CEIS

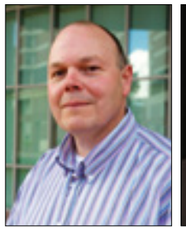
Center for
Emerging and
Innovative Sciences

ANNUAL REPORT 2015–2016

CEIS

Contents

DIRECTORS' MESSAGE



MARK F. BOCKO

PAUL H. BALLENTINE

Thank you for taking a few moments to peruse this latest volume of the CEIS annual report. It has been another eventful and successful year at our center.

We began the year with the good news that CEIS was renewed by the State of New York as one of its 15 Centers for Advanced Technology. Our center has been awarded $9.2 million in funding over the next 10 years, which will enable us to continue our mission of promoting economic development across New York State through technical partnerships between industry and academe. In the past 10 years, the Center for Emerging and Innovative Sciences has accrued $740 million of direct economic impact and created more than 400 jobs across New York State. In the last year alone CEIS had an economic impact of $110 million stemming from 27 different projects; this includes 61 new jobs created, 28 jobs retained, and increased company revenue of $18 million, with the balance in cost savings and new funds acquired. All of this has been possible through the continued support of NYSTAR, Empire State Development's Division of Science, Technology and Innovation, and the collaborative efforts of our many corporate partners and university researchers.

Throughout the last year Rochester continued to build its profile as the national hub for photonics and imaging with the establishment of the headquarters of AIM Photonics in Rochester. AIM Photonics is a $600 million initiative including $110 million of federal funds, $250 million in state funding, and the balance in industry investments. Many faculty members from the University of Rochester and Rochester Institute of Technology are playing key roles in the development of AIM Photonics, and we look forward to many future successes made possible by this incredible opportunity.

In other CEIS activities, the 17th annual CEIS Technology Showcase drew a crowd of more than 200 people, and during that event Mark Mayton of Flint Creek Resources was recognized by CEIS for his outstanding leadership in the Rochester technical and business community. Our workforce training program, which is sponsored by a grant from the federal government under the Department of Labor, saw 13 of 19 participants (2015–16) attain employment in the advanced manufacturing sector. Through our federally sponsored AMJIAC (Advanced Manufacturing Jobs and Innovation Accelerator Challenge) program, CEIS will continue to assist trainees in achieving employment in our region's photonics industries. With the generous support of Governor Andrew Cuomo and the State of New York, we look forward to continuing our work over the next decade and to initiating new projects on topics as diverse and far ranging as photonic packaging to virtual reality and new media.

In closing, and as always, we would like to thank our dedicated and talented staff at CEIS without whose efforts our center's activities would come to a grinding halt; this is the CEIS business manager, Cathy Adams; the center's administrative assistant, Margaret Urzetta; and our student program assistants, Anya Khalid, Lesley Mah, and Vitumbiko Kambilonje.

Sincerely,

Mark F. Bocko, *Director*

Paul H. Ballentine, *Executive Director*

CEIS TEAM

CEIS STAFF

CEIS staff prides itself on its commitment to fostering industry-university partnerships that lead to economic development for our region.

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CEIS ADVISORY BOARD

CEIS leadership meets with the advisory board to develop action-oriented plans to keep innovative technologies in the pipeline, connecting academic research with corporate product development. CEIS acknowledges and applauds its advisory board members for their leadership, expertise, and forward-thinking ideas.

Bob Naum
EMF Corporation,
Rochester Site (Chair)

Ian Cox
Consultant

Alan Evans
Corning, Inc.

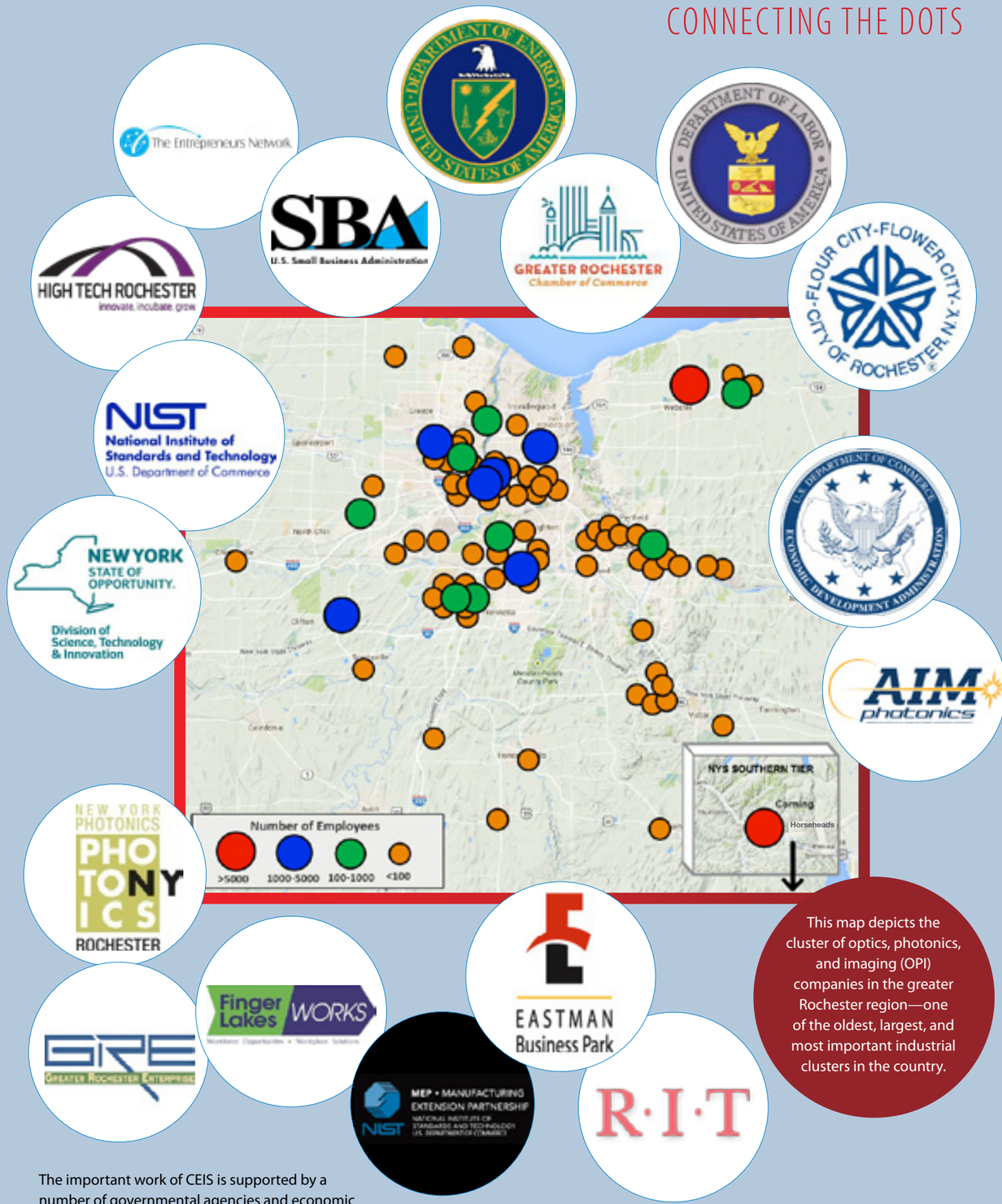
Bob Fiete
Harris Corporation

Julie Gerstenberger
Consultant

Mark S. Peterson
Greater Rochester Enterprise

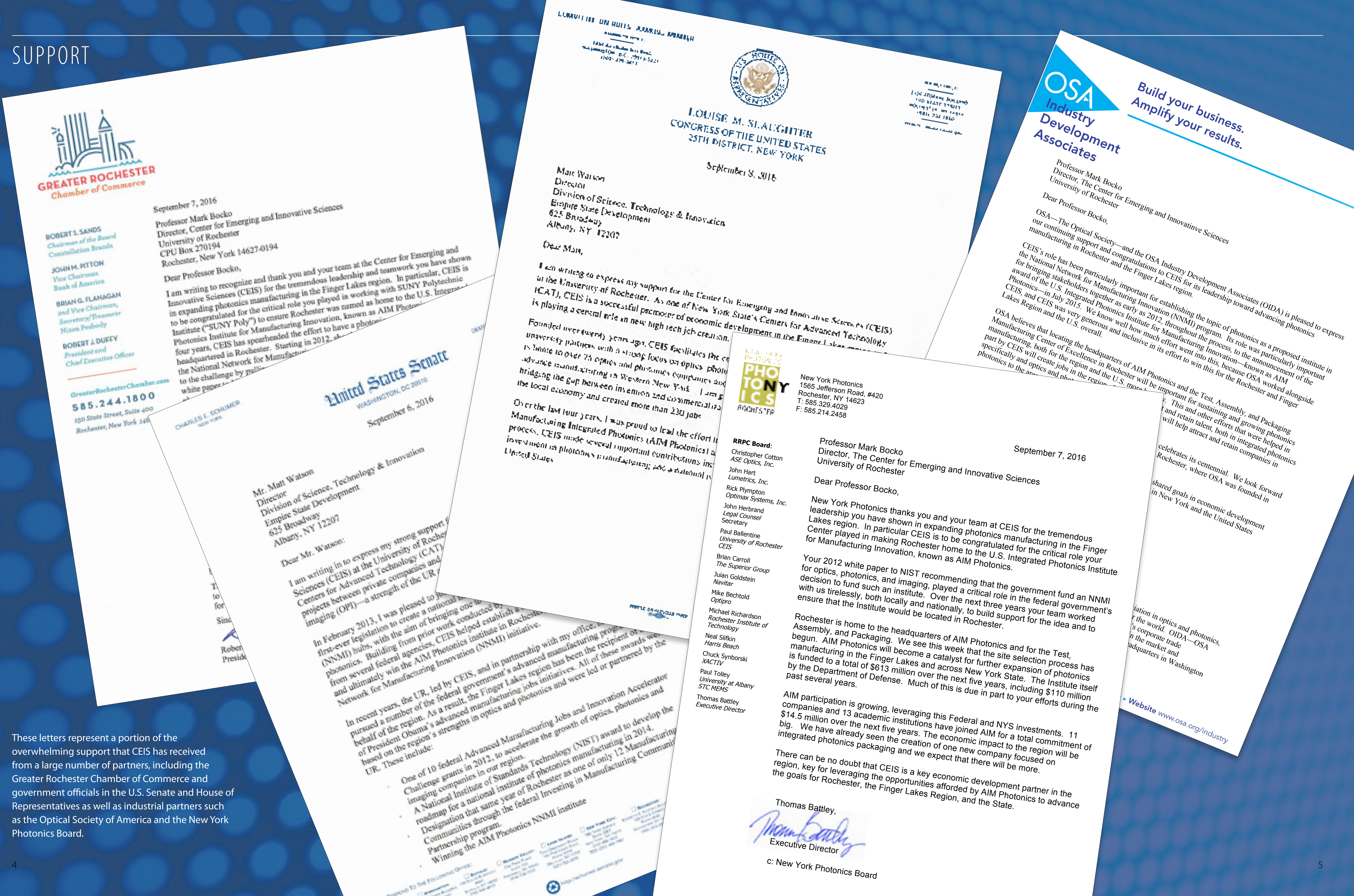
Ryne Raffaelle
Rochester Institute of Technology

CONNECTING THE DOTS



This map depicts the cluster of optics, photonics, and imaging (OPI) companies in the greater Rochester region—one of the oldest, largest, and most important industrial clusters in the country.

The important work of CEIS is supported by a number of governmental agencies and economic development partners, shown here.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Rochester, NY 14623
T: 585.329.4029
F: 585.214.2458

RRPC Board:
Christopher Cotton, ASE Optics, Inc.
John Hart, Lumetrics, Inc.
Rick Plympton, Optimax Systems, Inc.
John Herbrand, Legal Counsel, Secretary
Paul Ballentine, University of Rochester CEIS
Brian Carroll, The Superior Group
Juian Goldstein, Navitar
Mike Bechtold, Optipro
Michael Richardson, Rochester Institute of Technology
Neal Slifkin, Harris Beach
Chuck Synborski, XACTIV
Paul Tolley, University at Albany STC MEMS
Thomas Battley, Executive Director

September 7, 2016

Professor Mark Bocko
Director, The Center for Emerging and Innovative Sciences
University of Rochester

Dear Professor Bocko,

New York Photonics thanks you and your team at CEIS for the tremendous leadership you have shown in expanding photonics manufacturing in the Finger Lakes region. In particular CEIS is to be congratulated for the critical role your Center played in making Rochester home to the U.S. Integrated Photonics Institute for Manufacturing Innovation, known as AIM Photonics.

Your 2012 white paper to NIST recommending that the government fund an NNMI for optics, photonics, and imaging, played a critical role in the federal government's decision to fund such an institute. Over the next three years your team worked with us tirelessly, both locally and nationally, to build support for the idea and to ensure that the Institute would be located in Rochester.

Rochester is home to the headquarters of AIM Photonics and for the Test, Assembly, and Packaging. We see this week that the site selection process has begun. AIM Photonics will become a catalyst for further expansion of photonics manufacturing in the Finger Lakes and across New York State. The Institute itself is funded to a total of $613 million over the next five years, including $110 million by the Department of Defense. Much of this is due in part to your efforts during the past several years.

AIM participation is growing, leveraging this Federal and NYS investments. 11 companies and 13 academic institutions have joined AIM for a total commitment of $14.5 million over the next five years. The economic impact to the region will be big. We have already seen the creation of one new company focused on integrated photonics packaging and we expect that there will be more.

There can be no doubt that CEIS is a key economic development partner in the region, key for leveraging the opportunities afforded by AIM Photonics to advance the goals for Rochester, the Finger Lakes Region, and the State.

Thomas Battley,
Executive Director

c: New York Photonics Board

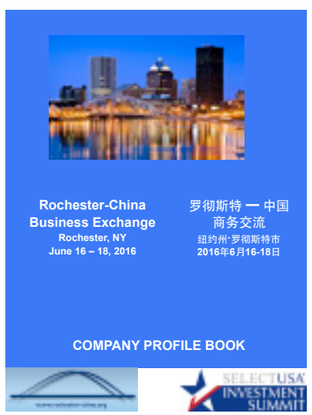
These letters represent a portion of the overwhelming support that CEIS has received from a large number of partners, including the Greater Rochester Chamber of Commerce and government officials in the U.S. Senate and House of Representatives as well as industrial partners such as the Optical Society of America and the New York Photonics Board.

OUTREACH AND FEDERAL INITIATIVES

In addition to providing financial support for industry/university collaboration, CEIS has continued to promote economic development through a number of outreach activities and federal grants.

Our AMJIAC grant, known as the Rochester Regional Photonics Accelerator, is winding down after four years. The RRPA program was funded by five different federal agencies and helped us bring together several key stakeholders to strengthen the region's optics, photonics, and imaging cluster. The participants included the University of Rochester, Rochester Institute of Technology, the Rochester Regional Photonics Cluster, High Tech Rochester, and the Finger Lakes Workforce Investment Board. The RRPA produced a number of successful outcomes, including helping Flint Creek Resources expand its polishing slurry reclamation business and helping to jump start a workforce-training program developed by Finger Lakes Advanced Manufacturers' Enterprise (FAME).

Our second federal grant comes from NIST under the AMTech (Advanced Manufacturing Technology Consortia) program. We are using this grant to develop a set of roadmaps for optics, photonics, and imaging industries and to expand photonics manufacturing in New York. The AMTech grant has allowed CEIS to go beyond helping to bring AIM Photonics to Rochester and to play a lead role in defining collaborations in advanced optics manufacturing, lasers, and the intersection of data science and imaging. These three areas have been the subjects of proposals to the Finger Lakes Regional Economic Development Council (FLREDC) for funding under the Upstate Revitalization Initiative.



Our industry outreach continued along several fronts this past year. In addition to the University Technology Showcase, CEIS worked with the U.S. Department of Commerce to bring a delegation of investors from China to Rochester. The Rochester-China Business Exchange (RCBE) consisted of 20 Chinese delegates meeting with 71 New York companies. The event spanned five days and was extremely well received by those involved. As a result of the RCBE, there are multiple investment discussions taking place, and there is an effort under way to establish a permanent organization that will expand foreign investment and international trade with China and other countries. There has already been one local optics manufacturer helped by this activity. Attracting investment is a key part of growing the region's OPI industry.

Other outreach activities include our leadership roles in the FLREDC Optics, Photonics, and Imaging workgroup and New York Photonics. In addition, we are working with AIM Photonics to help identify opportunities for collaborating with small and medium-sized OPI companies in the Rochester region.

We are pleased with what CEIS has accomplished this past year, and we continue to look for synergistic opportunities to leverage state, federal, and community resources to further our economic development mission.

PARTNERS

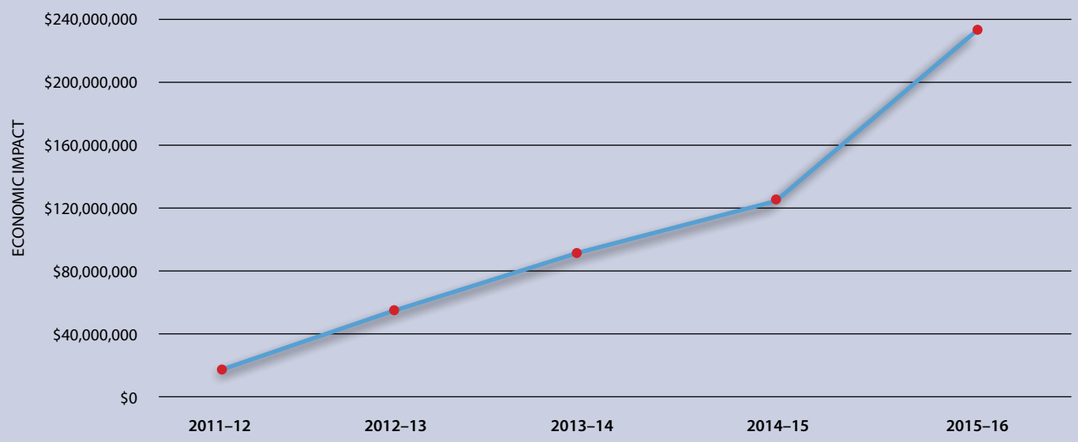
CLERIO VISION
iCardiac TECHNOLOGIES
CORNING
aait Advanced Acoustic Imaging Technologies
intrinsiq materials
INT
Omni-ID Identify with innovation
ThermoFisher SCIENTIFIC
Adarza BioSystems
OVITZ
GE Oil & Gas
GE Global Research
xerox
HARRIS
FCR
PLE-COMMUNICATIONS, LLC
Kodak
alaris
ADVIS
HYPRES The Digital Superconductor Company™
Kitware
FluxData
STEFAN SYDOR OPTICS
HARBEC Technical Innovation with Environmental Responsibility
micropen TECHNOLOGIES
POSITIVE SCIENCE
OPTIPRO
IBM
Synaptics
Carestream
LighTopTech
B+L
CALIBER I.D.
SiMPore Inc. Precision Membrane Technologies
BAUSCH+LOMB

ECONOMIC IMPACT

For the fiscal year July 1, 2015, to June 30, 2016, the total documented dollar value of the economic impact of CEIS-supported research and outreach was more than $110 million. This self-reported data (new and retained jobs, increased sales, cost savings, capital investments and additional funds acquired) from thirteen of our partners continues to be a promising indicator of the region's economic position.

A special shout out to Harris Corporation: the local RF and Space & Intelligence Systems divisions topped the chart, reporting more than half the retained jobs during the reporting period and $19 million in non-job impacts. In the small company category, Adarza BioSystems led the way, reporting ten retained jobs and nearly $5.5 million in non-job impact. Last but not least, the AIM Photonics initiative reported forty newly created jobs and $72.6 million in monetary impacts.

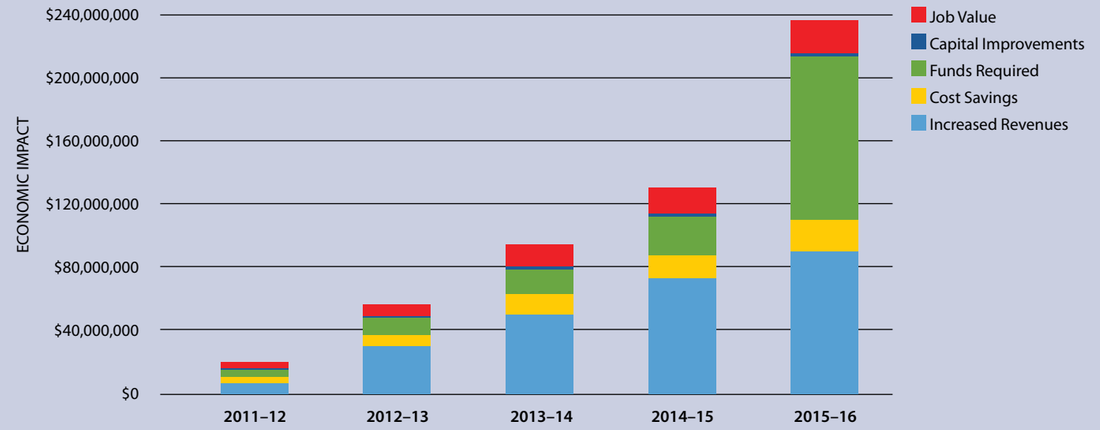
FIVE-YEAR CUMULATIVE ECONOMIC IMPACT



FIVE-YEAR SUMMARY OF ECONOMIC IMPACT

Year	2011–12	2012–13	2013–14	2014–15	2015–16	Total
Increased Revenues	$7,493,412	$22,058,613	$20,816,657	$22,548,794	$18,635,000	$91,552,476
Cost Savings	$3,444,000	$3,146,200	$6,276,553	$1,989,100	$3,927,488	$18,783,341
Funds Acquired	$4,040,141	$7,380,774	$3,103,808	$8,050,720	$81,269,321	$103,844,764
Capital Improvements	$176,000	$679,000	$792,806	$263,421	$204,549	$2,115,776
Job Value	$3,015,652	$4,921,362	$4,245,605	$2,944,601	$6,106,332	$21,233,552
New Jobs	7.75	28.35	21	20	61	138
Retained Jobs	34.5	43	40	26	28	172
Total Impact	$18,169,205	$38,185,949	$35,235,429	$35,796,636	$110,142,690	$237,529,909
Total Cumulative Impact	$18,169,205	$56,355,154	$91,590,583	$127,387,219	$237,529,909	$237,529,909

FIVE–YEAR ECONOMIC IMPACT



CAT PROGRAM FINANCIAL INFORMATION

	7/1/15–6/30/16
FUNDING FROM NYSTAR*	
Research Expenditures	
Personnel Related	$141,939
Non-Personnel Related	$181,786
Operational Expenditures†	
Personnel Related	$348,207
Non-Personnel Related	$284,379
Total NYSTAR Contribution	$956,311
OTHER SOURCES OF FUNDS*	
Cash from Companies	
Personnel Related	$383,526
Non–Personnel Related	$549,759
Other Contributions	
Personnel Related	
Non–Personnel Related	
Total Other Sources	$933,285

**Combined financials for CAT-funding period overlap*
†Research- and Center-related, including applicable overhead

COMPANIES REPORTING ECONOMIC IMPACT IN 2015–16 FROM CEIS INTERACTIONS

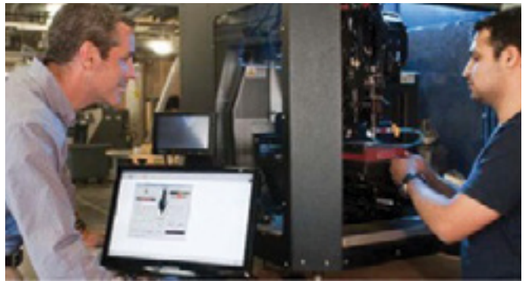
AIM Photonics
Adarza Biosystems, Inc.
Clerio Vision, Inc.
Corning, Inc.
Exelis (now Harris Space & Intelligence Systems)
Flint Creek Resources, Inc.
Harris Corporation
LighTop Tech Corporation
Optipro Systems, LLC
Ovitz Corporation
SiMPore, Inc.
Thermo Fisher Scientific
UR Ventures Technology Development Fund

A YEAR IN REVIEW

**JANURARY 1, 2015–
JANUARY 1, 2016**

The International Year of Light.

Denis Cormier, RIT CAT director, with a student



JANUARY 19, 2016

Rochester-based Omni ID, Inc. has raised $21 million in new funding to expand its global presence and its product portfolio.

JULY 10, 2015

Harris Corporation announced that its new Communications Systems segment will be based in Rochester.

AUGUST 2015

RIT joins the network of 15 Centers for Advanced Technology. RIT's CAT will focus on 3D printing, additive manufacturing, and functional printing.

AUGUST 2015

CEIS was renewed as the State's Center for Advanced Technology (CAT) in optics, photonics, and imaging.

OCTOBER 12–15, 2015

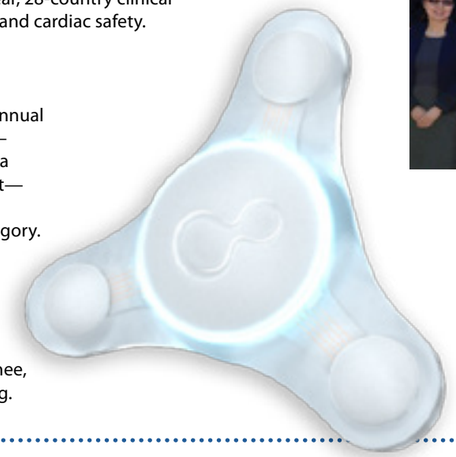
SPIE Optifab is the largest optical fabrication event in North America; it is held in Rochester every other year. Representatives from 30 nations were represented along with optical machinery displays.

FEBRUARY 24, 2016

iCardiac is starting a three-year, 28-country clinical trial that will test respiratory and cardiac safety.

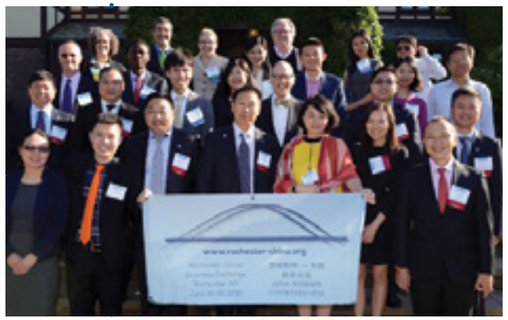
FEBRUARY 25, 2016

The Wearable Technologies annual conference named ADAMM—Automated Device for Asthma Monitoring and Management—the best innovation in the Healthcare and Wellness category. The ADAMM was developed through a collaboration between Mark Bocko, Chair and Distinguished Professor of Electrical and Computer Engineering, and Hyekyun Rhee, Associate Professor of Nursing.



JUNE 17, 2016

The Communications Systems segment at Harris Corporation was awarded a contract worth up to $1.7 billion through the U.S. Foreign Military Sales program.



JUNE 16–17, 2016

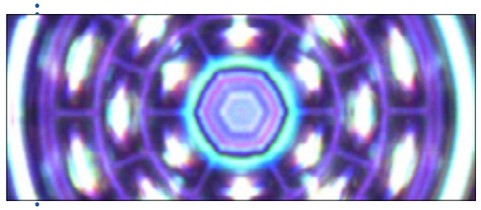
CEIS was instrumental in hosting the Rochester China Business Exchange, an effort to attract Chinese investment to the Rochester region with a focus on optics, photonics, and imaging. Twenty delegates from China representing nine industrial companies, two banks, and two economic development entities participated.

JULY 27, 2015

Vice President Joe Biden was in Rochester to announce the region had been awarded a $600 million Institute for Manufacturing Innovation (IMI) in Integrated Photonics, and the headquarters for AIM Photonics would be in Rochester.

SEPTEMBER 17, 2015

The New York Photonics annual meeting held at the Rochester Museum and Science Center was sold out. Bob Bicksler, CEO of JML Optical Industries, received the RRPC Entrepreneur Award; the RRPC leadership award went to Duncan Moore; and the RRPC Education Award recipient for 2015 was East High School science teacher Paul Conrow (left).



JANUARY 6, 2016

The University of Rochester was awarded $411,738 to support its photonics research efforts. The money will help scientists at the university investigate quantum photonics in order to develop new materials to support the next generation of photonic devices.

JANUARY 8, 2016

CEIS hosted a Rochester Optics, Photonics, and Imaging Speed Dating event. More than 100 people attended, and fifty-three companies presented to their peers followed by break-out session discussing optics, photonics, and imaging.

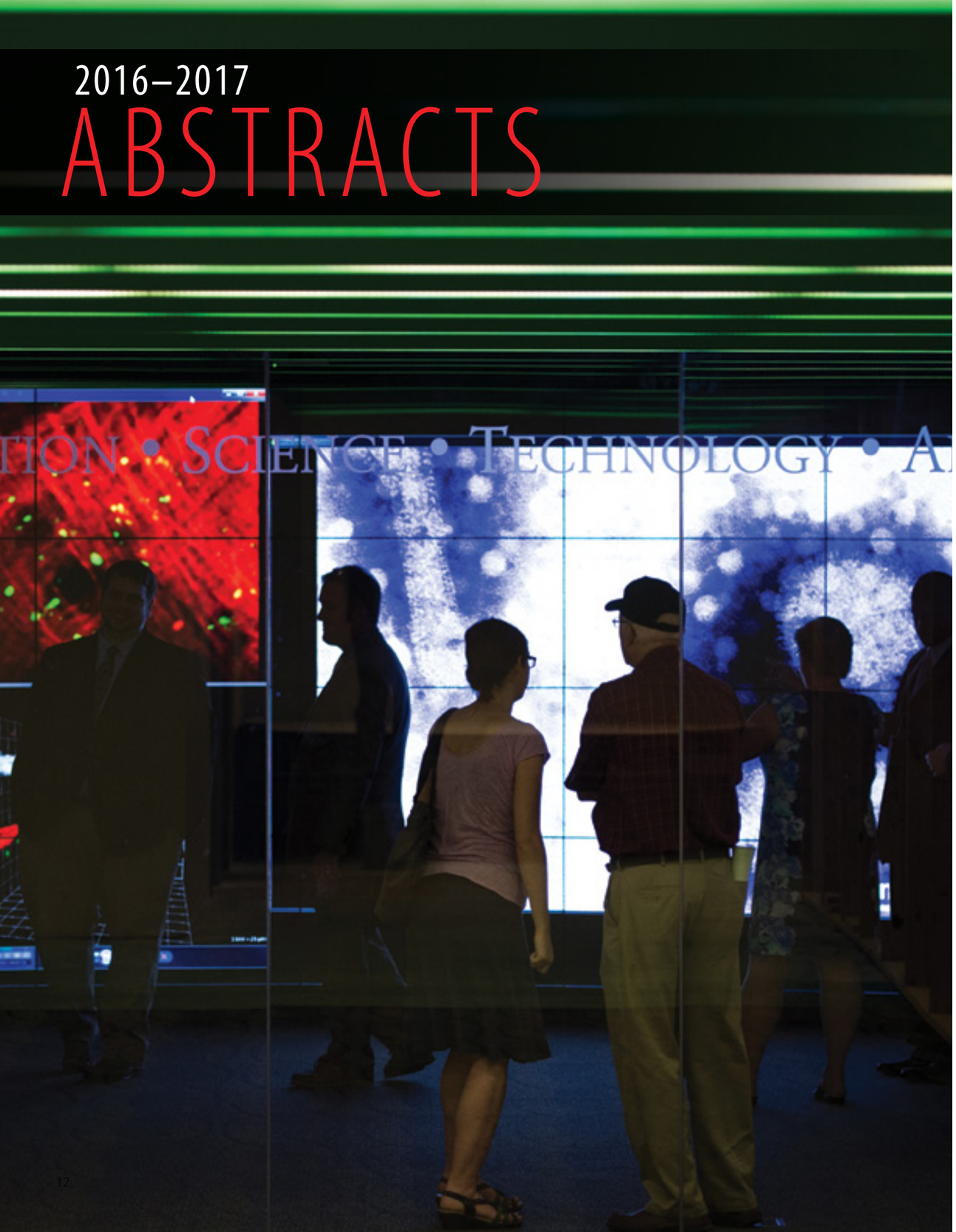
APRIL 7, 2016

More than 200 people attended the 17th-annual CEIS Technology Showcase. Walt Johnson of Xerox PARC and Mikael Totterman of Clerio Vision, Inc. were the featured speakers. Mark Mayton of Flint Creek Resources was recognized for his work.

MAY 2, 2016

SiMPore and the University of Rochester were awarded a National Science Foundation grant for almost $200,000. SiMPore hopes to make affordable sensors that can be used in biometric health screenings, hazard detection, and chemical quality control.

SiMPore Inc.
Precision Membrane Technologies



2016–2017 PROJECT ABSTRACTS

Accelerating Optical Biosensor Development with Polymer Microgels
Benjamin Miller
University of Rochester
Adarza BioSystems, Inc.

Adarza BioSystems, a company with research and development headquarters in Henrietta, New York, and manufacturing operations in St. Peters, Missouri, is commercializing Arrayed Imaging Reflectometry (AIR), an optical biosensor platform that enables detection of up to hundreds of analytes in a biological sample (such as a drop of blood) using a simple work flow. This proposal seeks to address a significant challenge in Adarza's product development and manufacturing by testing the utility of antibody-conjugated polymer microgel particles on the AIR platform. We anticipate these will dramatically simplify the development process and provide substantial performance enhancements.

Mathematical Model and Computer Simulation of the Motion of a Contact Lens During and After a Blink
David Ross and Kara Maki
Rochester Institute of Technology
Bausch & Lomb

In recent work supported by Bausch & Lomb, we developed a model of the suction pressure induced in the tear film by a symmetric contact lens conformed to a rigid, symmetric eye. Here we will extend that work and model the motion of an asymmetric lens that is displaced by a blink and which resettles under the influence of shear stresses produced by gradients in the suction pressure. We will produce a code in collaboration with Bausch & Lomb engineers that can be used in development and design work.

Adaptive optics bench testing for presbyopia-correcting contact lenses
Geunyoung Yoon
University of Rochester
Bausch & Lomb

Presbyopia is a visual condition that all adults over the age of approximately 40 years face. Individuals with presbyopia lose the ability to focus on nearby objects, which significantly impacts quality of life. Although extending depth of focus via a multifocal contact lens to overcome presbyopia is increasingly popular, clinical outcomes with these lenses are variable and often unpredictable. A better understanding of the role of practical factors when a multifocal lens is on the corneal surface improves our ability to predict its performance. The project is aimed towards the evaluation of through-focus performance of multifocal contact lens designs in which these realistic factors are simulated by using an adaptive optics bench testing system.

Compressive Beamforming for Portable Ultrasound
Zeljko Ignjatovic
University of Rochester
Carestream Health, Inc.

We propose a Compressive Parallel-Beamforming ultrasound imaging method that is a dramatic departure from conventional approaches and has the potential to disrupt the state-of-the-art in ultrasound imaging. Rather than using an expensive linear array with hundreds of transducer elements and associated electronics, the new method eliminates the expensive electronic components (amplifiers, A/D and D/A converters) connected to each element of the array and replaces them with a single channel that is shared by the entire array to significantly reduce array complexity and allow genuinely portable implementations. The proposed system uses unfocused imaging of the target medium via a binary-coded aperture, which gives much improved spatial resolution and reduces the sidelobe artifacts commonly seen in traditional ultrasound systems and allows a significant speedup of image acquisition. This method could have a profound impact on health and quality of life for humans by providing a compact, portable, and easy-to-use ultrasound imaging system with improved performance.

Towards Automated Clinical Evaluation of Tendon through Shear Wave Elastography
Stephen McAleavey
University of Rochester
Carestream Health, Inc.

Musculoskeletal (MSK) conditions, including rotator cuff and ACL injuries, are the leading cause of disability in the United States. The realignment of health care delivery in the United States toward "accountable care" necessitates the development of effective yet low-cost methods to diagnose MSK conditions. Ultrasound shear wave elastography (USWE) is a promising technology with high potential to address this need, but existing implementations are challenged in their ability to characterize a tendon. Building on our expertise in USWE and tendon biomechanics, we will experimentally measure shear wave propagation in a tendon, characterize the interaction of tendon, bone, and ultrasound, and develop a tendon-appropriate USWE implementation.

Plane Wave and Elastographic Imaging of AAA and Carotid Arteries
Michael Richards
University of Rochester
Carestream Health, Inc.

The overall goal of the proposed research is to improve the patient-specific assessment of the pathological severity associated with the onset of cardiovascular disease such as aneurysm and atherosclerosis. The recent development of clinical ultrasound (US) based tissue mechanical property measurements (e.g., elastography) has motivated the use of these technologies to measure the spatial variations in in-vivo vascular mechanical properties in real time or pseudo real time. The patient-specific information gathered in a diagnostic or screening mode can be then used to improve treatment recommendations for a variety of life-threatening vascular diseases.

2016–2017 PROJECT ABSTRACTS

Visual Acuity of Clinically Relevant Refractive Correctors Using LIRIC
Jonathan Ellis
University of Rochester
Clerio Vision, Inc.

Our long-term goal is to use femtosecond micromachining to customize refractive corrections in human eyes, be it in the cornea, contact lenses, or implanted IOLs. This requires high-numerical aperture (NA) lenses (>0.6), placing severe limits on optical scanning. We have used previous CEIS support to develop a scalable manufacturing platform for manufacturing clinically relevant refractive devices. Our goal now is to use this platform to build arbitrary refractive corrections in contact lenses and assess the visual acuity of the refractive correction.

Modeling and Optimizing the LIRIC Writing Process
Paul D. Funkenbusch
University of Rochester
Clerio Vision, Inc.

LIRIC is a multiphoton absorption process that is used to locally change the refractive index of cornea tissue and hydrogels. The LIRIC process requires a high-numerical aperture beam with a known optical quality that is scanned rapidly through the material. This process depends on numerous parameters, including NA, beam quality, pulse width, laser repetition rate, focal spot velocity, and material properties. This project will establish a framework model of the LIRIC writing process and design experiments to determine the coupling between parameters. The overall objective is to optimize the LIRIC process for both hydrogel and cornea tissue applications.

Biological Impact of LIRIC in the Cornea (continuation)
Krystel Huxlin
University of Rochester
Clerio Vision, Inc.

We are now in advanced stages of developing femtosecond micromachining as a nondamaging method of custom correcting refractive error in humans. To date, all our pilot experiments have been performed in hydrogels and cat corneas. The proposed experiments will test the relative efficacy of different laser wavelengths with and without doping in cat cornea and contrast the relative efficacy of refractive index modifications in cat and human corneas. These experiments are critical for establishing parameters that will be used in our first in-human trials of this technology.

Polarization-Time-Space Multiplexer for Femtosecond Micromachining of Ophthalmic Devices
Wayne Knox
University of Rochester
Clerio Vision, Inc.

Our ultimate goal is to use femtosecond micromachining as a nondamaging method of custom correcting refractive error in human cornea and intra-ocular lenses (IOLs). The proposed experiments will investigate new methods of writing high-density line patterns faster using a new polarization time-space multiplexer.

Computer Modeling of Telecom Signals in Multimode Optical Fibers
Govind P. Agrawal
University of Rochester
Corning, Inc.

In this project, my research group will work with Dr. William Wood of Corning, Inc. to develop a comprehensive computer model for studying transmission of optical pulses through multicore and/or multimode fibers capable of supporting several optical modes. A computer model will be developed in stages and tested through experimental verification whenever possible. This work is important to Corning because multimode and multicore fibers are likely to be used in the near future for implementing the technique of space-division multiplexing.

Light Diffusing Fiber as a Disinfectant or Antimicrobial Agent
Paul M. Dunman
University of Rochester
Corning, Inc.

Antibiotic resistance has emerged as a major health care concern that has compromised common medical procedures, resulted in enormous monetary costs, and yielded unacceptable rates of morbidity and mortality. In response, the World Health Organization (WHO) has urgently called for the development of new antimicrobial approaches, warning that the population is facing a return to the pre-antibiotic era, in which patients will succumb to common bacterial infections, and therapeutic interventions that limit the patient immune status will be severely impacted (i.e., organ transplant and cancer). To that end, the application of high-intensity violet light ($\lambda = 405$ nm) is an exciting and newly appreciated approach to mitigate bacterial disease that is distinct from ultra-violet treatment and has far-reaching applications. The current proposal is designed to investigate the antimicrobial therapeutic utility of a newly developed Corning, Inc. product, Light Diffusing Fiber, as an antimicrobial $\lambda = 405$ nm delivery vector.

Hyperspectral imaging for noninvasive, comprehensive measurement of microvascular function in humans
Anthony P. Pietropaoli
University of Rochester
Corning, Inc.

The purpose of this project is to determine whether hyperspectral imaging is capable of noninvasively quantifying microvascular blood flow, microvascular reserve, tissue respiration, and vascular permeability in healthy human subjects. Hyperspectral imaging has the potential to overcome current barriers to practical, precise, comprehensive, and noninvasive measurements of microvascular function. If so, this technology could provide an innovative window into the common and deadly microcirculatory derangements that occur in patients with sepsis and other acute and chronic illnesses. The business applications would include job growth and increased revenue at Corning Incorporated during the invention, design, and commercialization of this novel technology for biomedical applications.

Support for Distributed Computing and Network Management in Mobile Ad Hoc Networks
Wendi Heinzelman
University of Rochester
Harris Corporation

Performing communication and computation in an ad hoc network of mobile devices is challenging yet critical for next-generation military networks. Not only must we ensure that data can be securely communicated where it is needed, when it is needed, even in the face of network dynamics, but we must also ensure that computation can be accomplished quickly using available resources within the network. The goal of this research is to optimize and secure the formation and evolution of a robust network to support communication and computation within a mobile ad hoc network environment.

Further Development of THz Imager Array in Support of Harris's Commercial THz Imaging Development
Zeljko Ignjatovic
University of Rochester
Harris Space and Intelligence Systems

Our group at the University of Rochester proposes to conduct a variety of THz measurements and parameter characterization and develop design methodologies for THz focal plane arrays in standard CMOS technologies in support of Harris' (formerly ITT Exelis, Inc.) THz imaging initiative. Preliminary experimental results indicate that our technology shows a great deal of promise in detecting THz radiation up to 2 THz with responsivities that far exceed that of more expensive and less scalable pyroelectric detectors. During 2016–17 academic year, we will begin tests on the fourth generation of our CMOS THz prototype imagers designed and fabricated during the 2015–16 project period. The results of this analysis will be used to model and optimize noise performance of our THz focal plane array, which will be fabricated and tested subsequently. In addition, we will explore the use of our direct detection method in CMOS based on thermionic emission for long-infrared imaging.

THz Modeling and Testing
Zoran Ninkov
Rochester Institute of Technology
Harris Space and Intelligence Systems

A group consisting of Harris engineers, Rochester Institute of Technology scientists, and University of Rochester engineers and scientists have designed and manufactured a room-temperature silicon imager that is able to detect THz radiation. In order to optimize the devices, a variety of pixel architectures using various design dimensions, including with and without antennas, has been designed, fabricated, and tested. The RIT group from the Chester F. Carlson Center for Imaging Science has developed a testing system for terahertz single-pixel characterization. This effort will ultimately determine the ideal pixel structure and configuration for optimal THz response that will then enable a commercial imaging array design to move forward. A custom low-noise enclosure and cabling setup, along with a low-noise preamplifier, performs MOSFET voltage and current sweeps for transconductance, channel conductance and resistance measurements, and terahertz radiation responsivity.

A tunable, multiplied Gunn diode is the current primary radiation source for testing, with plans to move toward a tunable source with multiple bands from 0.1 to 1.0 terahertz. The ultimate goal of this multiyear effort is to build a (near) room-temperature, compact THz imaging system that our sponsor (Harris) can market to commercial (e.g., package inspection, crowd monitoring) and military (e.g., on aerial drones) customers.

2016–2017 PROJECT ABSTRACTS

Further Studies and Development of THz Detector Arrays
Judith Pipher
University of Rochester
Harris Space and Intelligence Systems

This project aims to continue development of THz detector arrays to be used in cameras for security and surveillance applications for stand-off distance threat detection, package inspection, medical imaging applications, and material testing, and to extend performance to the infrared (~10–15 μm). Our lab has designed the enclosures (vacuum-tight, cold) and has constructed and operates an array controller that can be programmed for each generation of array. Each generation has exhibited improvements derived from experimental results from the prior generation. Each generation focal plane (for past and future arrays which are not all-digital) requires changes to clocking and biasing, and our lab executes those programs; we can also address single pixels with our array controller design. We continue to support RIT colleagues with their needs—e.g., designing and constructing fanout boards, helping with thermoelectric coolers, consulting on radiometry. This year we will concentrate on completing the generation 3 testing and will work in tandem with the RIT group on testing of the various THz test structures, as well as verifying performance of the IR test structures. Once an IR focal plane is produced, we will work on that.

Smart Sensor for Classical and Quantum Data Links
Roman Sobolewski
University of Rochester
HYPRES, Inc.

The objective of the project is to explore the possibilities to develop the "smart sensor"—the superconducting nanowire single photon detector (SNSPD) integrated with Josephson junction based mixed-signal circuits to provide readout, tuning, and control of the detector. This digitally assisted sensor will have performance characteristics far surpassing those of the traditional analog SNSPDs and will unlock straightforward scalability to larger SNSPD arrays. We will target high-value applications in quantum networks for quantum information applications, including high-data-rate quantum key distribution. Our smart sensor will also find many applications in classical data channels for energy-efficient computing, LIDAR, and laser communications.

Global Surveillance Augmentation for Deep Learning
Andreas Savakis
Rochester Institute of Technology
Kitware, Inc.

In this project we plan to explore deep learning in algorithms for global surveillance applications, including object detection and change detection in satellite images. Our first goal is to train deep convolutional neural networks (DCNNs) for the detection of important object classes in panchromatic and color satellite imagery. To accomplish this goal, we will generate a dataset of augmented data that is sufficiently large and diverse for training DCNNs. Another goal is to develop change detection algorithms that identify important changes in satellite imagery taken at different times

Determination of the Attributes of Aesthetically Pleasing Images and Methods to Improve Consumer Images to Make Them More Aesthetically Pleasing
David Messinger
Rochester Institute of Technology
Kodak Alaris

Kodak Alaris has selected RIT to conduct research to develop image-processing algorithms for improvement of consumer images through application of certain heuristics to make the images more aesthetically pleasing. Kodak Alaris will use these algorithms in their software to assist in the creation of imaging products that consumers find more appealing and pleasing.

Video Analysis and Summarization Research
Carl Salvaggio
Rochester Institute of Technology
Kodak Alaris

The goal of the research will be to propose and validate a unified Video Analytics Framework for automatically processing, analyzing, segmenting, and summarizing "unstructured" and "unrestricted" consumer videos published to the Internet (YouTube, Facebook, etc.). This research will also investigate and prototype new video and multimedia applications using the proposed framework and related algorithms developed.

Nondestructive/noninvasive three-dimensional imaging with Gabor-domain optical coherence microscopy
Jannick Rolland
University of Rochester
LighTopTech Corporation

Real-time, high-resolution nondestructive inspection methods are needed to characterize materials, including plastics, glass and human tissue, through their depth. Fast, accurate metrology brings value to the manufacturing industry by improving quality, increasing productivity, and reducing costs. This project will advance the development of a Gabor-domain optical coherence microscopy (GD-OCM) instrument, the Explorer4D™, to qualify materials in the manufacturing process. Hardware and software tools will be developed for fast, nondestructive metrology of contact lenses in manufacturing. GD-OCM will be applied to on-line, automated characterization of contact lenses.

Ultrafast Lasers for Advanced Optic/Photonics Fabrication
Jie Qiao
Rochester Institute of Technology
OptiPro Systems

This project develops an ultrafast laser-based polishing technology to enable the fabrication of freeform and integrated optics for sensing and imaging. This project will integrate a femtosecond laser with a high-speed beam-scanning system and investigate the optimum laser processing parameters via numerical modeling and experimental verifications.

High-Power, Low-Cost CO_2 Laser for Laser-Enhanced Pyrolysis
John Marciante
University of Rochester
Solid Cell

Laser-enhanced pyrolysis has recently been demonstrated to provide a substantial energy and cost savings over the conventional heat-only production method for generating olefin from shale gas (specifically, converting ethane into ethylene). To reap this cost benefit and enable a new market for otherwise wasted (burned) ethane at the refineries, high-power lasers must be realized at low cost, in direct opposition to the common trend. The goals of this program are to (a) develop a prototype laser system assembled from low-cost components, and (b) apply the laser system to Solid Cell's pyrolysis reactor to demonstrate the scalability of the low-cost approach.

Multimodal Displays: Sight, Sound, and Touch for Personal Computing Devices
Mark Bocko
University of Rochester
Synaptics, Inc.

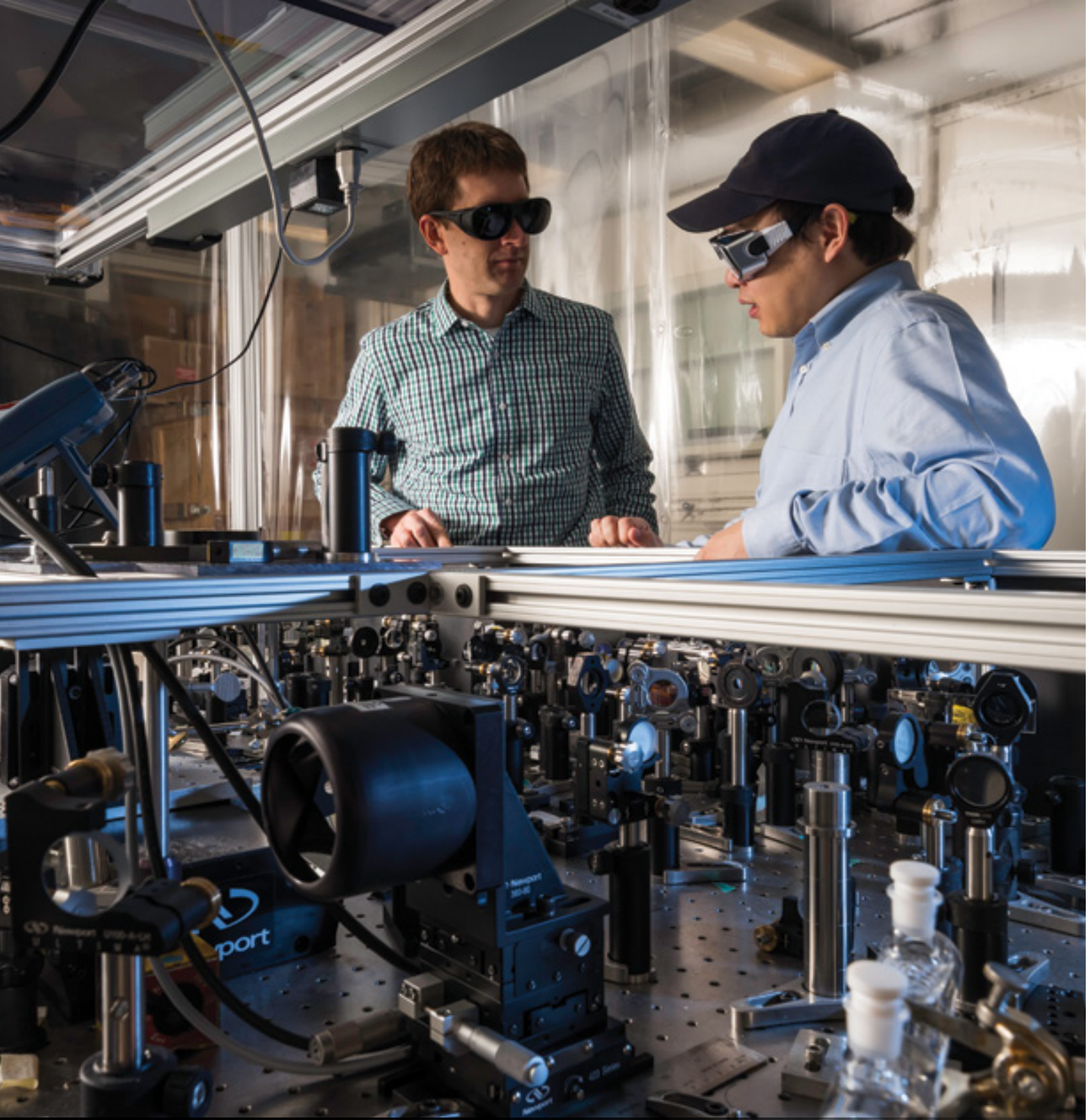
In this collaborative project with Synaptics Incorporated, we will employ flat panel audio and haptic (touch feedback) technology developed at the University of Rochester to create integrated multimodal displays that provide users with visual, sound, and touch interfaces in handheld devices. The research plan is focused on developing low-cost piezoelectric force exciter arrays and the necessary control electronics for integration with ultra-thin OLED displays in smartphones and other handheld intelligent devices.

Enhancing the UV/VUV sensitivity of CMOS Image Sensors
Zoran Ninkov
Rochester Institute of Technology
Thermo Fisher Scientific

This project continues our effort to improve the UV/VUV/X-ray sensitivity of CMOS image sensors by coating the arrays with quantum dots (QD) that fluoresce at visible wavelengths. This year's work will proceed with developing the techniques to utilize aerosol jet deposition of commercially produced quantum dots onto CMOS detector arrays supplied by Thermo Fisher Scientific. In order for Thermo Fisher to proceed with the plans for commercialization, two key measurements are required. These tests are (a) radiation testing of the CMOS and (b) deep UV/VUV/X-ray absolute sensitivity measurements of the QD-coated devices. If these two tests are positive, these devices would see widespread application in the markets served by Thermo Fisher Scientific, namely UV/VUV/X-ray spectroscopy and radiation hard applications. We will be conducting the two tests at (a) the NIST SURF III Cyclotron Facility in Gaithersburg, Maryland, and (b) the Texas A&M Cyclotron. One exciting commercial application for these devices is to build an X-ray spectrometer on a CMOS chip where discrete areas of the chip are coated with different-sized quantum dots that have a cross-section for fluorescence tuned to specific X-ray wavelengths. NASA has already expressed interest in such devices to enable the use of miniaturized X-ray detecting spacecraft.

Skin Lesion Morphology Characterization and Disease Classification
Jiebo Luo
University of Rochester
VisualDx

In this study, we investigate a novel approach to greatly improve skin disease diagnosis. A direct approach is to target the ground truth disease labels, while an alternative approach instead focuses on determining skin lesion characteristics that are more visually consistent and discernible. We hypothesize that, for computer-aided skin disease diagnosis, it is both more realistic and more useful that lesion morphology tags should be considered as the target of an automated diagnosis system such that the system can first achieve a high accuracy in describing skin lesions and in turn facilitate disease diagnosis using lesion characteristics in conjunction with other evidences. To further meet such an objective, we propose to employ the state-of-the-art multilabel convolutional neutral networks (ML-CNN) for machine learning. To ensure that the system will be robust for data from diverse clinical sources, we propose to build a large-scale and diverse dataset with detailed annotations at both image and lesion levels in collaboration with VisualDx. The developed algorithms will be integrated with the existing VisualDx system to validate the benefit of automatic skin image analysis.



2015–2016 ABSTRACTS

2015–2016 PROJECT ABSTRACTS

Exploring Advanced Image Processing and Segmentation Tools for Patient-Specific Anatomical Modeling and 3D Printing for Advanced Therapy Planning, Simulation and Guidance

Cristian A. Linte, PhD
Rochester Institute of Technology
Carestream Health, Inc.

We propose the development of methods to extract anatomical objects from CT data sets and translate them into 3D printed replicas for use in orthopedic applications. A life-size model that is specific to the patient allows for pre-procedural simulation, training, and practice (i.e., visual inspection of the anatomy and how a surgical intervention will proceed), leading to superior treatment planning and better patient outcomes. The availability of life-size models of patient-specific anatomy will also represent a significant training component, enabling students, trainees, residents, and fellows to conduct and practice emulating procedures on realistic anatomic models. Lastly, the project will also investigate the development of methods to translate CT data directly into 3D printed models without the need for an intermediate file data format, thereby reducing artifacts and other unintended challenges.

Pathway towards in-vivo IRIS: Femtosecond micromachining system for writing refractive corrections

Jonathan Ellis
University of Rochester
Clerio Vision, Inc.

Our long-term goal is to use femtosecond micromachining to customize refractive corrections in human eyes, be it in the cornea, contact lenses, or implanted IOLs. This requires high-numerical-aperture (NA) lenses (>0.6), placing severe limits on optical scanning. To achieve high throughput either for manufacturing or clinical applications, high-speed scanning over a 6.5 mm field is needed with synchronized laser intensity control and applanation to the patient/material. Our goal is to develop an optical scanner capable of micromachining with high NA lenses in <5 minutes over a large area and with intensity modulation. These properties together are necessary for writing customized corrective structures for ophthalmic applications.

Pathway towards in-vivo LIRIC: Modeling and Optimizing the LIRIC Writing Process

Paul D. Funkenbusch
University of Rochester
Clerio Vision, Inc.

LIRIC is a multi-photon absorption process that is used to locally change the refractive index of cornea tissue and hydrogels. The LIRIC process requires a high-numerical-aperture beam with a known optical quality that is scanned rapidly through the material. This process depends on numerous parameters, including NA, beam quality, pulse width, laser repetition rate, focal spot velocity, and material properties. This project will establish a framework model of the LIRIC writing process and design experiments to determine the coupling between parameters. The overall objective is to optimize the LIRIC process for both hydrogel and cornea tissue applications.

Biological Impact of Blue-IRIS in the Cornea

Krystel Huxlin
University of Rochester
Clerio Vision, Inc.

Our long-term goal is to use femtosecond micromachining as a nondamaging method of custom-correcting refractive error in humans. The proposed experiments focus on corneal applications of this technology and will assess the biological and biomechanical impact of inscribed patterns in cat corneas. These experiments are critical to establish parameters that impact optical outcomes of this laser refractive procedure, which is being proposed for use in human patients.

Scalable Fiber Lasers for Optimized Femtosecond Micromachining of Ophthalmic Materials

Wayne Knox
University of Rochester
Clerio Vision, Inc.

Our long-term goal is to use femtosecond micromachining as a nondamaging method of custom correcting refractive error in humans. The proposed experiments will investigate which femtosecond laser conditions are optimum for writing refractive index changes into hydrogels and cornea. We will use current lasers and also build new scalable fiber lasers to investigate new conditions in order to find optimum laser parameters. In particular, we will investigate effects of doping on the 1030 nm wavelength response of hydrogels and cornea and build a repetition-rate scalable fiber laser to investigate repetition rate dependence of writing efficiency and damage thresholds.

Polycrystalline Silicon and Metal Oxide Thin Film Transistor (TFT) Development

Karl D. Hirschman
Rochester Institute of Technology
Corning, Inc.

The purpose of this project is to investigate the influence of alternative glass formulations on the electrical characteristics of fabricated TFTs and develop innovative process integration strategies. The project involves process development, device fabrication, and parameter extraction of TFTs on glass substrates prepared by Corning Incorporated. Semiconductor materials include low-temperature polycrystalline silicon (LTPS) and Indium-Gallium-Zinc-Oxide (IGZO). Glass substrates will be prepared by Corning. Device fabrication will be done at the Semiconductor & Microsystems Fabrication Laboratory (SMFL) at RIT, with certain thin-film deposition processes and treatments performed at the Corning clean room facility.

2015–2016 PROJECT ABSTRACTS

Hyperspectral imaging for non-invasive, comprehensive measurement of microvascular function in humans
Anthony P. Pietropaoli
University of Rochester
Corning, Inc.

The purpose of this project is to determine whether hyperspectral imaging is capable of noninvasively quantifying microvascular blood flow, microvascular reserve, tissue respiration, and vascular permeability in healthy human subjects. Hyperspectral imaging has the potential to overcome current barriers to practical, precise, comprehensive, and noninvasive measurements of microvascular function. If so, this technology could provide an innovative window into the common and deadly microcirculatory derangements that occur in patients with sepsis and other acute and chronic illnesses. The business applications would include job growth and increased revenue at Corning Incorporated during the invention, design, and commercialization of this novel technology for biomedical applications.

Superhydrophobic Surfaces by Laser Treatment of Metal
Chunlei Guo
University of Rochester
GE Oil & Gas

Our lab has developed a technique that makes any material permanently super water repellent (superhydrophobic) using high-powered lasers. This process is performed by scanning our laser across a material's surface to create specific micro- and nanoscale structures, causing the material to repel water. Our technology will be able to reduce scaling in down hole production pipelines. By making the walls of the pipes superhydrophobic, we will greatly reduce the contact between the water and the pipes, thus reducing or stopping the rate of halite buildup. Unlike chemically based superhydrophobic processes, our superhydrophobic process creates a permanent, physical change.

Support for Distributed Computing and Network Management in Mobile Ad Hoc Networks
Wendi Heinzelman
University of Rochester
Harris Corporation

Performing communication and computation in an ad hoc network of mobile devices is challenging yet critical for next-generation military networks. Not only must we ensure that data can be communicated where it is needed, when it is needed, we must also ensure that computation can be accomplished quickly using available resources within the network. The goal of this research is to optimize the formation, monitoring, and evolution of a robust network to support communication and computation within a mobile ad hoc network environment.

Design, fabrication and testing of a compact THz focal plane
Zeljko Ignjatovic
University of Rochester
Harris Geospatial Systems

Our group at the University of Rochester proposes to conduct a variety of THz measurements and parameter characterization and develop design methodologies for THz focal plane arrays in standard CMOS technologies in support of Harris's THz imaging initiative. The proposed work is a continuation of our current efforts with Harris. Preliminary experimental results indicate that our technology shows a great deal of promise in detecting THz radiation up to 2THz with responsivities that far exceed that of more expensive and less scalable pyroelectric detector. During the 2015–16 academic year, we will begin tests on the CMOS THz prototype imagers fabricated during 2014–15. The results of this analysis will be used to model and optimize noise performance of our THz focal plane array, which will be subsequently fabricated and tested.

THz Modeling and Testing
Zoran Ninkov
Rochester Institute of Technology
Harris Geospatial Systems

This effort will determine the ideal pixel structure and configuration for optimal responsivity, allowing the imaging array design to move forward. A custom low-noise enclosure and cabling setup, along with a source-measurement unit, performs MOSFET voltage and current sweeps for transconductance, channel conductance and resistance measurements, and terahertz radiation responsivity. A 188GHz Gunn diode is the current primary radiation source under test, with plans to move toward a tunable source with multiple bands from 0.1 to 1.0 terahertz. Results of these tests have provided input for next-generation design. This year we plan to produce a THz Imaging Prototype System that can be used by Harris for future product development.

Further Studies and Development of THz Detector Arrays
Judith Pipher
University of Rochester
Harris Geospatial Systems

This project aims to develop THz detector arrays to be used in cameras for security and surveillance applications for stand-off-distance threat detection, package inspection, medical imaging applications, and material testing. In collaboration with colleagues from the Department of Electrical and Computer Engineering at the University of Rochester, the Chester F. Carlson Center for Imaging Science at RIT, and physicists and engineers from Harris, we have made steady progress in the development, understanding of detection mechanisms, and characterization of THz arrays designed by our ECE colleague and fabricated by MOSIS. Each generation has exhibited improvements derived from experimental results on the prior generation. We expect new deliverables in July: our team will write new clock/bias/read software for the arrays and will characterize their operation.

Determination of the Attributes of Aesthetically Pleasing Images and Methods to Improve Consumer Images to Make Them More Aesthetically Pleasing
David Messinger/James Ferwerda
Rochester Institute of Technology
Kodak Alaris

The project will determine what attributes make an image "aesthetically pleasing" along with methods and heuristics used by professional photographers to create aesthetically pleasing images and use that work to develop automated methods and algorithms that can be applied to typical consumer images to make them more aesthetically pleasing. These algorithms will then be incorporated into Kodak Alaris imaging systems for creation of more pleasing products with increased sales.

Nondestructive/noninvasive three-dimensional imaging with Gabor-domain optical coherence microscopy
Jannick Rolland
University of Rochester
LighTopTech Corporation

Real-time, high-resolution nondestructive inspection methods are needed to characterize materials—including plastics, glass, and human tissue—through their depth. Fast, accurate metrology brings value to the manufacturing industry by improving quality, increasing productivity, and reducing costs. This project will advance the development of a Gabor-domain optical coherence microscopy (GD-OCM) instrument, the Explorer4D™, to qualify materials in the manufacturing process. Hardware and software tools will be developed for fast, nondestructive metrology of contact lenses in manufacturing. GD-OCM will be applied to on-line, automated characterization of contact lenses.

Thickness estimation with Gabor-domain optical coherence microscopy
Jannick Rolland
University of Rochester
LighTopTech Corporation

This project will explore the applicability of a Gabor-domain optical coherence microscopy (GD-OCM) instrument to quantify the sub-micrometer thickness of layers within the stratum corneum of skin with nanometer precision. Numerical tools will be developed to implement a maximum-likelihood unbiased estimator for thickness and number of layers estimation of subcomponents making the stratum corneum.

Continued Development of Portable, Low-cost Wavefront Sensors on Human Subjects
Tara Vaz
University of Rochester
Ovitz Corporation

Ovitz Corporation is a small startup developing a portable ocular medical device with combined wavefront sensor and keratometer. They have tested the device extensively in simulated laboratory settings but have had limited access to human subjects. The University of Rochester's Flaum Eye Institute and Strong Vision Optical have both expertise in the technology and active clinics to provide controlled, ethical human testing. Small-scale testing (12 patients) has already been completed and provided important but limited inputs for design modification. A database of 300 additional measurements/eyes (150 subjects) will be created and delivered to Ovitz with wider prescription ranges and more diverse demographics for further study.

Feasibility of Bioprocess Filtration Using Large Area Ultrathin Nanomembranes
Thomas Gaborski
Rochester Institute of Technology
SiMPore, Inc.

This proposal aims to integrate ultrathin nanomembranes into conventional stirred cells and tangential flow filtration cartridges for bioprocess applications. SiMPore's unique silicon-based nanomembranes are typically fabricated on silicon wafers with relatively small active areas that limit use to unique applications and microscale laboratory separations. The development of lift-off fabrication techniques by the Gaborski laboratory is enabling larger-scale production of these membranes for biomedical applications such as hemodialysis. The goals of this proposal are to determine the feasibility of using this new class of ultrathin membranes for biomolecule separations and purifications typically performed in the biopharmaceutical industry.

Nanomembranes for Artificial Lungs
James McGrath
University of Rochester
SiMPore, Inc.

An estimated 30 million Americans now live with chronic obstructive pulmonary diseases (COPD) such as emphysema and chronic bronchitis. While artificial hearts have revolutionized the treatment of patients with heart failure, artificial lungs have lagged far behind because of a technical inability to build systems with the efficiency of the natural lung. This exploratory project will examine the ability of SiMPore's high-permeability membranes to revolutionize artificial lung technology. We are developing MEMs devices featuring SiMPore's membranes and will test the membranes for efficient gas exchange and hemocompatibility. Devices will be scaled to prepare for small-animal experiments.

2015–2016 PROJECT ABSTRACTS

Enhancing the UV/VUV sensitivity of CMOS Image Sensors
Zoran Ninkov
Rochester Institute of Technology
Thermo Fisher Scientific

This project continues our effort to improve the UV/VUV sensitivity of CMOS image sensors by coating the arrays with quantum dots (QD). This year's work will proceed with detailed testing of the devices that are now routinely coated with QD. In order for Thermo Fisher to proceed with the plans for commercialization, two key measurements are required. These tests are (a) radiation testing of the CMOS and (b) deep UV/VUV absolute sensitivity measurements. If these two tests are positive, these devices would see widespread application in the markets served by Thermo Fisher Scientific, namely UV/VUV spectroscopy and radiation hard applications. We will be conducting the two tests at (a) the NIST SURF III Cyclotron Facility in Gaithersburg, Maryland, and (b) the Texas A&M Cyclotron.

Multi-view 3D Displays with no head-worn component
John Howell
University of Rochester
UR Ventures Technology Development Fund

We propose to build a high-brightness and portable volumetric display and a virtual window, a multiviewer continuous-view flat panel stereoscopic display. Both systems use technology that obviates the use of head-worn components required by multiviewer traditional 3D displays.

Fiber Laser for Display Applications
John Marciante
University of Rochester
UR Ventures Technology Development Fund/Toptica Photonics Inc.

We have recently developed a technique to obtain high-efficiency direct lasing at green wavelengths in a fiber laser without the use of inefficient and expensive nonlinear frequency conversion crystals. The challenges associated with this concept require the balance of multiple physical phenomena and the design of a unique optical fiber. In this program, the unique fiber will be procured and tested. A laser cavity will be built using this fiber, and efficient green laser emission will be demonstrated for the first time in a fiber laser.

CORPORATE PARTNERS

CORPORATE PARTNERS

ADARZA BIOSYSTEMS, INC.
www.adarzabio.com

Adarza BioSystems Inc. is an early-stage medical diagnostics company developing a rapid and label-free biological assay platform for measuring clinical and point-of-care (POC) samples. In addition to performing sophisticated clinical tests within minutes, this technology is fully arrayable, potentially allowing hundreds of tests to be run simultaneously on a single chip. Adarza's propriety chip-based platform, Arrayed Imaging Reflectometry (AIR), achieves high sensitivity by detecting intensity changes in images of antireflective chips functionalized with highly specified detection molecules (proteins, DNA, etc.).

BAUSCH AND LOMB
www.bausch.com

Bausch and Lomb offers one of the world's most comprehensive portfolios of eye health products. B+L markets five broad categories of products: contact lenses, lens care, pharmaceuticals, cataract and vitreoretinal surgery, and refractive surgery.

CALIBER I.D.
www.caliberid.com

New York State–based Caliber Imaging & Diagnostics (formerly Lucid Inc.) is a medical technologies company that designs, develops, and markets innovative imaging solutions that shows tissue at the cellular level. Caliber I.D. Inc. is currently the only company in the world to offer in vivo confocal microscopes designed specifically for imaging skin and other tissue. Caliber I.D.'s Rapid Cell ID technology enables scientists and physicians to characterize intact normal and abnormal cellular architecture that is otherwise invisible to the naked eye.

CARESTREAM
www.carestream.com

Carestream is a dynamic global company with more than 100 years of leadership. In today's rapidly changing global health care environment, where the mandate to provide better outcomes has never been greater, we add value by delivering personalized, affordable, and practical options to help our customers advance. Medical providers large and small, from clinics and single hospitals to large networks and even entire countries, are upgrading their radiology and IT systems using our latest solutions.

CLERIO VISION
www.cleriovision.com

Clerio Vision is developing a novel vision correction procedure based on technology licensed from the University of Rochester. Instead of changing the shape of the cornea, as current LASIK-based approaches do, its approach is to use a femtosecond laser to change the refractive index of the cornea with small pulses to "write" a corrective prescription onto the cornea non-invasively. Because this approach doesn't thin the cornea, it can be repeated as needed to correct vision changes over a person's lifetime. The approach, called LIRIC, is being commercialized by some of the original architects of the world's first LASIK systems. Clerio's core technology has been in development for over a decade and is based on more than 40 issued and pending patents. Currently more than 150 million individuals in the United States alone require some form of vision correction.

CORNING INC.
www.corning.com

Corning Inc. is a diversified technology company that develops breakthrough technologies that significantly improve people's lives. Corning pursues innovation and focuses on high-impact growth opportunities in the telecommunications, flat panel display, environmental, life sciences, and semiconductor industries.

FLINT CREEK RESOURCES
www.flintcr.com

Flint Creek Resources is a unique company that offers services to make your used rare earth and zirconia glass polishing compounds better than new. Spent polishing compounds are processed through a proprietary system that removes glass, polishing pad fragments, and contamination from the slurry. The resulting clean polishing particles are then custom formulated to produce excellent stock removal, surface finish, suspension, and cleanability.

FLUXDATA, INC.
www.fluxdata.com

FluxData develops and manufactures multispectral and polarimetric imaging systems for aerospace, defense, industrial, medical, and scientific markets. FluxData is a privately held, women-owned company located in Rochester, New York. FluxData's imaging and system integration expertise helps guide customers from camera specification to delivery of the final system. Our staff of imaging experts work with customers to frame problems and deliver optimized systems based on a broad suite of options. Every product comes with FluxData's commitment to first-rate customer support.

GE OIL & GAS
www.geoilandgas.com

As the world's first digital industrial company, GE is transforming energy markets with software-defined machines and solutions that are connected, responsive, and predictive—bringing speed, scale, and greater insight to our oil and gas customers. And with the best minds and machines, we're reducing equipment downtime, optimizing assets, and building new partnership models for the sector.

It will take more energy, ingenuity, and trust to fulfill our aspirations for the future. And GE Oil & Gas is ready to do its part. We've been an industry leader through constantly evolving energy sector dynamics and increasingly complex infrastructure challenges across the globe for more than 120 years.

We understand the entire energy value chain and know that oil and gas will continue to play a critical role. That's why our technologies extract, transport, and refine oil and gas with productivity and the environment in mind

HARRIS CORPORATION
www.harris.com

Harris provides advanced, technology-based solutions that solve government and commercial customers' mission critical challenges. The company has approximately $8 billion in annual revenue and about 23,000 employees—including 9,000 engineers and scientists—supporting customers in more than 125 countries. Harris Corporation is a top-10 defense contractor providing mission-critical solutions through its Communication Systems, Critical Networks, Electronic Systems, and Space and Intelligence Systems segments.

CORPORATE PARTNERS

HYPRES, INC.
www.hypres.com

Hypres Inc. manufactures superconducting microelectronics, including superconducting Integrated Circuits (ICs). Its products include voltage standard circuits and systems, wide bandwidth semiconductor-based amplifiers, and superconducting circuit foundry service. The company was founded in 1983 and is based in Elmsford, New York.

KITWARE
www.kitware.com

Kitware Inc. is a leader in the creation and support of open-source software and state of the art technology. Through our long-standing commitment to open source, detailed in our open source mission statement, we have become one of the fastest growing software companies in the country. By fostering extended, collaborative communities, Kitware is able to provide flexible, cost-effective visualization, computer vision, medical imaging, data publishing, and quality software process solutions to a variety of academic and government institutions and private corporations worldwide.

KODAK ALARIS
www.kodakalaris.com/en-us

We're a new company born from one of the world's most iconic brands. A company that is passionate about using technology to transform organizations and improve people's lives across the planet. From our digital scanners and intelligent state-of-the-art software services that power some of the world's largest companies to our photographic paper production, printing kiosks and suite of consumer apps that help people capture and connect with the emotional moments that define all our lives. We're on a mission to unlock the power of images and information for the world. We work behind the scenes, making the connections, pushing the boundaries of technology, and helping you to make sense of and exploit the ever-expanding volume of data that is the hallmark of the 21st century.

LIGHTOPTECH
www.lightoptech.com

LighTopTech Corp., founded in 2013, is a women-owned optical technology company based in Rochester, New York. Our goal is to build innovative optical instruments to improve noninvasive imaging in medical and manufacturing fields.

OPTIPRO SYSTEMS LLC
www.optipro.com

OptiPro was founded on one revolutionary, yet simple, concept: optical fabricators deserve more. In the past 30 years, since we introduced the first affordable CNC machine designed specifically for the optics industry, we have consistently built a culture that cares— a culture of employees who live and breathe by our strong OptiPro values and a culture of best-in-breed customers who are collectively on a relentless pursuit of process efficiencies, design improvements, capability enhancements, and marketplace superiority.

OVITZ
www.o-vitz.com

Ovitz is an exciting medical device company specializing in developing, manufacturing, and marketing novel and portable ophthalmic equipment and accessories that facilitate the delivery of ophthalmic care in eye doctors' and primary care physicians' offices and in schools, rural areas, and developing nations.

SIMPORE INC.
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SiMPore is a Rochester, New York–based nanotechnology company that designs and produces membranes and membrane-enabled products based on its unique patent-pending platform technology—the NanoBarrier™ ultrathin nanoporous silicon membrane. The NanoBarrier™ membrane is the world's first membrane to offer both tunable nanometer-scale thickness and pore size. SiMPore is developing products that take advantage of these one-of-a-kind features, including filters for separating and concentrating biological molecules and nanoparticles, cell culture substrates for growing cells, and electron microscopy grids for preparing and imaging samples at the nanoscale.

SOLID CELL
www.solidcell.com

Solid Cell is a developer of stationary and portable solid-oxide fuel cell technologies for residential, commercial, industrial, and other critical off-grid applications. The company's headquarters are located in New York City. Solid Cell's principal product development and manufacturing center is in Rochester, New York. Solid Cell also supports R&D activities at research institutions in the cities of Novosibirsk and Yekaterinburg, Russia, where the company's proprietary fuel cell technology was originally developed and where research continues on next-generation fuel cell technologies. The company's European subsidiary is based in Dublin, Ireland, with further expansion in Europe planned in the near term.

Solid Cell's products provide clean energy using state-of-the-art fuel cell technology at commercially competitive costs. The company has targeted several specific applications to satisfy a wide variety of global power requirements. Widespread use of Solid Cell's fuel cells will reduce reliance on scarce natural resources like natural gas and oil.

SYNAPTICS INC.
www.synaptics.com

We are the pioneers and leaders of the human interface revolution, bringing innovative and intuitive user experiences to intelligent devices. From usability and R&D to supply chain and support, we collaborate with our partners to invent, build, and deliver human interface solutions that integrate seamlessly and optimize system value. The improved ease of use, functionality, and aesthetics of Synaptics-enabled products help make the digital lives of people more productive, secure, and enjoyable.

CORPORATE PARTNERS

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Thermo Fisher Scientific Inc. (NYSE: TMO) is the world leader in serving science, with revenues of $17 billion and 50,000 employees in 50 countries. Our mission is to enable our customers to make the world healthier, cleaner, and safer. We help our customers accelerate life sciences research, solve complex analytical challenges, improve patient diagnostics, and increase laboratory productivity. Through our four premier brands—Thermo Scientific, Life Technologies, Fisher Scientific, and Unity Lab Services—we offer an unmatched combination of innovative technologies, purchasing convenience, and comprehensive support.

UR VENTURES
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UR Ventures develops University of Rochester innovations into valuable products and services to make the world ever better. Technology transfer functions are mandated by federal law. Even if they weren't, we would still do it because it's the right thing to do. Not only does the transfer of technologies make the world a better place, but the revenues generated are unrestricted and support the amazing research of the future. By rewarding our inventors, we also motivate them to solve real-world problems. Finally, the relationships we create help to attract and maintain industrial support for research.

VISUALDX
www.visualdx.com

When unsure of a diagnosis, VisualDx is the go-to tool for fast, accurate decision making. Quickly build a differential to evaluate the possibilities, compare variations, and improve diagnostic accuracy at the point of care. VisualDx is the leader in clinical decision support, used in more than 1,500 hospitals and institutions and over 50 percent of U.S. medical schools. Trusted by physicians and nurses all over the world, VisualDx is utilized across several professional specialties.

XEROX CORPORATION
www.xerox.com

For more than a half a century, Xerox has been a leader in document technology and services. We continue to build on this heritage of innovation. We now are the world's leading enterprise for business process and document management, offering global services from claims reimbursement and automated toll transaction to customer care centers and HR benefits management. The new Xerox is dedicated to innovation, service, and giving our customers the freedom to focus on what matters most: your real business.

FACULTY RESEARCHERS

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Research Interests Quantum electronics, Nonlinear photonics, Fiber-optic communications

Recent Research Projects Transmission of optical pulses, Semiconductor lasers, Nonlinear fiber optics, Optical communications

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Education PhD, The Institute of Optics, University of Rochester, Optics, 1996; MS, Universidad Autonoma Metropolitana, Physics, 1990

Research Interests Propagation of waves, Connection between rays and waves, Integral transforms, Phase space representations, Uncertainty relations

Recent Research Projects Building accurate estimates of wave fields propagating based on ray information alone

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Education MD, Medicine, Italy-Fac Med U Naples, 1957; BA, Johns Hopkins University, Biological Sciences, 1952

Research Interests Ocular surface tear film, Cornea wound healing, Keratoprosthesis—artificial cornea transplantation

Recent Research Projects Ocular metrology and inflammatory mediator response to topical administration of anti-inflammatory drugs

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Research Interests Imaging microelectronics, Wireless sensors, Multimedia signal processing

Recent Research Projects Digital audio watermarking and steganography, Image sensors with built-in image compression, Digital CMOS image sensor read-out circuits

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Professor of Optics and Director, Robert E. Hopkins Center for Optical Design and Engineering, University of Rochester

Education PhD, University of Rochester, Optics, 1987; BS, Gordon College, Physics, 1979

Research Interests Optical polarization and metrology, Optoelectronic modeling, Integrated optoelectronics

Recent Research Projects Enhancing image contrast using polarization correlations, Stress engineering for polarimetry and imaging, Polarization control of optical nanostructures, Nonlinear properties of microstructured optical fibers

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Education PhD, North Carolina State University; MS, University at Buffalo

Research Interests Rapid Prototyping, Rapid Manufacturing

Recent Research Projects Cu Ink Adhesion Solutions

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Associate Professor of Medicine, Department of Cardiology, University of Rochester

Education PhD, National Institute of Applied Science (France), Biomedical Engineering, 1997; MBA, Simon Business School, Health Care Management, 2003; MS, Medical Specialties Non-Medical School (France), 1994

Research Interests Computational science and engineering, Numerical analysis, Applications of computer science in electrophysiological signaling stabilization, Refractometry, Flexure systems, Stage metrology

Recent Research Projects Noncontact video-based detector of cardiac arrhythmias

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Education PhD, University of Medicine and Dentistry-NJ (UMDNJ), Microbiology, 1999; BS, Delaware Valley College, Arts and Sciences, 1992

Research Interests Novel strategies for the therapeutic intervention of bacterial infections, Modulation of mRNA turnover

Recent Research Projects Light Diffusing Fiber as a Disinfectant or Antimicrobial Agent, Efflux pumps and inhibitors of serum-grown *Acinetobacter baumannii,* Identifying new antimicrobial agents against *Mycobacterium tuberculosis,* Terfenadine as a new *S. aureus* antibiotic

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Research Interests Linear displacement interferometry, High-power gas laser frequency stabilization, Refractometry, Flexure systems, Stage metrology

Recent Research Projects Designing and developing smart optical sensors for compact, remote displacement sensing and for multi-DOF interferometry

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Associate Professor in the Munsell Color Science Laboratory and in the Center for Imaging Science, Rochester Institute of Technology

Education PhD, Cornell University, Experimental Psychology, 1998; MS, Cornell University, Computer Graphics, 1987; BA, Cornell University, Psychology with Honors, 1980

Research Interests Computer graphics, Digital imaging, Data visualization, Visual perception, Low vision, Assistive technologies

Recent Research Projects Effects of image dynamic range on apparent surface gloss

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Professor of Mechanical Engineering and of Materials Science, University of Rochester

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Research Interests Relationships among microstructure, properties, and processing of materials

Recent Research Projects Optical Probing for Freeform Optics Metrology

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Education PhD, University of Rochester, Biomedical Engineering, 2008; MS, University of Rochester, Biomedical Engineering, 2004; BS, Cornell University, Biological and Environmental Engineering, 2002

Research Interests Nanomaterials and membrane fabrication, Microfluidics, separations, and device design, Cellular biophysics, Quantitative fluorescence imaging

Recent Research Projects Cellular co-culture screening assays

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Research Interests Femtosecond Laser-Matter Interactions at High Intensities

Recent Research Projects Superwicking cooling devices for computer CPU and microelectronics

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Research Interests Multimedia communication, Wireless sensor networks, RFID systems, Cloud computing, Heterogeneous networking

Recent Research Projects Developing RFID systems for inventory management, Designing a QoS-aware protocol architecture to support real-time multimedia data transmission, Optimizing video-based sensor networks

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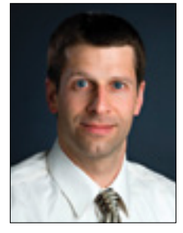

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Education PhD, University of Rochester, Electrical and Computer Engineering, 2000; MS, Rochester Institute of Technology, Electrical Engineering, 1992; BS, Rochester Institute of Technology, Microelectronic Engineering, 1990

Research Interests Silicon device integration on nontraditional substrates, Metal-oxide semiconductors for thin-film electronics, Silicon-based optoelectronics

Recent Research Projects Development and characterization of high-performance transistors on glass, Development of bipolar and MOS high-power microwave transistors

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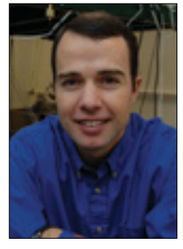

JOHN C. HOWELL

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Education PhD and MS, Pennsylvania State University, Physics, 2000; BS, Utah State University, Physics, 1995

Research Interests Quantum Optics, Quantum Physics

Recent Research Projects Experimental Quantum Optics and Quantum Information, Multi-view 3D Displays no head–worn component

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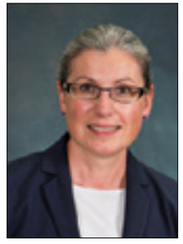
FACULTY RESEARCHERS



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Education PhD and MS, Pennsylvania State University, Physics, 2000; BS, Utah State University, Physics, 1995

Research Interests Optics of the eye, Femtosecond laser micro-machining in cornea and lens, Visual perception and psychophysics, Biomedical imaging

Recent Research Projects Femtosecond laser micromachining, Effect of corneal wound healing on physiological optics of the eye, Perceptual learning with a damaged visual system

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Education PhD, University of Rochester, Electrical and Computer Engineering, 2004; MS, University of Rochester, Electrical and Computer Engineering, 2001; BS, University of Novi Sad, Electrical Engineering and Computer Science, 1999

Research Interests A/D conversion, CMOS analog circuits, Low power circuit architectures, Image sensors

Recent Research Projects Developing and investigating focal plane compression techniques where majority of multiplication computations required by the compression are rendered unnecessary

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Education PhD, University of Rochester, The Institute of Optics, 1983; BS, University of Rochester, The Institute of Optics, 1979

Research Interests Ultrafast laser physics and prototyping, Ultra-broadband laser systems, Biomedical optics using novel ultrafast lasers, Femtosecond micromachining of polymers, Nonlinear fiber and semiconductor devices

Recent Research Projects Femtosecond micromachining of ophthalmic polymers

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Education PhD, Harvard University, Mechanical Engineering, 1984; MS, Harvard University, Applied Sciences and Mechanical Engineering, 1981; BS, Brown University, Applied Mechanics, 1980

Research Interests Describing macroscopic behavior of solids by examining underlying microstructural features; Mechanical, electrical, and/or optical affects to response of homogenous or heterogeneous materials

Recent Research Projects Optimization of optics manufacturing techniques such as deterministic microgrinding, loose abrasive lapping, Magnetorheological Finishing (MRF), and loose abrasive finishing of optical glasses and ceramics

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Education PhD, University of Western Ontario, Biomedical Engineering, 2010; MA University of Western Ontario, Biomedical Engineering, 2006; BS, University of Windsor, Mechanical and Materials Engineering, 2004

Research Interests Development, evaluation and preclinical integration of image guidance environments for surgical navigation of minimally invasive cardiac interventions

Recent Research Projects Predicting target vessel location in robot-assisted CABD interventions using feature-based CT to US registration

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Research Interests Computer vision, Machine learning, Social media data mining, Human computer interaction, Biomedical informatics, Mobile and pervasive computing, Computational photography

Recent Research Projects Fine-grained user profiling from multiple social multimedia platforms, Wine recommendation for grocery shoppers

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Assistant Professor in the School of Mathematical Sciences, Rochester Institute of Technology

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Research Interests Physical systems and industrial problems pertaining to flows of biological and complex fluids, Modeling, Ordinary and partial differential equations, Scientific Computing

Recent Research Projects Affect of contact lens distortion on exchange of tears, Model for suction pressure under a contact lens

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Education PhD, University of Rochester, 1997; MS, University of Rochester, 1992; BS, University of Illinois, 1991

Research Interests Lasers, Waveguides, Fiber Optics

Recent Research Projects Large-mode area fibers, Visible Fiber lasers, brightness semiconductor lasers, Fiber laser for display applications, High-efficiency fiber amplifiers, All-fiber optical components

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Research Interests Use of motion-tracking techniques to enhance the contrast of ultrasound images, Acoustic Radiation Force Impulse (ARFI), Magnetically induces vibration of brachytherapy seeds

Recent Research Projects Acoustic radiation force imaging techniques, Spatially Modulated Ultrasound Radiation (SMURF) imaging, Single tracking location (STL) Shear wave elastography imaging (SWEI)

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Research Interests Nanoparticle and molecular separations, Nanotechnology, MEMS and micro fabrication, Cell culture technologies

Recent Research Projects The interaction of nanoparticles with cells and protein mixtures, Ultrathin silicon-based nanomembranes for filtration of molecules and nanoparticles, Ultrathin silicon-based nanomembranes for biological co-cultures

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Education PhD, Rensselaer Polytechnic Institute, Physics, 1998; BS, Clarkson University, Physics, 1991

Research Interests Remote sensing and image exploitation, Advanced mathematical approaches for spectral image processing, Target detection in hyperspectral imagery

Recent Research Projects Spatial segmentation of multi/hyperspectral imagery by fusion of spectral-gradient textural attributes, Knowledge-Based Automated Road Network Extraction System Using Multispectral Images

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Education PhD, Stanford University, Organic Chemistry, 1994; BS, BA, Miami University, Chemistry, Mathematics, German, 1988

Research Interests Biomedical nanotechnology, Combinatorial chemistry, Biophysical methods, Biosensors

Recent Research Projects The AIR Flu Chip: A Multiplex Optical Biosensor of Influenza Serology

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ZORAN NINKOV

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Research Interests Novel 2-D CMOS detector arrays, Fundamental limitations of visible and IR arrays, Miniaturized multispectral systems

Recent Research Projects Development of novel two-dimensional detector arrays, Development of image processing techniques for optimal analysis of such two-dimensional astronomical image data

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Research Interests Internal Medicine, Pulmonary Disease, Critical Care Medicine

Recent Research Projects Protocols and Hospital Mortality in Critically Ill Patients: The United States Critical Illness and Injury Trials Group Critical Illness Outcomes Study

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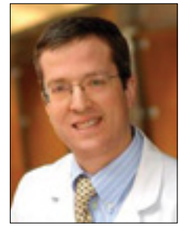

RICHARD PHIPPS

Dean's Professor of Environmental Medicine, Professor of Oncology, of Pediatrics, and of Microbiology and Immunology; Director of the Lung Biology and Disease Program, University of Rochester

Education PhD, Medical College of Virginia, Immunology, 1980; BS, Loyola College, Medical Technology, 1977

Research Interests Cellular and molecular characterization of fibroblasts, Control of normal and malignant lymphocyte activation

Recent Research Projects Ocular surface metrology and inflammatory mediator response to topical administration of anti-inflammatory drugs

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JUDITH L. PIPHER

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Education PhD, Cornell University, Astronomy, 1971; MS, Cornell University, Astronomy, 1970; BS, University of Toronto, Physics and Astronomy, 1962

Research Interests Infrared observations of star-forming regions, Infrared detector array development and applications to astronomy and to persistent surveillance

Recent Research Projects Teledyne HgCdTe 10 micron cutoff detector arrays for use in future space experiments with particular emphasis on NEOCam (Near Earth Object Camera), Characterization of Raytheon long-wavelength HgCdTe detector arrays, FIRE spectrometer development, Persistent surveillance-driven projects

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Research Interests Optical metrology, Optical instrumentations, Adaptive and active optics, Segmented large-scale optics alignment and testing, Pulse compression, ultrafast laser systems and applications, Optical system design and performance evaluation

Recent Research Projects Development and investigation of an integrated laser-based optics polishing and manufacturing technology, Laser polishing for additive manufacturing

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Education PhD, Boston University, Biomedical Engineering, 2007; MS, Boston University, Biomedical Engineering, 2007; BS, University of Rochester, Biomedical Engineering, 2001

Research Interests Biomechanics of soft tissues and measuring the change in mechanical properties of diseased tissues using clinical imaging modalities

Recent Research Projects Development, validation, and implementation of elasticity imaging, or elastography, for diagnosing vascular diseases

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Education PhD, University of Arizona, Optical Science, 1990; MA, University of Arizona, Optical Science, 1987; Diplôme Grandes Ecoles, Institut d'Optique (France), 1984

Research Interests Optical system design for imaging and non-imaging optics, Physics-based modeling, Image quality assessment

Recent Research Projects Gabor-domain optical coherence microscopy for detection of defects in manufacturing, Optical coherence tomography for quantification of contact lens properties

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LEWIS ROTHBERG

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Research Interests Organic device science, Metal nanoparticle enhanced spectroscopy and imaging, Bio-molecular sensing

Recent Research Projects Novel optical technologies for sensing of nucleic acids and proteins, Mechanistic studies of electronic polymers used in luminescent devices, Plasmonic enhancement of molecular absorption and luminescence, Small fragment removal for next-generation sequencing

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Professor in the Center for Applied and Computational Mathematics, Rochester Institute of Technology

Education PhD, New York University, Mathematics, 1985; BA, Colombia University Mathematics, 1980

Research Interests Statistical physics of protein mixtures, Cell signaling dynamics, Fluid mechanics and solid mechanics of contact lenses and tear film

Recent Research Projects Affect of contact lens distortion on exchange of tears, Model of suction under contact lens

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CARL SALVAGGIO

Professor of Imaging Sciences in the Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology

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Research Interests Three-dimensional geometry extraction from multiview imagery, Material optical properties measurement and modeling, Still and motion image processing for various applications, Thermal infrared phenomenology, exploitation, and simulation, Design and implementation of novel imaging and ground-based measurement systems

Recent Research Projects Signatures Modeling, Derivation, and Exploitation, RIT Immersive Living Room, START-X ISP Signatures and SWIR Measurement Support

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Research Interests Real-time computer vision, Multimedia systems, Medical imaging

Recent Research Projects Real-time systems for object tracking and activity recognition; Algorithms and systems for robust scene categorization and object classification in consumer photographs; Document processing algorithms for thresholding, compression, and rendering in high-speed scanners; Digital Image Processing; and Computer Vision

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Research Interests Ultrafast optoelectronics, Quantum optoelectronic and spintronic devices, Ballistic transport in electronic nanodevices, Quantum communication and information

Recent Research Projects Quantum key distribution using polarized infrared single photons for practical quantum cryptography and deep space optical communications, Subpicosecond electro- and magneto-optic characterization of electronic, optoelectronic, and spintronic materials and systems, Smart sensor for classical and quantum data links

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Research Interests Contact lenses, Lens solution, Ophthalmic drops

Recent Research Projects High and low contrast visual acuity measurements in spherical and aspheric soft contact lens wearers, Continued development of portable low-cost wavefront sensors

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Education PhD, Osaka University, Laser Optics, 1998; MS, Osaka University, Laser Optics, 1995; BS, SungKyunKwan University, Physics, 1990

Research Interests Adaptive optics and in-vivo ocular surface and intraocular imaging, Customized vision correction, Presbyopic correction

Recent Research Projects Large stroke adaptive optics for correcting highly aberrated eyes, Investigation of accommodation and presbyopic lenses (multifocal and accommodative intraocular lenses)

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Education PhD, The Institute of Optics, University of Rochester, 1988; BS, The Institute of Optics, University of Rochester, 1981

Research Interests Improving the performance of optical imaging systems, Optical design, Optical fabrication, Optical design using anisotropic optical materials, Tolerancing of optical systems

Recent Research Projects Multi-model tumor mapping systems, Handheld Enhanced Reflectance Confocal Microscopy for Neuropathy Screening

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Cover photo: A section of 3D-printed vertebrae in the lab of Michael Richards, a research assistant professor in the Department of Surgery at the University of Rochester Medical Center. Photo by J. Adam Fenster.

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