photovoltaic Specialists Conference, vol.1, pp. 1-6 (2009).

S. Bailey, J. McNatt, R. Raffaelle, **S. Hubbard**, D. Forbes, L. Fritzenmeier, and W. Maurer, "The future of space photovoltaics," in *Photovoltaic Specialists Conference (PVSC), 2009 34th IEEE*, 2009, pp. 001909-001913.

S. M. Hubbard, C. Bailey, C. D. Cress, S. Polly, J. Clark, D. V. Forbes, R. P. Raffaelle, S. G. Bailey, D. M. Wilt, "Short circuit current enhancement of GaAs solar cells using strain compensated InAs quantum dots", *Proc. of 33rd IEEE Photovoltaic Specialists Conf.* 1, pp. 1-6 (2008).

D. Cress, C. G. Bailey, **S. M. Hubbard**, D. M. Wilt, S. G. Bailey, and R. P. Raffaelle, "Radiation effects on strain compensated quantum dot solar cells," in *Photovoltaic Specialists Conference, 2008. PVSC '08. 33rd IEEE*, 2008, pp. 1-6.

S. G. Bailey, D. M. Wilt, J. S. McNatt, L. Fritzenmeier, **S. M. Hubbard**, C. G. Bailey, and R. P. Raffaelle, "Thin film poly III-V space solar cells," in *Photovoltaic Specialists Conference, 2008. PVSC '08. 33rd IEEE*, 2008, pp. 1-5.

S.M. Hubbard, D. Wilt, S. Bailey, D. Byrnes, R. Raffaelle, "OMVPE Grown InAs Quantum Dots for Application in Nanostructured Photovoltaics", Proc. of the IEEE World Conference on Photovoltaic Energy Conversion, 2006, pp. 118-121.

S.M. Hubbard, G. Zhao, D. Pavlidis, W. Sutton, E. Cho, "Optimization of GaN Channel Conductivity in AlGaN/GaN HFET Structures Grown by OMVPE", Mater. Res. Soc. Symp. Proc. 831, E11.11.1 (2004).

C. Chelli, D. Cui, **S.M. Hubbard**, A. Eisenbach, D. Pavlidis, S.K. Krawczyk, B. Sermage, "Minority carrier lifetime in MOCVD-grown C- and Zn-doped InGaAs" Conference Proceedings. Eleventh International Conference on Indium Phosphide and Related Materials (IPRM'99), 1999, p 127-30.

S.M. Hubbard, M. Tabib-Azar, S. Bailey, G. Rybicki, P. Neudeck, R. Raffaelle, "Effect of crystal defects on minority carrier diffusion lengths in 6H SiC", Conference Record of the IEEE Photovoltaic Specialists Conference (PVSC), 1997, p 975-978.

Invited Talks:

"Performance Enhancement in QD Solar Cells using Epitaxial Lift Off and Periodic Texturing", 2016 Space Power Workshop, Manhattan Beach Marriott, CA, April 2016.

"Novel Materials and Nanostructures for Photovoltaic Energy Conversion", Saint John Fisher, Rochester, NY, March 2015.

"Novel Materials and Nanostructures for Photovoltaic Energy Conversion", SUNY Geneseo, Geneseo, NY, Feb. 2015.

"Novel Materials and Nanostructures for Photovoltaic Energy Conversion", Tufts University, Boston, MA, Dec. 2014.

"Study of InAs Quantum Dots in a AlAsSb Matrix for Intermediate Band Solar Cell Application", 6th World Conference on Photovoltaic Energy Conversion, Kobe, Japan, November 2014.

"Novel Materials and Nanostructures for Photovoltaic Energy Conversion", South Dakota School of Mines and Technology, Rapid City, SD, April 2014.

"Novel Materials and Nanostructures for Photovoltaic Energy Conversion", University of Oklahoma, Norman, OK, March 2014.

"Single and Multi-junction Quantum Dot Solar Cells", University of Massachusetts Lowell, Feb. 2014.

"Single and Multi-junction Quantum Dot Solar Cells", University of Delaware, Jan. 2014.

"Absorption Enhancement and Dark Current Reduction in Quantum Dot Solar Cells", JSAP-MRS Joint Symposia, Kobe, Japan, September 17, 2013.

"Single and Multi-junction Quantum Dot Solar Cells", 4th International Workshop on Quantum Nanostructure Solar Cells, Dec. 4-5, 2012, Kobe, Japan.

"Absorption Enhancement and Dark Current Reduction in Quantum Dot Solar Cells", MRS Fall Meeting, Boston, MA, December 1, 2012.

"Optimization of Growth and Device Performance for InAs Quantum Dot Solar Cells", 39th International Symposium on Compound Semiconductors, August 27-30, 2012, Santa Barbara, CA

"Analysis of Multi Junction Solar Cells with a Quantum Dot Enhanced Middle Junction", Space Power Workshop, Los Angeles, CA 4/17/2012.

"Voltage Improvement in InAs Quantum Dot Solar Cells", SPIE Photonics West, San Francisco, CA, 1/23/2012

"GaAs Substrate Misorientation and the Effect on InAs Quantum Dot Solar Cells" SPRAT Cleveland, OH 9/21/2011

"Next Generation Solar Cells", Rochester Optical Society, Rochester, NY, 11/22/2012.

"Quantum dot photovoltaics for space power application", Space Power Workshop, Los Angelses, April 19-21, 2011.

"InAs Quantum Dot Solar Cells", NREL Quantum Dot Workshop, Golden, CO, February 7, 2011.

"Epitaxial grown quantum dots for photovoltaic application", XIX International Materials Research Congress, Cancun, Mexico, August 16-19, 2010.

"Characterization of Quantum Dot Enhanced Solar Cells under Solar Concentration", SPRAT XXI, Cleveland, OH, October 6 2009.

"Future of Nanostructured Photovoltaics", Electronic Materials Conference, Penn State, PA, 2009.

"Application of Quantum Dot Photovoltaics", Miami University of Ohio, Feb. 14 2009.

"Short circuit current enhancement of GaAs solar cells using strain compensated InAs quantum dots", 33rd Photovoltaic Specialist Conference, San Diego, May 2008.

"Third Generation Photovoltaics", RIT Microelectronics Engineering Seminar Series, September 2008.

"Third Generation Photovoltaics", University of Rochester Materials Research Society, April 2008.

"Nanomaterials for Space Power", Society for the Advancement of Material and Process Engineering, Cincinnati, OH, October 2007.

"Workshop on Nanostructured Photovoltaics", Space Photovoltaics Research and Technology (SPRAT), Cleveland, OH, September 2007.

Published Abstracts:

Seth M. Hubbard, Michael A. Slocum, Brittany L. Smith, Zachary Bittner, George Nelson, David V. Forbes, "Growth of InAlAs and InAlAsSb by MOVPE for photovoltaic applications", *18th International Conference on Metal Organic Vapor Phase Epitaxy*, San Diego, CA, July12, 2016

Seth Hubbard, Yushuai Dai, Stephen Polly, Staffan Hellström, David V. Forbes, "Investigation of Carrier Collection in InAs Quantum Dots Solar Cell", 2015 SPIE Photonics West, San Francisco, CA, February 11, 2015.

Seth M. Hubbard, Zachary S. Bittner, Elisabeth L. McClure, Michael A. Slocum, David V. Forbes, "Modeling the Effects of Using Polycrystalline Substrates for Low Cost III-V Photovoltaics", 2015 MRS Fall Meeting, Boston, MA, December 1, 2015.

Seth M. Hubbard, Yushuai Dai, Stephen Polly, Kristina Driscoll, Staffan Hellström, David V. Forbes, "Effects of electric field on thermal and tunneling carrier escape in quantum dot solar cells", 2014 SPIE Photonics West, San Francisco, CA, February 3, 2014.

Brittany L. Smith, David Forbes, Zac Bittner, George Nelson and **Seth Hubbard**, "Development of InAlAs solar cell towards integration as top cell in triple-junction photovoltaic designs" 23rd Space Photovoltaics Research and Technology (SPRAT), Cleveland, OH, September 2014.

Christopher Kerestes, Christopher Bailey, Zac Bittner, Stephen Polly, David Forbes, and **Seth Hubbard**, "Investigation of Quantum Dot Enhanced Triple Junction Solar Cells". 22nd Space Photovoltaics Research and Technology (SPRAT), Cleveland, OH, September 2011.

Seth M. Hubbard, Jamie Gardner, Eric Albers, Christopher Bailey, David Forbes and Ryan Raffaelle, "Thermal and Spectral Characteristics of Quantum Dot Solar Cells", in *Advanced Nanostructured Solar Cells*, Materials Research Society Fall Meeting, November 30-December 4, Boston, MA, 2009.

Ryne Raffaelle, **Seth Hubbard**, Christopher Bailey, Stephen Polly and David Forbes, "InAs Quantum Dot Enhancement of GaAs Solar Cells", in *Advanced Nanostructured Solar Cells*, Materials Research Society Fall Meeting, November 30-December 4, Boston, MA, 2009.

Christopher Bailey, David Forbes, Michael Harris, Stephen Polly, **Seth Hubbard** and Ryne Raffaelle, "Effect of Barrier Thickness on Interband Transition Energies of InAs QD / GaAs Solar Cells", in *Advanced Nanostructured Solar Cells* , Materials Research Society Fall Meeting, November 30-December 4, Boston, MA, 2009.

Stephen J. Polly, Christopher G. Bailey, Michael L. Harris, David V. Forbes, Ryne P. Raffaelle and **Seth M. Hubbard**, "Reduction of Power Loss Mechanisms in InAs/GaAs QD Concentrator Solar Cell Grid Design", in *Advanced Nanostructured Solar Cells* , Materials Research Society Fall Meeting, November 30-December 4, Boston, MA, 2009.

Ryne Raffaelle, **Seth Hubbard**, Chris Bailey, Stephen Polly and Cory Cress, "Quantum Dot Spectral Tuning of Multijunction III-V Solar Cells", in *Next-Generation and Nano-Architectured Photovoltaics*, Materials Research Society Fall Meeting, December 1-5, Boston, MA, 2008.

Seth M Hubbard, David Forbes, Ryne Raffaelle, Christopher Bailey, Stephen Polly and Cory Cress, "Behavior of Quantum Dot Enhanced Solar Cells under Solar Concentration", in *Next-Generation and Nano-Architectured Photovoltaics*, Materials Research Society Fall Meeting, December 1-5, Boston, MA, 2008.

Ryne Raffaelle, **Seth Hubbard**, Chris Bailey, Stephen Polly and Cory Cress, "Quantum Dot Spectral Tuning of Multijunction III-V Solar Cells", in *Next-Generation and Nano-Architectured Photovoltaics*, Materials Research Society Fall Meeting, December 1-5, Boston, MA, 2008.

C. Bailey, **S. Hubbard**, D. Forbes, C. Cress, S. Polly, R. Raffaelle "Effect of Strain Compensation Thickness and Material on Quantum Dot Enhanced Solar Cell Characteristics", 50th Electronic Materials Conference, Santa Barbara, CA, June 2008.

S. Hubbard, C. Bailey, C. Cress, S. Bailey, R. Raffaelle, "Strain Balanced Quantum Dot Solar Cell Development", Space Photovoltaics Research and Technology (SPRAT), Cleveland, OH, September 2007.

Thesis:

S.M. Hubbard, "Metalorganic Vapor Phase Epitaxy (MOVPE) Growth and Characterization of III-Nitride Heterostructures for Application in Electronic Devices", Ph.D. Thesis, University of Michigan, 2005.

S.M. Hubbard, "Effect of Crystal Defects on Minority Carrier Diffusion Length in 6H-SiC Measured Using the Electron Beam Induced Current Method", M.S. Thesis, Case Western Reserve University, 1998.

COURSES TAUGHT AT RIT

Spring 2016:	Microsystem Engineering 889, Epitaxial Thin Film Deposition (10 students)
Fall 2015:	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 10 students)
Fall 2014:	Physics 214, Modern Physics II (30 students)
	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 10 students)
Spring 2013:	Microsystems Engineering 772, Thin Film Science and Technology (4 students)
Winter 2013:	Physics 431, Electronics (29 students)
Fall 2012:	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 10 students)
Spring 2012:	Physics 315, Modern Physics II (30 students)
Winter 2012:	Microsystems Engineering 703, Introduction to Materials Science (10 students)
Fall 2011:	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 10 students)
Spring 2011:	Microsystems Engineering 703, Introduction to Materials Science (5 students)
Winter 2011:	Physics 431, Electronics (26 students)
	Physics 595, Capstone Research II (2 student)
Fall 2010:	Materials Science 701, Introduction to Materials Science (13 students)
	Physics 595, Capstone Research I (2 student)
	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 10 students)
Winter 2010:	Physics 431, Electronics (29 students)
	Physics 595, Capstone Research II (1 student)
Fall 2009:	Physics 314, Modern Physics I (24 students)
	Physics 595, Capstone Research I (1 student)
	Microsystems Engineering 702, Introduction to Nanotechnology and Microsystems (1 week guest lecture on III-V heterojunctions, 12 students)
Spring 2009:	Physics 311, Physics I (11 students)
Winter 2009:	Physics 431, Electronics (16 students)
	Physics 595, Capstone Research II (1 student)
Fall 2008:	Physics 595, Capstone Research I (1 student)
Spring 2008:	Physics 359, Electronics for Technology Students (20 students)
Winter 2008:	Physics 431, Electronics (lab only, 8 students)
	Physics 595, Capstone Research II (2 student)
Fall 2007:	Physics 595, Capstone Research I (2 student)
Spring 2007:	Physics 314, Physics III(14 students)
Winter 2007:	Physics 421, Experimental Physics (7 students)