CENTER FOR EMERGING AND INNOVATIVE SCIENCES

University Technology Showcase

Tuesday, March 26, 2013

Research Focus Areas:

Optics, Photonics, and Imaging
Biomedical Technology
Microelectronics, Software, and Communications
Energy and Materials

WELCOME

Dear Colleagues,

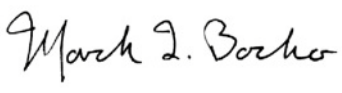
Welcome to the 13th annual University Technology Showcase sponsored by the Center for Emerging and Innovative Sciences at the University of Rochester, a New York State Center for Advanced Technology. This year's event features over 40 examples of the high quality applied research being conducted at the University of Rochester, the Rochester Institute of Technology, and Cornell University. The purpose of this annual event is to provide a forum where people from the business community can learn about some of the work taking place at these great universities. This event also provides an opportunity for members of the business and academic communities to meet and discuss topics of mutual interest. We hope these discussions will lead to continued interaction that will allow companies to tap into the wealth of technology and expertise available at these institutions. Another important aspect of the Showcase is that it provides an opportunity for graduate students to discuss their work with people from industry and establish ties that lead to career placement. The ultimate goal is to help the region incubate, grow, and attract businesses, resulting in job growth and economic expansion.

Rochester is very fortunate to have the University of Rochester and Rochester Institute of Technology located so close to the city and to have Cornell University less than two hours away. Western New York also has several other top research universities that the region's businesses can draw on as sources of innovation and a well-trained workforce. This academic strength helps support one of the top industrial regions in the nation. Given the difficult economic environment we are in, there has never been a time when industry-university collaboration was more important.

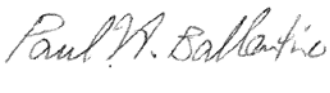
As with past years, we have broken up the research projects into four areas: optics, imaging, and photonics; energy and materials; biomedical technology; and microelectronics, software, and communications. These groupings will help direct you to the areas that interest you the most, but we encourage you to spend time looking at posters in all areas, as innovation often comes from applying knowledge in one area to solve problems in another. Based on feedback from previous years, this year's Showcase will only have the poster and networking session. We appreciate your feedback and encourage you to fill out our survey.

The University Technology Showcase is one way we at CEIS work to foster industry-university collaboration and technology transfer. Our primary role is to provide New York State (NYS) matching funds for company-sponsored research on campus. Over the past five years CEIS has helped support collaborations with over 70 NYS companies at the University of Rochester, Rochester Institute of Technology, Cornell University, and other NYS Universities. We also put on workshops and seminars that bring people from industry and academia together to discuss opportunities for technology-driven economic development. This past year CEIS has also expanded its role in the community by leveraging federal funds to help grow the region's optics, photonics, and imaging cluster. Feel free to stop by the CEIS table to learn about these efforts.

Warm Regards,



Mark Bocko, PhD
Director, CEIS



Paul Ballentine, PhD
Deputy Director, CEIS

SUPPORTERS

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Empire State Development
Division of Science, Technology & Innovation

University of Rochester

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MedTech

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UNIVERSITY of ROCHESTER

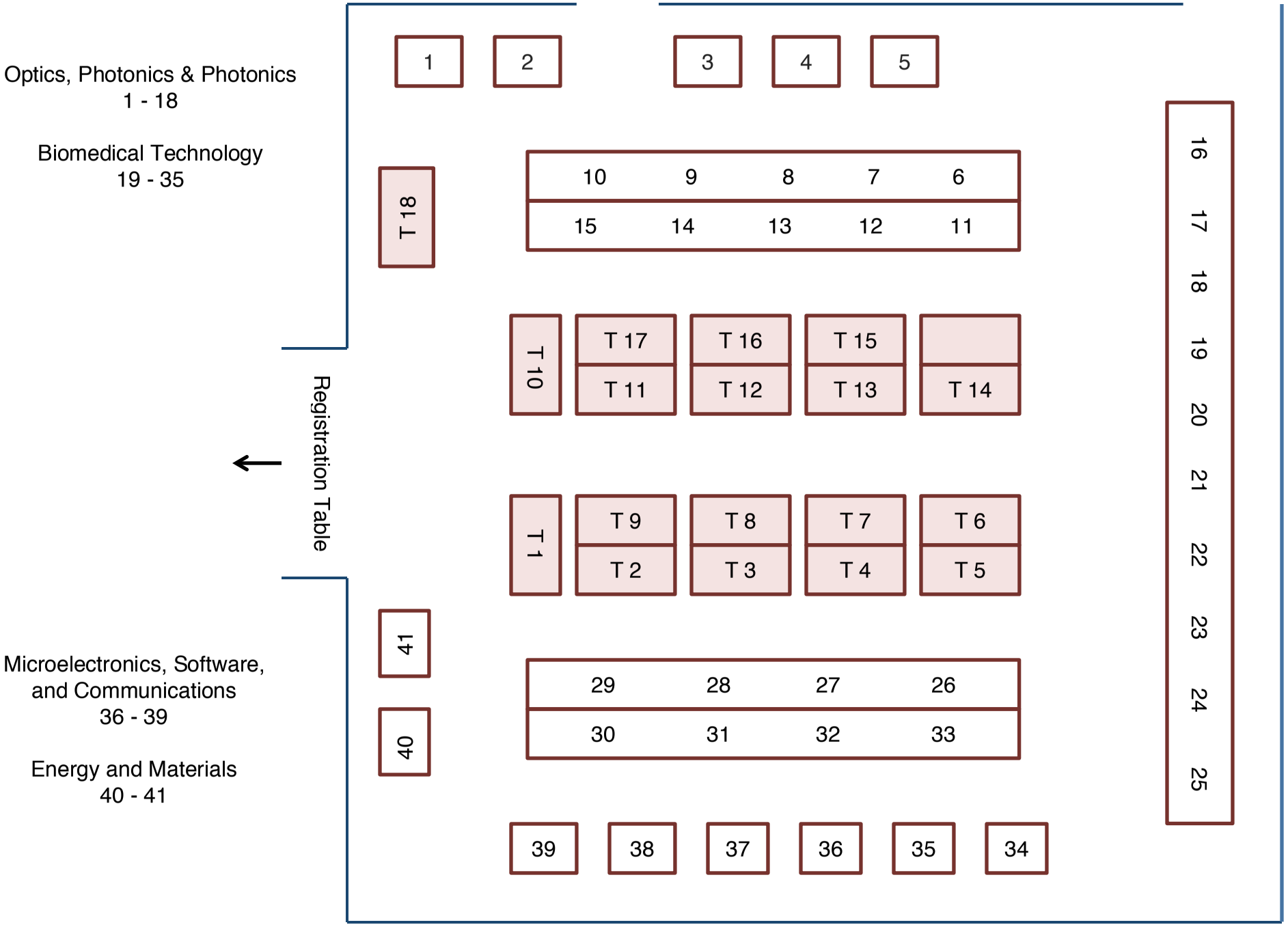
Monroe County Finger Lakes Procurement Technical Assistance Center

CENTER for INTEGRATED RESEARCH COMPUTING

COUNTY OF MONROE
STATE OF NEW YORK
Maggie Brooks
County Executive

New York State Center of Excellence in Bioinformatics & Life Sciences

STC SMART SYSTEM TECHNOLOGY & COMMERCIALIZATION CENTER
COLLEGE OF NANOSCALE SCIENCE & ENGINEERING


Optics, Photonics & Photonics
1 - 18
Biomedical Technology
19 - 35
Microelectronics, Software,
and Communications
36 - 39
Energy and Materials
40 - 41
Registration Table
1
2
3
4
5
16
17
18
19
20
21
22
23
24
25
T 18
10
9
8
7
6
15
14
13
12
11
T 10
T 17
T 16
T 15
T 11
T 12
T 13
T 14
T 1
T 9
T 8
T 7
T 6
T 2
T 3
T 4
T 5
41
40
29
28
27
26
30
31
32
33
39
38
37
36
35
34

TECHNOLOGY SUPPORTERS

T 1 **University of Rochester Office of Technology Transfer**

T 2 **Woods, Oviatt, Gilman, LLP**

T 3 **Excell Partners, Inc.**

T 4 **McVac Mfg. Co. Inc**

T 5 **Monroe County Finger Lakes Procurement Technical Assistance Center, (MLFL PTAC)**

T 6 **Center for Integrated Research Computing (CIRC)**

T 7 **MedTech**

T 8 **High Tech Rochester (HTR)**

T 9 **Cornell Center for Materials Research (CMR)**

T 10 **RIT Offices of Research Relations and Technology Transfer**

T 11 **Eastman Business Park**

T 12 **University of Rochester Center for Entrepreneurship/ Technical Entrepreneurship and Management (TEAM) M.S. Program at the University of Rochester**

T 13 **Advanced Technology Education for 21st Century**

T 14 **UB Center for Advanced Biomedical and Bioengineering Technology**

T 15 **Monroe County Economic Development**

T 16 **Smart Systems Technology & Commercialization Center (STC)**

T 17 **Bond, Schoeneck, & King**

T 18 **Center for Emerging and Innovative Excellence (CEIS)**

TECHNOLOGY SUPPORTERS

T 1 **University of Rochester Office of Technology Transfer**

We are the team that facilitates the protection of Intellectual Property and the commercialization — or transfer — of technologies resulting from the cutting-edge research being conducted by our world-class scientists, faculty, and staff here at the University of Rochester. We are here to translate scientific innovation into tangible products or methods that advance knowledge and serve the public good while returning income to the inventor and to the University to support further research.

T 2 **Woods, Oviatt, Gilman LLP**

Woods, Oviatt, Gilman LLP is a full-service law firm and has been serving the Rochester Community since 1852. Our Patent Attorneys represent companies in a variety of intellectual property matters. We have worked with companies in industrial, retail, and medical industries to obtain and protect intellectual property including trade secrets. Additionally, we assist companies in protecting their intellectual property from undesired exploitation by employees, independent contractors and third-parties.

T 3 **Excell Partners, Inc.**

Excell Partners is a unique regional economic development partnership established in cooperation with the University of Rochester and the State of New York to manage a state-supported fund which provides pre-seed and seed stage financing to high-tech start-up companies in the Upstate New York region.

Because of the high risks inherent in very early stage investing, few venture funds make seed investments, particularly in this region. Yet a tremendous research base exists in Upstate NY which generates commercializable technologies. Excell Partners is positioned to tap into this research base, help identify promising technologies, and accelerate the creation of new technology-based businesses which offer high potential for commercial success. In particular, we provide the financing necessary to launch these companies and link them with the critical services, mentoring, and follow-on capital they need to become self-sustaining businesses.

The mission of the fund is to support regional economic development by bridging the pre-seed and seed stage funding gap in Upstate NY while generating sufficient returns so that, over time, the fund becomes self-sustaining.

T 4 **McVac Mfg. Co. Inc**

At McVac, we manufacture Thin Film Coating Instruments and Custom Vacuum Components for the vacuum coating industry. Our Crystal Sensors, Feedthroughs, and related products are used in production and research systems all over the world. Our quality services and capabilities include Precision T.I.G. welding, Helium Mass Spectrometer Leak testing, and Custom Machining. We especially enjoy working with Universities and R&D facilities, where our ability to modify our standard products, or design new products, can flourish in new and exciting markets and areas of Science Exploration.

TECHNOLOGY SUPPORTERS

T 5 **Monroe County Finger Lakes Procurement Technical Assistance Center, (MLFL PTAC)**
Administered by the Monroe County Economic Development Division, the PTAC is part of our strong commitment to growing small businesses and creating jobs.The Monroe County Finger Lakes PTAC helps businesses secure government contracts that will keep them competitive and thriving in our region. The U.S. government is the world's largest purchaser of goods and services, and New York State budgets for more than $35 billion in contracts each year.

T 6 **Center for Integrated Research Computing (CIRC)**
The University of Rochester established the Center for Integrated Research Computing (CIRC) to provide researchers with technology, software, training, and support necessary to utilize high-performance computing (HPC) and big data technology fully in research activities in all areas of academic scholarship. CIRC currently maintains systems with an aggregated computational performance of about 240 TFLOPS (including a leadership-class IBM Blue Gene/Q supercomputer), 640 TB of disk storage, and a variety of scientific software applications and tools. CIRC hosts a number of collaborative events to help the research community learn how to use computing technology in research and development projects. Consultants and computing time are available to help enable research projects at the University and its business partners.

T 7 **MedTech**
MedTech is the hub of the bioscience and medical technology industry in Upstate New York. We are an active association of pharmaceutical, biotech and medical technology companies, their suppliers and service providers, and research universities. MedTech boosts the success and growth of our members and the Upstate Bio/Med industry through collaboration, information, education, advocacy and by trumpeting the story. We work with universities and institutions engaged in bioscience and biomedical research and connect them with Bio/Med companies to find applications for their basic research, and career opportunities for students and graduates. Learn more at www.medtech.org.

T 8 **High Tech Rochester (HTR)**
HTR is the catalyst for innovators and entrepreneurs who plan to build high-growth businesses and for manufacturing companies that wish to grow via innovation as well as by enhancement of their sales, efficiency, productivity and quality.Early-stage companies and start-ups will find the bulk of relevant HTR services in the Innovate and Incubate stages, which provide a variety of foundation-building services such as business-plan and market-opportunity assessment and a three-day Pre-Seed Workshop.

T 9 **Cornell Center for Materials Research (CCMR)**
The mission of CCMR is to advance, explore and exploit the science and engineering of advanced materials. The unifying theme of our current research is the study of materials purposefully structured at the nanoscale (near-atomic dimensions). Our aim is to be world leaders in the design, control and understanding of the behavior of both crystalline and disordered nanomaterials. This objective is pursued through fundamental experimental and theoretical studies of the assembly and processing of nanomaterials and of their resulting behavior.

T 10 **RIT Offices of Research Relations and Technology Transfer**

Welcome to RIT's Intellectual Property Management Office (IPMO), and Research Relations Offices (RRO); IPMO is responsible for managing RIT's intellectual property (IP) portfolio and bringing that IP to the marketplace through licenses and formation of start-up companies. RRO is responsible for connecting RIT's faculty to companies for sponsored research projects. We are happy to make connections to RIT research faculty across RIT's campus – Imaging, Computing, Sustainability, Microsystems, Engineering, Science and Biomedical topic areas plus many more – see our website at www.RIT.edu/research. Welcome to RIT's Intellectual Property Management Office (IPMO), and Research Relations Offices (RRO); IPMO is responsible for managing RIT's intellectual property (IP) portfolio and bringing that IP to the marketplace through licenses and formation of start-up companies. RRO is responsible for connecting RIT's faculty to companies for sponsored research projects. We are happy to make connections to RIT research faculty across RIT's campus – Imaging, Computing, Sustainability, Microsystems, Engineering, Science and Biomedical topic areas plus many more – see our website at www.RIT.edu/research.

T 11 **Eastman Business Park**

Eastman Business Park is home to manufacturing, tenant and site infrastructure facilities, with several facilities currently for sale and/or lease, along with space for new buildings and development. Kodak currently has 2.5M sq. ft. of existing facility space of virtually all types, and over 300 acres of developable property for commercial or industrial use.

T 12 **University of Rochester Center for Entrepreneurship/ Technical Entrepreneurship and Management (TEAM) M.S. Program at the University of Rochester**

The University of Rochester Center for Entrepreneurship, launched by a grant from the Ewing Marion Kauffman Foundation grant awarded to the University in 2003, serves to identify and create new partnerships with alumni, local businesses, and non-profit organizations; coordinates and publicizes school-based experiences, including courses and signature programming; informs faculty of grant and bridging fellowship opportunities; and encourages collaboration among the schools engaged in entrepreneurship education at the University of Rochester. Learn more online at www.rochester.edu/entrepreneurship. The Center also administers a joint business and engineering master's degree program, technical entrepreneurship and management (www.rochester.edu/team).

The Technical Entrepreneurship and Management (TEAM) M.S. Program at the University of Rochester. The University of Rochester has recently launched a joint engineering/business program: the Master of Science in Technical Entrepreneurship and Management (TEAM). This program offers students the opportunity to immerse themselves in a technical concentration of their choice while receiving a strong foundation in entrepreneurial management. Through a fast-paced curriculum at the University's Hajim School of Engineering and Applied Sciences and the Simon School of Business, students can complete the 32-credit program in as little as one academic year. A three-semester option, which includes a summer internship, and part-time study are also available. Degree requirements include a one-semester practicum and written business plan and oral presentation. TEAM students also have access to a comprehensive career placement program.

T 13 **Advanced Technology Education for the 21st Century**

The growth of high-tech businesses is often limited by local availability of well trained workforce. To meet this challenge of training technologists with adaptable skills critical for rapid innovations, we partnered with over two dozen local high-tech businesses to launch a two-year academic program, Instrumentation and Control Technologies at FLCC Victor Campus Center. Skills crucial for designing, testing, manufacturing and quality control across high-tech industries are learned through hands-on exercises and project work in Automated Data Acquisition, Motion Control and Machine Vision using LabVIEW and other tools of automation including Microcontrollers, PLCs and FPGAs. Required co-op experience of 270 hours prepares students for specific business/industry.

T 14 **UB Center for Advanced Biomedical and Bioengineering Technology**

The University at Buffalo Center for Advanced Biomedical and Bioengineering Technology (UB CAT) is one of 15 centers across New York State supporting university-industry collaboration in research, education and technology transfer, with a strong focus on helping New York State-based businesses gain a technological edge on their competition. The UB CAT is fueling continued growth in promising technologies of tomorrow across the life sciences spectrum including biotechnology, biomedical informatics, diagnostics, medical devices, pharmaceuticals, and research and development products or services. The UB CAT fosters the creation of new life sciences companies and helps existing businesses expand through new or improved product lines by utilizing the R&D assets and expertise within the University. Projects supported by the UB CAT drive substantial economic impact for New York State annually. Hand-in-hand with funding, the UB CAT also provides R&D resources, business development assistance, workforce development programming, and other outreach and networking opportunities.

T 15 **Monroe County Economic Development**

Monroe County Economic Development's goals are your goals. A return on investment, the creation of jobs and the retention of jobs. Through private, state, federal and county financial resources and technical assistance, the Economic Development Division supports businesses, developers, units of local government and major county facilities like the airport and landfill in economic development activities. The division provides administrative support to the County of Monroe Industrial Development Agency (COMIDA) and the Procurement Technical Assistance Center (PTAC)

T 16 **Smart Systems Technology & Commercialization Center (STC)**

In 2010, Smart Systems Technology & Commercialization Center (STC) was created through a merger of New York State's Center of Excellence, the Infotonics Technology Center (ITC) in Canandaigua, with the College of Nanoscale Science and Engineering (CNSE) of the University at Albany, State University of New York (SUNY). This allowed for a natural alignment of STC with CNSE's NYS Center of Excellence in Nanoelectronics and Nanotechnology.

This merger creates a vertically integrated "one-stop-shop" positioning New York State as the global leader in smart system and smart device innovation and manufacturing. These capabilities are unmatched the world over, providing the capacity, infrastructure and operational capabilities to create immediate job and investment opportunities in all areas of semiconductor and advanced manufacturing, covering a diverse number of markets including aerospace, biomed, communications, defense, and energy.

Located just outside of Rochester, NY, STC's 120,000-square-foot, state-of-the-art facility includes over 26,000 square feet of certified cleanroom space with 150mm and 200mm MEMS foundry services, complemented by a dedicated 8,000-square-foot MEMS and optoelectronic packaging facility. STC offers the largest array of world-class MEMS related solutions from design to fabrication, packaging and testing, all under one roof.

T 17 **Bond, Schoeneck & King**

For over a century, Bond has helped protect our clients' innovations and technologies. Today, Bond's Intellectual Property and Technology Group represents technology clients throughout United States, including Fortune 100 companies, high-tech start-ups, service-oriented businesses, manufacturers, financial institutions, major universities, and research organizations. Then Group has considerable experience in all areas of intellectual property, including our core areas of patent and trademark prosecution and portfolio development, intellectual property litigation and dispute resolution, and technology transfer and licensing.

Bond's Group, comprised of nearly 20 attorneys, includes registered patent attorneys who hold various Bachelor of Science degrees and several who hold Ph.D.s or Masters degrees. With respect to intellectual property litigation, our trial attorneys have successfully litigated high-stakes technology cases and have considerable experience in trials and dispute resolution.
We offer "big city" expertise at business-friendly rates, an attraction for a surprisingly varied clientele.

T 18 **Center for Emerging and Innovative Sciences (CEIS)**

The Center for Emerging & Innovative Sciences promotes economic development through industry-university collaboration and technology transfer. We are based at the Hajim School of Engineering & Applied Sciences at the University of Rochester. We are one of 15 Centers for Advanced Technology (CATs) funded by NYSTAR, a division of the New York State Department of Economic Development. We work primarily with faculty and scientists at the University of Rochester and the Rochester Institute of Technology although we do support some research at other universities in New York. And we work closely with small, mid-sized, and large companies in the Finger Lakes region and across the state. CEIS is presenting two posters at our table:

The Rochester Regional Optics, Photonics, and Imaging Accelerator

The Rochester Regional Optics, Photonics, and Imaging Accelerator (or RRPA) is a program to help grow the Rochester cluster of companies in the OPI industries. The project is funded through an award from five different federal agencies with additional funding from New York State. The five federal agencies are the Economic Development Administration (EDA), NIST, DOE, the Employee and Training Administration (ETA) and the Small Business Administration (SBA). These five agencies have teamed up in what is called the Advanced Manufacturing Jobs and Innovation Accelerator Challenge (AMJIAC). The purpose of this Challenge is to coordinate the governments' investments in economic development in some of the Nation's most important industrial clusters. Our proposal was one of only ten chosen last year and represents the federal government's strong commitment to the Rochester OPI cluster. The award is for $1.9M over three years with an additional $190K from the state. The RRPA brings together for the first time five leading regional organizations to help strengthen the region's OPI cluster of companies in a coordinated and comprehensive manner. The participating organizations are the University of Rochester, Rochester Institute of Technology, Monroe Community College, High Tech Rochester, and the Rochester Regional Photonics Cluster. The Accelerator program covers 4 key areas for the cluster: Cluster Development, Business Development, Technology Development, and Workforce Development. This poster will provide details on what each team member is doing in each of these four areas.

POMATECH

POMAtech stands for Photonics and Optics Manufacturing Technology. It is a non-profit Industry-University-Government consortium based in Rochester New York. POMAtech is the entity that will apply for one of the federal government's National Network for Manufacturing Innovation (NNMI) awards. The NNMI program is a one billion dollar initiative launched by the administration in March of last year (2012) to create a network of 15 Institute's for Manufacturing Innovation (IMIs) across the nation. President Obama spoke about the NNMI program in his State of the Union Address in February of this year (2013). The purpose of the NNMI program is to strengthen the US manufacturing sector by developing and transferring to industry manufacturing technologies that are needed to take the results of research and development into commercial production. A second goal of the NNMI program is to develop large industrial clusters around the IMIs by leveraging existing regional assets including educational institutions and small businesses. POMAtech will be comprised of four separate divisions: Lasers, Advanced Optics Manufacturing, Integrated Photonic Devices, and Displays. This poster will provide information on the overall scope of POMAtech and on the four individual focus areas.

Optics, Imaging and Photonics

1 **THz-ABCD: a spectrometer covering the Terahertz gap**
Fabrizio Buccheri[1], Brian Schulkin[2], Justin James[2], Thomas Tongues[2], X.-C. Zhang[1,2]
[1]University of Rochester, [2]Zomega Terahertz Corporation

2 **THz Shoe Scanner**
J. Zhang[1], A. Redo-Sanchez[2], T. Tongue[2] and X.-C. Zhang[1,2]
[1] University of Rochester, [2] Zomega Terahertz Corporation

3 **A Vortex-phase Filtering Scheme for Obtaining Spatial Information from an Arbitrary Unresolved Source**
Garreth J. Ruane, Prachyathit Kanburapa, Grover A. Swartzlander, Jr.; Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology

4 **Broadband Remote Sensing using Terahertz-Radiation-Enhanced Emission of Fluorescence**
Kang Liu, Fabrizio Buccheri, Jingle Liu, Jianming Dai, Xuan Sun, Xi-cheng Zhang; Institute of Optics, University of Rochester

5 **Terahertz Pulse Imaging for Cultural Heritage Investigations**
J Bianca Jackson, Institute of Optics, University of Rochester

6 **Determining the Dynamic Coefficient of Friction in UltraForm Finishing**
Dennis E. Briggs[1], Samantha Echaves[1], Brendan Pidgeon[1], Nathan Travis[1], Jonathan D. Ellis[1,2]
[1]Department of Mechanical Engineering, University of Rochester; [2] Institute of Optics, University of Rochester

7 **Unconventional Polarization States for Nanoscale Testing**
Michael Theisen[1], Aizhong Zhang[1], Stephen Head[1], Gheorghe Salahura[1], Miguel Alonso[1], Jonathan Ellis[1,2] , Thomas Brown[1]
[1]The Institute of Optics, University of Rochester; [2]Department of Mechanical Engineering, University of Rochester

8 **Measurement of Spatial Coherence Through Diffraction from a Transparent Mask with a Phase Discontinuity: experimental results**
Thomas Brown[1], Miguel Alonso[1], Katelynn Sharma[1], Seongkeun Cho[2]
[1]The Institute of Optics, University of Rochester; [2]Department of Mechanical Engineering, Massachusetts Institute of Technology

9 **3-D Printers for Prototyping Freeform Optical Reflective Illumination Systems**
S. J. Burns, Materials Science Program, Department of Mechanical Engineering, University of Rochester

10 **Large-scale Synthesis of Semiconductor Quantum Dots for Biomedical Imaging and other Applications**
Brett Swartz, Todd Krauss; Department of Chemistry, University of Rochester

11 Visibility of Artifacts in Flat-Panel Displays
James A. Ferwerda[1], Alicia Stillwell[1], Howard Hovagimian[2], Ellen M. Kosik Williams[2]
[1]Munsell Color Science Laboratory, Center for Imaging Science, Rochester Institute of Technology; [2]Corning Incorporated, Corning NY

12 Investigations on Silicon-Based and Metal-Oxide Semiconductor Materials and Processing Techniques for Thin-Film Electronics
T. Mudgal, Q. Li, S. Slavin, N. Walsh, P.M. Meller, K.D. Hirschman; Electrical & Microelectronic Engineering Department, Rochester Institute of Technology

13 Preliminary Imaging Tests at THz Frequencies
Craig W. McMurtry[1a], Judith L. Pipher[1a], Mark V. Bocko[1b], Zeljko Ignjatovic[1b], Jianming Dai[1c], Xi-Cheng Zhang[1c], Zoran Ninkov[2a], Kenneth D. Fourspring[2a, 3a], Christiaan Richter[2b], Chih-Yu Jen[2b], J. Daniel Newman[3a], Paul P. K. Lee[3a], Andrew P. Sacco3[a], Tom Chamberlain[3b], David A. Willems[3a], Robert D. Fiete[3a]
[1]University of Rochester, [a]Department of Physics & Astronomy, [b]Department of Electrical & Computer Engineering, [c]Institute of Optics; [2] Rochester Institute of Technology, [a]Center for Imaging Science, [b]Department of Chemical Engineering; [3]ITT Exelis, [a]Geospatial Systems, [b] Electronic Systems

14 Eikonal+: A simulation platform for innovative research in optical instrumentation
Martin Huarte-Espinosa, Andrea Cogliati, Tianyu Li, Jannick P. Rolland; The Institute of Optics, University of Rochester

15 Reclamation of Slurries Used in Optical Manufacturing
Mark M. Mayton, Flint Creek Resources; Zachary Hobbs, Sydor Optics; Stephen D. Jacobs, Laboratory for Laser Energetics, University of Rochester

16 Towards 3D: algorithm for freeform reflector illumination design
Cristina Canavesi[1], William J. Cassarly2, and Jannick P. Rolland[1]
[1]The Institute of Optics, University of Rochester; [2]Synopsys, Inc.

17 Nondestructive Testing of Optical GRIN Materials for Optical Manufacturing
Jianing Yao[1], Jinxin Huang[1], Panomsak Meemon[1,2], Kye-Sung Lee[1], Stephen Head[1], Jungeun Won, Ke Xu[1], Jannick P. Rolland[1]
[1]The Institute of Optics, University of Rochester; [2]Korea Basic Science Institute, Daejeon, South Korea

18 Object Tracking And Abnormality Detection For Video Analytics
Yuncheng Li, Lam Tran, Jiebo Luo; Department of Computer Science, University of Rochester

Biomedical Technology

19 **High-Dimensional Image and Video Analysis for Biomedical Applications**
Junhuan Zhu, Lam Tran, Jiebo Luo; Department of Computer Science, University of Rochester

20 **Lipid Layer Dry Eye Classification using Quantitative Tearfilm Imaging**
J.M. Zavislan[1,2,3], Gheorghe Salahura[1,2], Aizhong Zhang[1], Ranjini Kottaiyan[2], G. Yoon[1,2,3], J.V. Aquavella[2,3].
[1]The Institute of Optics, The University of Rochester; [2]Fluam Eye Institute, University of Rochester; [3]Center for Visual Science, University of Rochester Eye Institute

21 **Overcoming Presbyopia with Pupil Amplitude Apodization and Wavefront Multifocality**
Len Zheleznyak, HaeWon Jung, Scott MacRae, Geunyoung Yoon; The Institute of Optics, University of Rochester

22 **Quantitative Measurement of Tear Film Dynamics with Optical Coherence Tomography and Maximum-likelihood Estimation**
[1]Jinxin Huang, [1]Kye-sung Lee, [1]Jannick P. Rolland, [2]Eric Clarkson, [2]Matthew Kupinski, [3]Kara L. Maki, [3]David S. Ross,
[1]University of Rochester, [2]University of Arizona, [3]Rochester Institute of Technology

23 **A Mathematical Model to Help Combat Dry Eye Syndrome**
Kara Maki[1], Richard Braun[2], William Henshaw[3], P. Ewen King-Smith[4]
[1]School of Mathematical Sciences, Rochester Institute of Technology; [2]School of Mathematical Sciences, University of Delaware; [3]Center for Applied Science and Computing, Lawrence Livermore National Laboratory; [4]College of Optometry, Ohio State University

24 **A Novel Model for the Suction Pressure Under the Contact Lens**
Kara L. Maki[1], David S. Ross[1], Emily K. Holz[2]
[1]School of Mathematical Sciences, Rochester Institute of Technology; [2]Department of Chemical and Biomedical Engineering, Rochester Institute of Technology

25 **Refractive index shaping in live cat cornea tissue**
Daniel Savage[1], Daniel Brooks[1], Lisen Xu[1], Jonathan D. Ellis[1], Wayne H. Knox[1,2], Krystel R. Huxlin[2]
[1]The Institute of Optics, University of Rochester; [2]Center for Visual Science, University of Rochester

26 **Gradient Index Lens Writing in Ophthalmic Hydrogels using Femtosecond Micromachining**
Daniel Savage[1], Lisen Xu[1], Daniel Brooks[1], Jonathan D. Ellis[1], Wayne H. Knox[1,2]
[1]The Institute of Optics, University of Rocheter; [2]Center for Visual Science, University of Rochester

27 **Reducing Computation Time for Protein Structure Prediction using Sensor Network Coverage Algorithms**
Na Yang and Wendi Heinzelman, Department of Electrical and Computer Engineering, University of Rochester; Jiye Shi, UCB Pharma

28 **Patient Awareness Device for Aging Populations with Atrial Fibrillation Risk**
Behnaz Ghoraani, Biomedical Engineering Department, Rochester Institute of Technology

29 **Feasibility of High-Throughput Cellular Co-Culture Screening Assays**
Katelyn N. Busse[1], Joshua J. Miller[1], Christopher C. Striemer[2], Thomas R. Gaborski[1]
[1]Department of Chemical and Biomedical Engineering, Rochester Institute of Technology; [2]SiMPore Inc.

30 **Hollow Microneedle Arrays for High-throughput, High efficiency Gene Delivery to Microalgae**
Andrew R. Durney, Shiori Kawaguchi, Ellen Sadri, Gregory W. Pennamon, Hitomi Mukaibo; Department of Chemical Engineering, University of Rochester

31 **Microfluidic Studies of Red Blood Cell Dynamics and Microemulsions**
Jiandi Wan; Microsystem Engineering, Rochester Institute of Technology

32 **Hydroxyapatite Coated Titanium for Controlled Drug Delivery**
Keith Savino; Chemical Engineering, University of Rochester

33 **Touchy Feely Physics of Cells**
Moumita Das, School of Physics and Astronomy, Rochester Institute of Technology

34 **Surface Modification of Silicon Membranes for Biomedical Applications**
Dr. James McGrath[1], Tejas Khire[1], Dean Johnson[1], Karl Smith[2]
[1]Biomedical Engineering, University of Rochester; [2]Biophysics, University of Rochester

35 **Two-Dimensional Micropatterns of Self-Assembled Poly(N-isopropylacrylamide) Microgels for Patterned Adhesion and Temperature-Responsive Detachment of Fibroblasts**
Hsin-Yi Tsai[1], Kanika Vats[2], Matthew Z. Yates[1], and Danielle S.W. Benoit,[1,2,3], [1]Department of Chemical Engineering, [2]Department of Biomedical Engineering, [3]The Center for Musculoskeletal Research and Department of Orthopaedics, University of Rochester Medical Center, University of Rochester

Microelectronics, Software, and Communications

36 **Mobile Computing - A Green Computing Resource**
He Ba[1], Wendi Heinzelman[1], Charles-Antoine Janssen[2], Jiye Shi[3]
[1]Department of Electrical and Computer Engineering, University of Rochester; [2]HealthyBill, Belgium; [3]UCB Pharma, United Kingdom.

37 **Proactive Detection of Risky Software Changes**
Emad Shihab, Department of Software Engineering, Rochester Institute of Technology

38 **Bandwidth and Energy Efficient Coordinated MAC Protocol Design and Implementation on SDRs**
Bora Karaoglu and Wendi Heinzelman, Department of Electrical and Computer Engineering, University of Rochester

39 **Building Blocks for CMOS/Memristor Hardware Neural Networks**
Cory Merkel, Microsystems Engineering, Rochester Institute of Technology; Dhireesha Kudithipudi, Computer Engineering, Rochester Institute of Technology

Energy and Materials

40 **The Other Valley of Death, Product Standards and Obstacles to Commercialization**
David Gower, Intertek - Center for Evaluation of Clean Energy Technology (CeCeT)

41 **Enhanced Conductivity and Polarization Properties of C-axis Oriented Hydroxyapatite Membranes**
Cong Fu, Keith Savino, Professor Matthew Yates; Department of Chemical Engineering, University of Rochester

Optics, Imaging and Photonics

1 THz-ABCD: a spectrometer covering the Terahertz gap

Fabrizio Buccheri[1], Brian Schulkin[2], Justin James[2], Thomas Tongues[2], X.-C. Zhang[1,2]
[1]University of Rochester, [2]Zomega Terahertz Corporation

Air at atmospheric pressure can be used to generate ultrabroadband and intense Terahertz (THz) radiation. For that to happen, the air has to be ionized by a dual color laser field, whose pulses are as short as tenths of femtoseconds. The same ionized air can be used to detect THz electric field when biased with a local AC field. This sensing technique is called Terahertz Air Biased Coherent Detection (THz-ABCD). Integration of THz generation in ionized air and THz-ABCD in a Time Domain Spectrometer (TDS) results in an instrument with a dynamic range of 60dB and a bandwidth greater than 10 THz covering the entire THz gap.

2 THz Shoe Scanner

J. Zhang[1], A. Redo-Sanchez[2], T. Tongue[2] and X.-C. Zhang[1,2]
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This project aims to develop a reliable device capable of retrieving the internal structure of a shoe and performing spectroscopic analysis to identify hazardous materials. Our goal is to develop a real-time scanner that can inspect shoe soles without requiring the passengers to take off their footwear, thereby facilitating passenger screening in the transportation industry. The shoe scanner will ensure passenger safety, reduce passenger inconvenience, and maintain throughput levels within the current security architecture. We propose a shoe scanner that contains a continuous wave (CW) terahertz (THz) system and a THz Time-Domain Spectroscopic (TDS) system. This work is supported by Zomega Corporation.

3 A Vortex-phase Filtering Scheme for Obtaining Spatial Information from an Arbitrary Unresolved Source

Garreth J. Ruane, Prachyathit Kanburapa, Grover A. Swartzlander, Jr.; Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology

The optical vortex coronagraph is a spatial filtering tool wherein a point-vortex phase mask, placed at the focal plane, acts to filter out the zero spatial frequency at the reimaged entrance pupil; that is, light from a distant point source that coincides with the optical axis is spatially separated from that originating from off-axis sources. Consequently, the OVC is adept at small-angle high-contrast astronomical observations. Spatial filtering with vortex phase masks can also be used to target specific information about unresolved incoherent source distributions. The design presented here uses a computer generated point-vortex hologram and a dispersion compensating grating to demonstrate for the first time a vortex-phase spatial filtering scheme for measuring the size of an extremely unresolved incoherent broadband source distribution.

4 Broadband Remote Sensing Using Terahertz-Radiation-Enhanced Emission of Fluorescence

Kang Liu, Fabrizio Buccheri, Jingle Liu, Jianming Dai, Xuan Sun, Xi-cheng Zhang; Institute of Optics, University of Rochester

With the soaring demands for remote spectroscopy in homeland security, the fields of astronomy and environmental monitoring, terahertz wave sensing and imaging has drawn a significant amount of attention because of its capability to acquire chemical spectral signatures non-invasively and its technological potential, yet the development of remote open-air terahertz sensing and imaging has always been impeded by the strong ambient moisture absorption. However, the technology we introduced, Terahertz-Radiation-Enhanced Emission of Fluorescence (THz-REEF), together with the previous work demonstrated on long-distance terahertz wave generation up to 116 m, makes broadband stand-off remote spectroscopy possible, due to the omni-directional emission pattern and minimal ambient water vapor absorption of THz-REEF.

Our THz-REEF system realizes all-optical broadband terahertz wave detection by coherently manipulating the fluorescence emission from two-colour laser-induced gas plasma interacting with terahertz wave. We had reported THz-REEF from single colour excited gas plasma before, but that method only detects terahertz wave intensity, not the terahertz field ETHz(t) as we can directly detect from two-colour excited plasma. We have studied the two-colour phase dependence of REEF ΔIFL by using a semiclassical model of electron heating by a terahertz wave, electron-molecule energy transfer and ionization of the high-lying states. So far, we demonstrated coherent terahertz wave detection at a distance of 10m and we are on our way to push the limit of this technology toward a further distance. At the same time, alternative counter-propagation THz-REEF geometry has been studied to understand the plasma-terahertz interaction more.

5 Terahertz Pulse Imaging for Cultural Heritage Investigations

J Bianca Jackson, Institute of Optics, University of Rochester

Terahertz pulse imaging and spectroscopy is emerging as a tool of high potential for the nondestructive investigation of historical artworks, architecture and archaeological objects for the purpose of research and conservation. We studied a section of the fresco Trois hommes armés des lances from the Louvre's Campana collection using time-domain terahertz imaging. The top painting is 19th C, while the support is composed of wall sections recovered from Roman ruins. For this piece, no other technique--including X-ray radiography, XRF, infrared photography, infrared reflectometry and UV florescence--has produced an image of a lost fresco. A composite of the photograph of the section and the composite terahertz image reveals a face hidden beneath the 1st man's drape. Other examples of this application will also be presented, including a Russian icon, a wall painting from the Riga Dom cathedral and an Egyptian bird mummy.

6 Determining the Dynamic Coefficient of Friction in UltraForm Finishing

Dennis E. Briggs[1], Samantha Echaves[1], Brendan Pidgeon[1], Nathan Travis[1], Jonathan D. Ellis[1,2]
[1]Department of Mechanical Engineering, University of Rochester; [2] Institute of Optics, University of Rochester

UltraForm Finishing (UFF) is a deterministic subaperture computer numerically controlled grinding and polishing platform designed by OptiPro Systems. UFF is used to grind and polish a variety optics from simple spherical to fully freeform, and numerous materials from glasses to optical ceramics. The UFF system consists of an abrasive belt around a compliant wheel that rotates and contacts the part to remove material. This work aims to accurately measure the dynamic coefficient of friction (μ), how it changes as a function of belt wear, and how this ultimately affects material removal rates. The coefficient of friction has been examined in terms of contact mechanics and Preston's equation to determine accurate material removal rates. By accurately predicting changes in μ, polishing iterations can be more accurately predicted, reducing the total number of iterations required to meet specifications. We have established an experimental apparatus that can accurately measure μ by measuring triaxial forces under translating loading conditions. Using this system, we will demonstrate μ measurements for UFF belts during different states of their lifecycle and assess the material removal function from spot diagrams as a function of wear. Ultimately, we will be able to use this system for qualifying belt-wheel-material combinations to develop a spot-morphing model to better predict instantaneous material removal functions.

7 Unconventional Polarization States for Nanoscale Testing

Michael Theisen[1], Aizhong Zhang[1], Stephen Head[1], Gheorghe Salahura[1], Miguel Alonso[1], Jonathan Ellis[1,2] , Thomas Brown[1]
[1]The Institute of Optics, University of Rochester; [2]Department of Mechanical Engineering, University of Rochester

Model-based optical scatterometry is a technique often used for inline testing of deep subwavelength nanostructures used in semiconductor fabrication. We apply the concept of unconventional polarization states to scatterometry by considering the interaction of a focused beam of complex polarization with a semiconductor test target.

8 Measurement of Spatial Coherence Through Diffraction from a Transparent Mask with a Phase Discontinuity: experimental results

Thomas Brown[1], Miguel Alonso[1], Katelynn Sharma[1], Seongkeun Cho[2]
[1]The Institute of Optics, University of Rochester; [2]Department of Mechanical Engineering, Massachusetts Institute of Technology

A simple scheme is implemented for the measurement of the spatial coherence of paraxial stationary fields, based on the measurements of their radiant intensity with and without a planar binary transparent phase mask.

9 3-D Printers for Prototyping Freeform Optical Reflective Illumination Systems

S. J. Burns, Materials Science Program, Department of Mechanical Engineering, University of Rochester

There are many prototype printers that are in the commercial marketplace especially for mechanical devices. Engineers predict that prototype printing will be the next revolution in manufacturing as supported by the recent NNMI in additive manufacturing. However, printers, processes and materials have yet to be developed for constructing optical devices and optical quality surfaces. The processes described in this poster combine both processes, materials and CNC software with compatible stereo lithography files for 3-D printing to demonstrate that specialized reflective, illumination optics can be achieved using additive manufacturing. Our ultimate goal of general freeform optical designs has not been realized. The research is singularly directed towards making and testing systems that gives high quality surfaces for optical illumination; the printhead, processing and the materials ejects have been adapted for specific narrow optical uses. It is noted that the process designs, materials and CNC controlled software for general freeform optical systems have yet be achieved for 3-D printers i.e., prototype optical printing.

10 Large-scale Synthesis of Semiconductor Quantum Dots for Biomedical Imaging and Other Applications

Brett Swartz, Todd Krauss; Department of Chemistry, University of Rochester

Semiconductor nanocrystals (NCs), which are also called semiconductor quantum dots, are small, highly fluorescent inorganic particles that potentially combine the positive qualities of crystalline semiconductors and small organic molecules. For example, NCs can be chemically and physically manipulated using inexpensive solution based techniques. Yet, they are inherently crystalline and thus very robust with respect to physical and chemical degradation. NCs can potentially drive novel technology in areas that are traditionally the exclusive domain of either molecules (e.g. biomedical imaging) or semiconductors (e.g. solar cells, displays, LEDs and novel lasers). For example, NCs have many advantages over organic dyes traditionally used for biological imaging including much brighter fluorescence, orders of magnitude more photostability, and the ability to image at several wavelengths simultaneously. However, NCs have yet to deliver on their well-hyped promise in part due to a synthetic procedure that lacks scalability, is inefficient, and is not highly reproducible.

11 Visibility of Artifacts in Flat-Panel Displays

James A. Ferwerda[1], Alicia Stillwell[1], Howard Hovagimian[2], Ellen M. Kosik Williams[2]
[1]Munsell Color Science Laboratory, Center for Imaging Science, Rochester Institute of Technology; [2]Corning Incorporated, Corning NY

Modern electronic displays are typically composed of emissive elements (LCD/backlight, OLED, etc.) faced with a sheet of cover glass. Bright light sources and high contrast surrounds can produce veiling reflections that seriously reduce the quality and usability of displayed images. To address this problem, anti-glare (AG) treatments can be applied that typically provide a rough surface to reduce the contrast and visibility of surface reflections. While these treatments can be effective in reducing the impact of surface reflections, they can sometimes produce a transmission artifact known as "sparkle" where the displayed image appears to be covered by small colored highlights that scintillate with relative movement of the display and observer. In this presentation we describe a series of psychophysical experiments to quantify the relationships between anti-glare glass treatments and perceived sparkle in emissive displays.

12 Investigations on Silicon-Based and Metal-Oxide Semiconductor Materials and Processing Techniques for Thin-Film Electronics

T. Mudgal, Q. Li, S. Slavin, N. Walsh, P.M. Meller, K.D. Hirschman; Electrical & Microelectronic Engineering Department, Rochester Institute of Technology

Low-temperature polysilicon (LTPS) has emerged as a dominant technology for high performance TFTs used in LCD and OLED display products, however there are challenges in scaling excimer-laser annealing (ELA) techniques for backplane manufacturing on large glass panels. This work presents two approaches towards achieving higher performance thin-film electronics that are compatible with large panel manufacturing.

Solid-phase crystallization (SPC) offers an alternative method of forming LTPS without the complexity of ELA. While CMOS devices can be realized in SPC-LTPS, there are noted tradeoffs in transistor performance due to inferior carrier mobility. Recent interest in higher performance electronics for large-format displays has provided the motivation to develop process techniques for improved SPC-LTPS transistor performance. Metal-induced crystallization (MIC) and flash-lamp annealing (FLA) are shown to be promising techniques that can enable silicon crystallization at either lower temperature or ultra-short time conditions. Material properties and device characteristics on TFTs fabricated using these techniques will be presented.

Metal-oxide thin-film transistors (TFTs) are of high interest in display and imaging array applications which require higher performance over amorphous silicon (a-Si) TFT processes. These materials have demonstrated significantly higher electron mobility than hydrogenated amorphous silicon (a-Si:H), without the added process complexity required by low-temperature polycrystalline silicon (LTPS) manufacturing. Indium-Gallium-Zinc-Oxide (IGZO) is a metal-oxide semiconductor candidate for a TFT channel layer. This material is under investigation using sputtering as the deposition method. Material properties and the device performance of fabricated TFTs will be presented.

13 Preliminary Imaging Tests at THz Frequencies

Craig W. McMurtry[1a], Judith L. Pipher[1a], Mark V. Bocko[1b], Zeljko Ignjatovic[1b], Jianming Dai[1c], Xi-Cheng Zhang[1c], Zoran Ninkov[2a], Kenneth D. Fourspring[2a, 3a], Christiaan Richter[2b], Chih-Yu Jen[2b], J. Daniel Newman[3a], Paul P. K. Lee[3a], Andrew P. Sacco3[a], Tom Chamberlain[3b], David A. Willems[3a], Robert D. Fiete[3a]

[1]University of Rochester, [a]Department of Physics & Astronomy, [b]Department of Electrical & Computer Engineering, [c]Institute of Optics; [2] Rochester Institute of Technology, [a]Center for Imaging Science, [b]Department of Chemical Engineering; [3]ITT Exelis, [a]Geospatial Systems, [b] Electronic Systems

In order to inform design considerations for a silicon THz imaging array, we have conducted imaging tests on a bolometer array, and as proof of concept, plasmonic detection by silicon FETs on a bare silicon readout integrated circuit array, at 1.63 and 2.52 THz. First results will be presented. In addition, THz antenna modeling and testing have been conducted to inform the new array design.

14 Eikonal+: A simulation platform for innovative research in optical instrumentation

Martin Huarte-Espinosa, Andrea Cogliati, Tianyu Li, Jannick P. Rolland; The Institute of Optics, University of Rochester

Much of research is evolving to rely more on simulation and often less on hardware based experimentation. Often, the most innovative work starts by first extending aspects of an existing simulation code. For optical instrumentation, academics have not had direct access to a robust, highly featured research interface optics performance simulation code since the codes became commercial products some decades ago. In this project, an existing code will be enabled to accept research based extensions to allow innovation research in optical wavefront propagation and optical instrumentation to have both a simulation and an experimental component.

15 Reclamation of Slurries Used in Optical Manufacturing

Mark M. Mayton, Flint Creek Resources; Zachary Hobbs, Sydor Optics; Stephen D. Jacobs, Laboratory for Laser Energetics, University of Rochester

Flint Creek Resources has developed an economically viable, safe and environmentally friendly process to reclaim cerium oxide abrasive particles used to polish glass optics. Initial success from a collaboration with fabricator Sydor Optics is being expanded in a three-year effort to increase reclamation efficiency of spent polishing slurry from 20% to 95%, and to extend reclamation efforts to other NY optics fabricators.

16 Towards 3D: algorithm for freeform reflector illumination design

Cristina Canavesi[1], William J. Cassarly2, Jannick P. Rolland[1]
[1]The Institute of Optics, University of Rochester; [2]Synopsys, Inc.

Freeform surfaces are used for most illumination tasks in every day applications – from automotive headlights to streetlights and luminaires. When applications with complex illumination requirements cannot be achieved with conventional optical components, freeform surfaces are needed. Combined with light-emitting diodes (LEDs), illumination systems using freeform surfaces can yield compact systems with high efficiency, long lifetime, and low power consumption. For instance, street lighting applications using these surfaces can achieve superior light control, directing light only where it is needed, and therefore save energy while reducing light pollution. Freeform automotive headlight designs increase performance while enabling innovative styles.

Freeform surfaces are designed to convert light emitted by a source into the desired light distribution. However, despite decades of investigation, designing freeform surfaces has remained a challenging exercise, and frequently relies on tedious processes and heuristic iterations. While most current design attempts in illumination deal with specific applications and point sources, this project aims to propose a new design method that is generally applicable and addresses the extended source problem. The freeform surfaces generated in the design process will interface closely with the fabrication and testing capabilities to ensure manufacturability at reasonable costs.

17 Nondestructive Testing of Optical GRIN Materials for Optical Manufacturing

Jianing Yao[1], Jinxin Huang[1], Panomsak Meemon[1,2], Kye-Sung Lee[1], Stephen Head[1], Jungeun Won, Ke Xu[1], Jannick P. Rolland[1]
[1]The Institute of Optics, University of Rochester; [2]Korea Basic Science Institute, Daejeon, South Korea

We present a technique of using optical coherence tomography (OCT) for nondestructive testing of optical GRIN materials. The results will be mainly focused on the capability of an angularly scanning laboratory OCT system, which enables high-resolution 3D characterization of the internal structures of GRIN lenses and quantitative analysis of the concentricity of a GRIN preform. Additionally, preliminary results of measuring the refractive index of a BK7 wafer to the accuracy of 10-3 will also be provided to demonstrate the capability of our most recently established index-mapping OCT system, which will be further investigated to measure the index profiles of GRIN materials in the future.

18 Object Tracking And Abnormality Detection For Video Analytics

Yuncheng Li, Lam Tran, Jiebo Luo; Department of Computer Science, University of Rochester

Object tracking and abnormalty detection are two of the major problems in video analytics. Within the context of the Learning from Narrated Demonstration, a key vision component is to detect the task-relevant object for further processing. In a recent study, we take advantage of the fact the task-relevant object is often connected to the supervisor's hand and recast the problem as handheld object detection and tracking. Achieving robust handheld object detection and tracking has its own challenges, including arbitrary object appearance, viewpoint and non-rigid deformation. We propose a robust vision system that integrates speech information to perform handheld object detection via CRF, and MeanShift based tracking. Extensive evaluation on five sets of data has demonstrated the validity and robustness of the proposed system. In addition, we are investigating algorithms that can detect generic "normality" with little or no reliance on domain knowledge such that they can be applied to a wide range of applications

Biomedical Technology

19 High-Dimensional Image and Video Analysis for Biomedical Applications

Junhuan Zhu, Lam Tran, Jiebo Luo; Department of Computer Science, University of Rochester

High-dimensional image and video data are being increasingly used in biomedical applications in both clinical and research domains. Due to the conflict between the increasing amount of imaging data and the limited number of experts, computerized analysis becomes imperative. One such system we are building is for analyzing the cataract surgery videos obtained in the operating rooms or wet labs in order to evaluate the performance of the residents while avoiding the time consuming task of manual grading. Our system extracts both low-level and high-level visual features from the videos. First, we detect the pupil in frames through a robustified circular Hough transform with temporal interpolation when needed. Next, we figure out frames where the surgeon is taking surgical actions or simply doing preparation according to the presence of surgical tools. Finally, we determine the timing of surgical stages using several boosting classification procedures and Hidden Markov Model-based refinement. Experimental results indicate that reliability of our proposed system, thus paving the foundation for further analysis. Furthermore, we are developing new algorithms for other biomedical data such as time-elapsed sequences of multi-photon 3D imaging volumes

20 Lipid Layer Dry Eye Classification using Quantitative Tearfilm Imaging

J.M. Zavislan[1,2,3], Gheorghe Salahura[1,2], Aizhong Zhang[1], Ranjini Kottaiyan[2], G. Yoon[1,2,3], J.V. Aquavella[2,3].
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Our group has developed a quantitative tear scope that allows us to image the ocular tear surface and resolve both spatial and temporal changes in the lipid layer thickness over 70 % of the cornea surface. Using this capability we are objectively characterizing the lipid layer in normal and dry eye patients under various environmental conditions.

A recent study of 20 dry eye subjects (5 Aqueous Deficient Dry Eye or ADDE and 15 Meibomiam Gland Dysfunction or MGD) were classified in 5 groups based on tear-film lipid parameters using Principal Component Analysis (PCA) and k-means clustering.

The results show that dry eye subjects have a wide range of lipid patterns and that both ADDE and MGD subjects can be classified together in statistically significant groups that share similar tear-film lipid characteristics. This classification could potentially be used as a tool for a more targeted approach when designing dry eye treatments.

From this work we intend to compare clinical diagnosis of dry eye with objective measurements and study the effect of dry eye treatments on the lipid layer.

21 Overcoming Presbyopia with Pupil Amplitude Apodization and Wavefront Multifocality

Len Zheleznyak, HaeWon Jung, Scott MacRae, Geunyoung Yoon; The Institute of Optics, University of Rochester

Presbyopia, the age-related loss of accommodation, has a significant impact on the quality of life for the population over the age of 45 years. Prosthetic intraocular lenses and corneal inlays aimed at extending the eye's depth of focus are clinically well-established. However, significant side-effects include halos and glare which reduce image quality at all object distances. To overcome this limitation of presbyopia correction strategies, we propose to apodize the transmission of the eye's pupil. The impact of pupil amplitude apodization was examined by measuring through-focus visual performance with an adaptive-optics vision simulator. This device allows for simultaneous manipulation of the eye's transmission function and wavefront multifocality during vision testing. We confirm our psychophysical investigation with in-vitro optical metrology and a theoretical eye model. We found that halos and glare associated with multifocal presbyopic corrections can be lessened with pupil amplitude apodization, due to reduction in contribution of peripheral rays to the retinal image. Apodization is a promising approach for improving through-focus image quality in the presbyopic eye.

22 Quantitative Measurement of Tear Film Dynamics with Optical Coherence Tomography and Maximum-likelihood Estimation

[1]Jinxin Huang, [1]Kye-sung Lee, [1]Jannick P. Rolland, [2]Eric Clarkson, [2]Matthew Kupinski, [3]Kara L. Maki, [3]David S. Ross,
[1]University of Rochester, [2]University of Arizona, [3]Rochester Institute of Technology

Currently, there are about 40 to 60 million Americans suffering from Dry Eye Syndrome (DES); this serious public health problem will worsen with the increase of aging population, where DES has a high incidence. Unfortunately, a quantitative diagnosis, which is the prerequisite to advance the management of DES, is yet to be realized. We are seeking the next breakthrough in DES management by providing a quantitative diagnosis, with the combination of optical coherence tomography (OCT) imaging and statistical decision theory.

We have developed a comprehensive mathematical model for Fourier-domain OCT where we take into account the Gaussian statistics from the broadband source, the Poisson statistics from the detector, and the dark noise. In this model, we formulate the first-order and second-order statistical quantities of the output from an OCT system. Concerning the object being imaged, we modeled the tear film as a layered structure with two interfaces, air-tear film and tear film-cornea interfaces. Based on this structure, we further modeled the impact of corneal surface roughness. For the first time, we implement a Maximum-likelihood (ML) estimator to interpret the OCT data, which is a platform to infer specimen information from the imaging datasets. In specific, the ML estimator is applied to estimate the thickness of the tear film. In terms of system performance assessment, we use the root mean square error (RMSE) of the estimates as a metric to evaluate the system parameters. Among all the operating parameters, integration time is shown to drive performance, which determines the speed limit of the imaging system. Finally, we validate the ML estimator using a digital phantom of the tear film dynamics.

23 A Mathematical Model to Help Combat Dry Eye Syndrome

Kara Maki[1], Richard Braun[2], William Henshaw[3], P. Ewen King-Smith[4]
[1]School of Mathematical Sciences, Rochester Institute of Technology; [2]School of Mathematical Sciences, University of Delaware; [3]Center for Applied Science and Computing, Lawrence Livermore National Laboratory; [4]College of Optometry, Ohio State University

We present recent progress in understanding the dynamics of human tear film on an eye-shaped domain. Using lubrication theory, we model the evolution of the tear film over a blink cycle. The highly nonlinear governing equation is solved on an overset grid by a method of lines coupled with finite difference in the Overture framework. Comparisons with experimental observations show qualitative agreement.

24 A Novel Model for the Suction Pressure Under the Contact Lens

Kara L. Maki[1], David S. Ross[1], Emily K. Holz[2]
[1]School of Mathematical Sciences, Rochester Institute of Technology; [2]Department of Chemical and Biomedical Engineering, Rochester Institute of Technology

We study the settling dynamics of the contact lens to better understand how the design of the lens can be optimized for patient comfort and ocular fit. When a contact lens is inserted on an eye, it is subjected to forces from both the tear film in which it is immersed and the blinking eyelid. In response, the lens bends and stretches. These forces center the lens, and they produce the suction pressure that keeps the lens on the cornea. In this talk, we couple fluid and solid mechanics to determine the most prominent forces acting on the lens. We present a mathematical model that predicts the suction pressure. We explore the influence of contact lens properties on the suction pressure. This work was supported by, and done in collaboration with, Bausch + Lomb.

25 Refractive Index Shaping in Live Cat Cornea Tissue

Daniel Savage[1], Daniel Brooks[1], Lisen Xu[1], Jonathan D. Ellis[1], Wayne H. Knox[1,2], Krystel R. Huxlin[2]
[1]The Institute of Optics, University of Rochester; [2]Center for Visual Science, University of Rochester

Blue intratissue refractive index shaping (Blue-IRIS), a femtosecond (fs) micromachining technique, has been performed in living cat cornea in vivo to inscribe refractive structures. Blue-IRIS uses 400 nm, tightly focused, femtosecond laser pulses to induce large refractive index changes in cornea up to 0.037 without causing overt damage or cell death. The inscribed structures were shown to induce a change in cylinder power up to -2.7 diopters in cat cornea.

26 Gradient Index Lens Writing in Ophthalmic Hydrogels Using Femtosecond Micromachining

Daniel Savage[1], Lisen Xu[1], Daniel Brooks[1], Jonathan D. Ellis[1], Wayne H. Knox[1,2]
[1]The Institute of Optics, University of Rocheter; [2]Center for Visual Science, University of Rochester

In the present study a femtosecond (fs) laser micromachining technique was used to inscribe a refractive structure in a flat ophthalmic hydrogel sample. This technique uses tightly focused, near-infrared pulses to obtain pure refractive index changes in the bulk hydrogel sample with no overt damage. The inscribed structure was shown to have a cylinder power of -2.4 ± 0.4 diopters using in-house metrology instruments.

27 Reducing Computation Time for Protein Structure Prediction using Sensor Network Coverage Algorithms

Na Yang and Wendi Heinzelman, Department of Electrical and Computer Engineering, University of Rochester; Jiye Shi, UCB Pharma

We propose an innovative interdisciplinary study that combines the research fields of Structural Bioinformatics and Communications to provide effective and efficient solutions to the protein structure prediction problem. Well-developed theories in Communications, such as directional sensor network (DSN), are utilized to develop a novel approach to protein side-chain prediction, offering information critical to structure-based drug discovery and rational drug design. The covered sensing areas in DSNs are represented by the 3D space occupied by atoms both on the backbone and on side-chains of proteins. Similar to maximizing coverage for a randomly-deployed DSN, we initialize all rotamers with their most preferred angles, and use a greedy algorithm to solve atom collisions starting from the least crowded area. Similar to consuming energy when moving sensor nodes away from their initial locations in DSNs, we introduce cost in the score function when tuning rotamers away from their most preferred angles. Rotamer preference is derived from Dunbrack's Backbone Dependent Rotamer Library, and backbone information is obtained from the Protein Data Bank.

28 Patient Awareness Device for Aging Populations with Atrial Fibrillation Risk

Behnaz Ghoraani, Biomedical Engineering Department, Rochester Institute of Technology

Atrial fibrillation affects 3 million Americans and is a major cause of morbidity and mortality. This specific arrhythmia has been seen to affect a range of age groups, however, it is most prevalent in the aging population. The incidence of atrial fibrillation (AFib or AF) is markedly increased with the advancement of age. Therefore, the scope of this study is focused on developing an assistive technology, supported by clinical data from Rochester Cardiopulmonary Group, for the benefit of the elderly and aging population. The inspiration for such a project was founded through the primary investigator's interactions with asymptomatic AFib patients who earnestly desire a way to know when they are in atrial fibrillation.

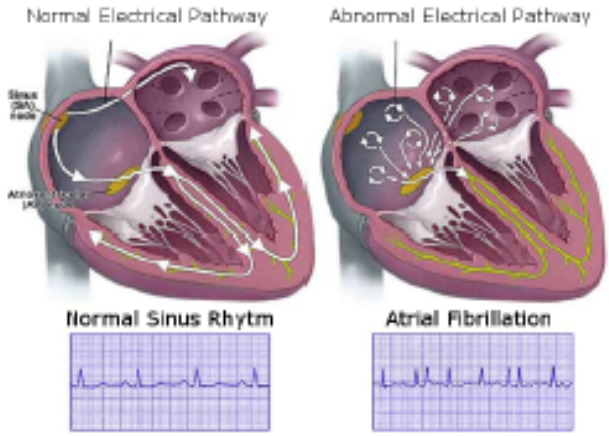

Figure 1 - Normal Sinus Rhythm vs Atrial Fibrillation

AFib is the most common cardiac arrhythmia in clinical medicine, and is also the most commonly sustained among the aging population. Atrial fibrillation is characterized as an irregular heart rhythm (see Figure 1) that results in poor circulation of blood from the heart to the rest of the body. AFib can lead to a variety of life threatening conditions including heart failure and thromboembolisms (blood clots that travels through the body). These complications can lead to death.

Unfortunately, current treatments for atrial fibrillation do not have guaranteed long-term success rates - recurrence is not uncommon. Initial treatment methods are typically pharmacologic in nature. If unsuccessful, a procedure called atrial fibrillation ablation is ordered. However, even if an individual has been previously diagnosed with and treated for AFib with such a procedure, they may still have recurrence and may still be susceptible to subsequent complications. Accordingly, regular monitoring of heart rhythm and detection of atrial fibrillation will lead to the prevention of further complications that would otherwise go unnoticed. This early detection could likely prevent a stroke, heart failure, or death. Current AFib detection methods are reactive in nature (i.e. the patient must experience symptoms, associate those symptoms with their AFib condition, and pursue medical testing to diagnose an AFib attack). Atrial fibrillation episodes are frequently asymptomatic and commonly go unnoticed. For this reason, it is necessary that a promptive device be developed that will alert individuals when they enter atrial fibrillation. At Biomedical Signal and Image (BSIA) Lab, we are developing an at-home device with such characteristics. As a multidisciplinary team, we are working in order to research, design, and develop an atrial fibrillation detection device specifically for the aging population. This device will implement current electrocardiography (ECG) and AFib detection technologies in the form of a chest strap and watchband operating in conjunction. When the wearer enters atrial fibrillation, the device will alarm. This will inform the patient to seek medical guidance or to change their level of activity. Ultimately this device will be implemented for patients to monitor atrial fibrillation in patients at high risk of a stroke or heart failure.

29 Feasibility of High-Throughput Cellular Co-Culture Screening Assays

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A new class of porous membrane has been fabricated that is unique in its combination of nanoscale thickness (< 100 nm) with macroscopic, yet robust, centimeter-scale lateral dimensions and tunable pore sizes in the range of 5 to 100 nm. The membrane material is porous nanocrystalline Si (pnc-Si), first reported in a 2007 Nature paper and now being scaled-up to sheets that are suitable for cell culture and tissue engineering applications. Pnc-Si is ideally suited for cell culture and tissue engineering due to its unique combination of nanometer thinness and high permeability that enable rapid diffusion of low abundance species with minimal loss. Pnc-Si membranes support cell culture similarly to other surfaces, with comparable cell viability and low cytotoxicity. Two cell types can be cultured within tens of nanometers from one another, allowing cell-cell communication, feeder-layer support of a second cell type and other microenvironment-dependent co-culture studies. Cells grown on pnc-Si membranes also experience a highly permeable apical and basal microenvironment, possibly creating a more biologically relevant substrate. Additionally, pnc-Si membranes are extraordinarily transparent to light, permitting their use in image-based, high-content screening assays. This technology enables development of cellular co-culture microarrays to perform small volume high-throughput screening assays. We have used photo-polymerized polyethylene glycol to create miniature microwells supported on the ultrathin membranes. These microwells can be used to help screen for heterogeneity within cellular populations with applications ranging from stem cell differentiation to personalized drug screening.

30 Hollow microneedle Arrays for High-throughput, High Efficiency Gene Delivery to Microalgae

Andrew R. Durney, Shiori Kawaguchi, Ellen Sadri, Gregory W. Pennamon, Hitomi Mukaibo;
Department of Chemical Engineering, University of Rochester

Genetically engineered microalgae are a major focus of recent research due to their potential use in biofuel production and in protein and drug biosynthesis. In the process of genetic engineering, delivering genetic material of interest into the algal cell is a crucial step. However, the cell wall that surrounds the unicellular organism acts as a formidable barrier to the gene delivery, resulting in low transformation efficiency. The large variance of composition, hardness and thickness between different algal species further increases the challenge of achieving high transformation efficiency. In our lab, we are developing a promising new technology that increases the efficiency and the throughput of each transformation experiment. Briefly, this entails the application of hollow microneedle arrays that are loaded with genetic materials. The algae are pierced by these needles and the materials are injected into their cytoplasm for subsequent expression of target proteins or other molecules. In this presentation, we will highlight our recent progress of this project, which includes the preparation of the microneedle array platform and some preliminary results on algae piercing

31 Microfluidic Studies of Red Blood Cell Dynamics and Microemulsions

Jiandi Wan, Microsystem Engineering, Rochester Institute of Technology

Microfluidics is the science and technology of systems that can precisely manipulate small amounts of fluids, including the control of cell behaviors and multiphase materials. Microfluidic-based systems, therefore, have the advantages for quantitative and integrative study of biological phenomena and controlled synthesis of functional materials. In this talk, I will introduce a microfluidic approach that can probe the dynamics of shear-induced ATP release from red blood cells (RBCs) with millisecond resolution and provide quantitative understandings of the mechano-sensitive ATP release processes in RBCs. Since extracellular ATP is an important regulatory molecule for many cellular functions, and, in particular, for vascular signaling, the developed microfluidic approach is important for mechanistic study of vascular disease, diabetes, and to design effective therapeutic strategies. Furthermore, I will also describe microfluidic approaches that enable the controlled formation of three-phase materials to obtain micron-dimension structuring, e.g., gas-liquid-liquid microemulsions and microparticles with controlled porosity and shell thickness. The developed technology has applications for synthesis of biomedical materials, such as drug delivery particles and ultrasound contrast imaging materials.

32 Hydroxyapatite Coated Titanium for Controlled Drug Delivery

Keith Savino, Chemical Engineering, University of Rochester

In the United States alone, over 2.6 million orthopedic implants are inserted annually, and the number is increasing each year with an aging population. Roughly 112,000 (4.3%) of the orthopedic implants in the United States became infected, with annual medical costs in excess of $3 billion to treat these infections. Infections can slow down patient recovery, cause an implant to need removal, or in a worst case scenario lead to amputation or even lethal sepsis. While systemic delivery of antibiotics can help prevent infections, the high dosage of antibiotics delivered may cause negative side effects. Therefore, localized drug delivery at the surgical site is the best solution for preventing potential infections. The Yates group in the chemical engineering department at the University of Rochester has developed a novel method to coat highly crystalline and oriented hydroxyapatite (Ca5(PO4)3OH) crystal membranes on titanium substrates using a two-step electrochemical-hydrothermal synthesis. Hydroxyapatite is often used in orthopedic implants due to its similar composition to bone and osteoconductive properties, helping speed up the integration of the implant with the body. Many studies have shown that hydroxyapatite crystal surfaces are negatively charged, with the negative charge being due to preferential surface migration of PO43- groups. Therefore, with a highly oriented HAP membrane that has very prominent crystalline surfaces, electrostatic interactions between the negatively charged apatite surface and positively charged antibiotics offer a unique mechanism to load and control the release of antibiotics, while simultaneously providing a bioconductive surface.

33 Touchy Feely Physics of Cells

Moumita Das, School of Physics and Astronomy, Rochester Institute of Technology

34 Surface Modification of Silicon Membranes for Biomedical Applications

Dr. James McGrath[1], Tejas Khire[1], Dean Johnson[1], Karl Smith[2]
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With the advancement in micro- and nano-fabrication technologies, lab-on-chip assays like microfluidic devices are rapidly replacing the conventional diagnostic and operational procedures. Porous silicon membranes are an important components in these microfluidic devices used for various separation purposes as in dialysis, filtration, and also for cell and tissue culturing. An important concern with the use of synthetic materials in biological application is the time dependent biofouling of these surfaces, as well as possible host-immune responses occurring due to exposure with charged membranes. Hence a significant effort needs to be put to reduce the antifouling of silicon surfaces as well as rendering the surfaces bio and hemocompatible to avoid any kind of unnecessary coagulation and immune responses upon contact with these surfaces. Poly ethylene glycol (PEG) is an organic compound with long chains of glycol units [H-(O-CH2-CH2)n-OH]. PEG is commonly used polymer for surface coatings and is reported to prevent any kind of bacterial adhesion on the native surfaces, thus acting as an antifouling agent. Presence of hydroxyl groups in PEG makes it a hydrophilic material, which prevents protein adsorption on the surface and is compatible with most of the biological fluids like blood, serum, and plasma due to their high water content. We investigated multiple solution based and vapor based silanization approaches to provide a monolayer of PEG silane molecule on silicon surface. Solution based deposition completely prevented any kind of platelet adhesion, and also helped in avoiding platelet aggregation and activation. Vapor deposition approaches to coat PEG silanes resulted into reduced levels of protein attachment as verified under various assays. We are currently investigating the long-term stability of these PEG coatings.

35 Two-Dimensional Micropatterns of Self-Assembled Poly(N-isopropylacrylamide) Microgels for Patterned Adhesion and Temperature-Responsive Detachment of Fibroblasts

Hsin-Yi Tsai[1], Kanika Vats[2], Matthew Z. Yates[1], and Danielle S.W. Benoit,[1,2,3],
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Thermoresponsive poly(N-isopropyl acrylamide) (PNIPAM) microgels were patterned on poly(styrene) substrates via a dip coating method to create cytocompatible substrates that provide spatial control over cell adhesion. This method allows facile generation of PNIPAM micropatterns of desired dimensions with regularly-spaced regions of cell adhesion. This simple dip coating method forms stripes of densely-packed PNIPAM microparticles. The spacings between the stripes contain few sparsely-distributed PNIPAM microparticles on the bare underlying substrate. We report and investigate three different PNIPAM microgel patterns, namely pattern composed of 50 µm stripes/ 50 µm spacings, 50 µm stripes/ 100 µm spacings, and 100 µm stripes/ 100 µm spacings. Upon cell seeding on PNIPAM micropatterned substrates, NIH3T3 fibroblast cells preferentially adhered within spacings to form cell patterns. Seventy two hours after cell seeding, cells proliferated to cover the entire substrate, forming confluent cell layers. The thermo-responsiveness of underlying PNIPAM microgels was then utilized to recover NIH3T3 cell sheets from substrates simply by lowering the temperature below the lower critical solution temperature (LCST) of PNIPAM. This enzyme-free recovery of cell-sheets is extremely desirable for applications in tissue engineerin

Microelectronics, Software, and Communications

36 Mobile Computing - A Green Computing Resource

He Ba[1], Wendi Heinzelman[1], Charles-Antoine Janssen[2], Jiye Shi[3]
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Cloud computing provides an approach to accessing shared computing resources. However, a traditional cloud is composed of powerful but energy-hungry workstations. In this work, we describe the design and implementation of a mobile computing system prototype named GEMCloud that utilizes energy efficient mobile devices (e.g., smartphones and tablets) as computing resources. We evaluate the computing power and energy efficiency of the mobile devices through comprehensive experiments. The results show that a cloud computing system with enough mobile devices working cooperatively is able to save 55% to 98% of the energy consumption of conventional server-based clouds while providing comparable computing speed.

37 Proactive Detection of Risky Software Changes

Emad Shihab, Department of Software Engineering, Rochester Institute of Technology
In this work, we will present our work which uses data stored in software repositories to proactively flag risky changes, i.e., changes that may break or cause errors in the software system, so defects can be avoided before they are widely integrated into the code. The work will discuss the results of a year-long study involving more than 450 developers, spanning more than 60 teams to better understand and identify the risky changes. We find that attributes such as the number of lines of code added and the history of the files being modified by the change can be used to accurately identify risky changes with a recall of more than 67% and a precision that is 37-87% higher than a baseline model. Our risk models are being used today by an industrial partner to manage the risk of their software projects.

38 Bandwidth and Energy Efficient Coordinated MAC Protocol Design and Implementation on SDRs

Bora Karaoglu and Wendi Heinzelman, Department of Electrical and Computer Engineering, University of Rochester

Mobile ad hoc networks (MANETs) are becoming increasingly common, and typical network loads considered for MANETs are increasing as applications evolve. This, in turn, increases the importance of bandwidth efficiency while maintaining tight requirements on energy consumption, delay and jitter. Coordinated channel access protocols have been shown to be well suited for highly loaded MANETs under uniform load distributions. However, these protocols are in general not as well suited for non-uniform load distributions as uncoordinated channel access protocols due to the lack of on-demand dynamic channel allocation mechanisms that exist in infrastructure based coordinated protocols. In this project, we developed a lightweight dynamic channel allocation mechanism and a cooperative load balancing strategy that are applicable to cluster based MANETs to address this problem. We propose protocols that utilize these algorithms to improve performance in terms of throughput, energy consumption and inter-packet delay variation (IPDV). Through extensive simulations we show that both dynamic channel allocation and cooperative load balancing improve the bandwidth efficiency under non-uniform load distributions compared with protocols that do not use these mechanisms as well as compared with the IEEE 802.11 uncoordinated protocol.

Although simulations are efficient tools to comparatively evaluate the efficiency of the protocols, they cannot reflect many of the challenges for real implementation of these protocols, such as clock-drift, synchronization, imperfect physical layers, and interference from devices out of the system. In this project we use SORA software defined radios to implement the TRACE protocol and determine the challenges in implementing this protocol in a real world communication system.

39 Building Blocks for CMOS/Memristor Hardware Neural Networks

Cory Merkel, Microsystems Engineering, Rochester Institute of Technology; Dhireesha Kudithipudi, Computer Engineering, Rochester Institute of Technology

The advent of nanoscale memristor devices, which provide high-density multi-level memory, ultra-low static power consumption, and behavioral similarity to biological synapses, represents a major step towards emulating the incredible processing capacity of biological nervous systems in hardware neural network (HNN) architectures. The neuroscience community has made significant progress in understanding the biological processes, such as synaptic plasticity, neuron excitability, and communication along neural pathways, which have served as the inspiration for HNN designs. However, efficiently mapping these processes to emerging CMOS/memristor HNNs (CMHNNs) to achieve a desired system-level behavior is a formidable challenge. This work explores several aspects of CMHNN design, with a focus on circuit-level building blocks for achieving different synaptic and neuronal behavior.

Energy and Materials

40 The Other Valley of Death, Product Standards and Obstacles to Commercialization
David Gower, Intertek - Center for Evaluation of Clean Energy Technology (CeCeT)

41 Enhanced Conductivity and Polarization Properties of C-axis Oriented Hydroxyapatite Membranes
Cong Fu, Keith Savino, Professor Matthew Yates; Department of Chemical Engineering, University of Rochester

Due to the special structure of hydroxyapatite (HAp, $Ca_5(PO_4)_3OH$), protons are quite mobile along the c-axis at elevated temperatures. Thus, it has been regarded as a one-dimensional anionic conductor. In our recent research, HAp membranes coated on metal substrates with near perfect c-axis aligned crystal domains have been successfully prepared. The unique structure would provide the coating with some special properties which are promising in energy and medical applications.

My research mainly focuses on applications of c-axis oriented carbonated hydroxyapatite (CHAp) coatings for alternative energy and biomedical fields. The conductivity of a typical CHAp coating is 5×10^{-5} S/cm at 450 °C, which is two orders of magnitude higher than a traditional sintered CHAp membrane with similar composition[1]. The novel CHAp membrane on a palladium substrate has promising potential as the electrolyte membrane of intermediate temperature solid oxide fuel cells. On the other hand, when CHAp membranes are polarized by an external DC field, high stored charge was detected due to its unique structure. Compared with 0.365 $\mu C/cm^2$ obtained for a randomly oriented HAp coating on a titanium substrate, 1.48 mC/cm^2 of surface charge was obtained using our sample [2]. The huge charge storage capacity would provide the coating with some applications as electrets and in drug delivery systems.

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