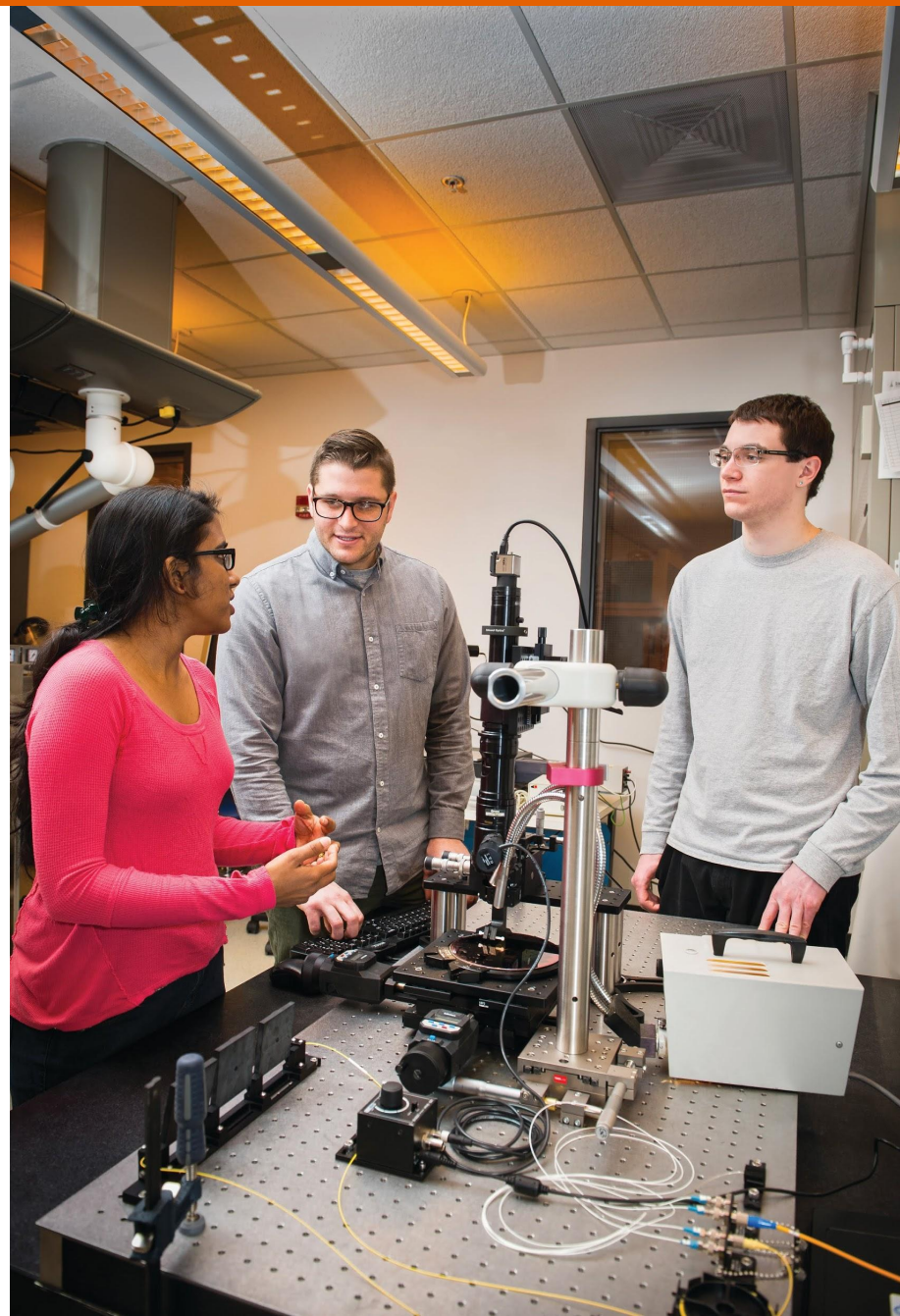
Microsystems Engineering Ph.D. Program

Dr. Bruce Smith, Distinguished Professor and Director

Dr. Stefan Preble, Professor

Graduate Open House

October 28, 2020



Introduction

The Kate Gleason College of Engineering offers a graduate program leading to the Doctor of Philosophy (PhD) degree in Microsystems Engineering. The program builds on the knowledge and skills of traditional engineering and science with concentration in micro- and nano-scale engineering and systems. Graduate students in the program conduct research in a wide variety of areas including nanotechnology, microelectronics, MEMS and NEMS, nanolithography, photonics, nanoelectronics, biological microsystems, microfluidics, micropower devices, and nanomaterials.

Contact Information

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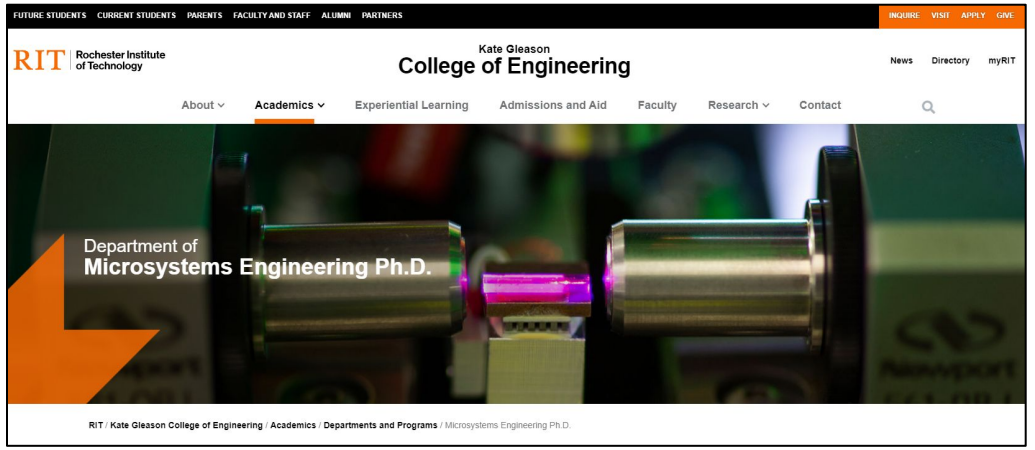


https://microsystems.rit.edu

Microsystems Faculty

Dr. Bruce Smith – Microsys. Eng.
Dr. David Borkholder – Microsys. Eng. and Elect. Micro. Eng.
Dr. Ferat Sahin – Elect. Micro. Eng.
Dr. Karl Hirschman – Elect. Micro. Eng.
Dr. Lynn Fuller – Elect. Micro. Eng.
Dr. Santosh Kurinec – Elect. Micro Eng.
Dr. Sean L Rommel – Elect. Micro. Eng.
Dr. Seth M Hubbard – Physics and Microsys. Eng.
Dr. Stefan F Preble – Microsys. Eng. and Elect. Micro. Eng.
Dr. Parsian Mohseni – Microsys. Eng. and Elect. Micro. Eng.
Dr. Mustafa Abushagur – Microsys. Eng.
Dr. Jing Zhang – Elect. Micro. Eng.
Dr. Kai Ni – Microsys. Eng. and Elect. Micro. Eng.
Dr. Greg Howland – Physics and Microsys. Eng.
Dr. Mishkat Bhattacharya – Physics
Dr. Shima Parsa – Physics

Dr. Patricia Taboada-Serrano – Chem. Eng.
Dr. Brian Landi – Chem. Eng.
Dr. Poornima Padmanabhan – Chem. Eng.
Dr. Blanca Lapizco-Encinas – Biomed. Eng.
Dr. Thomas Gaborski – Biomed. Eng.
Dr. Vinay Abhyankar – Biomed. Eng.
Dr. Satish Kandlikar – Mech. Eng.
Dr. Michael Schrlau – Mech. Eng.
Dr. Kathleen Lamkin-Kennard – Mech. Eng.
Dr. Ke Du – Mech. Eng.
Dr. Thomas Smith – Chemistry
Dr. Christopher Collison – Chemistry
Dr. Drew Maywar – Elec. Comp. Eng. Tech.
Dr. Denis Cormier – Ind. Sys. Eng.

Microsystems Research Thrusts

"Collaborative research with industry, government, and other institutions with a broad array of projects in the fields of microsystems and nanotechnology."

- Next-generation nanoelectronics including:
  - development of new techniques, processes and architectures for nanoelectronic and nano-optoelectronic devices
  - exploration into new materials research including germanium, III-V materials, carbon nanotubes, ferroelectrics, and spintronics
- Photovoltaic research in silicon, compound semiconductor, and organic solar cells
- Integrated Photonics, nanophotonics and optoelectronics, including: imaging, communications, sensing, and computing:
  - Quantum Photonics, heterogenous and hybrid integrated micro-lasers, detectors, LED's, spectrometers, and biosensors
- MEMS (micro-electro-mechanical systems), MEOMS (micro-electro-optical-mechanical systems) and NEMS (nano-electro-mechanical systems) device, processing and materials research for smart sensors, actuators, biochips, and micro-implantable appliances
- Biomedical Microsystems, NanoBio Devices and Bio-Robotics
- Nanomaterials research including carbon nanotubes, nanowires, nanoparticles, quantum dots, self-assembly materials and their applications in electronics, optics, energy and materials science
- Batteries and Fuel Cells
- Microfluidics research on the behavior, control, and manipulation of fluids at the micro-scale

Admission Requirements

To be considered for admission to the doctorate program in microsystems engineering, candidates must complete a graduate application and fulfill the following requirements:

- Complete a graduate application (https://www.rit.edu/emcs/ptgrad/apply)
- Hold a baccalaureate degree (or equivalent) from an accredited university or college in the physical sciences or engineering.
- Submit official transcripts (in English) from all previously completed undergraduate and graduate course work.
- Have a minimum cumulative GPA of 3.0 (or equivalent).
- Submit scores from the GRE with minimum requirements of 156 (verbal), 156 (quantitative), and 3.5 writing.
- Submit a current resume or curriculum vitae.
- Submit a personal statement of educational objectives which specifically addresses research interests.
- Submit at least two letters of academic and/or professional recommendation.
- International applicants whose native language is not English must submit scores from the TOEFL, IELTS, or PTE. A minimum TOEFL score of 100 (internet-based) is required. A minimum IELTS score of 7.0 is required. The English language test score requirement is waived for native speakers of English or for those submitting transcripts from degrees earned at American institutions.

Ph.D. Program Phases

Phase 1: The first phase of the Ph.D. program is to prepare the student with the foundation in science and engineering required for the program as well as to determine the student's ability to do independent research. This includes the foundation and specialization courses taken during the first year together with the successful completion of **the Qualifying Exam**. The Qualifying Exam tests the student's ability to think and learn independently, to critically evaluate current research work in microsystems engineering, and to use good judgment and creativity to determine appropriate directions for future research work.

Phase 2: The second phase of the Ph.D. program consists of course work in the Program of Study and preliminary dissertation research. Much of this course work will support the student's research to be conducted in the third phase. This second phase will be completed when the student has finished most of the formal course work as prescribed in the Program of Study (i.e. near the end of the third year), has prepared the Dissertation Proposal, and has passed **the Candidacy Examination**.

Phase 3: The third stage of the Ph.D. program consists of the completion of the experimental and/or theoretical work needed to complete the student's dissertation along with the required publication of results. **The Research Review Milestone** is held as a meeting in the third phase as is **the Defense of the Dissertation**, which consists of a public oral presentation and examination.

Ph.D. Degree Requirements

1. A total of 66 semester credit hours
    a. A minimum of 39 of graduate-level coursework credit hours
      – Master's degree holders may be permitted to transfer up to 24 credit hours
    b. A minimum of 18 research credit hours

2. Pass the Qualifying Examination (at end of first year)

3. Pass the Candidacy Examination (before the end of third year and no less than 12 months before the Dissertation Defense Examination)

4. Hold a Research Review Milestone meeting (at least 6 months before the Dissertation Defense Examination)

5. Publish two papers (including at least one referred journal paper) based on dissertation research

6. Pass the Dissertation Defense Examination

Ph.D. Coursework Plan

Group I: Foundation Courses (4x3=12 + 6 cr. hrs.)

1. MCSE-702 Introduction to Nanotechnology and Microsystems
2. MTSE-704 Theor. Methods in Material Science and Engineering or equivalent
3. MCEE-701 Microelectronic Fabrication I or equivalent
4. MCSE-703 Material Science for Microsystems Engineering or equivalent
5. MCSE-795 Microsystems Ph.D. Seminar (1cr./sem.)

Group II: Major Technical Interest Area (4x3=12 cr. hrs)

A sequence of four courses in the major technical research area

Group III: One Minor Technical Interest Area (2x3=6 cr. hrs)

A sequence of two courses in a minor technical area

Group IV: Electives (1x3=3 hrs minimum)

Total minimum graduate-level coursework: *39 semester credit hours*
Total minimum of research credit: *18 semester credit hours*
Minimum total required: *66 semester hours (balance coursework or research)*

Research Support

- **Research Advisor:** In first year, a student is expected to identify a research advisor
  - Advisors are prepared to assist students with issues regarding curriculum requirements, elective choices, stipend support, presentations and publication, RIT support facilities, and concerns of a more personal nature (such as time management).
- **Graduate Research Assistantships (GRAs)** are offered to full-time students for the purpose of supporting student research under the supervision of their advisor and in pursuit of their degree requirements.
  - Students receive a predetermined stipend over the term of their appointment (normally evaluated yearly)
  - These stipends are taxable and no taxes are withheld from payments.
- You are expected to put forth the effort necessary to carry out the research plan identified by your advisor and necessary to complete your PhD degree.
- **External Fellowships:** Students should consider applying for outside Fellowships.

Current Microsystems Student Research

NanoPower Photovoltaics Research Group

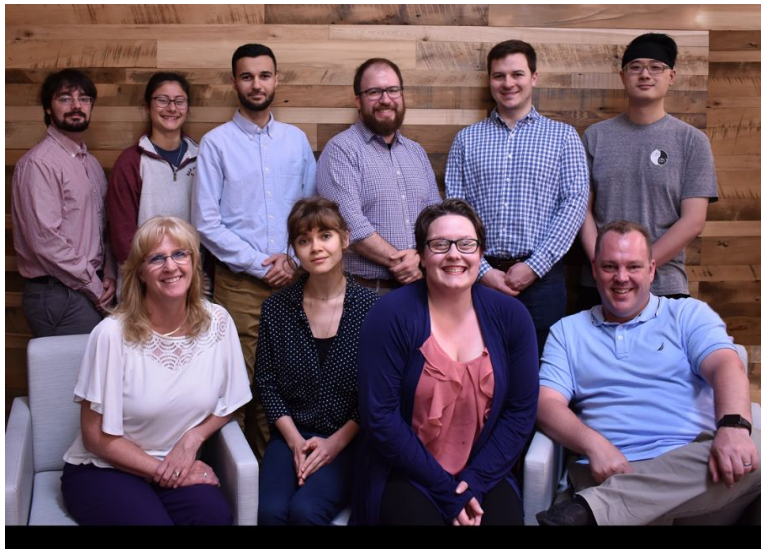
NPRL NanoPower Research Laboratories
Rochester Institute of Technology

Julia D'Rozario

Undergraduate Degree (2012-2016):
B.S. in Physics from the State University of New York (SUNY) at Oswego

Current Degree (2017-present):
4th year Microsystems Engineering Ph.D. Candidate

Research Group:
3 Ph.D., 2 masters, 1 postdoctoral research fellow, 1 research scientist, and 1 epitaxial materials specialist

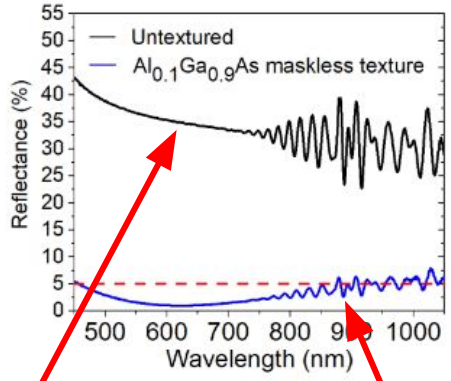


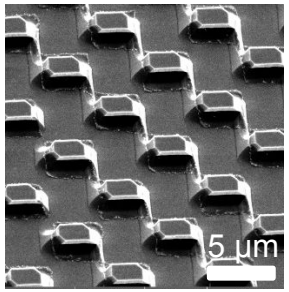
Aixtron 3x2" Close-Coupled Showerhead

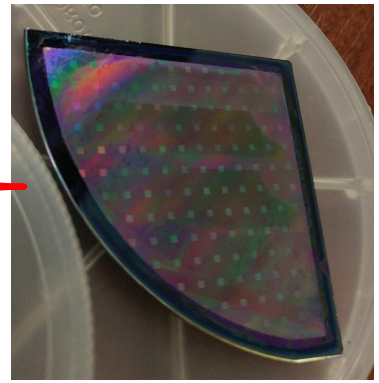
Solar Cell Growth: Metal Organic Chemical Vapor Deposition

Device Fabrication: III-V wet/dry etching, photolithography, metallization tools

Light Trapping Structure Development



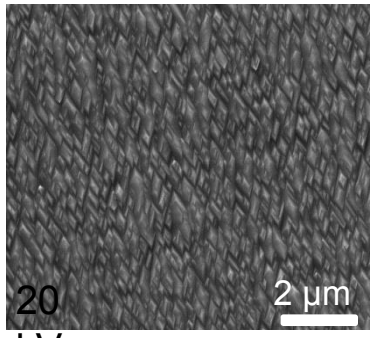




Ultraviolet photolithography patterning and wet chemical etching

Flat $Al_{0.1}Ga_{0.9}As$

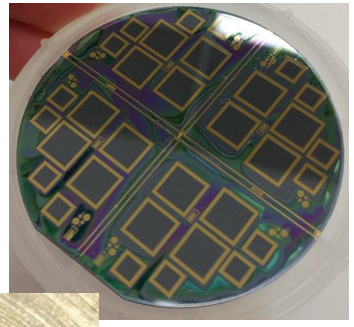
Random $Al_{0.1}Ga_{0.9}As$

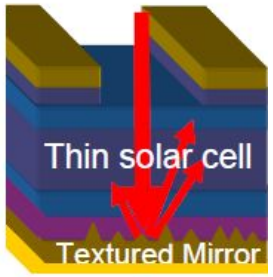


Lithography-free texture

Solar Cell Characterization

TS Space systems close-match solar simulator and spectral response measurement





Matthew Hartensveld

μ-LED Research

PhD Student/CTO

BS/MS MicroE/Material Science

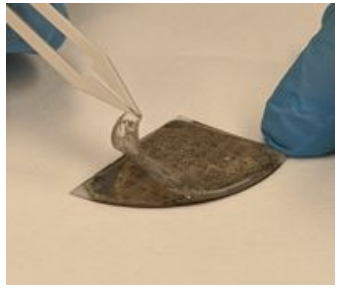
3rd year in the program

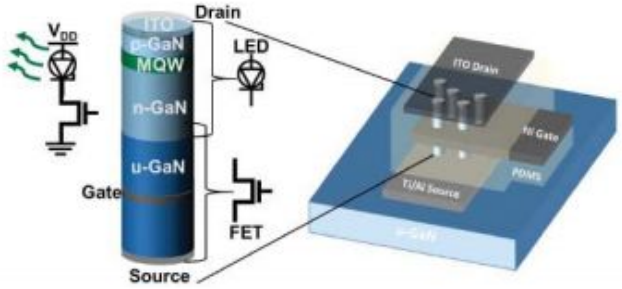
Works with Dr. Zhang

Pursuit of μ-LED advances

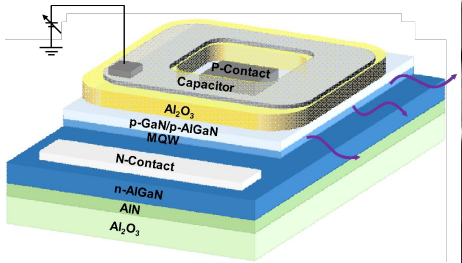
Developed IP

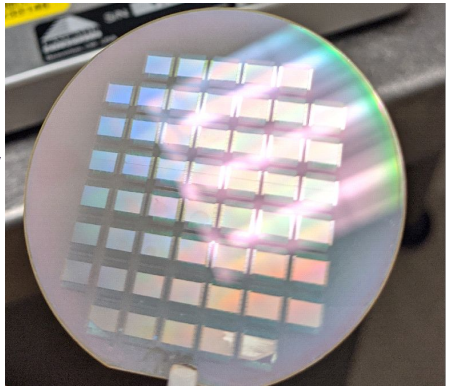
Started company based on IP

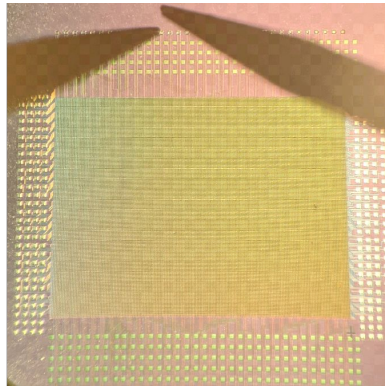




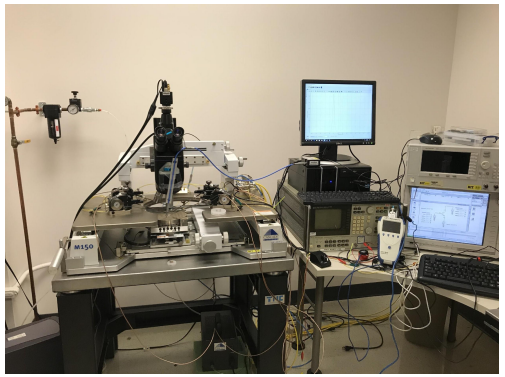
innovation Semiconductor
Transforming the Display Industry



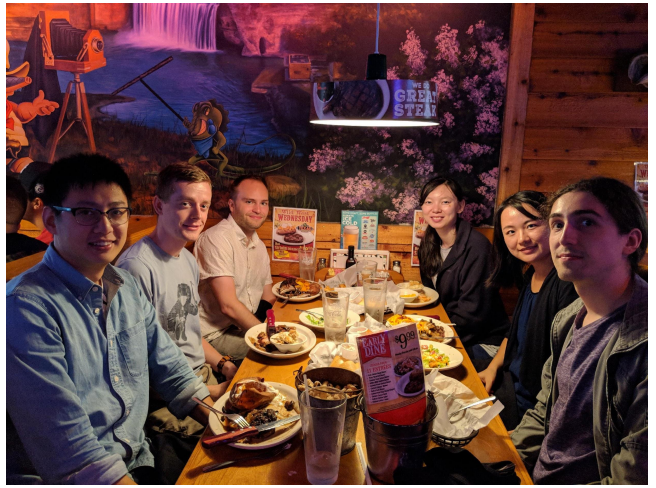




Cleanroom Fabrication



Community



Krittika Goyal

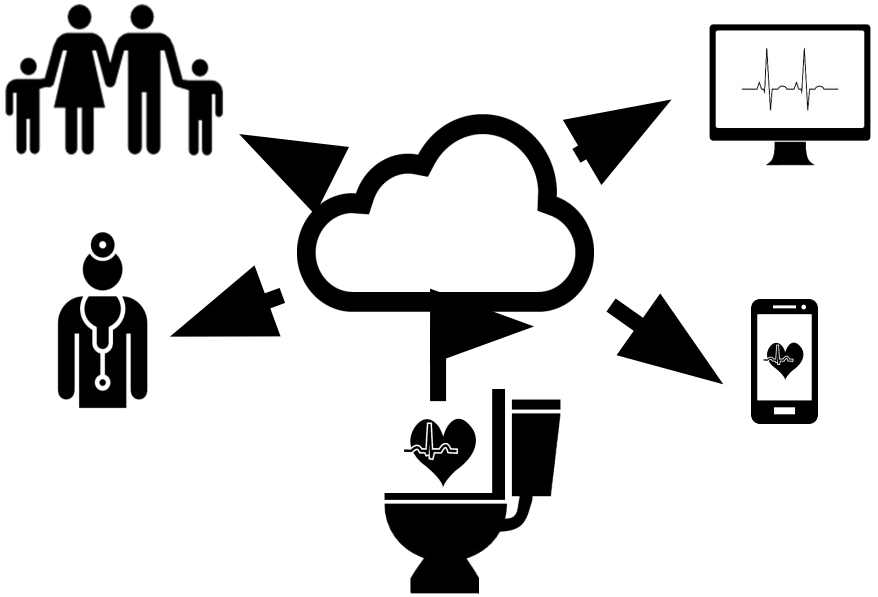
Third year Ph.D. Student

M.E. 2016 (Thapar Univerisity, India), Electronics Instrumentation & Control

B.E. 2014 (Thapar University, India), Electronics Instrumentation & Control

BIOMEDICAL MICROSYSTEMS LABORATORY

Fully Integrated Toilet Seat for Inconspicuous Daily Monitoring of Cardiovascular Health



- **Current Work with FIT Seat:**
  - To accurately capture clinically relevant ECG metrics, reproducibility and high-quality signal
- **Facilities:**
  - In Lab Testing (IRB approved studies)
  - Clinical studies with FIT Seat:
    - University of Rochester Medical Center
    - MD Anderson Cancer Center, Texas
- **Research Projects:**
  - Cardiovascular monitoring and Modelling including:
    - Non-invasive physiologic measurements
    - Biomedical Signal Processing
  - Inner Ear Drug delivery (Implantable micropump)

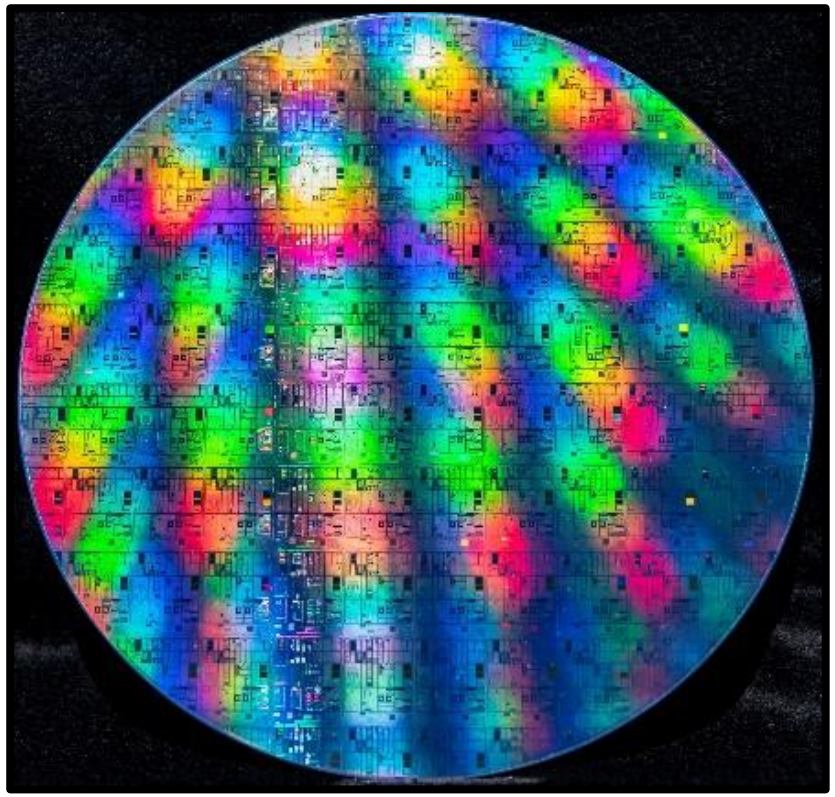
Stefan Preble

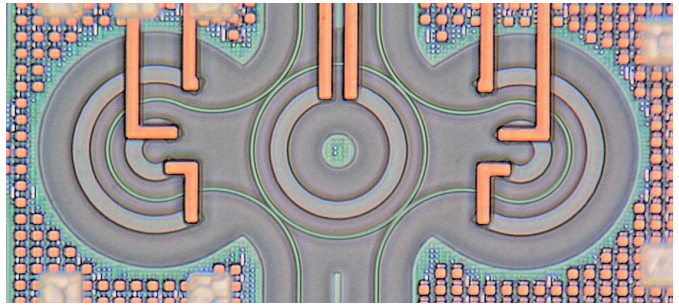
Professor

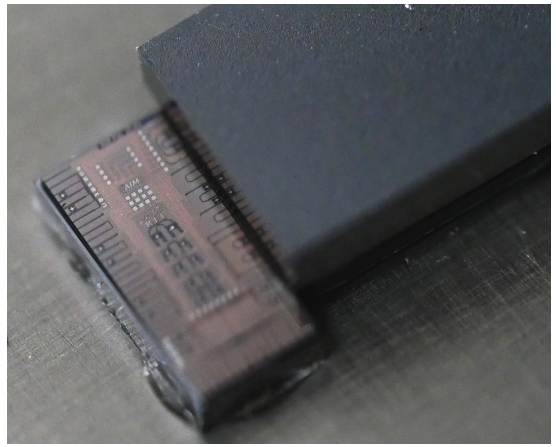
Ph.D. 2007 (Cornell University), Electrical & Computer Engineering

B.S. 2002 (RIT), Electrical Engineering

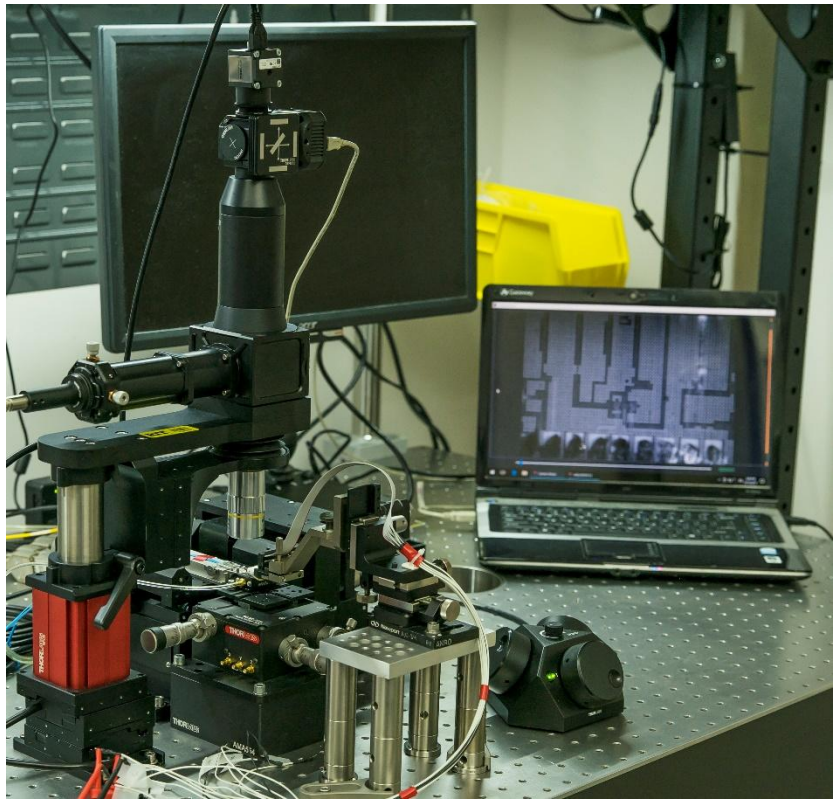
Integrated Photonics







- **Integrated Photonics Group:**
  - 4 Ph.D., 1 Postdoc, 1 M.S., 2 Engineers, 1 Technician
- **Facilities:**
  - Three optics labs, including:
    - Lobozzo Photonics and Optical Characterization Lab
    - Photonics Packaging Lab
  - Future Photon Initiative
  - Center for Detectors
- **Projects:**
  - Quantum Integrated Photonics
  - Neuromorphic Photonics (Photonic Neural Networks)
  - Photonic Packaging
  - Education – edX Course: Photonic Integrated Circuits 1



Conclusion

Microsystems Engineering Ph.D. Program

Research Areas:

- Nanoelectronics
- Photovoltaics [Silicon, III-V and Organics]
- Ultra-wide bandgap semiconductors (III-N), photonic and optoelectronic devices
- Nanomaterials and Nanowires
- Batteries
- Carbon Nanotubes
- Additive Manufacturing
- Integrated Photonics
- Quantum Photonics
- MEMS/NEMS
- Biomedical Microsystems
- Microscale Bio Separations
- Nano-Bio Interfaces

Multidisciplinary program that is addressing the scientific and technical challenges of *micro*- and *nano*-systems

- Research that spans across fields of: biomedical, electronic, photonic, mechanical, materials and computing engineering and sciences
- Average enrollment of 50 students
- Key Facilities:
  - Semiconductor and Microsystems Fabrication Laboratory (SMFL)
  - NanoPower Research Laboratories (NPRL)
  - Metal organic vapor phase epitaxy (MOVPE) for III-V's
  - Integrated Photonic Packaging & AIM Photonics
  - AMPrint Center

Questions?