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Optics, Photonics, and Imaging

1 **Terahertz Techniques Based on Laser-Induced Microplasmas**

Fabrizio Buccheri, Institute of Optics, University of Rochester

Ambient air becomes a source of ultrabroadband terahertz pulses and an ultrafast terahertz sensor when ionized by femtosecond laser fields. The integration of such a plasma source and sensor in terahertz time-domain techniques allows spectral measurements covering the elusive terahertz gap (0.1 to 10 THz), further increasing the impact of those scientific tools in the study of the four states of matter.

I report on a new paradigm for implementing THz plasma techniques. Specifically, we replaced the use of elongated plasmas, ranging from few mm to several cm, with sub-mm plasmas, which I will refer to as microplasmas, obtained by focusing ultrafast laser pulses with high numerical aperture optics (NA > 0.5).

Those microplasmas have in fact unique properties compared to any other THz source and sensor, with the potential of enabling new and exciting applications. Specifically, they require orders of magnitude less laser pulse energy to be created, enabling plasma-based terahertz technique to be implemented with low energy ultrafast lasers. Moreover, they offer a generation, or detection, volume with sub-wavelength size (1 THz = 300 μm), which could be exploited to implement near field THz plasma techniques.

2 **HapTech - Haptic Enabled VR for a Developing Market**

Lucian Copeland, Computer Science Department, University of Rochester / HapTech

Haptech is a multi-system computational and hardware platform for environmental virtual reality, capable of tracking a user's movements, translating them into a virtually constructed space, and providing full body haptic feedback when the user comes into contact with a virtual object. In layman's terms, this allows a user to "feel" a virtual object simulated in front of them via a computer program, in conjunction with visual feedback with a VR headset such as the Oculus Rift. The project is currently capable of performing this task using vibrational feedback on the hands within a confined space, using infrared camera tracking to interpret the user's location. Our future goals for the project include a hybridized system for tracking that fuses 9 axis sensors with camera motion capture, multi-camera tracking for large and flexible environments, and more sophisticated methods of force feedback for user interactions. Our team has recently placed in both the Microsoft Imagine Cup and Intel-Cornell Cup national finals, and will additionally be entering the Mark Aim and Forbes business plan competitions at the conclusion of the academic year.

3 **Thickness Estimation with Optical Coherence Tomography and Statistical Decision Theory**

Jinxin Huang[1], Patrice Tankam[1], Cristina Canvesi[2], and Jannick P. Rolland[1,2], [1]Institute of Optics, University of Rochester, [2]LighTopTech Corporation

In the optical imaging field, one important and quantitative imaging task is for thickness estimation. In this study, we investigate a new approach—combining optical coherence tomography (OCT) and statistical decision theory—for thickness estimation. Through mathematical modeling of the imaging chain with the statistical noise taken into account, a maximum-likelihood estimator is implemented to interpret the OCT raw data. Theoretical study shows that an OCT system with one micron axial point spread function (FWHM) allows estimates down to nanometers with nanometer precision. The theoretical predictions in thickness estimation are then experimentally validated with physical phantoms, which are made of layer-structures with known thickness. The framework can be applied to a broad range of applications, such as: industrial metrology and biological layer estimation.

4 **Further THz Array Development and Characterization**

Craig McMurtry[1], Judith L. Pipher[1], Zeljko Ignjatovic[1], Mark Bocko[1], Jagannath Dayalu[1], Zoran Ninkov[2], Katherine Seery[2], Sahil Bhandari[2], Kenneth D. Fourspring[3], Dan Newman[3], Andrew P. Sacco[3], Frank Ryan[3], Paul Lee[4], [1]University of Rochester, [2]Rochester Institute of Technology, [3]Exelis, [4]Consultant

In order to characterize the latest version of a 7 x 7 THz array (see Ignjatovic et al. this conference), an aluminum enclosure was constructed in which the array was mounted, and a high purity Si window installed to block intrinsic response of the silicon array but passes THz radiation. This array has an antenna on each pixel optimized for 188 GHz operation. Programs to operate the array utilizing the Rochester array controller were written, and to operate a shutter within the beam. The THz array was characterized to obtain the bias parameters which gave the optimal performance for each pixel. Data were obtained using a TPX lens to focus the 188 GHz radiation from a Gunn Diode onto the array. Images of objects were obtained with and without obstructions in the optical path. Results from these tests indicate that the next generation array will need to be modified so that pixel to pixel offsets are similar.

5 **Lensless measurements of spatial coherence in the Fresnel region**

Katelynn A. Sharma, Amber C. Betzold, Miguel A. Alonso, Thomas G. Brown, Institute of Optics, University of Rochester

We present a method to measure spatial coherence that uses no lenses to calculate the mutual intensity function. Previous methods using an amplitude mask in the far-field have yielded favorable results, showing promise for this new experiment.

6 Fiber Pump-Delivery System for Spectral Narrowing and Wavelength Stabilization of Broad-Area Lasers

Jordan P. Leidner, John R. Marciante, Institute of Optics, University of Rochester

High-power broad-area lasers are used for optical pumping of fiber devices due to their high efficiency, compact form, and robust form factor. However, broad-area lasers operate at multiple longitudinal and lateral modes, decreasing their spectral and spatial brightness and thus reducing their effectiveness in applications with narrow absorption features. In this work, we assess the potential of using off-axis feedback from a single-mode fiber Bragg grating (FBG) as a means of spectral narrowing and stabilization, while simultaneously improving the spatial performance of the device. Full-width-half-max of the FBG-coupled laser was improved (narrowed) by a factor of 10 and made independent of both temperature and operating power. Additionally, FBG feedback was shown to improve the beam quality of the laser. A novel scheme for integrating this method into pump delivery fiber packaging is proposed, making the method fully compatible with existing packaging methods – U.S. Provisional Patent Application No. 61/934,201.

7 Cerium Oxide Polishing Slurry Reclamation Project: Characterization Techniques and Results

Kameron Tinkham[1,4], Tess Jacobs[1,4], Mark Mayton[2], Zachary Hobbs[3], Stephen Jacobs[1,4], [1]Institute of Optics, University of Rochester, [2]Flint Creek Resources, Inc., Gorham, NY, [3]Sydor Optics, Rochester, NY, [4]Laboratory for Laser Energetics, University of Rochester

Flint Creek Resources (FCR) has developed an economically viable, safe, and environmentally friendly process to reclaim the cerium oxide abrasive used to polish glass optics. Success from a collaboration with local Rochester, NY fabricator, Sydor Optics, is in its second year of a three-year effort to increase reclamation efficiency of spent polishing slurry from 20% to 95%. To achieve this goal, FCR is purchasing new equipment and is being supported by research currently being conducted at the University of Rochester Laboratory for Laser Energetics (LLE). Our group is assisting in these efforts by conducting polishing experiments to evaluate efficiency of reclaimed polishing slurries and new slurries. These experiments as well as the success at Sydor Optics, allows FRC to consider including other optics fabrication companies in this recycling effort. Sydor Optics is increasing its usage of FCR's services and products and could realize a total saving of up to $100,000 in 2014.

8 **Eikonal+: Optical Design and Visualization Platform for Freeform Optical Instrumentation**

Daniel Nikolov[1], Adam Hayes[1,] Robert Gray[1], Miguel A. Alonso[1], Jon Petruccelli[2], Jannick P. Rolland[1]
[1]Institute of Optics, University of Rochester, [2]Department of Physics, University of Albany

Eikonal+ is a computational research platform being developed that builds on an optical design application originally called Eikonal. The Eikonal source code was donated in 2009 to Prof. Rolland (PI) by the family of the late Juan Rayces, with whom she worked in 1986. The lack of an optical system design platform focused on research has hindered progress in this field since the 80s, when codes went commercial. The Eikonal source code allows building a research platform in which we can integrate custom modules and algorithms, especially algorithms related to the aberrations of freeform optics that we have developed. We also plan to develop modules to facilitate bridging between design and manufacturing. Importantly, we started on building a cross-platform 3D visualization module aimed at displaying complex folded geometries in 3D to ease the visualization of these systems throughout the development cycle from design to full assembly. With the current advances in manufacturing and testing of freeform optics, there will be an increasing demand for a platform where new capabilities may be tested and solutions researched. It is an exciting opportunity to provide a robust and intuitive software solution to support the process of creating new generations of optical systems.

We acknowledge support from a Federal grant through the U.S. Department of Energy (DOE) that supports development of the Rochester Regional Optics, Photonics, and Imaging Accelerator program and matching funds from the NYSTAR Foundation through the Center for Emerging Innovative Science (CEIS). This program plays in synergy with the NSF I/UCRC Center for Freeform Optics (CeFO).

9 **Off-null measurements applied to process monitoring using focused beam scatterometry**

Anthony Vella, Michael J. Theisen, Stephen Head, Thomas G. Brown, Miguel A. Alonso, Institute of Optics, University of Rochester

We present a novel strategy for the simultaneous estimation of several structural parameters of deep subwavelength structures, based on the use of the scatterometry of focused beams with spatially-varying polarization distributions. A Bayesian approach is applied to determine the optimal polarization distribution such that, following scattering by the structure and filtering by a uniform analyzer, the resulting measured intensity distribution allows the accurate estimation of the desired structure parameters.

10 Development of Si-MOSFET CMOS Technology for Terahertz Detection

Andrew P. Sacco[1], J. Daniel Newman[1], Kenneth D. Fourspring[1], John H. Osborn[1], Robert D. Fiete[1], Paul P. K. Lee[2], Mark V. Bocko[2], Zeljko Ignjatovic[2], Jagannath Dayalu[2], Judith L. Pipher[3], Craig W. McMurtry[3], Xi-Cheng Zhang[4], Katherine Seery[5], Sahil Bhandari[5], Chao Zhang[5], Zoran Ninkov[5], [1]Exelis Geospatial Systems, [2]Department of Electrical & Computer Engineering, University of Rochester, [3]Department. of Physics & Astronomy, University of Rochester,[4]Institute of Optics, University of Rochester, [5]Rochester Institute of Technology

A group of scientists and engineers at the Rochester Institute of Technology, the University of Rochester, and Exelis Geospatial Systems are developing a silicon MOSFET CMOS imager to detect terahertz frequencies. The first generation devices have already been shown to detect terahertz radiation (0.188 Thz from the available sources). The second generation devices were designed with an array of transistors, designed from the first generation device, and 15 individual test transistors with varying design dimensions and antennas. These test structures are being evaluated at RIT to determine the best design for terahertz detection for future designs.

11 Diode-pumped Visible Fiber Lasers without Nonlinear Frequency Conversion

Haomin Yao, John R. Marciante, Institute of Optics, University of Rochester

Visible lasers find wide applications in projection displays, health care, material processing, underwater communications, and more. Existing solutions are either bulky and unreliable (argon ion lasers and dye lasers), sensitive to environmental fluctuations (frequency doubled lasers), or limited in power and lifetime (laser diodes). We have developed a visible fiber laser concept that is compact and reliable with no nonlinear frequency conversion elements or active temperature stabilization. Unlike most fluoride-based visible fiber laser demonstrations, our fiber laser is readily manufacturable using conventional fused-silica fibers, with the power scaling ability of conventional cladding-pumped fiber lasers. Comprehensive rate-equation/kinetics modeling shows 0.38 W output at 544 nm with a pump power of 0.80 W at 488 nm, with similarly efficient lasing at other visible wavelengths. We are actively carrying out further experiments to demonstrate laser operation and characterize lasing performance. Preliminary experimental results will be shown.

12 Resonance Enhanced THz Generator

Xuan Sun, X –C. Zhang, Institute of Optics, University of Rochester

In addition to the enhanced electron tunneling process, Cs and Rb exhibit rich energy level structures that ensure the resonance-enhanced THz-involved nonlinear optical processes. Here we focus on the four-wave mixing process for potential THz wave generation. The idea is based upon two-photon transition where two near-infrared photons are used to produce a visible photon and a THz photon via two-photon resonance. This process is broadband in nature for THz wave since only the sum energy of the THz photon and the visible photon is required to resonate with the two energy levels.

13 Further Development of THz Imager Array in Support of ITT Exelis' Commercial THz Development

Zeljko Ignjatovic, Jagannath Dayalu, Electrical and Computer Engineering, University of Rochester

A novel detection method for Terahertz radiation in standard CMOS technology based on Thermionic Emission has been investigated and experimentally verified. Theoretical analysis and experimental data have shown that in response to THz radiation a MOSFET transistor under sub-threshold biasing conditions exhibits thermionic emission current over the source-to-channel potential barrier that is a much stronger function of the applied THz electric field when compared to other detection mechanisms in standard CMOS. We also demonstrate that the detection is further improved by extending the source region of the MOSFET transistor. Initial measurements indicate the detector's responsivity in excess of 40kV/W and corresponding measured Noise Equivalent Power of 10pW/sqrt(Hz). Thermionic emission detection using conventional CMOS technologies holds much promise due to low cost fabrication, ease of manufacturability, and the ability to integrate more functionality on chip. It also offers a better cost and performance alternative to microbolometers and pyroelectric detectors traditionally used in THz imaging.

14 ImageGlide: Touchless Interaction with Mobile Devices using Face Tracking

Bret Minnehan and Andreas Savakis, Department of Computer Engineering, Rochester Institute of Technology

Touchless interfaces are gaining importance with the growing ubiquity of mobile devices, cameras and robotic platforms. Advanced applications are relying on computer vision techniques, such as detection, tracking and recognition, to provide novel experiences for users. Designing efficient tracking algorithms and optimizing performance for mobile devices can result in better and more efficient tracking for applications, such as augmented reality. We present a Robust and Efficient object tracker based on Binary dEscriptors and Locality constraints (REBEL tracker) and that is used for real time face tracking on mobile devices. We will demo this tracker on iOS mobile platforms and show how it can be used with ImageGlide, a new, fun way of interacting with images.

15 Study of THz emission from ring-Airy beam induced plasma

Kang Liu[1], D. G. Papazoglou[2,3], A. D. Koulouklidis[2,3], S. Tzortzakis[2,3], and X.-C. Zhang[1], [1]The Institute of Optics, University of Rochester, [2]Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas, Heraklion, Greece, [3]Department of Material Science and Technology, University of Crete, Heraklion, Greece

We experimentally investigated the THz emission from two-color ring-Airy beam induced plasma in the ambient air. The results show that this exotic autofocusing beam tends to form an elongated weak filamentation with a main peak at the front and a 'tail' with certain oscillations following, which leads to a higher THz yield and a slightly narrower THz spectrum than the emission from a Gaussian beam plasma under the same circumstances.

Biomedical Engineering

16 **Portable Vision Defect Scanner**

Felix Kim[1], Sam Steven[1], HaeWon Jung[2,] Geunyoung Yoon[3],[1]Ovitz Corporation,[2]Institute of Optics, University of Rochester, [3]Department of Ophthalmology, University of Rochester

According to the World Health Organization, approximately 300 million people around the world are visually impaired: 50 million of these are completely blind, and the other 250 million suffer from moderate or severe visual impairment caused mainly by uncorrected refractive error. About 80% of these blindness cases are preventable through proper eye care programs, including regular eye exams and prompt corrective action.

Not unexpectedly, people living in poverty are at the greatest risk of undetected vision problems.

Ovitz mission is to break down the global barriers to vision care by delivering quality diagnostics and treatment of critical eye conditions. It is not surprising that even children in developed countries do not always recognize that they cannot see well until their parents take them to an eye doctor for the first time; this can lead to learning difficulties but most importantly, in a significant number of cases "lazy eye", a condition which never can be remedied, has already developed. In many cases there is poor local accessibility to currently available devices. Even where recognition of need exists, costly, time consuming visits are required to access clinical care; assuming such clinics and optometrists are available.

Why is this happening? What is needed to prevent these people from becoming visually impaired? … A very simple and fundamental diagnostic device and procedure.

17 **Scalable Fiber Lasers for Optimized Femtosecond Micromachining of Ophthalmic Materials**

Wayne H. Knox, Yuhong Yao, Institute of Optics, University of Rochester

In this CEIS-funded project, we are investigating new approaches to short pulse laser sources of high efficiency that are optimized for writing refractive corrections in ophthalmic materials such as hydrogels (for contact lenses or intra-ocular lenses) or human cornea. This project involves optical materials testing with new wavelengths, pulse widths, repetition rates and other conditions to determine the optimum laser parameters for refractive correction applications. The principal scaling variables are wavelength and repetition rate.

18 Systemic Health Evaluation of Radio Frequency Power Generators Using Gaussian Mixture Models

Ryan M. Bowen, Microsystems Engineering, Rochester Institute of Technology

Modern thin film processing of semiconductor integrated circuits is highly dependent upon reliable and accurate RF (Radio Frequency) power delivery to a plasma source. Unscheduled downtime of an RF subsystem can easily exceed the capital equipment cost of the RF system itself. In addition, a significant percentage of RF power generator field returns are classified as "No Trouble Found" (NTF), indicating that more accurate diagnosis of these complex systems in the field is needed to reduce the total Cost of Ownership (COO). Thus, we propose an application of specific machine learning techniques capable of evaluating systemic health of a RF power generator. System signatures or *fingerprints* are collected from multivariate time-series data samples of sensor values under typical operational loads. These fingerprints are preprocessed using standard scaling/translation methods and transformed into the frequency domain using the Fast Fourier Transform. Feature vectors are formed from the frequency components of the fingerprints. The number of features per fingerprint are reduced by banding neighboring frequencies and performing Principle Component Analysis (PCA). The reduced feature vectors are used with the Expectation Maximization (EM) algorithm to learn parameters for a Gaussian Mixture Model (GMM) to represent *normal* operation. One-class classification of *normal* fingerprints is achieved by thresholding the likelihood of a fingerprint feature vector's belonging to the *normal* GMM. The proposed methods have been tested on six different classes of RF power generators and over 400 unique units. Fingerprints were pre-collected from normal operational conditions and also under seeded faulty conditions. Robust testing results (3σ) have shown < 15% false positives and < 3% false negatives. Additionally, a custom C++ library was developed as an embedded solution capable of classification of fingerprint data within the RF power generator's embedded environment.

19 Femtosecond Micromachining of Custom Refractive Structures in Contact Lenses

Daniel Brooks[1], Gustavo Gandara-Montano[1], Wayne H. Knox[1,2], Jonathan D. Ellis[1,3], [1]The Institute of Optics, [2]Center for Visual Science, [3]Department of Mechanical Engineering University of Rochester

Femtosecond micromachining in contact lenses allows for micrometer scale alteration of the refractive index. By raster scanning across the contact lens it has been shown that custom refractive structures can be constructed. A functional expression has been developed that describes the refractive index change as a function of scan velocity and laser power. This expression has been used to write a set of Zernike structures over a 150 µm diameter aperture using a galvanometer based scanning system. Defocus with a magnitude of 0.88 Diopters as well as another distinct trefoil structure have also been demonstrated over a 2 mm diameter aperture using a custom flexure scanning system.

20 Feasibility of Large Area Nanoporous Silicon Nitride Membranes for Hemodialysis

R. N. Carter[1], T. R. Gaborski[1], J. J. Miller[2], J. Rousse[2], [1]Department of Biomedical Engineering, Rochester Institute of Technology, [2]SiMPore Inc.

This project concerns the development of a scale up fabrication technique for a nanoporous silicon nitride membrane technology that is being developed for application as a high performance membrane to enable portable hemodialysis. The fabrication technique is based on supporting the ultrathin (ca. 50 nm) membrane with a polymeric scaffold and then using a through-pore etch to separate the membrane from the silicon wafer substrate. This technique is termed “lift-off” and builds on recent success in our group involving similar thickness silicon nitride membranes with micropores that are used as optically transparent porous substrates for cell culture studies. Presently, the nanoporous membranes are fabricated with method that produces small active area membrane devices that are supported on rigid silicon chips through an expensive and time-consuming through-wafer etc. In contrast, the lift-off method yields radically higher active area membranes with a more flexible form factor while dramatically reducing production costs by eliminating the expensive through-wafer etch step. In extending this method to the nanoporous membrane we are addressing a number of anticipated challenges including optimization of the through-pore etch with pores that are approximately 100-fold smaller and developing a mechanical support scaffold with the appropriate properties for integration of the membrane technology into hemodialysis devices for laboratory animal studies.

21 Nondestructive imaging for quality control in manufacturing and medical imaging

Cristina Canavesi[1], P. Tankam[2,3,] Jungeun Won[2] , Jannick P. Rolland[1,2,3], [1]LighTopTech Corp., [2]The Institute of Optics, University of Rochester, [3]Center for Visual Science, University of Rochester

High-resolution, nondestructive 3D imaging is needed for quality control in manufacturing and for monitoring of diseases in clinical applications, including skin surgery and corneal transplants. An optical instrument based on a biomimetic microscope design and numerical algorithms for Gabor-domain fusion was developed. Through integration of a custom MEMS scanner module for robust and repeatable imaging, the full characterization of a volume of 1 x 1 x 0.6 mm^3 at a resolution of 2 µm is completed in less than two minutes. The instrument was used to characterize contact lenses both in air and in solution, and to qualify corneal tissue.

22 Method for Classifying Cardiac Arrhythmias using Photoplethysmography

Luisa F. Polania[1], Lalit K. Mestha[1], David T. Huang[2] and Jean-Philippe Couderc[2], [1]Palo Alto Research Center,[2]University of Rochester Medical Center

Advances in mobile computing and miniature devices have contributed to the accelerated development of wearable technologies for clinical applications. The new trend of wearable technologies has fostered a growth of interest for sensors that can be easily integrated into wearable devices. In particular, photoplethysmography (PPG) is especially suitable for wearable sensing, as it is low-cost, noninvasive, and does not require wet electrodes like the electrocardiogram. Photoplethysmograph signals contain rich information about the blood pulsating variation which is strongly related to the electrical activities of the heart. Therefore, in this paper we hypothesize that the ambulatory PPG monitoring could be employed for arrhythmia detection and classification. This paper presents a method for classifying ventricular premature contraction (VPC) and ventricular tachycardia (VT) from normal sinus rhythm (NSR) and supraventricular premature contraction (SVPC) recorded in patients going through ablation therapy for arrhythmia. Although occasional VPCs are benign, the increase in the frequency of VPC events may lead to VT, which in turn, could evolve into ventricular fibrillation and sudden cardiac death. Therefore the accurate measurement of VPC frequency and early detection of VT events becomes essential for patients with cardiac disease. The proposed method was studied with pacing protocol to mimic cardiac arrhythmias of upper and lower chambers of the heart on cardiac patients at the University of Rochester Medical Center. The study design was approved by local Institutional Review Board.

23 A System Architecture for Mobile Ad Hoc Networks Visualization and Interaction

Cristiano Tapparello, Colin Funai, Mohammed Ahmed, Jon Aho and Wendi Heinzelman Department of Electrical and Computer Engineering, University of Rochester

With the increasing availability of mobile devices that natively support Device-to-Device (D2D) communication protocols, we are presented with a unique opportunity to realize large scale ad hoc wireless networks. Wireless ad hoc networks have been largely developed to meet the needs of a variety of applications where infrastructure-based wireless networks are difficult to deploy and maintain. These protocols have mainly been used for tactical military communications, first responder applications and sensor network operations. In this poster, we propose and implement a system architecture that combines a mobile application with a web application to gather device and network characteristics through D2D communications, and visualize these informations on a map. In addition, this system allows the user to interact with the ad hoc network and change device and network characteristics on the fly.

24 Microbubble Array Technology for Therapeutics Discovery

James Kobie[1], Lisa DeLouise[2] [1]Infectious Diseases Division, Department of Medicine, [2]Departments of Dermatology and Biomedical Engineering, University of Rochester

High-content screening (HCS) or cellomics, is a methodology that typically combines automated microscopy with image analysis to enable the phenotypic profiling of cells for enhanced drug discovery and aid personalized medicine. We have developed an advanced HCS platform based on our patented microbubble (MB) well array technology. MB wells have circular opening ~50 µm diameter and ~ 1 nl volume. The unique spherical architecture enables the long-term survival and proliferation of cells, and the concentration of cell secreted products. It is a single cell high throughput screening platform that sorts living cells based on their functional activity such, cell surface protein expression, antibody or cytokine secretion, and/or morphology. We are leveraging our MB array platform and expertise in B cell biology and immunoglobulin (i.e. antibody) gene repertoire analysis to discover monoclonal antibody (mAbs) therapeutics for treating human disease (e.g. cancer and infectious disease). MB array technology can vastly accelerate the mAb discovery process and time to market of potent mAbs by allowing the selection and scale up of the most desirable antibodies with the precise functional profile required for therapeutic efficacy. Additionally, MB array technology has transformative potential in the areas of genomics, cancer profiling, stem cell development, and cell-based drug screening.

25 Short- and long-term biological impact of refractive index shaping using femtosecond micromachining in living cornea

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Blue intra-tissue refractive index shaping (Blue-IRIS) is a novel approach being developed for vision correction, which utilizes a femtosecond micromachining process to write custom refractive index patterns inside living corneal tissue. Histological analysis of feline corneas 6 hrs following Blue-IRIS reveals that most keratocytes at the laser focal point undergo apoptosis. However, there is minimal cell death outside of the focal area of the laser. Examination of 17-month old refractive pattern written in vivo in an adult cat eye showed no persistent cell death. However, Blue-IRIS created a permanent change in the corneal matrix, indicated by a lack of keratocytes re-populating the IRIS-affected region.

26 Characterization of SiO2 Membranes for Application as Cell Culture Substrates

Stephanie Casillo, Biomedical Engineering, Rochester Institute of Technology

This project involves the development and characterization of a permeable, porous silicon dioxide (SiO2) membrane for use as a cell culture substrate. The SiO2 membrane is an optically clear, 2D substrate that provides the opportunity for surface modification and has porous features that are useful for co-culture and multi-dimensional interactions with chemicals and other stimuli. Human Umbilical Vein Endothelial Cells (HUVECs) are used to characterize the membrane by studying various cell culture variables, including cell adhesion, spreading, proliferation rate, and adhesion protein expression. Effects on cell adhesion and spreading were studied by culturing HUVEC using SiO2 membranes of varying pore size and porosity. To further quantify cellular behavior on these substrates, HUVEC proliferation was studied as the cells were cultured in three different media on a porous SiO2 membrane, non-porous SiO2 membrane, and tissue culture plastic (TCP). Finally, HUVEC were grown to confluence on a SiO2 membrane and TCP and stained for VE-cadherin, a cell-cell adhesion protein that is necessary to form junction between endothelial cells.

27 Engineering Solutions for Lung Disease Research

Risa Robinson, Professor and Head of Mechanical Engineering Department, Rochester Institute of Technology

The Family Prevention and Tobacco Control Act of 2009 gives the Food and Drug Administration influence over the formulation and marketing of tobacco products. However, tobacco companies are innovative in their designs, and include complex additives to control delivery of nicotine in manners that are undetectable under standard testing protocols. As a result, although the use of low tar and filtered cigarettes increased over the last 50 years, lung disease has not declined. This paradox is alarming as new products enter the market with similar claims of reduced risk. Smokers will alter their smoking patterns to achieve the desired dose of nicotine and thereby inhale a non-reduced concentration of harmful constituents. Furthermore, adoption of reduced exposure products may lead to reduced cessation rates for current smokers or promote nicotine addiction for non-smokers. A multidisciplinary approach is needed to address the public health threat; an approach that incorporates the latest technology in health and behavior monitoring with clinical and laboratory studies on health effects and toxicity.

28 Integrated Multimodal Technology in Noninvasive Ocular Surface and Tear Film Imaging

Ranjini Kottaiyan[1]; Geunyoung Yoon[1, 2, 3]; James M. Zavislan[2, 1]; James V. Aquavella[1], [1] Flaum Eye Institute, [2] Center for Vision Science, [3] The Institute of Optics, University of Rochester

The clinical tests used to assess tear film and diagnose dry eye are invasive and produce results that are different from natural tear characteristics. There is a need to objectively and noninvasively assess tear parameters under controlled environmental circumstances to refine dry eye diagnosis and therapy. We have developed multimodal tear imaging systems integrated in a chamber in which individual environmental factors can be precisely varied to investigate their impacts on tear parameters. With the custom-built high-resolution wavefront sensor combined with placido disc, it is possible to objectively detect two dimensional tear breakups in real time and evaluate its impact on visual quality. The ocular surface imaging ellipsometer uses polarized illumination from which both the lipid refractive index and thickness can be measured at a very high resolution. Using an enhanced thermal camera, we measure the ocular surface temperature noninvasively, which makes it possible to study spatial and temporal changes in tear evaporation. The multimodal deployment of these components in the controlled chamber will assist in better differentiating the various clinical dry eye entities and will lead to the development of specific dry eye treatments.

Electrical Engineering, Computer Engineering, and Computer Sciences

29 **Harvesting the Healing Power of Big Data**

Jiebo Luo[1], Junhuan Zhu[1], Jianbo Yuan[1], Vincent Silenzio[2], Tristram Smith[3], Yousuf Kahlifa[4], [1]Department of Computer Science, University of Rochester; [2]Department of Psychiatry, University of Rochester; [3]Department of Pediatrics, Neurodevelopmental & Behavioral Pediatrics;[4]Emory Eye Center, Emory University

We present a number of projects centered around the theme of using big data including both image and text information to develop novel solutions to mental health management, autism spectral disorder screening, and surgical training video grading.

30 **Transmitter-Receiver Energy Trade-off in Wireless Sensor Networks**

Hoda Ayatollahi, Electrical and Chemical Engineering, University of Rochester

Power and energy consumption are the most important factors in extending the lifetime of Wireless Sensor Networks (WSN). Many energy efficiency techniques that consider both the transmission and circuit power consumption have been proposed for the case of Single-Input Single-Output (SISO) WSNs. However, the power consumption of the receiver should also be considered in order to maximize the network lifetime. In this poster, we introduce a novel communication protocol for Multiple-Input Multiple-Output (MIMO) WSNs. In this protocol, the number of antennas to be used at both the transmitter and receiver are selected according to the energy consumption of the scheme, the remaining energy at the nodes, the distance between the nodes, and the target bit error rate. Starting from a policy that selects the optimal number of antennas, we then propose 3 low complexity heuristics with different information requirements. Numerical results show that our proposed communication protocols dramatically outperform the performance of a traditional fixed MIMO system in terms of energy consumption and system lifetime.

31 **Fine-Grained User Profiling from Social Multimedia Platforms**

Quanzeng You[1], Jiebo Luo[1], Arvind Agarwal[2], Sumit Bhatia[2], [1]Department of Computer Science, University of Rochester; [2]Xerox PARC

Using rich multimodal data from social media platforms such as Twitter, Instagram, and Pinterest, we demonstrate the potential for inferring user demographics and building comprehensive and fine-grained user profiles.

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

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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.

Flash-lamp annealing (FLA) is an alternative technique for crystallization of amorphous silicon (a-Si) which can be scaled to large substrates and reduce time & complexity in the process. This work investigates FLA for crystallization of thin-films of a-Si deposited on glass substrates. The FLA system used in this work is a NovaCentrix PulseForge 3300, which anneals the material using a series of short but intense bursts of broad spectrum light from xenon flash lamps. High peak power over microseconds time scale can provide control over the depth of heating to avoid damage when processing on substrates such as glass or plastic. Large-grain polysilicon has been achieved using this technology; the electronic quality of the material is under investigation.

Metal-oxide thin-film transistors (TFTs) are of high interest in display and imaging array applications which require higher performance over 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 traditional LTPS manufacturing. Sputter-deposited Indium-Gallium-Zinc-Oxide (IGZO) is a candidate material under investigation. Material properties and the device performance of fabricated TFTs with specific process variations will be presented.

33 Wine Recommendation and Beyond for Grocery Shoppers

Jiebo Luo[1] and Henry Kautz[2], [1]Department of Computer Science, University of Rochester; [2]Institute for Data Science, University of Rochester

With a team of undergraduate and graduate students, we perform analytics on demand for a locally owned supermarket chain in order to promote other products by mining extensive grocery shopping data.

34 Modeling and Analysis of a High Power Microwave Plasma Chamber

Vijay Katta, Dr. Jayanti Venkataraman, Department of Electrical and Microelectronic Engineering, Rochester Institute of Technology

In the present work, the high power microwave plasma chamber consists of circular waveguide carrying the TE_{11} mode, wrapped around as a loop and excited by the TE_{10} mode from a linear waveguide. The microwave power extracted through a slit along the cavity wall that is lined by quartz permeates a gas injected in the center and ionized it creating plasma. The excitation is sinusoidal at a frequency of 2.46GHz. The primary objective is to analyze the chamber using a nonlinear Drude model of the plasma. This has been done through simulations using CST (Computer Simulation Technology) microwave studio software. The primary use of such a chamber is for material processing which requires uniform electric field intensity. The cavity has been analyzed and compared using two types of process gasses, Argon and Oxygen. In each case the effect of input power and gas pressure has been analyzed. The simulations have been performed varying the input power from 500W to 2500W and varying the gas pressure from 10 milliTorr to 100 milliTorr. As expected, it is seen that a higher input power and higher gas pressure results in increasing the plasma electron density and consequently producing stronger electric field intensity. Finally in order to obtain a wideband response of the return loss in the cavity, a small Gaussian pulse is superimposed on the sinusoidal excitation signal. It is seen that the plasma chamber resonates at the same frequencies for both types of process gases, Argon and Oxygen. Finally it is shown that the simulated electric field in the plasma cavity compares well with experimental data available as photographs, provided by Tokyo Electron Limited (TEL), of the electric field intensity in the chamber.

35 Development of Full-Range Flat Panel Loudspeakers

David Anderson, Department of Electrical Engineering, University of Rochester

Plate loudspeakers suffer from poor transient characteristics due to low modes ringing in response to rapid changes in music and speech. Modal crossover networks use arrays of independently controlled drivers to actuate plate loudspeakers, allowing for increased ability to tune the frequency and transient response. A control system filters the input signal into frequency bands and further into spatial shapes, which are then amplified to drive the plate. In simulation, this method shows considerable promise at allowing plates to act as hi-fidelity loudspeakers.

36 Extending Mobile Computing Through Device-to-Device Communications

Colin Funai, Electrical and Computer Engineering, University of Rochester

As the cost of energy continues to rise, it is important to develop energy efficient high performance computing. As previously explored in the volunteer computing platform GEMCloud, mobile devices offer an energy efficient alternative to cloud computing, especially for highly parallelizable applications. However, current mobile device-based volunteer computing systems are limited to devices with Internet connectivity. In this project, we continue to explore the ad hoc extensions to GEMCloud, where mobile devices are invited to join the traditional mobile volunteer computing system via Device to Device communication, thus removing the requirement for an Internet connection. Using a prototype implementation running on Android devices, we investigate the impact of two ad hoc communication technologies, namely WiFi Direct and Bluetooth. Experimental results are integrated with a suitable analytical model to infer the system performance under different settings.

37 Zigzag Antennas in 3-D Wireless-Network-on-Chip (WNoc)

Chetan Kumar Munuswamy, Dr. Jayanti Venkataraman, Department of Electrical and Microelectronic Engineering, Dr. Amlan Ganguly, Department of Computer Engineering, Rochester Institute of Technology

Recent trends in 3-D Hybrid Network on a Chip (NoC) utilizing wireless and wired interconnects to improve communication speeds have been successful. Liquid cooling channels introduced on top and bottom still leave the interior of the chip as a hot spot. In the present work, the 3-D NoC of dimension (10mm x 10mm x 1.748mm) has a novel architecture with 7 active layer and two layers of embedded micro thermos-fluidic channels each layer consisting of 25 channels to address the interior heating. Since wired interconnects through the fluidic layers is not possible, 14 zigzag antennas are implemented, two antennas on each active layer, to serve as wireless interconnects. The primary challenge is to design the antennas capable of functioning efficiently in this complex and hostile environment. Design and simulation of the entire structure has been done using ANSYS High Frequency System Simulator (HFSS). The thermo-fluidic layers are modeled as dielectric tubes of dielectric constant 1.75. Each antenna has been individually designed and successfully tuned to resonate at 60 GHz with a return loss (RL) less than -10dB. The paper also discusses the transmission between the antennas and shows that the transmission coefficient (S_{21}) ranges between -10dB to -25dB.

38 High-Dynamic-Range, Single-Shot, 10-GHz Signal Processing

W. R. Donaldson, Laboratory for Laser Energetics, University of Rochester

We have developed a single-shot, 10-GHz electronic data-acquisition system with a dynamic range of 1800:1. The system encodes electrical transients on to an optical carrier with a 45-GHz electro-optic modulator. The optical encoding provides overvoltage protection and higher bandwidth transmission than conventional coaxial cables. Using passive optical techniques, the signal is replicated and averaged with itself to increase the dynamic range by a factor of 30 over currently available electronic oscilloscopes. The next phase of this research will extend the single-channel result into massively parallel architecture.

This material is based upon work supported by the Department of Energy National Nuclear Security Administration under Award Number DE-NA0001944, the University of Rochester, and the New York State Energy Research and Development Authority. The support of DOE does not constitute an endorsement by DOE of the views expressed in this article.

39 Music Classification and Recommendation System Based on Block-level Features

Shumin Xu, Department of Electrical and Computer Engineering, University of Rochester

The system is a content-based automatically music tag classification and recommendation system. The traditional user-based tag browsing system allows user to annotate the songs with semantic labels, which may cause the problem of unreliable information of rarely heard songs. The new system is mainly focused on the audio signal itself to give an approach of solving the cold-start problem.

The block-level features show significant aspects of audio clips, i.e. timbre features, rhythm features and mixed features. Then the system applies principal component analysis (PCA) to reduce feature matrix dimensions and adopts support vector machine (SVM) to classify and generate music genre tags. By using the classical multidimensional scaling method, the system has build a tag-based music universe to show the relationships between different genre and combined the feature-based and the tag-based similarity matrix together to make music recommendations. An audio feature map is introduced to indicate some natures of music.

40 RIT Microelectronic Engineering: Research and Education on Silicon Solar Cells

Michael A. Jackson, Alex Marshall, Kavya Duggimpudi, and Santosh K. Kurinec, Electrical and Microelectronic Engineering, Rochester Institute of Technology

The Microelectronic Engineering (MicroE) Program at RIT was created in 1982 to meet the workforce needs of the emerging semiconductor industry. Innovative for its focus on photolithography and IC manufacturing, the program remains the only ABET accredited BS degree program of its kind in the nation. Over its 33 year history, the program has placed over 850 undergraduate and 220 graduate (ME and MS) engineers in the semiconductor industry worldwide. With IC technology spawning emerging fields such as MEMS (Micro Electro Mechanical Systems), PV (Photovoltaics or Solar Cells), Solid State Imagers, Displays, and Solid State Lighting, there is no better resource for your educational or research needs. The Microelectronic Engineering faculty collaborated with industry and government to create a 10,000 Sq. Ft. cleanroom facility which enables a range of activity from developmental work of prototype devices on a range of substrate materials and sizes to a complete fabrication of CMOS devices on 150mm silicon substrates. Capabilities include IC Layout, Maskmaking, G and I line photolithography, simulation and modeling, and ion implant, as well as traditional processes of oxidation, diffusion, wet and plasma etch, PVD and CVD, electrical characterization, and metrology.

This poster will familiarize attendees with the activities within the Microelectronic Engineering program involving silicon based photovoltaics. Capabilities include a basic turn-key fabrication process producing 12-14% efficient cells for rapid evaluation of novel concepts. The authors are currently conducting research into the feasibility of copper metallization through a DOE grant involving NREL, Intrinsiq (a Rochester based start-up) and RIT. Characterization capabilities include solar simulation, contact resistance determination, and quantum efficiency measurements. The MicroE Program has a two day short course Photovoltaics Science and Technology for engineers and scientists in industry who need a rapid introduction into the basics of the field. A custom version of this class is being developed for K-12 teachers for their professional development, and to build a network of educators to enhance the STEM pipeline. Current K-12 collaborators include teachers through the HVCC NEATEC Center, Wayne County Science Teachers Consortium, and the Geneva City School District. These groups have availed themselves of the RIT MicroE resources to help meet their silicon based processing needs; how about you?

Chemical Engineering, Mechanical Engineering, and Materials Science

41 **Wear performance of new textured surfaces created by modulation machining**

Dr. Patricia Iglesias Victoria, Mechanical Engineering Department, Rochester Institute of Technology

Surface texturing technology has started to gain more and more attention in the tribology community as a method for improving friction and lubrication ability of various mechanical components [1-4]. Micro-sized depressions (e.g., grooves or dimples) intentionally created on a frictional surface are expected to act as fluid reservoirs and help to promote the retention of a lubricating thin film between mating components. The dimples or grooves also function as receptacles for debris and wear particles, eliminating potential scratching of the substrate surface during relative motion of the interface parts. In addition, the depressions boost the hydrodynamic pressure that causes separation of the surface [5]. Several fabrication techniques can be used to produce micro-dimple patterns on surfaces, but most of them show limitations when employed in practical efforts. The use of modulation-assisted machining (MAM) processes provides a cost-effective approach for creating surface textures over large areas that offers high control over the characteristic geometry of the textured surface.

In this work, the influence of the dimensions and layout of the micro-sized depressions on the wear performance of new textured surfaces created by MAM is studied. Brass mated with AISI 52100 steel are studied using a ball-on-flat reciprocating configuration. Textured surfaces reduced wear for all the materials texted. Tribological performance depended greatly on the density of the micro-dimples.

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42 An Open Source, Open Architecture Collaborative Environment for Engineering Design and Productive Development

Edward Hensel, Ph.D., Kate Gleason College of Engineering, Rochester Institute of Technology

We are designing a set of open-source engineering design tools for rapid product development, permitting engineers to better manage the design, development and delivery of new products. The Engineering Design Guide and Environment (EDGE) is a version-controlled document and information flow management system, incorporating several collaborative design and documentation capabilities in a single web-based environment. The intent of EDGE is provide a cloud-based design environment to allow teams of engineers from a variety of disciplines and geographical locations to design, develop, and launch new products. EDGE deals primarily with managing groups and information with a design group, and is built upon several open-source packages, to provide an access-controlled Apache Subversion project repository for every project team along with a basic user interface. Each project may represent a team of practicing engineers collaborating on design, product development, subsystem design, or concept design efforts. The EDGE system is intended to support teams with no fundamental limit on the size of membership. Information may be shared and cross-linked between projects, within administrator imposed security constraints. EDGE is currently in beta testing, and is used by hundreds of RIT engineering students, faculty and staff annually. EDGE has evolved over more than a decade and has been used by hundreds of Multi-disciplinary Senior Design (MSD) capstone project teams. Several capabilities are incorporated into EDGE to leverage the community of open-source software that has been developed world-wide. EDGE incorporates an underlying relational database system called FACETS, which provides an extensible suite of design and product development tools common to many industries. FACETS tools being developed include an "Affinity Diagram" tool to organize needs; a "Voice of the Customer" (VoC) to prioritize needs; a Voice of the Engineer" (VoE) tool to establish design and performance specifications; and a "House of Quality" (HoQ) tool to identify design trade-offs between conflicting customer needs and engineering specifications.

43 Ultrafast laser polishing of additively and conventionally manufactured materials

L. Taylor, J. Qiao, Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology

Unoptimized material surface roughness of parts used in applications such as optics, medicine, and aerospace can significantly degrade precision or performance, namely affecting the focusing and direction of light in optical elements; increasing friction, wear, and heat generation in moving parts; and reducing the compatibility of medical implants with the human body. Conventional grinding and polishing techniques used to optimize surface roughness on both conventionally machined and additively manufactured parts are often costly, generate waste through the use of coolants and abrasives, and may not be suited for specific freeform substrates because of the size and shape of mechanical finishing tools. Pulsed laser polishing has been demonstrated as an alternate polishing technique capable of achieving nanoscale roughness while offering waste-free fabrication, material-specific processing through direct tuning of laser radiation, and access to freeform shapes using refined beam delivery and focusing techniques. We have experimentally investigated the effect of femtosecond ablation on additively manufactured Ti-6Al-4V and maraging tool steel; silicon carbide, fused silica, and silicon; alumina ceramic; aluminum; and soda-lime glass. By substituting ultrafast laser radiation, polishing can be performed by direct evaporation of unwanted surface asperities with minimal heating and melting, offering damage-free polishing of materials. Processing was performed for different focal fluences and sample scanning speeds to determine the effect of parameter variation on material removal and surface roughness reduction. A factorial study on laser processing parameters is underway, where initial results have indicated material removal ranging from the order of 10 to 100 microns for processed substrates.

44 Ionic Liquids as additives in gearboxes lubricants of Wind Turbines

Dr. Patricia Iglesias Victoria, Mechanical Engineering Department, Rochester Institute of Technology

Wind turbines provide a clean and sustainable energy. While the wind energy industry has seen rapid growth within the last decade, the cost of maintain the turbines is a major drawback. Contact failures in gear and bearing components have been the source of costly repairs and downtime of the turbine's drivetrain. A potential solution to reduce contact failures in wind turbines is the use of ionic liquids (IL) as lubricant or additives of lubricants. ILs have the ability to form stable ordered layers on the contact area between the materials, reducing friction and wear.

For this particular work, the wear behavior of one IL used as additives (2.5, 5 and 10 wt%) in a base oil is studied and compared to commercially available fully formulated lubricant. Lubricated disks of steel AISI 52100 mated with AISI 440C stainless steel balls were studied using a ball-on-flat reciprocating configuration. The used of the ILs as additives in a wind turbine gearbox oil reduced the wear under the experimental conditions studied. The wear mechanisms and surface interactions are discussed in terms of IL-metal surface interactions from SEM, EDX.

45 Wearable Electroactive Polymer Biosensors

Kathleen Lamkin-Kennard, Wayne Walter, Department of Mechanical Engineering, Rochester Institute of Technology

Electroactive polymers (EAPs) are a class of polymeric smart materials that change physical properties in response to an external stimulus. EAPs are inherently lightweight, flexible, easy to manufacture, and provide repeatable electrical signals. Although the global market for EAPs is projected to exceed $3.4 billion by 2017, the use of EAPs for biosensing applications is still in its infancy. Wearable biosensors offer significant potential for non-invasive and non-obtrusive monitoring of a variety of physiological conditions and the novel integration of EAPs into textile biosensors could potentially transform the field of wearable biosensors. One area, in particular, in which robotic biosensors have significant potential to empower individuals in monitoring of their own health is in the area of peripheral edema monitoring. Lower extremity edema can be a consequence of a variety of disease states, such as heart disease, liver disease, diabetes, arthritis, or lymphedema, or can occur due to pregnancy, injury, medications, or clinical treatments, such as hemodialysis. Left untreated, edema can become painful and lead to skin and circulatory damage or life-threatening conditions, such as deep venous thrombosis. Individuals with lower extremity edema also have a higher risk for infection, injury due to falls, or tissue cancer. Our current research seeks to address this clinical need by characterizing and optimizing the design of a low-cost capacitive biosensor for edema monitoring using dielectric electroactive polymer materials. The primary aims of our research involve experimental characterization of flexible electrode and dielectric materials, material selection and modeling of all individual sensor components, and integration of the flexible components into a wearable garment configuration.

46 Overview of an Optical Wing

Alexandra B. Artusio-Glimpse, Grover A. Swartzlander, Jr., Carlson Center for Imaging Science, Rochester Institute of Technology

Consider the airfoil: a carefully designed structure that undergoes stable lift and drag forces when placed in a uniform air flow. Air pressure and radiation (or light) pressure are similar forces, which begs the question: does an optical analogue to the airfoil exist, and how does the shape of such a wing affect desired motion? In this research, refractive rods with various asymmetric cross-sections are designed, fabricated, and studied as optical analogues to aerodynamic wings; we shall call these “optical wings.” To study optical wings, we employ Lagrangian theory of mechanical motion, ray-based optical numerical models, and lab experiments to investigate the flight trajectories of a prototype wing shape - the semicylinder. This work finds that the asymmetric cross-section of the optical wing results in an angularly dependent, stable optical lift with complex parametrically-driven oscillation and shows possibilities for laser control of these devices. The realization of optical wings builds an infrastructure for future advancements in optical manipulation of shaped objects for micromanipulation and novel space flight applications.