Student Poster Presentations

P1 **Title:** An Optical Parametric Amplifier For Seeding Femtosecond Fe:Znse Lasers At 4.1 µm
Author list: Z. Alphonse Marra (presenter), Jialin Li, David Smerina, Fangjie Zhou, Yi Wu, Zenghu Chang
Abstract: Mid-infrared pulses with 200 nJ energy and 200 nm bandwidth were generated at 4.1 µm and 60 kHz repetition rate. The highly-stable $LiGaS_2$-based Optical Parametric Amplifier was pumped by a turn-key, commercially-available Yb:KGW laser.

P2 **Title**: Liquid Crystal Flat Optics for Augmented Reality
Author list: Jianghao Xiong (presenter), Tao Zhan, Kun Yin and Shin-Tson Wu
Abstract: Lately a new type of reflective liquid crystal optical elements has found pervasive applications in augmented reality displays. These optical elements exhibit unique properties like compact form factor, large diffraction angle, high diffraction efficiency and polarization selectivity. By applying them in augmented reality displays, we are able to solve various challenges in brand new ways, like enlargement of field of view and pupil steering to expand eye box.

P3 **Title** : Optical Beam Transformation Using Holographic Phase Masks
Author list: Nafiseh Mohammadian (presenter), Oussama Mhibik, Marc Segall, Leonid Glebov, Ivan Divliansky
Abstract: Spatial light modulators produce beams with a desired phase pattern, which directly affects the beam's power spatial distribution. We demonstrate an approach for creating holographic phase masks, which are permanently recorded in a photosensitive glass and do not require electric power in order to operate. The essence of the approach is that by means of holographic recording, an arbitrary phase pattern is encoded into a transmitting volume Bragg grating. Upon Bragg reconstruction, the phase pattern is reconstructed in the diffracted beam. These spatial light modulators are tunable and could be achromatic in broad spectral range.

P4 **Title:** Optimization of Laser Processing Parameters Through Automated Data Acquisition and Artificial Neural Networks
Author list: Cameron Vo(presenter), Boyang Zhou, Xiaoming Yu
Abstract: Finding the optimal parameters in a laser processing application can be time-consuming given the large parameter space and various sources of error. This problem is exacerbated by day-to-day variation in laser beam characteristics and a large variety of materials that need to be processed. The ideal laser processing system should be "smart", meaning that it can sense changes in the environment, make proper adjustment, and predict parameters for new materials. As a step towards this goal, we propose a method to efficiently extract the areas of a large number of laser-induced damages in-situ using an automated data acquisition system that controls laser parameters, movement of a motorized stage, image capturing/processing, and feature extraction. A large number of data points are collected automatically within an hour and reduction in time can be achieved by further hardware and software optimization. The damage areas are extracted and compared with direct measurements. Features such as ripples and sub-surface cracks are analyzed and fed into artificial neural networks (ANNs) for classification and prediction. With the capability of collecting a large amount of data in a short period of time, this system can be used to train sophisticated ANNs for complicated tasks such as quality control and failure prediction.

P5 **Title**: Generation And Amplification Of High Power Ultrafast Mid-Infrared Pulses Through ZGP

Author list: Fangjie Zhou (presenter), Yi Wu, Yanchun Yin, Krishna Murari, Zenghu Chang

Abstract: We present the generation of femtosecond pulses centered at 3 and 8 μm through a ZnGeP2-based Optical Parametric Chirped Pulse Amplifier. The output can be used for a two-color high harmonic generation scheme.

P6 **Title**: Sampling Laser Waveforms Using Tunneling in Solids

Author list: Yangyang Liu, Shima Gholam-Mirzae, John Beetar (presenter), Jonathan Nesper, Ahmed Yousif, Nrisimha Murty Madugula, & Michael Chini

Abstract: Characterizing the time-dependent electric field waveform of few-cycle laser pulses is a requirement for applications to attosecond science and other field-resolved spectroscopies. Recently, characterization techniques based on strong-field excitation have shown success in characterizing few-cycle pulses and waveforms ranging from the ultraviolet to mid-infrared. Unlike perturbative nonlinear optical techniques, these characterization methods do not rely on phase matching or retrieval algorithms, and they have been demonstrated to accurately characterize broad bandwidth pulses and sub-optical cycle field transients. Here, we extend one such technique, known as TIPTOE (tunneling ionization with a perturbation for time-domain observation of an electric field), to solid-state media. We show that tunneling and multiphoton excitation in a dielectric solid can provide an ultrafast temporal gate, as well as a simple detection scheme, for waveform characterization. The solid-state TIPTOE allows for full measurement of the electric field waveform from sources with relatively low pulse energies in comparison to the gas-phase TIPTOE. Furthermore, we experimentally demonstrate that the solid-state platform allows for single-shot, on-chip measurement of optical waveforms.

P7 **Title:** Image Transport In Disordered Optical Fiber Endoscopes

Author list: Xiaowen Hu, Jian Zhao, Jose E. Antonio-Lopez, Rodrigo Amezcua Correa, and Axel Schülzgen

Abstract: We demonstrate the advantages of disordered optical fibers in endoscopic imaging applications with increased robustness and broadband incoherent illumination. By using deep learning neural networks, we achieve high fidelity full-color cell imaging and accurate image classification under large fiber deformations.

P8 **Title:** A Study On Phosphor Thermometry Thermal Gradient Sensitivities For Gas Turbine Environments

Author list: Johnathan Hernandez (presenter), Quentin Fouliard, Ranajay Ghosh, Seetha Raghavan

Abstract: Power-Generation Turbines are the main source of energy and power distribution in the world. These systems rely on 300 micron ceramic based coating to ensure the high pressure turbine blades are protected over multiple cycles. However, in-situ monitoring of these systems is limited to very few techniques such as thermocouples and IR methods. Monitoring of these surface and subsurface temperatures can help increase temperature restrictions and provide operators to valuable information to ensure efficiency operation. Phosphor thermometry is a unique method that utilizes the luminance intensity, decay, and decay shift to measure thermal loads in rare earth dopants. In this work Rare earth dopants that ingressed into thermal barrier coatings are tested in simulated turbine environment. To do this a novel heat sink system was devised to ensure high thermal gradients within the coating. This work and future work will utilize

Phosphor thermometry as technique to measure sensitivity limits with in coatings with different thickness and dopants. Passive cooling in high heat flux testing has demonstrated roughly 1°C per micron. It is expected in future testing a more extreme thermal gradient will be experienced. This sensitivity analysis will give PTS users a fundamental understanding of possible limitations and restrictions to this technique in high thermal gradient environments such as power generation turbines.

P9 **Title:** Intracavity Spatial Mode Conversion by Mean of Holographic Phase Masks
Author list: Lam Mach (presenter), Nafiseh Mohammadian, Oussama Mhibik, Leonid Glebov, and Ivan Divliansky
Abstract: Holographic phase masks – i.e., complex phase structures coupled with the transmissive volume Bragg grating, possess a high degree of tunability and achromatism. Here we demonstrate a linear, wavelength-tunable, continuous-wave Yb3+:KYW laser capable of emitting customizable spatial modes by mean of holographic phase masks.

P10 **Title:** High-Sensitivity Experimental Setup for Measuring Optical Scattering In PTR Glass
Author list: Roberto Alvarez, Aleksandr Ryasnyanskiy, Pavel Shirshnev and Leonid Glebov
Abstract: One of the sources that introduce losses into holographic optical elements recorded in PTR glass is strong scattering produced by NaF nanocrystals that precipitate after UV exposure and thermal development. Previous investigations on the scattering properties of PTR glass were derived from optical attenuation spectra and no experimental tools for direct measurement of optical scattering were developed. Here, we present a high-sensitivity experimental setup for measuring scattering from a 1-mm probe beam at 405 nm. The system provides 2D image of the probe beam at 90° at this wavelength. A narrowband filter cuts off luminescence of the sample. A high-resolution CCD captures the image and values of scattering intensity is calculated with a specialized image processing software Image J. The system sensitivity is sufficient to detect the scattering level of highly homogeneous glasses including fused silica. Absolute values of scattering index in PTR glass are calculated by normalization to known scattering value in fused silica. This setup represents a fundamental tool for the exploration of structural transformations that take place during the holographic recording process.

P11 **Title**: Direct Modulation of Electrically Pumped Coupled Microring Lasers
Author list: Chi Xu (presenter), Mercedeh Khajavikhan, Patrick LiKamWa
Abstract: We demonstrate the use of gain-loss contrast between two coupled identical resonators, as a new degree of freedom to enhance the modulation frequency response of laser diodes. An electrically pumped microring laser system with a bending radius of 50 µm is developed on InAlGaAs/InP MQW p-i-n structure. The device lases in continuous-wave mode at room temperature with a threshold current of 27 mA. By tuning the ratio between injection current levels in the two coupled rings, our experimental results clearly show a bandwidth improvement of by up to 1.63 times the fundamental resonant frequency of the individual device. This matches well with our rate equation simulation model.

P12 **Title:** Pulse Width Dependence of The Effective Nonlinear Refractive Index In Air
Author list: Natalia Munera (presenter), Salimeh Tofighi, Eric W. Van Stryland, and David J. Hagan
Abstract: The existence of a transparency window in the Mid-IR has raised considerable interest in atmospheric propagation of short Mid-IR laser pulses. Propagation of high-power self-guided, diffraction-resistant laser filaments in the atmosphere has attracted attention in remote sensing and LIDAR [1]. It is therefore important to measure the nonlinear refraction governing high power

beam propagation in the atmosphere. We used the nonlinear refraction of air results from the polarization-sensitive, time-resolved Beam-Deflection technique, exciting in both the near and mid-IR and probing in the mid-IR [2]. As has been shown earlier, we assumed that the nuclear rotational nonlinear refraction is nearly dispersionless [3]. From these data, we find no dispersion of the bound-electronic nonlinear refractive index, $n_{2,el}(\lambda_p;\lambda_e)$, which allows us to model the pulsewidth dependence of the effective nonlinear refractive index, $n_{2,eff}$, i.e., as would be measured by a single beam. Interestingly, $n_{2,eff}$ is maximized for a pulsewidth of approximately 0.5 ps. The position of this maximum is nearly independent of pressure while its magnitude decreases with increasing pressure and temperature. From our measurements and modeling, we predict the nonlinear refraction in the atmosphere at different altitudes.

P13 **Title:** Tin-Gallium-Oxide Solar-Blind Photodetectors on Silicon (111) By MBE

Author list: Isa Hatipoglu, Daniel A. Hunter, Partha Mukhopadhyay, Martin Williams, Paul R. Edwards, Robert W. Martin, G. Naresh Kumar, and Winston Vaughan Schoenfeld

Abstract: Deep ultraviolet (DUV) frequencies of the Solar spectrum do not reach the Earth's surface thanks to the Ozone layer, leaving us with a background noise-free environment for wavelengths below ~280 nm. Detection of this solar-blind region is essential for many applications ranging from flame and missile detection, gas sensors, medical applications, non-line-of-sight communication, and space-to-space communication. AlGaN and MgZnO have been the choice of material for solar-blind photodetectors until Gallium Oxide came into play. Gallium oxide is a natural choice due to its bandgap of 4.8-4.9 eV (cut-off wavelength ~255nm), high breakdown voltage, and radiation hardness. However, there are several issues to be addressed to achieve the foremost device parameters: 1) Coverage of the entire solar-blind region, 2) higher responsivity, and 3) better transient response. Here we present heterogeneous integration of Tin-Gallium-Oxide UVC photodetectors on Silicon by molecular beam epitaxy (MBE). Direct correlation in structural and compositional and optical properties are studied by multimodal electron microscopy and spectroscopy techniques. The Sn composition is found to be x=2.2-2.6% by wavelength dispersive X-ray spectroscopy. There are clear peaks in cathodoluminescence intensity at 2.2 eV and 2.64 eV, a potential signature of intrinsic point defects. We suspect that these intragap states are the root of the ultrahigh photoconductive gain via hole trapping. Moreover, the Ga2O3 nucleation layer improves the surface quality and results in better device properties, including higher specific detectivity on the order of 1012 Jones compared to TGO growth directly on the Si substrate.

P14 **Title:** Non-Degenerate Two-Photon Absorption Spectroscopy of Bulk Silicon Using White-Light Continuum Probe

Author list: Sanaz Faryadras (presenter), Nick Cox, David J. Hagan, and Eric W. Van Stryland

Abstract: Extremely nondegenerate two-photon absorption (END-2PA) shows large enhancement over degenerate 2PA in direct and indirect gap semiconductors and can be utilized in applications such as sensitive mid-infrared detection and 3D infrared imaging. Due to its wide range of applications in integrated photonics, optical switching, and sensing, silicon is of special interest. Specially, 2PA across the indirect gap of silicon (1.12 eV) can be of importance because of its applications in telecommunication wavelengths (1300 and 1550 nm), when using with high optical irradiance. We perform pump-probe measurements of ND-2PA of bulk silicon across its indirect gap with a combination of several pump and probe wavelengths. Femtosecond pulses in the range 1700 nm<λ<2400 nm were used as the pump beam. Probe pulses in the range 1150 nm<λ<1500 nm were provided by filtering the white-light-continuum (WLC) generated in a YAG crystal. Enhancement of the 2PA coefficient is observed in our measurements for the more non-

degenerate wavelength combinations and its dispersion is compared with our recently developed theoretical model for the dominant transition in the band structure of silicon.

P15 **Title:** Laser-Aided Manufacturing and Micro-Processing of Materials

Author list: Tianyi Li(presenter), Gunjan Kulkarni and Christopher Kosan

Abstract: Depositing nanoparticles additively on rigid or flexible substrates as 2D films is of great importance when it comes to Photonics and Optoelectronics. The processes developed in our laboratories, Nano-Electrospray Laser Deposition (NELD) and Laser-Assisted Contact Printing, are presented.

In the NELD process, nanoparticle suspension is delivered to needle, through capillary tube, from the syringe pump at a specific flow rate and the substrate is fixed below the needle. Application of a very high electric field between needle and substrate creates a conical meniscus at needle tip, resulting in microdroplets. While the microdroplet falls towards the substrate, pulsed Nd:YAG laser, passing through an optical setup is focused on the substrate to evaporate liquid in the microdroplet and simultaneously sinter the nanoparticles onto the substrate. Furthermore, an analytical conduction model was developed to calculate temperature distribution within the droplet depending on its refractive index, reflectance, and absorption coefficient. As per the model, 20 wt% Ag nanoparticle microdroplet was predicted to explode mid-air and this was verified experimentally.

For Laser-Assisted Contact Printing, nanoparticle suspension is delivered to the needle through a capillary tube to draw a liquid line on the substrate fixed on an XYZ stage. CW CO_2 laser is passed through an optical setup and focused on the substrate to evaporate the liquid and simultaneously sinter the nanoparticles. Systematic selection of process parameters allows for numerous materials to be accepted into this apparatus and obtain the desired aspect ratio of the deposited film. Using this technique, we deposited Ag fingers on ITO-coated Si substrate and SiO_2 line on glass substrate. The experimental setup can also be used to laser-anneal Ag fingers deposited on solar cells through screen printing. An analytical model for laser-annealing of Ag fingers has been developed to understand the effects of laser power and substrate speed on the temperature distribution within the solar cell.

Implementation of the NELD process has yielded sub-wavelength features deposited on both rigid and flexible substrates while the contact printing method has been used to generate optically transparent thin films.