DR. SETH MARTIN HUBBARD

Rochester Institute of Technology
NanoPower Research Laboratory
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Rochester, NY 14623
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http://www.rit.edu/gis/research-centers/nanopower/

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

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

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

FUNDED RESEARCH AS PRINCIPLE INVESTIGATOR

Pending 7/1/2014 - 6/30/2015
Office of Naval Research $501,788
DURIP: 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 111-V nanostructured devices and materials for power generation, energy harvesting and adaptive multimodal sensing.

Pending 10/1/2014 - 9/31/2017
Office of Naval Research $499,576
Transition Of High-Performance 111-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.

FA9453-11-C-0253 8/1/2013 - 4/14/2015
AFRL/ Univ. of Toledo $158,498
Quantum Dot Doping Superlattice (nipi) Photovoltaic Devices
This proposal seeks to address these challenges and shed light on the technology and device physics leading to an intermediate band solar cell. We will accomplish this in two ways. 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.

Pending 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.

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 - 1/31/2015
Empire State Development (ESD) $300,000
CFA: Acquisition of Metal Orgn 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 - 08/31/15
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. The system would be installed in the Semiconductor and Mircrosystems Fabrication Laboratory (SMFL).

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.

Contract # Pending 2/1/2012-1/31/2016
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.

Contract # Pending 8/1/2012-7/31/2013
NASA $66,000
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 $843,697.00
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).

DMR-0955752 04/01/10 - 03/31/15
NSF CAREER $455,898
CAREER: Strain Balanced Quantum Dots for High Concentration Solar Photovoltaics
While there has been extensive theoretical work that indicates the benefits of nanostructures in enhancing solar cell efficiency, there remains a significant amount of fundamental materials development necessary for practical implementation. This research aims to i.) selecting the appropriate quantum confined material system ii.) study of the growth and incorporation mechanisms of epitaxial nanostructures into solar devices and iii.) relation of the

optical and electrical results to theoretical predictions.

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

DE-AR0000335 03/20/13 - 02/29/16
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 - 8/31/2014
MDA/CFD Research Corp $235,000
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.

N0017312-2-C002 4/30/2012 - 3/30/2015
ONR $299,280
Multijunction Solar Cells Lattice-Matched to InP - A Path to High-Efficiency Flexible Photovoltaics
Dr. Forbes and Hubbard will support Naval Research Laboratory's mission to develop high-efficiency, flexible photovoltaics by developing a novel triple-junction solar cell structure lattice-matched to InP, comprised of a bandgap stack of 0.7/1.17/1.80 eV subcells.

HDTRA1-10-1-0122 10/5/2010 – 10/04/2014
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
RIT, in collaboration with Firefly Technologies, proposes an STTR program for the development of a space solar cell having record efficiency exceeding 40% (AMO) by the introduction of nanowires within the active region of the current limiting sub-cell. The introduction of these nanoscale features may enable realization of an intermediate band solar cell (IBSC), while simultaneously increasing the effective absorption volume that can otherwise limit short circuit current generated by thin quantized layers.

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 08/31/08 - 09/30/09
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 08/04/10 - 05/04/11
NASA/Microlink Devices $50,000
Radiation Hard Photovoltaic Devices

HQ0006-10-c-7386 05/01/10-11/30/10
MDA/CFD Research Corp. $44,948
Radiation Hard Quantum Well Multijunction Solar Cells

PENDING RESEARCH PROPOSALS

AFRL/Microlink Devices 2 year $260,000
STTR Phase 2: Quantum and Nano-Structure Enhanced Epitaxial Life-Off (ELO) Solar Cells
Application for Phase 2 project.

DOE Bay Area Photovoltaics Consortium 1 year $250,000
High Mismatched GaSb-GaAs Thin Film Multijunction Solar Cells
Collaboration between RIT (lead) and University of California Los Angles. Multijunction (MJ) solar cells integrating Sb-based material into the InGaP/GaAs technology using the interfacial misfit (IMF) growth.

DOE Next Generation Photovoltaics III 4 year $1,493,813
High Mismatched GaSb-GaAs Thin Film Multijunction Solar Cells
Collaboration between RIT (Hubbard, lead), Naval Research Laboratory and University of California Los Angles. We propose to gain access to near optimal band gaps for a multijunction (MJ) solar cell by integrating Sb-based material into the InGaP/GaAs technology using the interfacial misfit (IMF) growth technique pioneered by our team members.

DOE Energy Frontier Research Center 4 year $2,731,467
Advanced Materials and Material Structures for Conversion of Optical and Thermal Energy to Electricity
Collaboration between University of Arkansas (Dr. Greg Salamo, lead), RIT (Hubbard), George Washington University and University of Maryland. The vision of this EFRC is to accelerate scientific breakthroughs in the discovery of nanoscale materials and structures that will advance the frontier of the conversion of light and heat to electricity. We propose to establish in collaboration with researchers and facilities at Argonne and NIST laboratories, a research program that will open new and exciting directions in the discovery of advanced materials and nanostructures to harvest energy.

DOE Energy Frontier Research Center 4 year $1,969,593
Center for Metamorphic Nanomaterials
Collaboration between South Dakota School of Mines (Dr. Phil Ahrenkiel, lead), RIT (Hubbard), South Dakota State, University of South Dakota, University of Connecticut and University of Arkansas as well as the Naval Research Laboratory. The proposed Center for Metamorphic Nanomaterials (CMN) will enlist university, industrial, and DOE national laboratory participation to navigate a vast parameter space of dissimilar or antipodal materials that may reveal new and enhanced nanoscale phenomena with potential impact on energy sciences.

Central Intelligence Agency (CIA) 2 year $360,568
Novel Materials and Device Architectures for Space Photovoltaics
Research and discoveries by this post-doctoral fellow will allow high efficiency, high mass specific power and more radiation hard solar arrays to be deployed on reconnaissance and communication satellites.

National Science Foundation 3 year $250,423
Collaborative Research: Type II Superlattice Intermediate Band Solar Cell: An Approach Towards Ideal Performance
The University of Massachusetts Lowell (UML) and Rochester Institute of Technology (RIT) propose a 3-year effort to develop next generation III-V intermediate band solar cell (IBSC) devices with novel type II superlattice heterostructures as the active material that are suitable to demonstrate the ideal Intermediate Band Solar Cell (IBSC) concept.

National Science Foundation 3 year $1,219,006
SNM: Self-aligned mechanically stacked multijunction solar cells by epitaxial lift-off technologies
The objective of this multidiscipline program is to investigate template based scalable nanomaterial fabrication technologies and the nanowire devices in the areas of high efficiency solar cells and high performance THz quantum cascade lasers. In the proposed effort, the first thrust will be the development of water scale and micro

fabrication compatible anodized aluminum oxide (AAO) nanopore templates that can be utilized for large scale nanopatterning.

National Science Foundation 3 year $90,692
STTR: Metamaterial Enhanced Thermophotovoltaics with Spectrally Tunable and Efficient Emitters
Dr. Seth Hubbard will support Mainstream Engineering through fabrication and characterization of a lattice matched InGaAs single junction solar cell

National Science Foundation 3 year $89,996
STTR: Self-Aligned Mechanically Stacked Multijunction Solar Cells by Epitaxial Lift-Off Technologies
The water bonding approach described in this proposal will draw on the proven epitaxial liftoff technique at Microlink combined with a novel alignment free wafer bonding technique developed at RIT.

PHYSICS DEPARTMENT SERVICE

2013-Present:	***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

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***
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

2007-Present:	College and Career Day Presentations on Nanomaterials and Solar Energy
2012-Present:	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

POSTDOCTORAL ADVISING

2012-Present: **Advisor**, Staffan Hellstroem, Postdoctoral Fellow, NanoPower, RIT.

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

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

2015-Present: **Advisor**, Elisabeth Bisaha, MS Materials Science, RIT, Thesis area: *Light trapping in nanostructured photovoltaics*.

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: Research Scientist, 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.

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

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

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

Past

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*

2012-2013: **Co-op**, John Hatakeyama, BS Electrical Engineering (2015), RIT. Project: *Fabrication and Analysis of 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*

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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*

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PUBLICATIONS

Archival Journal Articles:

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Patents:

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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.

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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.

Invited Talks:

"Analysis of Multi Junction Solar Cells with a Quantum Dot Enhanced Middle Junction", Space Power Workshop, Los Angles, 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, 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.

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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.

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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 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)