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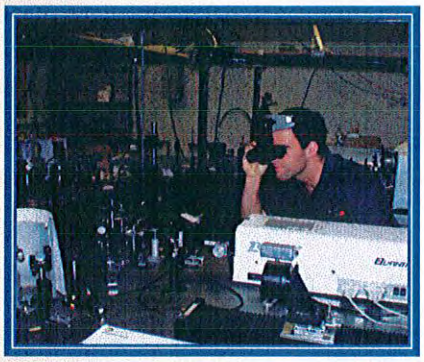

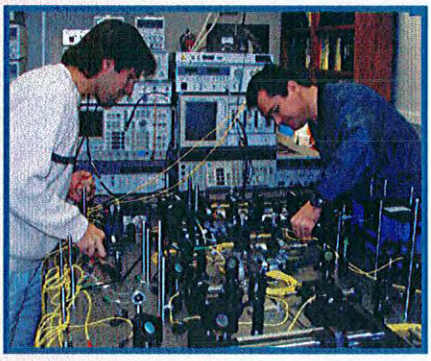

April 5, 2002

Optics Technology for Defense & Homeland Security

UCF School of Optics / CREOL Industrial Affiliates' Day 2002

Friday, April 5, 2002
University of Central Florida, Orlando

"Optics in National Defense and Homeland Security"

PROGRAM SCHEDULE

Morning Session -- UCF Student Union, Cape Florida Ballroom

8:30 a.m.	Continental Breakfast & Walk-in Registrations
9:00	Welcome **UCF President John Hitt** **M. J. Soileau**, UCF Vice President for Research **Eric W. Van Stryland**, School of Optics/CREOL Director
9:30	**David A. Honey**, DARPA Microsystems Technology Office *"Optical Telecommunications in Defense"*
10:00	**Edward W. Pogue**, Joint Technology Office HEL-JTO *"High Energy Lasers"*
10:30	Refreshment Break
11:00	**Filbert J. Bartoli**, National Science Foundation *"Nanophotonics"*
11:30	**Laurence P. Clarke** Imaging Technology Development, NHI *"Advanced Biomedical Imaging Technologies"*
12:00	Adjournment of morning session.

Afternoon Session -- CREOL Building

12:15 p.m.	**Lunch** Served, CREOL Lobby
1:15	**Eric W. Van Stryland**, Director, School of Optics/CREOL *"Research and Education at the School of Optics/CREOL"*
1:40	**School of Optics/CREOL Students of the Year,** Research Presentations Sergey Polyakov and Gabriel Popescu
2:00-3:00	Perspectives from Florida Industry **Ray Mott**, Executive Director, Florida Photonics Cluster **Greg Quarles**, Vice President for Research, VLOC, Inc. **Jeff Bullington**, President, Infinite Photonics, Inc. **Buck Burns**, President, Burns Engineering Corp. **Steve Guch**, Vice President, Northrop Grumman Laser Systems
3:15-5:00	**Poster Presentations, Lab Tours & Demonstrations**
5:00	**CREOL Reception and Award Presentations**

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Lab Tours and Demonstrations

Title	Room	Lab Director	Demonstrator	Time
Optical Technology for a Deployable 3-D Trauma Training Center	145-147	Jannick Rolland	Larry Davis	3:15, 3:45, 4:15, 4:45
Technology Development For Fiber Optic Based Sensing	142	Aristide Dogariu	Gabriel Popescu	3:15, 3:45, 4:15, 4:45
E-Beam Fabrication of IR Antennas	130	Glenn Boreman	Brian Monacelli	3:15, 3:45, 4:15, 4:45
2-D Display	157	Michael Bass	Michael Bass	3:15, 3:45, 4:15, 4:45
Volume Holographic Elements for High Power Lasers	249	Leon Glebov	Igor Ciapurin & Vadim Smirnov	3:15, 3:45, 4:15, 4:45
Femtosecond White Light Pulses and Nonlinear Spectroscopy	227	David Hagan/ Eric Van Stryland	Joel Hales	**3:15, 3:30, 3:45, 4:00 4:15, 4:30**
Tunable Nanosecond Laser & Optical Limiting	236	David Hagan/ Eric Van Stryland	Will Shensky	**3:15, 3:30, 3:45, 4:00 4:15, 4:30**

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ABSTRACTS OF

POSTER PRESENTATIONS

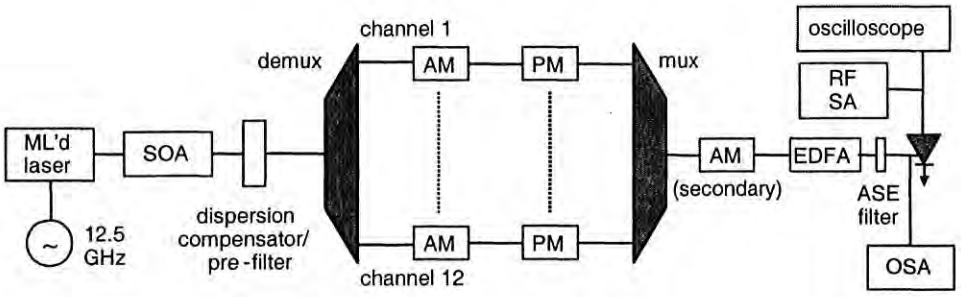
ABSTRACT NUMBER	TITLE OF ABSTRACT	AUTHORS
1	Photonic Arbitrary Waveform Generation and Photonic Synthesis with Modelocked Semiconductor Lasers	Tolga Yilmaz, Christopher M. DePriest and Peter J. Delfyett, Jr.
2	Nanometer X-ray Microscopy of Labeled Live Biological Organisms with a Nanosecond Laser-Plasma Source	Ma'am Raja Al-Ani, John Biggerstaff and Martin Richardson
3	Far-IR Semiconductor Laser for Future THz-Carrier Free-Space Communications	E.W. Nelson
4	Microfabrication of Waveguides and Gratings in Chalcogenide Glass Thin Films Using Femtosecond Pulses	A. Zoubir, M.C. Richardson, C. Rivero, C. Lopez and K.C. Richardson
5	Rigorous Calculations of the High Order Modes Guided In Photonic Crystal and Multicore Fibers	Waleed S. Mohammed and Eric G. Johnson
6	Multiwavelength Modelocked Diode Lasers for Hybrid OTDM-WDM Access Networks	Michael Mielke, Eric Park and Peter J. Delfyett, Jr.
7	Laser-Direct Writing and Doping of Wide Bandgap Materials	I.A. Salama, N.R. Quick and A. Kar
8	A Non-Paraxial Scalar Treatment of Sinusoidal Phase Gratings	Dijana Bogunovic, Andrey Krywonos and James E. Harvey
9	Diffuse Reflectance of Optical Coatings	Adela Apostol and Claudia Mujat
10	Free-Space Wavelength-Multiplexed Optical Scanner	Zahid Yaqoob and Nabeel A. Riza
11	Resonant Grating Reflection Filters	Don Jacob and Jim Moharam
12	Integrated InP/InGaAsP Mach-Zehnder Optical Switch Realized By Selective-Area Zinc In-Diffusion	D.A. May-Arrioja and Patrick LiKamWa
13	Beam Control Prisms For Diode Laser Arrays	Te-yuan Chung and Michael Bass
14	Three-Dimensional Two-Photon Fluorescence Lithographic Imaging in a New Photoresponsive Polymer	Kevin D. Belfield, Katherine J. Schafer and Stephen J. Andrasik
15	Multiphoton Effects in the Polydiacetylene Poly Bis (P-Toluene Sulfonate) of 2,4-Hexadiyne-1,6-Diol (PTS)	Fumiyo Yoshino, Sergey Polyakov and George Stegeman
16	Optical Limiting and Nonlinear Beam Propagation	Ion Cohanescu, F. Hernandez, W. Shensky, V. Dubikovskiy, D. Hagan, and E. Van Stryland
17	Two-Photon Absorption in Organic Molecules	Mihaela Balu, J. Hales, K. Belfield, D. Hagan and E. Van Stryland
18	Additive Lithography for Micro-optics Fabrication	Mahesh Pitchumani, Heidi Hockel, Waleed Mohammed and Eric G. Johnson
19	Multidirectional Asymmetrical Microlens-Array Light Control Films for High Performance Reflective Liquid Crystal Displays	Yi-Pai Huang, Fu-Jen Ko, Shin-Tson Wu and Han-Ping Shieh
20	Disperse-O-Matic: A Freeware Dispersion-Management Tool for Ultrafast Optics	Charles Middleton and C.W. Siders

Photonic Arbitrary Waveform Generation and Photonic Synthesis with Modelocked Semiconductor Lasers

Tolga Yilmaz, Christopher M. DePriest, Peter J. Delfyett, Jr.

Ultrahigh capacity information systems require a broad range of functionalities such as analog to digital conversion (ADC), digital to analog conversion (DAC), ultrahigh speed optical sampling for next generation bit error rate systems, optical clock recovery, etc. A useful solution is to develop a novel photonic arbitrary waveform generator/photonic synthesizer (PAWG/PS) that could be used for a broad range of functions in both optical analog and digital communications, direct detection and coherent detection architectures, and RF/microwave applications. In our poster, we present results that demonstrate the performance of a PAWG that produces 1) ultrashort, ultralow jitter optical pulses for OTDM applications, 2) coherent combs of phase locked optical carriers for dense WDM applications, 3) ultralow noise RF clock signals, and 4) arbitrary intensity modulation with 100 GHz of instantaneous bandwidth, using low frequency RF drive signals. The photonic arbitrary waveform generation demonstrated builds on our development of ultralow timing jitter optical pulse trains from modelocked semiconductor diode lasers.

The concept behind the PAWG relies on the fact that modelocked lasers produce a periodic comb of phase-locked optical carriers i.e. longitudinal modes. The phase-locked optical carriers serve as a basis set to produce an arbitrary modulation impressed on an optical signal. The arbitrary waveform synthesis is then achieved by controlling the intensity and phase of the individual longitudinal modes (see figure below).



PAWG/PS setup.

We present measurement results on noise characterization of our hybridly modelocked external linear cavity semiconductor laser. The residual phase noise knee position and the longitudinal mode linewidth as a function of laser cavity frequency have been measured. We show that the residual phase noise knee position and the average linewidth of the individual modelocked longitudinal modes are directly correlated with each other. This result shows that the average linewidth of the individual modelocked longitudinal modes can be measured by using residual noise measurement techniques, or conversely, the limits of RMS pulse-to-pulse timing jitter is determined by the linewidth of the modelocked longitudinal modes. For low noise, optical frequency stabilization techniques, such as the Pound-Drever-Hall scheme, are necessary.

We then show that the PAWG/PS can generate high quality RF signals directly in a single mixing step by heterodyne beating of the selected longitudinal modes of our modelocked laser. This is in stark contrast to conventional frequency synthesizers and arbitrary waveform generators which may require many mixing steps to realize complex, high frequency RF signals. In our PAWG/PS we demonstrate a channel-to-channel stability of less that 100 Hz on a 37.5 GHz optically induced RF tone, while simultaneously generating a variety of arbitrarily shaped RF waveforms by appropriately combining modulation signals on the individual stabilized WDM channels.

Nanometer x-ray microscopy of labeled live biological organisms with a nanosecond laser-plasma source

*Ma'an Raja Al-Ani, John Biggerstaff[#] & Martin Richardson**
School of Optics & CREOL, University of Central Florida, Orlando, FL

also of Dept Molecular & Microbiology, University of Central Florida, Orlando, Florida

Summary

One of the highest priorities of microbiology today is the need to visualize live micro-organisms, such as single cells, bacteria, viruses,etc., with sufficient temporal and spatial resolution and specificity to understand their structural and functional dynamics. Protein-specific, fluorescence-labeling, or 'molecular-tagging' and laser-scanning confocal-optical-microscopy [LSCM] is currently used, but is limited in spatial resolution to ~200-300nm[1]. X-ray microscopy [XRM] has achieved much higher spatial resolution[2], and x-ray labeling techniques have been used, with synchrotron sources[3]. However, these sources require exposure times of several seconds, and resort to rapid cryogenic freezing[4] of the specimen is needed for living organisms. Here we demonstrate, to our knowledge for the first time, the use of nanoparticle Au-labeling techniques in XRM using single, nanosecond, laser-plasma x-ray illumination of the specimen. In this case the specimen is in its natural state, and a high-resolution (~30 nm) x-ray radiograph is obtained in a time shorter than that required for any x-ray induced structural changes to the organism to be manifested on the image. Moreover we demonstrate, a technique in which *combined* labeled images of specific sites in the organism are obtained through both XRM and LSCM.

The sites of the organism to be imaged are identified by tagging them with particular antigens. In the two cases we have studied, melanoma tumor cells and human lymphocyte cells, mouse-α CD54 and CD3 antibodies respectively, were attached to antigens on the surface of the organism. To these antibodies were attached Oregon green dyed goat-α IgG antibodies, to provide a visible fluorescor for LSCM. Lastly, to these antibodies were then attached donkey-α goat antibodies seeded with 18nm Au nanoparticles.

The laser-plasma XRM described here[5] utilizes plasma emission in the so-called 'water window' (2.3-4.5nm) from an Yttrium target irradiated at $3x10^{12}W/cm^2$ with 3J, 10ns laser pulses from a Nd:glass laser[6]. The organisms, after sequential treatment by the three antibodies, are immersed in their natural fluid in a 10 μm-thick, vacuum-tight, specimen-cell having a 1 mm square, 100nm thick SiN x-ray window, and, opposite it, a thin layer of PMMA photo-resist deposited on a Si substrate. The specimen cell is then exposed to one shot of the 100 μm diameter laser plasma x-ray source, and a transmission radiograph recorded on the photoresist. The high resolution image is thus recorded as a

1:1 registration of the line-of-sight absorptivity of the specimen. After development, the three-dimensional relief recorded on the photo-resist is analyzed with a high resolution atomic force microscope. Fig.1 shows images of a melanoma tumor cell taken with both the XRM described above, and the LSCM. In Fig.1(a) is shown an x-ray image of the tumor cell without antibodies attached. Fig.1(b) shows a similar cell with the antibodies attached. The sites of local absorption by the 18nm Au nanoparticles can clearly be seen. Fig.1(c) show a comparable LSCM image of a similar cell. Although fluorescence from the visible molecular tags can clearly be seen, the resolution is limited. Similar images have been obtained with human lymphocyte cells.

We discuss the potential of this new form of high-resolution imaging, and describe measures made to quantify the structural effects identified by the nanoparticle x-ray tags.

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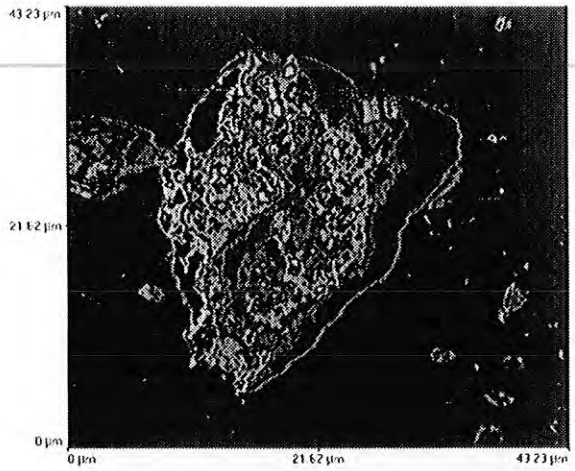
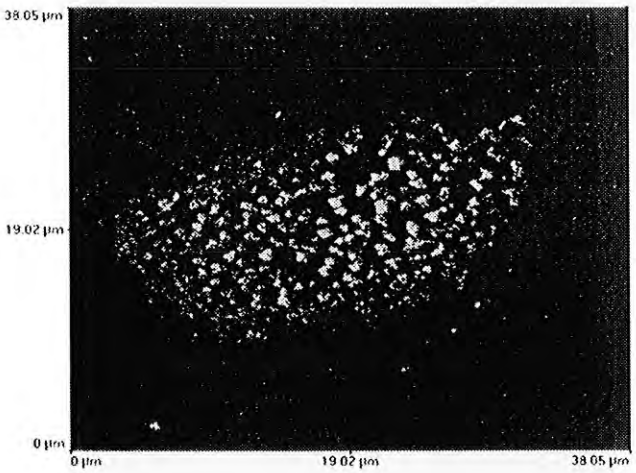
(a)



(b)



(c)

Fig 1. (a) X-ray microscope image of a melanoma cell without antibody tagging, (b) x-ray image of a similar cell with Au nano-particle antibody tagging (c) Confocal fluorescence microscope image of a similar melanoma cell

Far-IR semiconductor laser for future THz-carrier free-space communications

E. W. Nelson

New experimental results are presented for the far-infrared p-Ge laser that enhances its prospects for application to secure satellite and short-range terrestrial free-space communications on a THz carrier. An optical means of gain modulation has been discovered that may potentially permit far-IR pulse generation via active mode-locking with low drive power. A compact high-field permanent-magnet assembly is demonstrated for applying the magnetic field required for laser operation without need of liquid helium. Compact light-weight laser-excitation electronics have been designed to run off a low voltage direct current supply.

MICROFABRICATION OF WAVEGUIDES AND GRATINGS IN CHALCOGENIDE GLASS THIN FILMS USING FEMTOSECOND PULSES

A. Zoubir[1], M.C. Richardson[1], C. Rivero[2], C. Lopez[2] and K.C. Richardson[2]

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Unamplified mode-locked Ti:Sapphire lasers have demonstrated the ability to micromachine optical materials. Because the femtosecond regime minimizes the heat affected zone, cleaner, smaller and more repeatable structure feature sizes can be achieved. Amorphous chalcogenide glass films are candidates for all-optical integrated circuits for the telecommunication industry due to their excellent infrared transparency, large nonlinear refractive index, and low phonon energies. Micromachining of $As_2S_3/SiO_2/Si$ thin films was achieved in two distinct regimes: When the power was over the ablation threshold of the film, relief gratings with 1.5 μm deep grooves and a 20 μm period were recorded. When the power was slightly below, no ablation was observed but the refractive index changed locally due to the photorefractive effect of As_2S_3. Waveguides as small as 10 μm wide were fabricated in the film. Prior studies have linked bulk glass structural and optical property changes through Raman spectroscopy, showing that nonlinear absorption-induced index changes could be traced to local bonding changes in As_2S_3.

A special Ti:Sapphire laser was developed for these investigations. The purpose of this development was to generate pulses with energies in the 10's nJ range with sufficient intensity to reach thresholds for irreversible structural change at the optimal repetition-rate. The laser emission has a spectral bandwidth of approximately 40 nm (FWHM) centered at 800 nm and a repetition rate of 28 MHz. An interferometric autocorrelation measured sub-50 fs pulse duration. The system has an average output power of 0.55 W and produces energies up to 20 nJ per pulse. The output of the laser was focused by a 15x, 0.28NA reflective objective onto a target attached to a 3D motorized translation system. The reflective objective minimizes the reflection loss and the normal dispersion induced by a traditional refractive microscope objective. This approach to waveguide fabrication allows for the rapid production of volume microstructures as well as relief structures with the same laser without the need of costly and complex laser amplification systems.

Rigorous Calculations of the High Order Modes Guided in Photonic Crystal and Multicore Fibers

Waleed S. Mohammed and Eric G. Johnson

Photonic crystal fibers (PCF's) have recently gained a great deal of interest for their remarkable waveguiding properties. This new kind of fiber relies on the photonic band created by a deformed 2D periodic pattern of air rods in dielectric medium to guide the light. Moreover, control over the holes pattern enables tailoring modal and dispersion properties without having to resort to complex fiber perform.

The scattering matrix method is used to calculate higher order modes guided in PCF fibers and multicore fibers. We solve a boundary condition problem considering the rigorous coupling between electric and magnetic fields to solve different cavity structures and micro-cores arrangements. We present complete hybrid modal solution for multimode and ring shaped PCF as well as a super nodes characterization for the multicore fibers and photonic crystal multicore fiber.

Multiwavelength Modelocked Diode Lasers for Hybrid OTDM-WDM Access Networks

Michael Mielke, Eric Park, and Professor Peter J. Delfyett, Jr.

Offering significantly more bandwidth capacity, optical fiber has replaced electrical cable as the global telecommunications transmission backbone. Electrical transmission lines, however, still dominate the so-called 'last mile' of network infrastructure owing to the prohibitive expense of upgrading to optical components. Enabling technologies for the optical access network must be versatile and robust, as well as cost-effective. We have developed the multiwavelength modelocked semiconductor diode laser into a novel optical time division multiplexed (OTDM), wavelength division multiplexed (WDM) laser source that satisfies these requirements. The multiwavelength laser emits multiple WDM channels in the form of return-to-zero (RZ) modelocked pulse trains. Recent experiments have shown the simultaneous generation of up to 60 WDM channels from a single external cavity diode laser, automatic gain flattening via an intracavity spatial light modulator with a feedback loop, suppression of mode partition noise through hybrid modelocking, and the demonstration of a 50-Gb/s optical Ethernet link using the multiwavelength diode laser and 0.5 km of multimode fiber.

Laser-Direct Writing and Doping of Wide Bandgap Materials

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Laser-direct write technique is utilized to introduce stable conversion in electric properties of wide bandgap materials such as diamond and silicon carbide. Laser irradiation of silicon carbide (resistivity 10^{11}-10^{10} Ωcm) substrates in inert atmosphere (Ar and He) created carbon rich conductive phases with attendant decrease in electric resistivity (10^{-4}Ωcm). The conductivity of the laser-irradiated tracks increases asymptotically with both laser power density and number of irradiation exposures. The temperature dependence of electrical resistivity for laser generated phase revealed its metal-like behavior with possible electron-tunneling at the liquid nitrogen temperature. Repeated-irradiation experiment and isothermal annealing indicated the high temperature stability of the laser-generated phases. Both n-type and p-type doped tracks are generated by laser irradiation in nitrogen and in TMA and argon mixture, respectively. Laser-fabrication of n-type schottky barrier junction on silicon carbide and diamond like carbon (DLC) substrates is demonstrated. Capacitance-voltage and current-voltage

characteristics of the laser-fabricated junctions are measured and used to determine the dopant profile along the junction width. The dopant profile of the laser fabricated junctions is obtained using second ion mass spectroscopy (SIMS) and the corresponding dopant diffusivity is found to be four orders of magnitude faster than that obtained by conventional high temperature diffusion. Different analytical techniques (XPS, XRD, AFM, SEM, TEM and Raman spectroscopy) are used to study the laser irradiated tracks and the underlying mechanism of electronic properties conversion. Laser direct-write technique provides a reduced-number of steps, highly controllable, and cost-effective tool for rapid prototyping as well as commercial fabrication of wide bandgap semiconductor devices. This technique is capable of metallization, dielectric synthesis, selective area doping, epilayer growth as well as etching of a wide variety of semiconductor materials. It can also be utilized as a secondary process for defect annealing, doping activation and conductivity control of ion-implanted and as-grown substrates.

A Non-paraxial Scalar Treatment of Sinusoidal Phase Gratings

Dijana Bogunovic, Andrey Krywonos, and James E. Harvey

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Abstract

Scalar diffraction theory is frequently considered inadequate for predicting diffraction efficiencies for grating applications where $l/d > 0.1$. It has also been stated that scalar theory imposes energy upon the evanescent diffracted orders. These notions, as well as several other common misconceptions, are driven more by an unnecessary paraxial approximation than the scalar limitation. By scaling the spatial variables by the wavelength, we have previously shown that diffracted radiance is shift-invariant in direction cosine space. Thus simple Fourier techniques can now be used to predict a variety of wide-angle (non-paraxial) diffraction grating effects. These include: (1) the redistribution of energy from the evanescent orders to the propagating ones, (2) the angular broadening (and apparent shifting) of wide-angle diffracted orders, and (3) diffraction efficiencies predicted with an accuracy usually thought to require rigorous electromagnetic theory.

Diffuse reflectance of optical coatings

Adela Apostol and Claudia Mujat

Scattering properties of diffuse optical coatings are determined by their physical characteristics such as porosity, pore size distribution, refractive index contrast and losses. However, their measurable optical characteristics are influenced not only by the internal inhomogeneity, but also by the structure of the substrate and the substrate/coating and coating/air interfaces.

The purpose of this study is a complete characterization of coating/substrate systems which is realized by corroborating measurements of diffuse and specular spectral reflectance with surface topography and optical near field characteristics. Thus, optical non-invasive techniques are used to probe simultaneously both the structure and the scattering performance of a coating.

Theoretical predictions based on light diffusion in a semi-infinite medium, are also made for the spectral diffuse reflectance of a coating on a homogeneous substrate, and are correlated with the experimental data for three coatings with very different scattering efficiencies.

Free-space Wavelength-Multiplexed Optical Scanner

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An optical beam scanner with no-moving parts, wide angular scan range, large diameter aperture, and microsecond domain scan setting speeds is desired in many applications such as laser ultrasonics, biophotonics, and free-space communications. Previous technologies such as acousto-optics [1], electro-optics [2], microelectromechanical systems (MEMS) [3], and opto-mechanics [4] have been hard pressed in realizing these scanner goals. Recently, we have proposed a new approach called Multiplexed Optical Scanner Technology (MOST) [5] to realize the highly sought after scanner. In this poster, we present free-space Wavelength-Multiplexed Optical Scanner (W-MOS) [6], a member of the MOST family that simultaneously provides fast speed, large apertures, sub-degree one-dimensional wide angular scans, and simple control.

As shown in Fig. 1, the free-space W-MOS is based on the principle of wavelength selection and light interaction with a dispersive element such as a diffraction grating. Wavelength selection can be achieved using a tunable laser or a tunable optical filter such as an acousto-optic tunable filter cascaded to a broadband source. The in-line laser source with a collimated laser beam allows for beam expansion before striking the wavelength dispersive element. This further allows the scanner to have large several centimeter apertures leading to high resolution angular scans. The grating is tilted with respect to the incident Gaussian beam to optimize the output scan angle. Using fast tunable lasers or optical filters, this scanner features microsecond domain scan setting speeds.

A hand-held W-MOS unit is also built for demonstration purposes. The hand-held W-MOS uses a fiber collimator ($1/e^2$ beam size ~ 8 mm) and a 600 grooves/mm silver-coated blazed reflection grating mounted on a tip-tilt alignment stage. A fiber-coupled mechanically tuned laser with an 80-nm tunable bandwidth centered at 1560 nm is used as the tunable source. The hand-held W-MOS unit provides an angular scan of 14.58^{o} as wavelength of the tunable source is tuned over the available 80 nm bandwidth.

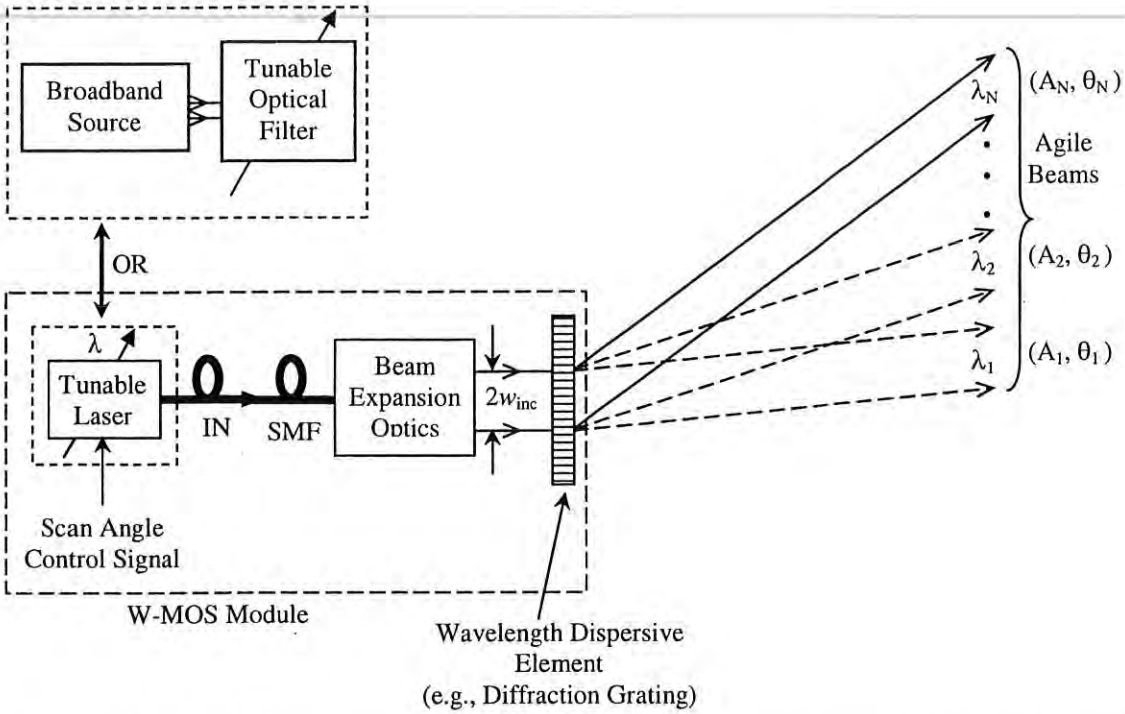

Fig. 1: Schematic of the free-space W-MOS for implementing a no moving parts, ultrahigh speed, desired output power profile, one-dimensional wide angular scan range optical scanner.

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RESONANT GRATING REFLECTION FILTERS

Don Jacob and Jim Moharam

SUMMARY

Diffraction grating anomalies, now called grating resonances, refer to the rapid variations in intensity of propagating orders over narrow ranges of wavelength or incident angle. A subwavelength dielectric grating for which only the reflected and transmitted zeroth orders propagate, can be designed such that nearly 100% of the incident energy is transmitted by the structure over a broad band of wavelengths (several hundreds of nanometers). This same structure when designed for resonance will switch from being nearly 100% transmissive to 100% reflective at a particular wavelength and incident angle. The linewidths of these resonances can range from several nanometers to hundredths of a nanometer thereby making these structures ideal candidates for narrow-band filtering applications. To better understand the resonance behavior we developed an interference-waveguide model. With this model we investigated infinite and finite length structures operating at oblique and normal incidence under plane wave and finite beam illumination and determined the dependence of the resonance on the parameters of the structure: refractive indices and thicknesses of individual layers and the grating period, its duty cycle and modulation. We determined that at oblique incidence the angular acceptance of the filter is directly related to the spectral linewidth, which results in inefficient filtering of finite beams especially in the IR. However, at normal incidence the angular acceptance can be significantly broader than what is achievable at oblique incidence thereby permitting efficient filtering of finite beams even in the IR. The insight gained from this analysis has provided clues on how the structure can be manipulated to construct narrow-band flat-top spectral filters with extremely broad angular selectivities as well as one- and two-dimensional polarization independent filters – both are necessary characteristics of filters used in optical communications applications.

INTEGRATED INP/INGAASP MACH-ZEHNDER OPTICAL SWITCH REALIZED BY SELECTIVE-AREA ZINC IN-DIFFUSION

D.A. May-Arrioja and Patrick LiKamWa

School of Optics/CREOL
University of Central Florida
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A dual output Mach-Zehnder electro-optic switch has been fabricated using an InP/InGaAsP multiple quantum well structure. A Zn in-diffusion technique was employed to selectively define p-n regions in the device. Our initial non-optimized device gave a 12 dB contrast ratio with a total voltage swing of <5 volts. The device operation bandwidth was in excess of 40nm.

Beam control prisms for diode laser arrays

Te-yuan Chung and Michael Bass
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We have designed and developed beam control prisms, a combination of a lens, a prism and/or a mirror, to control the light coming from a diode laser array. Fig.1 shows a typical beam control prism setup. It works as a lens to collect and focus the beam enabling control of the beam divergence at least in the fast axis of diode laser. By slightly tilting and/or shifting beam control prism, the laser beam can be focused or defocused to produce any desired spot size as shown in Fig. 2. Not only does the beam control prism provide the ability to focus or collimate the beam, but it can also aim the beam into any desired direction. This is achieved by slightly tilting and/or shifting the beam control prism as shown in Fig 3. Since we can control the beam direction, traditional dense stack packaging is not necessary. As a result the thermal management problem for the diode laser array is eased. As shown in Fig. 4 we can use spread out diode packaging designs and still direct light from different diode bars into the aperture of interest. Such a feature will be very helpful in most applications of diode laser arrays.

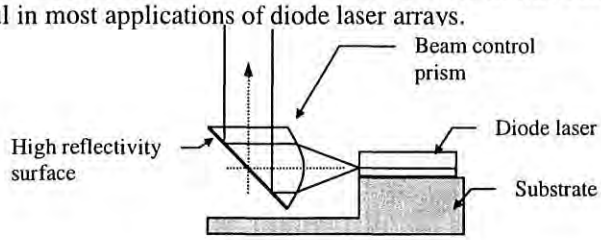

Fig.1

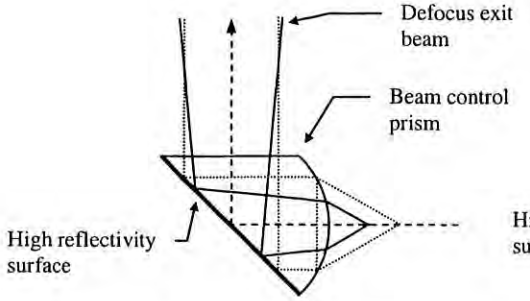

Fig.2

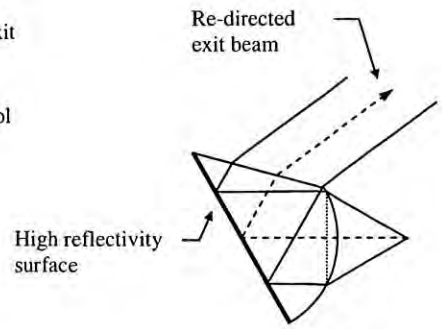

Fig.3

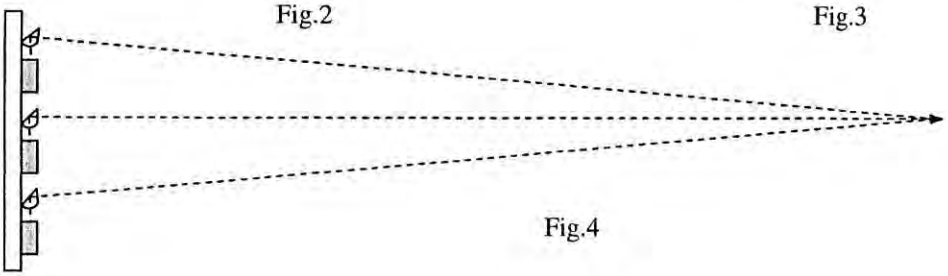

Fig.4

Three-dimensional two-photon fluorescence lithographic imaging in a new photoresponsive polymer

Kevin D. Belfield,* Katherine J. Schafer and Stephen J. Andrasik

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Abstract

We report image formation via photoinduced fluorescence changes in a photosensitive polymeric medium with two-photon fluorescence readout. A poly(styrene-*co*-maleic anhydride) was modified with a primary amine-containing two-photon absorbing fluorophore, affording the corresponding imide. Photophysical properties indicate the polymer undergoes two-photon upconverted fluorescence, and exhibits the characteristic quadratic behavior to the incident fs near-IR intensity. Modulation of fluorescence properties was exploited in the polymeric medium where multichannel two-photon fluorescence imaging provided both "positive" and "negative" contrast image readout capability with and without incorporation of a photoacid generator. A multi-layer assembly and bulk two-photon fluorescence lithographic imaging demonstrates the possibility of three-dimensional optical data read-out. Furthermore, the photosensitive polymer was also responsive to two-photon induced "writing" followed by "reading", indicating the possibility of high density write-once read-many (WORM) optical data storage in an organic material.

MULTIPHOTON EFFECTS IN THE POLYDIACETYLENE POLY BIS(P-TOLUENE SULFONATE) OF 2,4-HEXADIYNE-1,6-DIOL (PTS)

Fumiyo Yoshino, Sergey Polyakov and George Stegeman

Polydiacetylene-PTS (Poly [bis (p-toluene sulfonate)] of 2, 4-hexadine-1, 6-diol) is a conjugated polymer which exhibits strong π-electron delocalization that leads to a large third order nonlinear optical effects. In PTS one-photon absorption peaks at ~620 nm and two-photon absorption peaks at ~930 nm.[1] From these absorption spectra, one can expect a strong enhancement of 3 and 4 photon absorption at ~1860 nm. Multi-photon effects were studied experimentally and numerically.

High optical quality single crystals of PTS were grown by slow solvent evaporation growth technique. Most of the experiments were performed at 100 μm thickness. A Z-scan based setup was used in our experiments.[2] The laser system is an Optical Parametric Generator / Optical Parametric Amplifier with a Ti:sapphire source and regenerative amplifier. This system provides wavelengths from 1100 to 2200 nm with 100-fs pulses of ~10 μJ energy.

References:

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"Optical Limiting and Nonlinear Beam Propagation"

Presenting Author- Ion Cohanescu
Other Authors: F. Hernandez, W. Shensky, V. Dubikovskiy, D. Hagan, E. Van Stryland

Abstract:

By using the combined nonlinear optical effects of carbon disulfide and amorphous carbon suspensions (dilute ink), we demonstrate an optical limiter that protects eyes from damage for laser pulse energies up to 60 millijoules, which is 60,000 times the damage threshold of the eye. We also demonstrate our powerful beam propagation code used for modeling such limiting devices.

"Two-photon absorption in organic molecules"

Presenting Author - Mihaela Balu
Other Authors: J. Hales, K. Belfield, D. Hagan, E. Van Stryland

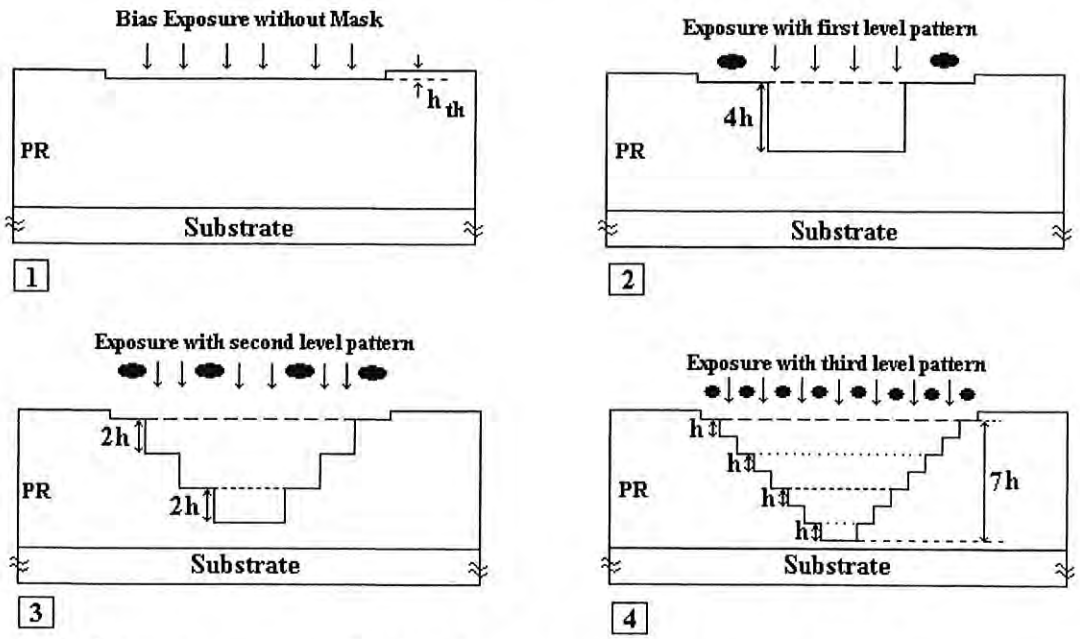
Abstract:

Two photon absorbing molecules are in significant demand for applications in 3-D microscopic imaging of bio-materials and in 3-D microfabrication. However, the two-photon coefficients of organics is not well characterized or theoretically understood. We describe the use of our femtosecond white-light spectrometer for the rapid characterization of new two-photon materials.

Additive Lithography for Micro-optics Fabrication

Mahesh Pitchumani, Heidi Hockel, Waleed Mohammed, and Eric G. Johnson

An innovative fabrication technique is introduced that is based on multiple exposure techniques for micro-optics fabrication. This approach is compatible with conventional lithography systems used in Integrated Circuit manufacturing and can be applied to thick and/or thin photoresists. The additive concept is centered on the idea of using multiple exposures to remove the desired amount of resist without resorting to multiple etching steps. This method utilizes varying exposure times and masks combining binary and analog photo-masks to sculpt complex photoresist profiles in a single, three-step process. One advantage of this technique is demonstrated through the formation of analog structures by reflowing the additively formed multilevel structures on the resist.



PR – Photoresist ● – Region with Transmittance = 0 on the mask

Poster Title: Multidirectional Asymmetrical Microlens-Array Light Control Films for High Performance Reflective Liquid Crystal Displays

Authors: Yi-Pai Huang, Exchange Ph.D student, School of Optics/CREOL, UCF.
Fu-Jen Ko, Doctor of NCTU IEO, AU Optronics Corp., Hsinchu, Taiwan.
Advisors: Shin-Tson Wu, Professor, School of Optics/CREOL, UCF.
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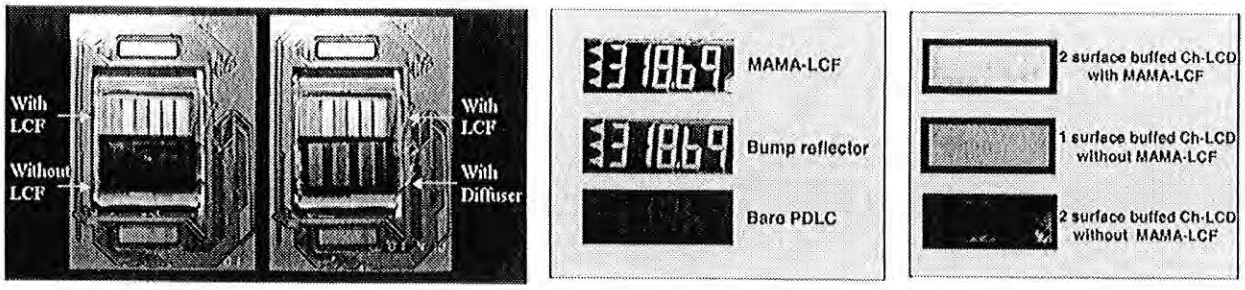
Reflective liquid crystal displays (LCDs) are being widely used in portable personal digital assistants and mobile communications. Varieties of new applications, e.g., STN-LCDs for mobile phones, PDLC for smart cards, and cholesteric LCD for e-books have been considered. In such applications, low power consumption, high brightness, high contrast ratio, and low cost are critical. Most single polarizer-based reflective color LCDs still suffer from inadequate reflectivity and contrast ratio (CR).

We developed the *multidirectional asymmetrical microlens array light control film* (MAMA-LCF) to enhance the image brightness and contrast ratio of reflective liquid crystal displays. Through optimized designs and optical alignments, the MAMA-LCF which is constructed with asymmetrical microlens arrays, leads to a ~5x gain in brightness over the MgO standard white and 12:1 contrast ratio for color STN-LCDs, 10x gain and 11.5:1 contrast ratio for PDLC, and 9x gain over the conventional Ch-LCD. In each display, the light control film does not induce visible surface diffusion, moiré patterns and parallax.

The photographs of displayed images using the MAMA-LCF on a color STN-LCD, PDLC and Ch-LCD, taken under ambient light condition are shown at the top of Figs. 1(a), (b) and (c), respectively. In comparison, the bottom of Fig. 1(a) shows bare STN-LCD (left) and STN-LCD with an 80% haze diffuser (right), which is commonly used to enhance the brightness of mobile displays. The photographs of PDLC with bump reflector and a bare PDLC are shown in the middle and bottom sections of Fig. 1(b). Additionally, the middle and bottom sections of Fig. 1(c) show the one-surface buffed Ch-LCD and the bare two-surface buffed Ch-LCD. The image quality with the MAMA light control film on the three different LCDs is clearly enhanced.



(a) (b) (c)

Fig.1. Sample photographs of (a) color-STN LCD, (b) PDLC, and (c) Ch-LCD. The displays with MAMA-LCF clearly show much brighter images.

Disperse-O-Matic: a freeware dispersion-management tool for ultrafast optics

Presenter: Charles Middleton, *School of Optics/CREOL*
Advisor: Prof. C.W. Siders, *Ultrafast Structural Dynamics of Matter Lab*

We present a method for managing the dispersion of a femtosecond pulse in an ultrafast laser system. The dispersive effects of each component of an ultrafast laser system are examined and evaluated using an easy-to-use LabView-based program called "Disperse-O-Matic." This program, written by School of Optics/CREOL experts in ultrafast lasers, easily and accurately evaluates the dispersion of ultrafast laser systems and their associated optical systems, greatly simplifying the design of such systems. With the support of commercial collaborators, the DoM is being distributed as freeware. In addition, we will discuss our use of the DoM with evolutionary optimization to design 10-fs class chirped-pulse-amplified laser systems.

School of Optics/CREOL
RESEARCH LABORATORIES
2002

Dr. M. Bass
Solid State Lasers
- Laser Spectroscopy and Optically Written Displays – 157
- Thermal Management of Diode and Solid State Lasers – 158

Dr. G. Boreman
- Infrared Systems – 130

Dr. P. Delfyett
- Ultrafast Optoelectronic Devices and Networks – 252

Dr. A. Dogariu
- Photonic Diagnostics in Random Media – 142, 144

Dr. L. Glebov
- Photo-Thermo-Refractive Glass, Melting – 255
- Grinding and Polishing – 152
- Volume Holographic Elements – 128
- Holographic Laser Beam Combining - 249

Drs. D. Hagan and E. Van Stryland
Nonlinear Materials Characterization Facilities:
- Femtosecond lasers – 227
- Nanosecond YAG's – 236
- Picosedond tunable OPO lab (400nm – 16 microns) - 230
- Picosecond YAG – 233
- Single Mode Nanosecond CO2 and Picosecond CO2 – 247
- Confocal Microscope with Verde Laser – 246

Dr. J. Harvey
- X-Ray Telescopes – Still being built
- Optical Surface Scattering – 155
- Generalized Scalar Diffraction Theory

Dr. H. Jenssen
- 4 μm Laser Development – 156A
- New Laser Materials - 156
- Crystal growth – MAP 153

Dr. E. Johnson
- Microphotonics Fabrication and Integration Lab 150, 153

Dr. A. Kar
- LAMMMP – 263, 264

(Laser-Aided Manufacturing, Material & Micro-processing)

Dr. G. Li
- Optical Fiber Communications – 246A, 241

Dr. P. Li Kam Wa
- Quantum Well Optoelectronics – 223

Dr. J. Moharam

- Diffractive Optics – 258

Dr. K. Richardson

- Glass Processing and Characterization – 255A
- ZYGO White Light Interferometer – 177
- X-Ray Defraction and Glass Polishing – 177

Dr. M. Richardson

Laser Plasma Laboratory

- Biological X-Ray Microsopy Facility – 140
- Laser Plasma EUV Source Applications Laboratory
- T.W. Femtosecond LaserInteraction Facility

Laser Development Lab – 141

- Femtosecond WaveGuide X Micromachining Laboratory
- New Solid State Laser Development

Dr. N. Riza

- Photonic Information Processing Systems – 250

Dr. J. Rolland

Optical Diagnostics and Applications Laboratory – ODALAB

- Augmented Reality and Virtual Reality – 147
- Optical Coherence Tomography (OCT) – 146

Dr. C. Siders

Ultrafast Structural Dynamics of Matter – 112

- Nano Scale Material Dynamics
- Femtosecond Chirped Pulse Amplifiier Development

Dr. W. Silfvast

- Extreme Ultraviolet Source Lab – 123
- Vacuum Ultraviolet Source Lab – 125

Dr. G. Stegeman

Nonlinear Guided-Wave Optics

- Picosecond OPG/OPA – 201, 203
  (optical parametric generator/amplifier)
- Femtosecond OPG/OPA– 202
- Color Center laser lab – 204
- Ti:Sapphire lab - 243

Drs. E. Van Stryland and D. Hagan

- See Drs. Hagan and Van Stryland

Dr. S.T. Wu

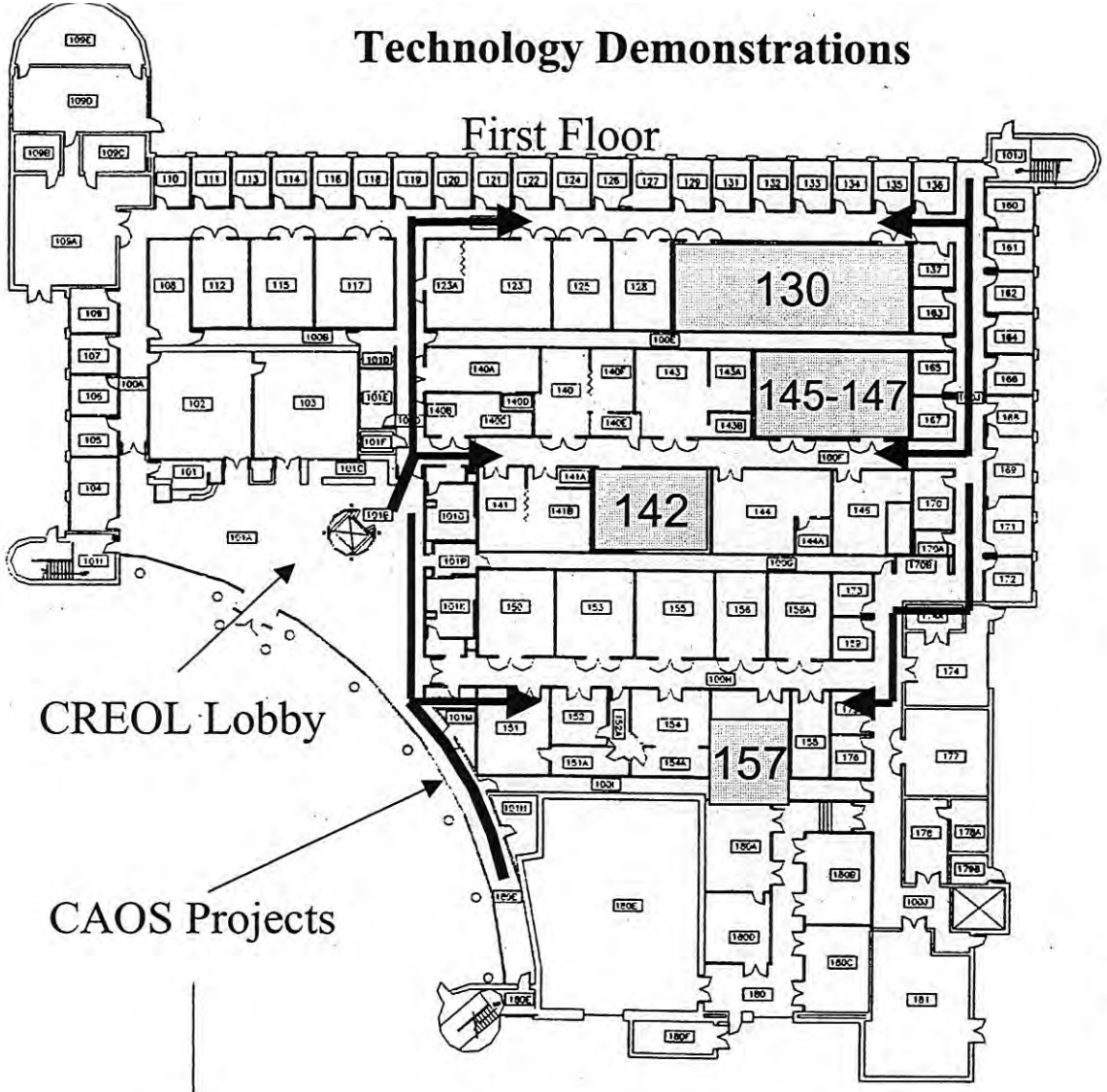
Photonics and Communication

- Nano Photonics – 260
- Laser Beam Steering - 259
- Liquid Crystal Displays - 245

Dr. B. Zeldovich

- Optical Beam Combining Quantum Optics – 249

Technology Demonstrations



-CAOS PROJECT LIST:
- Modulation through non-linear medium
- Hologram
- Direct link
- Polarization - Birefringence
- Diffraction
- Total internal reflection 1
- Phase conjugation
- Total internal reflection 2

E-beam Fabrication of IR Antennas

Room: 130

Lab Director: Dr. Glenn Boreman
Demonstrator: Brian Monacelli
Demo times: every 30 min. starting at 3:15

Technology Development for Fiber-optic Based Sensing

Room: 142

Lab Director: Dr. Aristide Dogariu
Demonstrator: Gabriel Popescu
Demo times: every 30 min. starting at 3:15

Optical Technology for a Deployable 3D Trauma Training Center

Room: 145-147

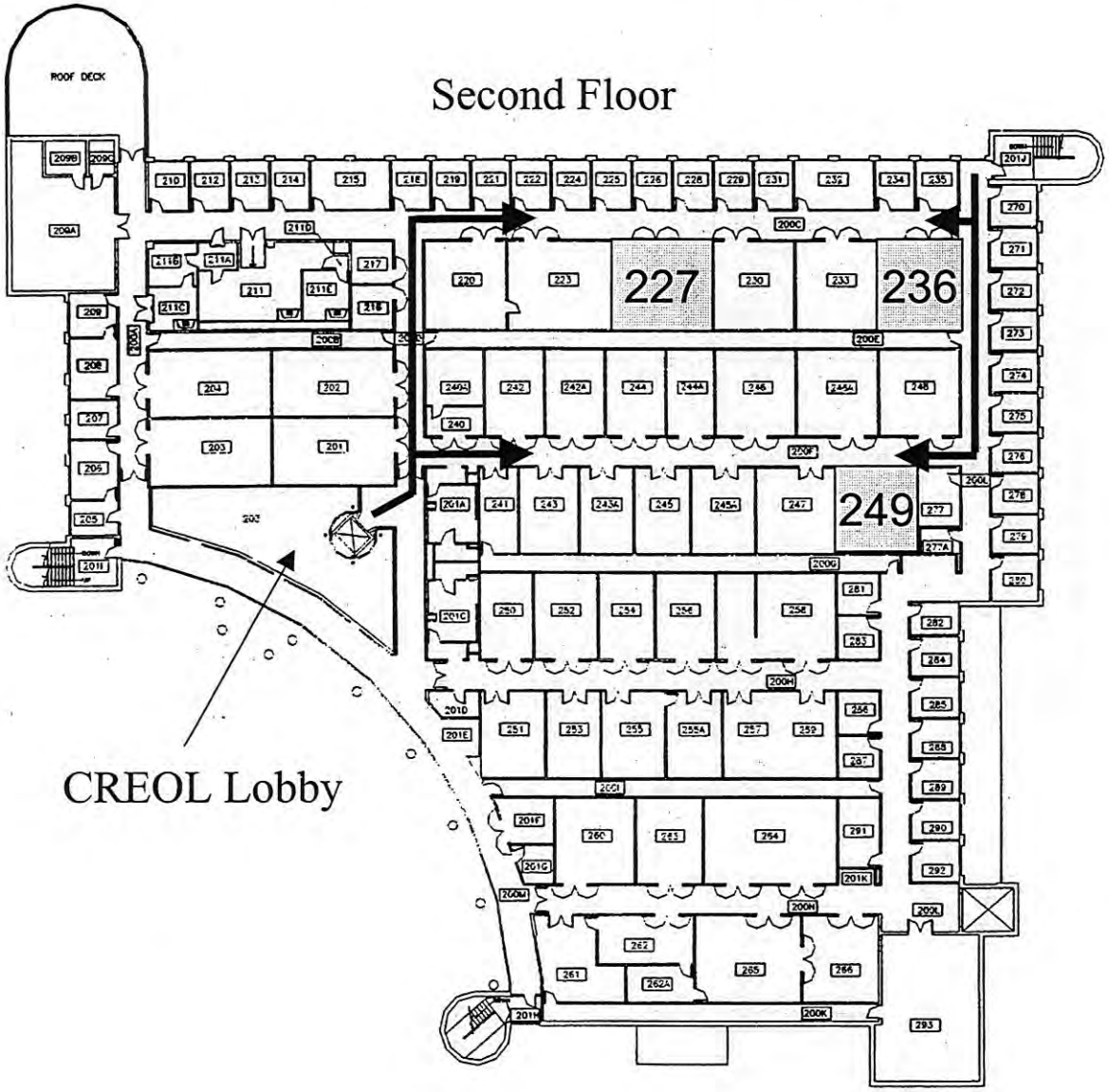
Lab Director: Dr. Jannick Rolland
Demonstrator: Larry Davis
Demo times: every 30 min. starting at 3:15

2-D Display

Room: 157

Lab Director: Dr. Michael Bass
Demonstrator: Dr. Michael Bass
Demo times: every 30 min. starting at 3:15

Technology Demonstrations



Room: 227

Femtosecond White Light Pulses and Nonlinear Spectroscopy

Lab Director: Drs. Hagan & Van Stryland
Demonstrator: Joel Hales
Demo times: every 15 min. starting at 3:15

Tunable Nanosecond Laser & Optical Limiting

Room: 236

Lab Director: Drs. Hagan & Van Stryland
Demonstrator: Will Shensky
Demo times: every 15 min starting at 3:15

Volume Holographic Elements for High-power Lasers

Room 249

Lab Director: Dr. Leon Glebov
Demonstrator: Igor Ciapurin/ Vadim Smirnov
Demo times: every 30 min starting at 3:15

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