CENTER FOR LASER APPLICATIONS

UTSI

THE UNIVERSITY of TENNESSEE SPACE INSTITUTE
TULLAHOMA, TENNESSEE

CENTER OF EXCELLENCE

ANNUAL REPORT 2012-2013

Welcoming Remarks

The Center for Laser Applications (CLA) at the University of Tennessee Space Institute is pleased to present our annual report the research projects funded by the Center and external sources for fiscal year 2012-2013.

Over the past year, The Center for Laser Applications supported the research efforts of eight UTSI Center-associated faculty who have made significant advancements in vision research, laser materials processing, chemical synthesis, single-molecule detection, nanotechnology, biotechnology, biomedical research, computational physics, plasma physics, laser-induced optical breakdown and fluid physics phenomena. Two CLA research efforts were commercialized, delivering an economic impact to the local community.

Productivity among Center faculty has been outstanding and diverse. While federal funding has been reduced and more difficult to obtain, our faculty has responded by finding direct commercial funding for research. The Tennessee Higher Education Commission (THEC) funding has proven the key to the advancement of innovation and the creation of intellectual property. THEC funds pay for the general operations of the Center and the research conducted in CLA, including the Center support staff, laboratory supplies, maintenance, travel for faculty and students to conferences, and research experiences for summer interns. Without this discretionary funding, advancement of new ideas would be limited. THEC resources allow faculty and students to pursue innovations. Capital equipment must also come from this budget. We have been fortunate to obtain a class 1000 clean room with a femtosecond nanomaching station and photolithography capability, an Optomec LENS™ machine for direct metal deposition, a modular fluorometer / phosphorimeter for fluorescence studies, a pulsed laser deposition system, and a JEOL 6320F field emission scanning electron microscope. With these capabilities CLA has been successful in the pursuit of new science and new sources of funding.

In spite of difficult economic times our research expenditures have been maintained. We are enthusiastic about our opportunities for the future and proud of the past accomplishments and hope you enjoy the research summaries that follow.

William Hofmeister

Director, Center for Laser Applications
Research Professor of Materials Science and Engineering

Center for Laser Applications Annual Report 2012-2013

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Introduction

The Center for Laser Applications (CLA) at the University of Tennessee Space Institute was established in 1984 as a state funded Center of Excellence to provide outstanding capabilities in research, education, and technology transfer in the area of laser applications. CLA began as an active multi-disciplined and collaborative research group at UTSI with expertise and significant industrial and university-based experience in phenomena related to the interactions of lasers with gases, liquids, and solids. The diverse background of the faculty and staff and the strong mission-related research programs of CLA provide a blend of applied and basic research that is unusual for universities.

Mission Statement

The CLA mission is to advance laser applications in spectroscopy and materials synthesis. We pursue our mission in three areas:

1) Education

- Provide a quality education to UTSI students with emphasis on apprenticeship
- Generate opportunities for undergraduate and high school student research

2) Innovation

- Develop a world class reputation for research and innovation

3) Service

- Assist businesses in development and implementation of technology
- Increase interest in STEM areas, i.e. support science education for local students and teachers

Focus Areas

The focus of the mission-related research programs of the Center is the application of lasers and associated technology to bio / nanophotonics, materials science, laser materials interaction, energy / power and spectroscopy. These focus areas of specialization were selected to correspond to known areas of scientific and engineering challenges and to areas of development and regional and national needs.

Bio / Nanophotonics

- Lloyd Davis - single molecule spectroscopy of biomolecules in confined spaces
- Ying-Ling Chen - vision research and modeling of human vision systems
- William Hofmeister and Lino Costa - devices for cellular chemotaxis
- Jacqueline Johnson - storage phosphor materials for mammography
- George Murray - colorimetric detection of bioactive molecules
- Christian Parigger - photo-acoustic imaging, diagnostics and applications
- Feng-Yuan Zhang - MEMS / NEMS, micro / nano fluidics

Materials Science

- George Murray - synthesis of molecularly imprinted polymers
- William Hofmeister - solidification, direct metal deposition and femtosecond nano-structuring of materials
- Lino Costa - phase transformations, laser cladding and modeling of direct metal deposition
- Lloyd Davis - trapping and diagnostics of quantum dots
- Christian Parigger - laser-induced materials physics
- Jacqueline Johnson - development of glass imaging material

Laser Materials Interaction

- Lino Costa - laser cladding and femtosecond laser machining
- William Hofmeister - direct metal deposition and femtosecond nanostructuring of materials
- Trevor Moeller - laser ablation dynamics and modeling of laser ablation for space propulsion
- Lloyd Davis - femtosecond fabrication of nanofluidic and wave guide devices
- Feng-Yuan Zhang - micro / nano manufacturing multifunctional materials

Spectroscopy

Advanced Manufacturing by Laser Additive Fabrication

- Charles Johnson - Mössbauer spectroscopy
- Christian Parigger - ultrasensitive spectroscopy and combustion diagnostics
- Lloyd Davis - single molecule spectroscopy
- Ying-Ling Chen - combustion diagnostics
- George Murray - Raman and electrochemical spectroscopy
- Feng-Yuan Zhang - Tomography, Diode-laser absorption spectroscopy, thermography

Non-Equilibrium Fluid Physics

- Trevor Moeller - plasma physics and combustion
- Christian Parigger - laser-plasma physics, combustion and fluid phenomena and computational modeling
- Feng-Yuan Zhang - hypersonic flow and reaction

Personnel

Dr. William Hofmeister, Research Professor of Materials Science and Engineering, was appointed Director of the Center in 2005. In 2007 Dr. Jacqueline Johnson joined CLA and secured a major grant from the National Institutes of Health for the development of materials for mammography. The National Science Foundation is also supporting this work. Her research is has attracted the attention of the community as evidenced by eleven invited talks this year alone! We are proud of Dr. Jackie Johnson's well deserved election as Fellow of the American Ceramic Society. This past fiscal year Dr. Murray completed the "spin off" or commercialization of his research with Raptor Detection Technologies. With the assistance of UTSI's ASSET (The Center for Advanced Scientific Support and Engineering Technology), Murray and Raptor created a small business with eight employees in incubator space at UTSI. Dr. Ying-Ling Chen's work with eye modeling and diagnostics is also being commercialized after clinical trials supported by Wang Vision Institute and NIH. Dr. Trevor Moeller continues to serve the aerospace establishment with a number of grants and task orders with Arnold Engineering Development Center. We are happy to announce the addition of a new faculty member to the CLA team, Dr. Feng-Yuan Zhang, Associate Professor, Mechanical, Aerospace & Biomedical Engineering, who will add expertise in micro-/nano-scale fluidics, transport, heat transfer, combustion, and energy conversion technologies to our center capabilities.

Dr. Murray checks the performance of molecular sequestration beads.

Collaborations

A significant fraction of the research and development program of the Center is supported by state, regional, and national industries. CLA actively collaborates with the Center for Industrial Services to provide studies for Tennessee industries, and CLA has also formed long-term research partnerships with regional and national industries. Supplementing these activities are research programs sponsored by the traditional federal agencies, the National Institutes of Health, the National Science Foundation, and National Laboratories at Oak Ridge and Albuquerque, over and above numerous collaborations with national and international Universities, and the nearby Arnold Engineering Development Center. These diverse research activities, an attractive student-to-faculty ratio, and outstanding facilities, combine to offer an unusual apprenticeship experience for diligent graduate students.

Graduate Student Support

Over the past five years CLA supported 25 graduate students with a combination of external research funding, UTSI support, ARRA and THEC funds.

- Aerospace Engineering

  MS: Andrew Williams, Erin Halpenny and James P. Rogers
- Bio Medical Engineering

  MS: Christian Foerster and Sharon Gray
- Materials Science

  PhD: Deepak Rajput

  MS: Matthew Parrish, Russell Lee Leonard and Mahn Vu
- Mechanical Engineering

  MS: Densu Aktas, Nicholas Lister, Richard Joel Thompson, and Nehemiah Williams
- Physics

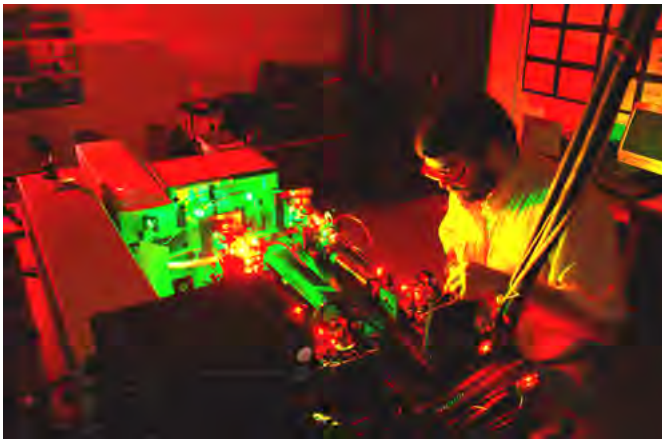
  PhD: William Robinson, Lei Shi, Jesse Labello, Kevin Baker and Bo Tan

  MS: William Ring, Alexander Woods, Jesse Ogle, You Li, Jason King, Justin Crawford and James Germann

Post Doctoral Support

The Center supports post doctoral fellows for continuing education and research support. Currently, Dr. Brian Canfield is working in the Davis lab on single molecule spectroscopy. Mr. Robert Rhodes continues to support the nonequilibrium fluid physics research with Dr. Moeller. Dr. Abhilasha Verma worked on molecular imprinting polymers for protein sequestration. Dr. George Owens was transitioned from post doctoral status to Raptor Detection Technologies. Past post doctoral fellows include: Dr. Paul Shen, Luna Innovations, Dr. Yelena White currently is an Assistant Professor of Physical Science for the Physics Department at East Georgia College. Dr. Zbigniew Sikorski remains active in the area of computational modeling and Dr. Xiaoxuan "Shaun" Li is a Materials Engineer at Secat, Inc. in Kentucky.

Post Doc Abhilasha Verma



Post Doc Brian Canfield

Outreach and Enrichment Programs

CLA is dedicated to impacting our community in a positive way with meaningful interactions. Faculty, staff and graduate students contribute to interactions with local students and teachers. We have worked hard to develop mini-courses, summer camps, and engaging enrichment programs to offer to local teachers and all levels of students from public schools to home school programs. To date 5,333 students and 141 teachers have participated in a learning experience presented by the faculty, staff, and students in CLA. The laboratory regularly hosts adult groups such as the Coffee County Leadership Program and the Precision Machinists. In addition, the graduate students have traveled to many schools in the community for events such as Friday School at Sewanee Elementary, Fantastic Fridays at Cowan Middle School and the Science Club at Shelbyville High School.

The ASM Materials Camp engaged high school students in learning about alternative energy strategies to performing a live play pertinent to the week's activities in the auditorium. TECH camp provided interactive, hands-on projects that facilitated career awareness and opened eyes to the excitement of scientific discovery to rising middle school students. The UTSI / CLA Computational Science camp hosted middle and high school students, as well as science and math teachers an opportunity to study computational astrophysics, meteorology, agriculture, genomics, epidemiology, pharmacokinetics, and programs using languages such as gnuplot, Perl, and NetLogo.

CLA has worked with the Tullahoma Hands On Science Center (HOSC) to provide educational experiences to alternative school students through a grant from the Peyback foundation. In 2010, UTSI teamed with the HOSC to win a grant to site a Fireball Network station at UTSI with an exhibit at the HOSC. The Fireball Network tracks meteors in the night sky. In 2010 UTSI moved its summer enrichment programs for younger learners to the HOSC as summer camp programs and assists in delivering those programs at the HOSC.

Science teachers and HOSC Bill Boss

What goes around comes around! Summer Intern Program

For the last three years CLA and UTSI have jointly funded a summer intern program, led by Dr. Jacqueline Johnson of Biomedical Engineering and CLA. The program is multifaceted in that it aims to provide a real research experience to prospective graduate students, promote diversity, educate and market. In year one the group was comprised of seven students, five females and two minorities, year two, three males and year three, three males and one female. The students range in educational level from high school to seniors in college. The interns undergo a lecture course, laboratory instruction and training in literature searches before being assigned to a research project. During the course of the summer the students write a paper, prepare a proposal, give a presentation, obtain career advice as well as participate in a full social program.

Summer internships have been found to be a valuable recruiting tool. Two of the students attending the first intern program are now in graduate school at UTSI and two more applied. CLA showcases its spacious laboratories, friendly faculty and staff and dedication to the involvement of students in research.

Each year feed results from a survey done verbally at the midpoint of the internship and a written survey at the end.

The photographs show two students hard at work in the laboratory and the 2013 interns with their supervisors at the ultimate departure bonfire.

Research Accomplishments and Five year Benchmark

Our research mission is growing. The funding provided by the Tennessee Higher Education Commission, coupled with support from the university, provided valuable leverage for sponsored research. The research awards continue to increase. This growth is possible because of the dedication of our faculty and the support of THEC and UTSI.

CLA remains active in Outreach and Business Development. The faculty are active in scientific conferences and local business meetings. Productivity among Center faculty has been outstanding during the last five year period. During fiscal years 2009 through 2013, Center faculty published 89 peer-reviewed articles, 9 books and presented at 172 regional, national, and international meetings.

Comparative Summary of Accomplishments

Benchmark Data	FY 2009-2013 Cumulative	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Publications						
Peer-reviewed articles	89	16	23	15	17	18
Book or book chapters	9	0	4	5	0	0
Presentations						
International	30	1	8	7	9	5
National	142	9	10	28	54	41
Research Awards						
External funding received	$5,829,101	$1,235,021	$1,676,546	$2,030,691	$278,700	$608,143
THEC State Appropriations	$4,445,012	$883,900	$965,200	$913,468	$858,064	$824,380
Research expenditures	$6,260,290	$1,280,931	$1,481,810	$1,395,390	$1,205,258	$896,901

Despite the current funding environment, we have managed to maintain research expenditures. The decrease in funding this year is due to the commercialization of the Raptor Detection Technologies project and the shift from Raptor's research resources to the new start up. Details of current faculty research are provided in the Faculty Reports section (pp. 13-21).

Future Directions

The University of Tennessee Space Institute's direction is changing from education and research to research and education; placing the greater emphasis on externally funded research. The Center for Laser Applications will follow that trend as well. We have built a vibrant multi-disciplinary research team broadly working in photonics, biophotonics, spectroscopy, laser materials interactions, plasma and non-equilibrium physics, fluid physics and computational modeling. These efforts will continue. Moving forward, the goal of CLA will be to involve more of the UTSI and UTK faculty and students in research using our laboratory resources. Currently, exploratory research is carried out guided by the Principals in CLA. In the future, exploratory research directions for the Center will be solicited from the faculty- at-large in the form of white paper proposals, and resources will be allocated based on this proposal process. We are confident that this plan will help serve the broader science community.

Laboratory space is one of CLA's greatest assets and in the future we will work to "broaden the tent" to make use of the facilities for more investigators. For example, we look forward to working with UT Research Foundation's ASSET program. CLA's space and infrastructure will contribute to the success of that program.

CLA Budget

Centers of Excellence / Actual, Proposed, and Requested Budget

University of Tennessee Space Institute, Center for Laser Applications

	FY 2012-13 Actuals			FY 2013-14 Proposed			FY 2014-15 Requested		
	Matching	Appropr.	Total	Matching	Appropr.	Total	Matching	Appropr.	Total
Expenditures	454,906	909,812	1,364,718	467,020	855,855	1,322,875	448,404	896,807	1,345,211
Salaries									
Faculty	66,839	133,677	200,516	68,844	137,688	206,532	72,286	144,572	216,858
Other Professional	101,029	202,058	303,087	101,029	202,058	303,087	106,081	212,161	318,242
Clerical / Supporting	37,672	75,345	113,017	37,672	75,345	113,017	39,556	79,112	118,668
Assistantships	35,216	70,432	105,648	35,216	70,432	105,648	36,977	73,953	110,930
Total Salaries	240,756	481,512	722,268	242,761	485,522	728,283	254,900	509,798	764,698
Fringe Benefits	67,913	135,827	203,740	67,913	135,827	203,740	71,309	142,618	213,927
Longevity	682	1,363	2,045	682	1,363	2,045	716	1,431	2,147
Total Personnel	309,351	618,702	928,053	311,356	622,712	934,068	326,925	653,848	980,773
Non-Personnel									
Travel	12,845	34,088	46,933	9,564	30,767	40,331	18,999	37,998	56,997
Software	121	320	441	90	290	380	179	358	537
Books & Journals	0	0	0	0	0	0	0	0	0
Other Supplies	15,252	40,478	55,730	11,359	36,540	47,899	22,564	45,127	67,691
Equipment	65,885	77,920	143,805	109,611	85,000	194,611	30,000	60,000	90,000
Maintenance	27,884	74,001	101,885	7,486	24,082	31,568	14,871	29,742	44,612
Scholarships	16,019	42,513	58,532	11,930	38,377	50,307	23,698	47,396	71,094
Consultants	0	0	0	0	0	0	0	0	0
Renovation	0	0	0	0	0	0	0	0	0
Professional Membership	192	509	700	143	459	602	283	567	850
Media Process	546	1,449	1,995	406	1,307	1,713	807	1,614	2,421
Communication	636	1,689	2,325	474	1,526	2,000	942	1,885	2,827
Rentals	2,133	5,662	7,795	1,589	5,111	6,700	3,156	6,312	9,468
Contractural Services	3,606	9,570	13,177	2,686	8,640	11,326	5,335	10,671	16,006
Other Expenditures	0	0	0	0	0	0	0	0	0
Cost Share	437	1,158	1,595	325	1,044	1,369	645	1,289	1,934
Total Non-Personnel	145,555	289,357	434,912	155,664	233,143	388,807	121,479	242,959	364,438
GRAND TOTAL	445,906	908,059	1,362,965	467,020	855,855	1,322,875	448,404	896,807	1,345,211
Revenue									
New State Appropriation		824,380	824,380		854,102	854,102		896,807	896,807
Carryover State Appropriation		85,432	85,432		1,753	1,753			0
New Matching Funds	454,906		454,906	467,020		467,020	448,404		448,404
Carryover from Previous Matching Funds			0			0			0
Total Revenue	454,906	909,812	1,364,718	467,020	855,855	1,322,875	448,404	896,807	1,345,211

Vision Science Research

Ying-Ling Chen

Research Assistant Professor
PhD, University of Tennessee Space Institute

For several years, Professor Chen's biophysics vision research in CLA has pioneered the development of numerical eye modeling and ophthalmic simulation that ranges in application from the optical design of ophthalmic instrumentation to refractive surgery, intraocular lenses, spectacle lens, contact lens design, bio-optical engineering, and medical education. Professor Chen has been awarded NIH research grants to support the creation and development of realistic eye models for diseased eyes and to develop a novel adaptive photorefraction technology to detect early keratoconus disorder, which is the major cause of failure of LASIK, the popular laser surgery technique.

In 2008, 2011, and 2013, Professor Chen and Dr. J.W.L. Lewis obtained three U.S. patents through The University of Tennessee Research Foundation (UTRF) for the adaptive photoscreening (APS) technology. The binocular prototype system includes a child-friendly screen that can display an animated video to attract the child's attention, to control the accommodation and ocular fixation, and to interact with examinees throughout the required infrared measurement procedures. The complete evaluation procedure includes assessments in binocular near- or far-sightedness, astigmatism, ocular motility / alignment, and optical opacity. The monocular design of the innovation makes possible the detection of cornea abnormalities, including dry eye, keratonconus, cataract, and corneal scars. Professor Chen collaborates with the Wang Vision Institute in Nashville to study primarily young adults' eye disorders such as keratoconus and dry eye syndrome and to show the feasibility of the CLA technique. In 2011, Professor Chen obtained the support from the Wal-Mart Vision Center in Tullahoma, TN for clinical studies of school-age children and, in 2012, to extend the clinical studies to pre-school children as young as 3 years old. In August and December 2012, 160 patients participated in the trial. The objective was to test measurements of binocular refraction, eye tracking / alignment, and dynamic pupillogram tests separately. Children love the use of familiar cartoon characters in the tests and thought the "surprise" monocular illumination in the pupil test was "very cool". Some parents showed great interest and expressed willingness to participate in future studies. The testing results were published in 2013 annual conference of The Association for Research in Vision and Ophthalmology. The children's clinical study is supported by 2012 Maturation award of UTRF. Dr. Chen was interviewed by (UTK media group) last summer and the press release for her research projects could be found in Tennessee Today, Quest, Newswise, MedicalExpress, and Tullahoma News, etc.

Currently Professor Chen is developing collaborations with several research groups in the Brain Institute and Eye Institute of Vanderbilt University to investigate the potential application of the APS detection of mental problems such as post traumatic stress disorder, dyslexia, and physical / emotional abuse through the ocular response and the hand-eye-stimulus interaction. Lastly, an investigation has begun of the effects of intraocular scattered radiation on vision and our future clinical measurements.

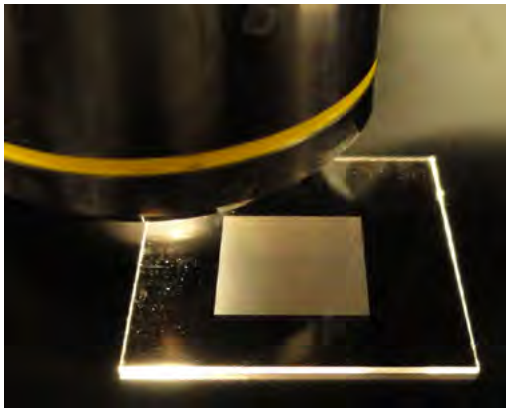
Materials Science

Dr. Lino Costa

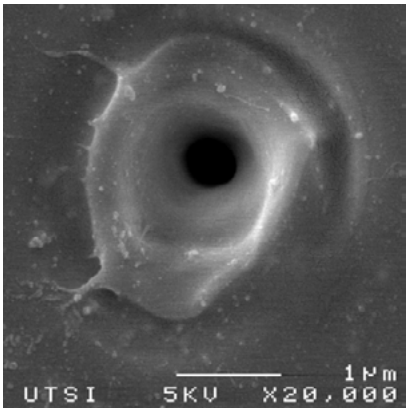
Research Assistant Professor of Materials Science and Engineering
PhD, Instituto Superior Tecnico, Universidade Tecnica de Lisboa

Dr. Lino Costa joined UTSI during the fall of 2005 as a research associate and became a research assistant professor during the fall of 2010. Dr. Costa has contributed to the advancement of various laser materials processing techniques, including Laser Powder Deposition applied to Solid Freeform Fabrication, Laser Induced Surface Improvement (LISI™) for development of wear and corrosion resistant surface coatings, and Femtosecond Laser Micromachining techniques for fabrication of microfluidic lab-on-a-chip devices for biomedical applications. He holds a Ph.D. degree in Materials Engineering from Instituto Superior Tecnico, in Lisbon Portugal, with a dissertation on finite element modeling of laser powder deposition of tool steels. On the topic of laser materials processing, he has 10 papers published in peer-reviewed scientific journals.

Dr. Costa's current research involves the use of fused silica master templates, containing millions of surface nanopores patterned using a femtosecond laser, to form polymer films covered with millions of nanowires via various replicating techniques, including hot embossing.



A 500 µm thick 22×22 mm² fused silica template containing over 4 million surface nanopores within a 1 cm² area, prepared in less than 60 minutes using a femtosecond laser.



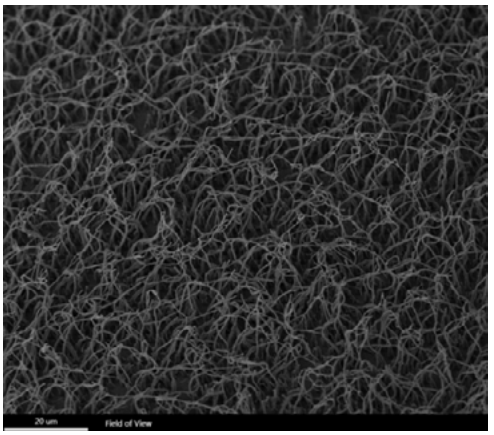
Scanning electron microscope image of a single nanopore machined on the surface of fused silica. Scale bar: 1 µm.

These nanowire structures can be loaded with nano-fillers and conformally coated with nanometer thick layers of metals and oxides to provide them with different functionalities for various applications.

Arrays of metal-coated nanowires can be used as high surface area electrodes for photovoltaic and electrical energy storage applications, whereas dense nanowire mats made from certain polymer materials are currently being tested as cell culture substrates for tissue regeneration applications.

Polymers nanowires have been successfully produced from numerous materials including cellulose acetate, polyethylene, polypropylene, polyvinyl alcohol, polycaprolactone, polyisoprene, polyvinyl chloride, polydimethylsiloxane, and nafion.

The individual nanowires have an average outer diameter of a few hundred nanometers and can be prepared with lengths ranging from a few micrometers up to 75 micrometers.



Scanning electron microscope image of polyethylene nanowires produced by hot embossing. Scale bar: 20 µm.

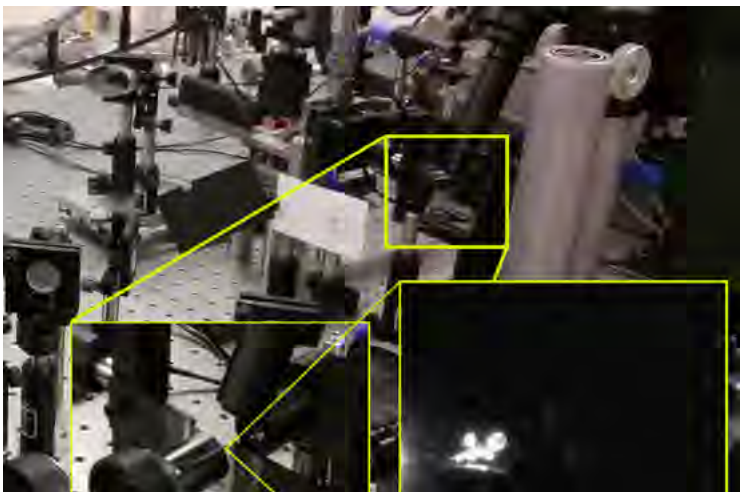
Ultrasensitive Spectroscopy

Lloyd M. Davis

B. H. Goethert Professor of Physics
PhD, University of Auckland, New Zealand
Visiting Researcher at Vanderbilt University
Visiting Researcher at JILA, UC Boulder
Visiting Researcher at the Photon Factory, University of Auckland
User/Visiting Researcher at CNMS, Oak Ridge National Laboratory

The research of Professor Davis and his group spans a range of activities in the areas of laser applications for chemical analysis and biotechnology. Much of this work is built on the group's earlier innovations in ultrasensitive fluorescence detection. Davis is a pioneer of experimental techniques in single-molecule fluorescence detection and spectroscopy, having co-developed the first experiments to successfully demonstrate detection of a single fluorophore in solution in the late 1980's, the first single-molecule detection in a "lab-on-a-chip" device in the 1990's, early experiments on single-molecule imaging for 3rd generation DNA sequencing in the early 2000's, and novel single-molecule detection and trapping in nano-fluidic channels around 2008-2010. In the past year, one student from the group has graduated with a PhD for studies on trapping of a single fluorescent nanoparticle in 3 dimensions (3-D) using a 4-electrode device; another doctoral student has developed an ultrasensitive confocal fluorescence microscope in which four laser foci are used as a 3-D quadrant detector for single-nanoparticle position determination and tracking. These two experiments rely on sub-diffraction imaging, in which the 3-D position of the emitter is measured more precisely than the diffraction limit of the microscope, together with real-time control of solution flow or sample position to counteract Brownian diffusion. Two new students are developing an experiment for measuring the diffusion of a single molecule in a nanochannel by alternating its motion using real-time control with a custom FPGA circuit.

Over the past year, several external collaborations have flourished, including an NSF-sponsored project with Vanderbilt University on ultrasensitive spectroscopy of nanoparticles for energy conversion applications, which grew from the 3-D trapping research. The methods for real-time control for trapping are also being applied in a project with JILA, at the UC Boulder, in which optical forces from a focused laser beam are used to sort mammalian cells in a microfluidic device as part of a process for developing new red fluorescent proteins with enhanced photostability and brightness. Super-resolution imaging of single proteins provides a means for nanoscale visualization of life processes inside cells, but further advances require these new improved proteins. In another collaboration with the Center for Nanophase Materials Science at Oak Ridge National Laboratory we are researching new methods for directly creating nano-channels and micro-channels using femtosecond lasers and special focusing conditions. One new doctoral student is studying fundamental processes that occur during femtosecond laser machining by time-resolved probing and imaging of the plasma. The figure shows part of an apparatus for some of these studies together with an image of the laser-induced plasma plume. We have also developed procedures for mitigating autofluorescence of the substrate induced by femtosecond laser machining and we are using arrays of nano-channels made by these procedures in experiments on highly parallelized single-molecule detection for biotechnology applications.



Experiment for time-gated imaging of femtosecond laser nanofabrication. The lower right inset shows nanoparticles ejected from the surface during the formation of nanoholes in a fused silica substrate.

Laser Materials

William Hofmeister

Research Professor of Materials Science and Engineering
PhD, Vanderbilt University
Adjoint Professor of Electrical Engineering, Vanderbilt University
University of Canterbury Visiting Erskine Fellow, 2011
Fellow of ASM International

Professor Hofmeister came to UTSI eight years ago to become Director of the Center for Laser Applications following eighteen years on the faculty of Vanderbilt University. His primary interest is in additive fabrication. Hofmeister was one of the developers of the Laser Engineered Net Shaping (LENS™) process at Sandia National Laboratories and holds a patent for a feedback control system for that process. He is working with NASA, the US Air Force and Sciaky, Inc. to develop sensors and control strategies for additive manufacture using electron beam technologies. Two patents have been awarded to NASA for his innovations in control of electron beam additive manufacture.

Currently, Professor Hofmeister is developing femtosecond laser ablation techniques for the fabrication of micro and nanofluidic devices for biological applications. He is an External Associate of the Vanderbilt Institute for Integrative Biosystems Research (VIIBRE) and holds two patents for bioreactors with members of VIIBRE. CLA has a state-of-the-art nanofabrication facility in our clean room with a femtosecond laser coupled to a microscope with four axis nanopositioning stages. CLA has built devices for the study of cell migration during chemotaxis with the Janetopolis group in Vanderbilt's Department of Biological Sciences. With Melissa Skala this collaboration was recently awarded a Discovery Grant for "Microfluidic Intravital Windows for Local Antiangiogenic Cancer Inhibition." Dr. Hofmeister's group has developed a unique 3D model for cell culture and is exploring the use of these models in several laboratories to study cancer mutagenesis, lymphocytes and tissue regeneration.

Professor Hofmeister's research in nucleation and solidification kinetics led to three space flight experiments in the 1990's to study the effects of fluid flow on nucleation using the TEMPUS facility on IML-2, MSL-1, and MSL-1R. Dr. Hofmeister was principal investigator for the TEMPUS Incandescence Measurement Instrument Project, which designed and implemented an infrared pyrometer on the existing TEMPUS flight hardware. TEMPUS experiments were conducted by "telescience" operation in low earth orbit using modeling and simulation software which Dr. Hofmeister developed for the space flight experiments.

Professor Hofmeister is active in professional societies and outreach to the local community. He has served as Board President of the Tullahoma Hands on Science Center. He frequently works with the University of Tennessee Center for Industrial Services to assist local industry such as Fischer USA, Nissan, Walker Die Casting, Ace Pump, and Jarden Zinc, with materials related problem solving.

Mössbauer Spectroscopy

Charles Johnson

Associate Director, UTSI
Emeritus Professor of Physics, University of Liverpool, England
M.A., Oxford University, England
D. Phil., Oxford University, England

Dr Charles Johnson studies glasses and nanoparticles using Mössbauer spectroscopy, most recently using the isotope ^{151}Eu.

The rare earths are an interesting group of elements which form solid compounds with important optical, electrical and magnetic properties which lead to technological applications. They usually form trivalent ions, differing only in the number of electrons n in the 4f shell, ranging from 1 in cerium to 13 in ytterbium. Particularly interesting is europium which can exist in the trivalent (n = 6) as well as the divalent (n = 7) state. Eu^{2+} is magnetic whereas Eu^{3+} is non-magnetic, and Eu^{2+} easily oxidizes to Eu^{3+}. Mössbauer spectroscopy provides a simple method for monitoring the oxidization state, through their different chemical shifts.

A detailed study has been made on Eu-doped ZBLAN fluorochlorozirconate glasses and glass ceramics containing $BaCl_2$. These have uses in optical devices (e.g. fiber lasers and amplifiers), up-converting and down-converting glass layers for solar cells, and x-ray storage phosphors or scintillators for x-ray detection and imaging (see Dr Jackie Johnson's report). The effective Debye temperatures for Eu^{2+} and Eu^{3+} have been measured. The results were used to optimize the performance of image plates for digital x-ray radiography. This involves maximizing the amount of Eu^{2+} and determining the conditions required for precipitating $BaCl_2$ nanocrystals containing Eu^{2+} from a barium chloro-fluorozirconate glass (ZBLAN). On x-irradation in this system Eu^{2+} stores defects and hence can be used in imaging. Eu^{3+} scintillates and so is a detector.

Studies have also been made on nanoparticles of europium sulfide, EuS, which is a non-metallic ferromagnet with a Curie temperature of 16.6 K. As well as obtaining data on superparamagnetism, the spectra have been used for monitoring sample preparation in order to improve the purity and obtain monodisperse samples.

Nd-Fe-B magnets are super-strong and require careful handling.

The magnetic properties of Fe_3O_4 nanoparticles have been studied. They have applications in medicine (targeting and destroying tumors, enhancing MRI signals) and in information technology. The well-known six-line spectrum of ferromagnetic iron results from the hyperfine interaction between the nuclei and the electrons. In paramagnetic iron compounds this splitting may be observed in large magnetic fields (~ 6 T) produced by superconducting magnets applied at low temperatures (~ 4 K). Magnetic nanoparticles are superparamagnets and the splitting may be observed in much smaller fields (< 1 T) even at room temperature. Such fields are now obtainable with neodymium iron boron permanent magnets and we have observed almost complete magnetic saturation at room temperature. The data enable the number of aligned iron magnetic moments in the nanoparticles to be measured and hence to check their size. In 5 nm particles we find 10^4 iron atoms.

Transparent Storage Phosphor Materials for Mammography

Jacqueline Johnson

Associate Professor

Mechanical, Aerospace and Biomedical Engineering (MABE)

B.Sc., University of Liverpool, England

Ph.D., University of Liverpool, England

Fellow of American Ceramic Society

In the last year work on ZBLAN glass ceramics has broadened considerably. Not only are plates being developed for x-ray imaging but for γ-ray and neutron applications as well. γ-ray detectors incorporate a large amount of lead and are being developed for non-destructive testing (Figure 1). UTSI has recently built its own scanner to read out images. This is in the early stages but the initial image in Figure 2 shows that it is working. Using a coherent light source will significantly improve the sharpness of the image.

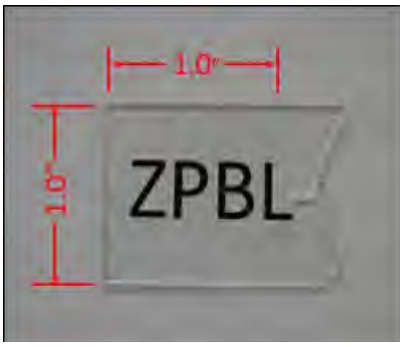


Figure 1: Test piece of γ-detector plate.

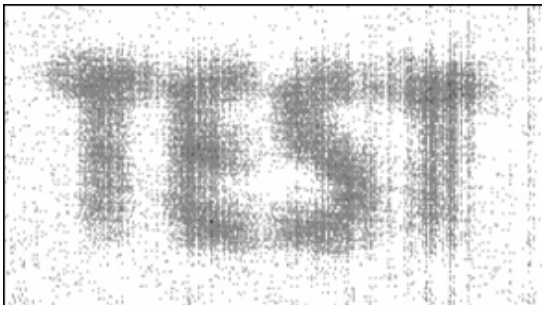


Figure 2: Storage phosphor readout scanner first image with non-coherent light source.Ho codoping.

Energy-filtered TEM (EFTEM) was successfully carried out for the first time on ZBLAN glass ceramics. EFTEM was used to map Ba and Cl independently over the same region. Figure 3 (left) shows a bright field TEM image of spheroid nanocrystals with significant diffraction contrast due to the overlapping crystals. The Ba (red) and Cl (green) EFTEM maps from the same region are also shown. High concentrations of Ba align with the location of the nanocrystals in the bright field image, meaning that the nanocrystals have a high Ba content. As seen in the Cl map, Cl can be identified at some of the nanocrystal locations, indicating that these are likely to be $BaCl_2$ (see e.g. nanocrystals at the left of the image). Some of the nanocrystals however, do not show a Cl signal, which suggest that they are BaF_2 nanocrystals.

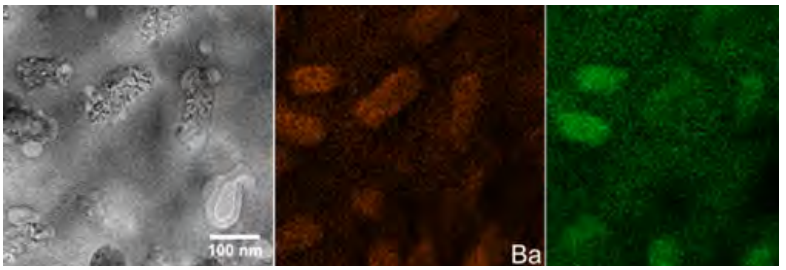


Figure 3: EFTEM images on ZBLAN glass ceramics showing barium and

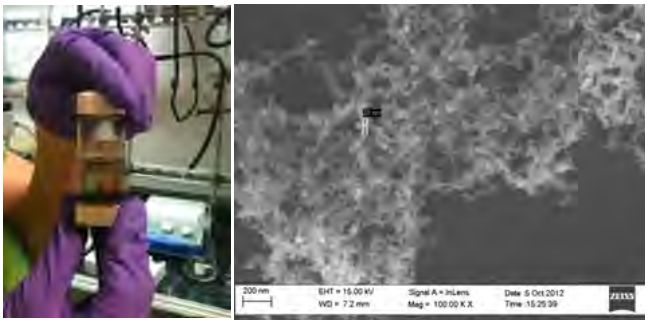


Figure 4: Fe nanoparticles separated by a neodymium magnet and SEM image of the same nanoparticles.

Iron nanoparticles are being developed for enhanced magnetic resonance imaging in the brain in collaboration with Vanderbilt University and Oak Ridge National Laboratory, see Figure 4.

Dr. Johnson was elected as a Fellow of the American Ceramic Society in 2013, continues to serve on review panels for NIH, NSF, NIST, DTRA, MBIE (New Zealand) and is on the Scientific Advisory Board at SNS / HFIR (ORNL). Dr. Johnson is grateful for the hard work by graduate students Lee Leonard, Jason Hah, Julie King and Michelle Wharton as well as summer intern, Jackson Tears.

Nonequilibrium Fluid

Trevor Moeller

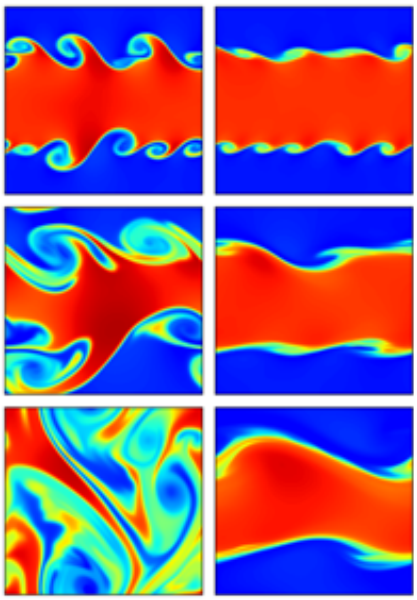
Assistant Professor

PhD, University of Tennessee

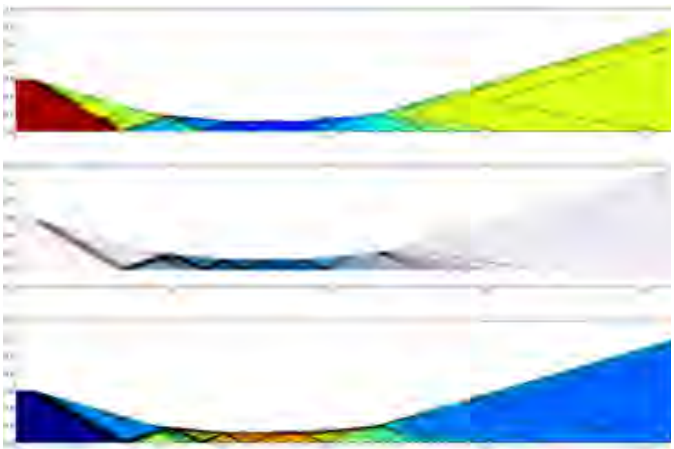
UTSI Program Coordinator for Mechanical, Aerospace, and Biomedical Engineering (MABE)

Dr. Trevor Moeller's research focuses primarily on high temperature gases and plasmas, including both modeling and experimentation. He has successfully completed projects involving technology development for a portable MHD generator, design and testing of a thermal storage and management system for the U.S. Air Force, and development of an ultrasensitive electric propulsion thrust stand. His current research activities for the U.S. Air Force include modeling and analysis of probes for high-temperature, high-velocity flows in rockets and gas turbine engines, precise measurement of convective heat transfer coefficients for unique probe geometries, and investigations of cryodeposit contamination in cryopumped vacuum chambers. The sensitive nature of these programs precludes the presentation of further details. Dr. Moeller also is conducting research in the development of tools for the modeling of coupled electromagnetic / fluid systems.

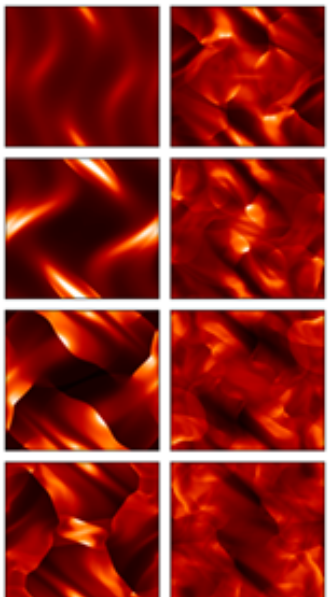
Key future engineering technologies such as advanced propulsion, hypersonic flight, and fusion drive Dr. Moeller's research. The accurate understanding, modeling and prediction of these technologies have motivated our new computational software and new theoretical framework. Our new software facilitates accurate quantitative modeling of plasma dynamics in complex-geometry, multidimensional problems, which permits us to resolve the complete multi-species, multiscale dynamics occurring within a plasma device both efficiently and accurately. We have successfully applied this new tool in investigations of high-temperature, multi-species plasmas in shock tubes and are applying them presently to plasma propulsion systems and high-Mach flight simulations. We have also succeeded in applying this modeling software to capture full electrodynamics, gasdynamic devices, and low-conductivity plasma regions. Our new theoretical framework allows us to predict and understand the full multiscale dynamics within a plasma using classic analytical techniques. We are continuing to apply these new transformational tools to new problems in our drive to improve the state-of-the-art, and are pursuing new paths that will continue to extend our capabilities.



Kelvin-Helmholtz plasma instability without (left) and with (right) applied magnetic field.



Scramjet flow field simulation



Fluid DNS simulation of turbulence for a compressible, inviscid plasma

Molecular Recognition

George M. Murray

Adjunct Professor

Mechanical, Aerospace and Biomedical Engineering (MABE)

PhD, University of Tennessee

Professor George Milton Murray is an Adjunct Professor of Mechanical Aerospace and Biomedical Engineering at the University of Tennessee Space Institute. He came to UTSI in 2007 from Johns Hopkins University Applied Physics Laboratory. He specializes in chemical analysis, sensors and molecularly imprinted polymers. One of Professor Murray's areas of expertise is the preparation of luminescent sensors for toxic compounds. The techniques of molecular imprinting and sensitized lanthanide luminescence have been combined to create the basis for a sensor that can selectively measure a specific organophosphorous compound. A complex of polymerizable sensitizing ligand europium [III) and an organophosphorous compound are copolymerized in a cross-linked polymer matrix. The best coordinators are trifluoromethyl-substituted b-diketones. The best polymerization mechanism is by Reversible Addition Fragmentation Transfer polymerization. This approach is allowing the production of soluble processable imprinted materials. Analogous methodologies are currently being applied to the production of sensors for the detection and determination of toxins, drugs of abuse, explosives and meat spoilage. Toxins are measured using piezo-electric transducers. Drugs are measured in an analogous manner to the nerve agents while explosives are being detected by the production of charge-transfer complexes between the explosives molecules, (acceptor) and immobilized amines (donor). Meat spoilage sensing is obtained using luminescence from a transition metal macrocyclic complex. All of the materials are also capable of providing highly selective binding sites to other transducers such as quartz crystal microbalance and surface plasmon resonance sensors.

Dr. Murray has published over 50 peer-reviewed papers in scientific journals as well as articles in the popular science press. He holds twenty U.S. patents and was named as one of the twenty Master Inventors of the Johns Hopkins University Applied Physics Laboratory. Dr. Murray's research interests are centered on developing methods for the sequestration and ultra-trace determination of toxic or useful substances in real samples. The means to this goal involves the production of molecularly Imprinted materials for sequestration and as specific polymer sensors. Laser spectroscopy is used for sensor transduction and verification. Laser processing is used to obtain specific form factors. Materials are also prepared for direct electronic or electrochemical transduction using electro-active polymers with imprinted polymer receptors.

Atomic and Molecular Laser Spectroscopy

Christian Parigger

Associate Professor of Physics and Astronomy

PhD, University of Otago, Dunedin, New Zealand

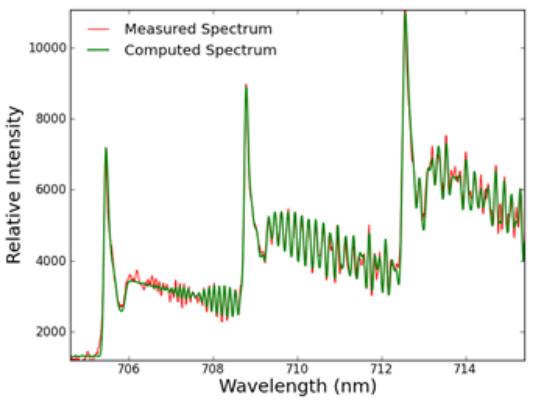
Dr. rer.nat. in Physics, University of Innsbruck, Austria

Professor Parigger research interests include experimental and theoretical and computational Physics, particularly electromagnetic interactions, fundamental and applied spectroscopy, nonlinear optics, quantum optics, ultrafast phenomena, ultrasensitive diagnostics, lasers, combustion and plasma Physics, optical diagnostics, applied optics, biomedical applications, and in general atomic and molecular and optical (AMO) Physics. His academic activities included recently service on various Masters and PhD committees both in Engineering and in Physics, Graduate Curriculum Committee in Physics, Graduate Council Policy Committee of the Faculty Senate of The University of Tennessee. Professor Parigger has been strongly engaged in postgraduate teaching, primarily doctoral research related courses for students of Physics and Engineering, and he also engages in teaching of Mathematics courses and courses with various numerical applications such as Computational Physics or Numerical Methods.

PhD Candidate Alexander Woods working on spectral studies of titanium monoxide (TiO).

Christian Parigger's research in the area of laser-induced breakdown spectroscopy, plasma and combustion Physics and diagnostics is ground breaking, well received and comprises a pioneering effort. His work is internationally and nationally well respected and recognized from a fundamental physics and laser applications point of view. His collaborations extend to international universities, to name a few, in Italy, Austria, Hungary, Russia, India, Brazil, to several national universities, e.g., Auburn University, Arkansas State University, New Mexico State University, Denver University, and to National Laboratories including at Oak Ridge and at Albuquerque.

Christian Parigger's recent research efforts continue to be comprised of various diagnostics applications in AMO (Atomic Molecular Optical) Physics. Recent interests include study of titanium monoxide, Swan spectra of carbon, aluminum monoxide, and hydrogen emission spectra together with students Alexander C. Woods, Michael J. Witte, David M. Surmick, and Lauren D. Swafford. Alexander Woods received the UT Chancellor's Citation Award for extraordinary promise in 'work on atomic and molecular spectroscopy connected with the characterization of plasma in space-related applications.' Moreover, David Surmick received an internship during the summer to work at Sandia National Laboratories in pursuit of collaborative efforts in aluminum combustion. Research activities also include organization of the 22nd International conference on Spectral Line Shapes set for June 1-6, 2014 at UTSI, see http://icsls22.utsi.edu. Contents include line shapes studies of atomic and molecular transitions in neutral gaseous mixtures, high and low temperature plasmas, spectroscopy of stellar atmospheres and interstellar media, cold atoms and molecules, collision-induced spectra, laser-induced breakdown spectroscopy, spectroscopy with ultra-short light pulses, applications to materials and biomedical studies, and/or combustion diagnostics.



TiO $A^3\Phi \rightarrow X^3\triangle$ transition collected at a time delay of 95 µs with a 2 µs gate width. The inferred temperature amounts to 3335 Kelvin.

Awards, Publications, Proceedings, Presentations and Patents for FY 2012-2013

Awards:

J. A. Johnson, Fellow of the American Ceramic Society (2013)

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Christian G. Parigger, Alexander C. Woods, and Mohammad R. Rezaee, "Atomic Hydrogen and Molecular Carbon Emissions in Laser-Induced Breakdown Spectroscopy", Journal of Physics: Conference Series, Volume 397, 012022; http: / / dx.doi.org / 10.1088 / 1742-6596 / 397 / 1 / 012022 (5 pages), (2012).

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G. M. Murray, “Sensors Based on Ionic Imprinting of Polymers”, US Army TARDEC, Warren, MI 48092, July 18, 2012.

Robert J. Baltz, Gregg R. Beitel , Nickolas A. Galyen, T. M. Moeller, and M. M. May, “AEDC / UTSI J85 Turbojet Test Stands”, 48th AIAA / ASME / SAE / ASEE Joint Propulsion Conference, Atlanta, GA, July 30–August 1, 2012.

Trevor M. Moeller, L. Montgomery Smith, Frank G. Collins, Jesse M. Labello, James P. Rogers, Heard S. Lowry, Dustin H. Crider, “Measurement of the accumulation of water ice on optical components in cryogenic vacuum environments,” the SPIE Optics + Photonics 2012 Conference, San Diego, CA, August 12-16, 2012.

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Jacqueline Johnson, Carlos Alvarez, Yuzi Liu, Charles Johnson and Amanda Petford-Long, "Phase Transformations in ZBLAN Glass Ceramics", AVS 59th International Symposium and Exhibition, Tampa, FL, USA, October 28 - November 2, 2012.

Alexander C. Woods and Christian G. Parigger, "Acquisition and Analysis of Titanium Monoxide Spectra in Plasma", Poster presentation, 79th Annual Meeting of the Southeastern Section of the American Physical Society (APS), Tallahassee, FL, November 14–17, 2012.

David M. Surmick, Alexander C. Woods, Christian G. Parigger, Jonathan L. Height, A. B. Donaldson and Walt Gill, "Spectroscopy of Aluminum Monoxide in Flames", Poster presentation, 79th Annual Meeting of the Southeastern Section of the American Physical Society (APS), Tallahassee, FL, USA, November 14 -17, 2012.

J. K. King, B. K. Canfield, L. M. Davis, "Electrokinetic trapping of a single fluorescent nanobead", Annual Meeting of the South East Section of the American Physical Society, Tallahassee, FL, November 14–17, 2012.

J. A. Germann, B. K. Canfield, L. M. Davis, "Single emitter localization using a four-focus confocal fluorescence microscope", Annual Meeting of the South East Section of the American Physical Society, Tallahassee, FL, November 14–17, 2012.

Mohammad R. Rezaee and Christian G. Parigger, "Self-absorption of hydrogen Balmer lines in laser induced plasma," 79th Annual Meeting of the American Physical Society Southeastern Section, Bulletin of the American Physical Society, p. 45, Tallahassee, FL, USA, November 14-17, 2012.

Michael Witte, Christian G. Parigger, Nathan A. Bullock, Jonathan A. Merten and Susan D. Allen, "Measurement and Analysis of C2 Swan Spectra Following Breakdown of Nitro Compound Simulants", 79th Annual Meeting of the APS Southeastern Section, Bulletin of the American Physical Society, p. 44, Tallahassee, FL, USA, November 14-17, 2012.

L. D. Swafford, C. G. Parigger, H. Y.Hah, S. Gray, M. Cole, D. Warnberg, C. E. Johnson, J. A. Johnson and E. Shafranovsky, "Iron Nanoparticle Mössbauer Spectroscopy with Rare-Earth Permanent Magnets", 79th Annual Meeting of the American Physical Society Southeastern Section, Bulletin of the American Physical Society 57 (16) p. 48, Tallahassee, FL, USA, November 14-17, 2012.

H. Y. Hah, M. Cole, S. Gray, C. E. Johnson, J. A. Johnson, V. Kolesnichenko, P. Kucheryavy and G. Goloverda, "Stoichiometry of Fe_3O_4 nanoparticles determined by Mössbauer spectroscopy", 79th Annual Meeting of the American Physical Society Southeastern Section, Bulletin of the American Physical Society 57 (16) p. 50, Tallahassee, FL, November 14 -17, 2012.

Christian G. Parigger, “On Interests in Applied Physics”, Rotary International, December 4, 2012, Winchester, TN, USA.

Richard J. Thompson, Andrew Wilson, Trevor Moeller, Charles L. Merkle, “A Strong Conservative Implicit Riemann Solver for Coupled Navier-Stokes and Full Maxwell Equations”, Presented at the 51st AIAA Aerospace Sciences Meeting, including the New Horizons Forum and Aerospace Exhibition, Paper number AIAA-2013-0210, Chapter DOI: 10.2514 / 6.2013-210, Grapevine, TX, January 7-10, 2013.

G. M. Murray, “Development of Colorimetric Imprinted Polymers for Explosive Detection,” Royal Oaks Industries, Detroit, MI, January 11, 2013.

L. M. Davis, “Physics and the Center for Laser Applications at the University of Tennessee Space Institute”, NASA Marshall, Huntsville, AL, February 22, 2013.

L. M. Davis, N. J. Orfield, S. Rosenthal, “Ultrasensitive spectroscopy of ultrasmall quantum dots for energy conversion and lighting applications”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

J. A Germann, B. K Canfield, J. K King, L. M Davis, “Sub-diffraction position determination with four laser diodes for tracking / trapping a single molecule”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

T. Bowman, B. Canfield, L.M. Davis, “Pump-probe experiments of single-pulse femtosecond laser plasma-channel formation in fused silica”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

S. Behery, B. Wang, B. Canfield, L.M. Davis, “FPGA for single-molecule recycling in a nanochannel”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

B. K. Canfield, W. H. Hofmeister, L. M. Davis, “Femtosecond laser fabrication of micro / nano-channel array devices for parallelized fluorescence detection”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

J. K. King, B. K. Canfield, L. M. Davis, “Electrokinetic device for three-dimensional trapping of single fluorescent emitters”, Annual Meeting of American Physical Society, Baltimore, MD, March 18–22, 2013.

William Hofmeister, “Reflections on Research, Education and Learning”, Vanderbilt Chapter Sigma Xi Annual Banquet, University Club Nashville, TN, April 27, 2013.

Jonathan A. Merten, Christian G. Parigger, Cheyenne J. Sheppard, Matthew P. Jones, and Susan D. Allen, “Spatiotemporal evolution of plasma molecular emission following laser ablation of explosive analogs”, Oral presentation, paper 8710-32, 2013 Defense Security + Sensing Conference of the SPIE, Baltimore, MD, USA, April 29 – May 3, 2013.

Lei Shi, Ying-Ling Chen, J. W. L. Lewis, Ming Wang, “Clinical Testing of a New Objective Binocular Refraction Device for Pediatric Vision Screening”, Invest Ophthalmol Vis Sci, 54: E-Abstract 5673, ARVO 2013 Annual Meeting, Seattle, WA, May 5-9, 2013.

Ying-Ling Chen, Lei Shi, J. W. L. Lewis, Ming Wang, "Pilot Testing of a Multi-Functional Device for Pediatric Vision Screening Application", Invest Ophthalmol Vis Sci, 54: E-Abstract 5681, ARVO 2013 Annual Meeting, Seattle, WA, May 5-9, 2013.

Christian G. Parigger, David M. Surmick, Alexander C. Woods, A.B. Donaldson, and Jonathan L. Height, "Measurement and analysis of aluminum monoxide flame emission spectra", Oral presentation, 8th Meeting of the Combustion Institute, Park City, UT, USA, May 19-22, 2013.

Hien-Yoong Hah, Lee Leonard, Sharon Gray, Charles Johnson and Jacqueline Johnson, "Rare-earth doped downshifting glass ceramics for photovoltaic applications", 10th Pacific Rim Conference on Ceramic and Glass Technology, San Diego, CA, USA, June 2-7, 2013.

Christian G. Parigger, "Grassroots 06-04-2013 UTSI Physics", Charter Channel 6 the Link -PeaHead Productions, http: / / www.youtube.com / watch?v=gen1jJ0-SNI, Talk show guest, June 4, 2013, Tullahoma, TN, USA.

J. K. King, J. A. Germann, L. M. Davis, "Anti-Brownian Electrokinetic Trapping of Single Nanoparticles in Solution", TN-SCORE Annual Conference, Nashville Airport Marriott, Nashville, TN, June 10-11, 2013.

Thomspon, R. J., Wilson, A., Moeller, T. M., Merkle, C. L., "An AUSM-based Algorithm for Solving the Coupled Navier-Stokes and Maxwell Equations", Presented at the 44th AIAA Plasmadynamics and Lasers Conference, Paper number AIAA 2013-3005. 10.2514 / 6.2013-3005, San Diego, CA, June 24-27, 2013.

Christian G. Parigger, Jacqueline A. Johnson, and Robert Splinter, "Optical Diagnostic and Therapy Applications of Femtosecond Laser Radiation using Lens-Axicon Focusing", 35th Annual International IEEE EMBS Conference of the IEEE Engineering in Medicine and Biology Society, Osaka, Japan, July 3-7, 2013.

Invited Presentations:

L. Leonard, C. Foerster, C. Alvarez, A. Petford-Long, R. Weber, C. Paßlick and S. Schweizer, "Crystallization studies of ZBLAN glasses by DSC and in situ TEM", Glass and Optical Materials Division Annual Meeting, American Ceramic Society, St. Louis, MO, USA, May 2012.

Christian G. Parigger, Jacqueline A. Johnson and Robert Splinter, "On Optical Imaging of Tissue: Aspects of Photo-Acoustic Femtosecond Spectroscopy", 34th Annual International Conference on the IEEE Engineering in Medicine and Biology San Diego, USA, August 28-September 1, 2012.

Jacqueline Johnson, Lee Leonard, Sharon Gray, Christian Paßlick, Carlos Alvarez, Stefan Schweizer and Amanda Petford-Long, "X-ray imaging enhancement with glass ceramic plates", Innovations in Biomedical Materials 2012, Raleigh, NC, USA, September 10-13, 2012.

C. Paßlick, J. A. Johnson, A. R. Lubinsky and S. Schweizer, "Glass ceramics for storage phosphor applications", 8th International Conference on Luminescent Detectors and Transformers of Ionizing Radiation – LUMDETR 2012, Halle (Saale), Germany, September 10-14, 2012.

Jacqueline Anne Johnson, Rick Lubinsky and Stefan Schweizer, "Glass Ceramics for Radiation Detection", Materials Science & Technology 2012 Conference & Exhibition, Pittsburgh, PA, USA, October 7-11, 2012.

Christian G. Parigger, Jacqueline A. Johnson and Robert Splinter, “Physiological Sensing through Tissue with Femto-second Laser Radiation”, 2012 9th International Conference on High Capacity Optical Networks and Emerging / Enabling Technologies (HONET) Istanbul, Turkey, December 12-14, 2012.

Jacqueline Johnson, “Nanoparticles in Medicine”, Seminar, Middle Tennessee State University, Murfreesboro, TN, USA, (2013).

C. E. Johnson, L. Costa, J. A. Johnson, D. E. Brown, S. Somarajan, W. He and J. H. Dickerson, “Mössbauer Spectra and Superparamagnetism of Europium Sulfide Nanoparticles”, 7th North American Mössbauer Symposium, Austin, TX, USA, January 11-12, 2013.

Jacqueline Johnson, Lee Leonard, Carlos Alvarez, Sharon Gray, Rick Lubinsky, Amanda Petford-Long, Stefan Schweizer and Charles Johnson, “X-ray imaging enhancement using nanoscience”, 37th International Conference and Expo on Advanced Ceramics and Composites, Daytona Beach, FL, USA, January 27 – February 1, 2013.

J. Johnson, L. Leonard, H. Hah, C. Alvarez, R. Lubinsky, C. Johnson, A. Petford-Long, “Nanostructured glass-ceramic x-ray imaging plate”, (PACRIM10-S24-007-2013), 10th Pacific Rim Conference on Ceramic and Glass Technology, San Diego, CA, USA, June 2-7, 2013.

Patents, Patent Applications and Disclosures:

“Molecularly Imprinted Sensor Device”, Murray, G. M. et al, U. S. Patent Number 8,241,575, Publication Date: August 14, 2012.

“Use of Beam Deflection to Control an Electron Beam Wire Deposition Process”, K. M. Taminger, W. H. Hofmeister and R. A. Hafley, U. S. Patent Number 8,344,281 issued January 1, 2013.

“Nanostructures from Laser-Ablated Nanohole Templates”, W. H. Hofmeister, A. Y. Terekhov, J. L. V. Da Costa, K. S. Lansford, D. Rajput, L. M. Davis, U. S. Patent Application 20130216779, Application Number 13 / 769,575; Publication Date: August 22, 2013, filed February 18, 2013.

“Adaptive Photoscreening System”, Ying-Ling Ann Chen, James W. L. Lewis, U.S. Patent No. 8,403,480, March 26, 2013.

Investigator	Contract Title	Funding Agency	Period of Performance	Awarded	2012-2013 Expended
Chen, Ying-Ling	Keratoconus Eye Model Bank for Virtual Clinical Trials and Medical Educations (R02-4313027)	National Institutes of Health – National Eye Institute	September 1, 2009 – August 31, 2012	$410,250	$45,309
Davis, Lloyd	Nanostructures for Enhancing Energy Efficiency, Tennessee Solar Conversion and Storage Using Outreach, Research and Education (TN-SCORE) (R02-4318034)	National Science Foundation	August 15, 2010 – July 31, 2015	$133,495	$38,107
Hofmeister, William	Closed-Loop Process Control for Electron Beam Direct Manufacturing Phase II (R02-4411039)	Sciaky, Inc.	April 15, 2011 – June 30, 2013	$143,030	$76,444
	SBIR Phase II – Electron Beam Direct Manufacturing of Titanium Alloys (R02-4411040)	Sciaky, Inc.	May 10, 2011 – June 30, 2013	$39,980	$22,997
	Microfluidic Intravital Windows for Local Antiangiogenic Cancer Inhibition (R02-4411044)	Vanderbilt University	January 1, 2012 – December 31, 2013	$15,000	$7,066
Johnson, Jacqueline	Advanced High-Resolution Two-Dimensional X-Ray Detector for Mammography (R02-4417020)	National Institutes of Health	February 1, 2008 – July 31, 2013	$1,768,678	$88,380
	Study of the Evolution of Nanoparticle Crystallization and Optical Properties in Glass Ceramics (R02-4417022)	National Science Foundation	July 1, 2010 – September 30, 2013	$299,157	$110,505
	Nanophase Glass Ceramic X-Ray Imaging Materials (R02-4417024)	National Institutes of Health / Materials Development, Inc. subcontract	October 1, 2010 – September 28, 2013	$30,000	$21,754

Investigator	Contract Title	Funding Agency	Period of Performance	Awarded	2011-2012 Expended
Johnson, Jacqueline	Large Area, High Resolution Storage Phosphor Detectors for High Energy (MeV) Digital Radiography (R02-4417025)	B&W Y-12 LLC	February 20, 2013 – September 30, 2013	$100,000	$43,907
Moeller, Trevor	NASA Tennessee Space Grant Consortium (R02-4320026)	Vanderbilt University	June 14, 2010 – June 13, 2015	$157,143	$47,902
	Cryo Deposition Research, Experimentation, and Development of Early Warning and Mitigation Technologies (R02-4348026)	Air Force / AEDC	November 21, 2008 – December 31, 2014	$294,500	$35,781
	Integration & Technical Support to the 12V Vertical Thrust Integration (R02-4348033)	Air Force / AEDC	September 22, 2010 – September 30, 2013	$60,000	$9,329
	Characterization of Heat Transfer Coefficient Uncertainty in Support of High Temperature Probe Measurement Technology (R02-4348036]	Air Force / AEDC	March 19, 2012 – September 30, 2012	$46,431	$21,626
	UCDS Enhancement for MDA Applications (R02-4348037)	Gloyer-Taylor Laboratories, LLC	July 1, 2012 – April 30, 2014	$225,000	$157,410
	Design, Fabrication and Operation of Bi-Directional Reflectance Function Generator (R02-4348038)	Air Force / AEDC	January 25, 2013 – September 30, 2013	$23,000	$4,474
	Engineering & Design Support of MHD Generator and Magnetic Bearing System (R02-4348039)	Gloyer-Taylor Laboratories, LLC	February 1, 2013 – May 30, 2013	$5,000	$693
	Induction Heater Technical Development Support and Structural Tests of GTL Samples (R02-4348040)	Gloyer-Taylor Laboratories, LLC	January 2, 2013 – August 30, 2013	$7,500	$1,664

Investigator	Contract Title	Funding Agency	Period of Performance	Awarded	2011-2012 Expended
Moeller, Trevor	Novel System for Cryodeposit Mitigation and Remediation (R02-4348041)	Physical Science, Inc.	March 3, 2013 – December 10, 2013	$60,000	$8,786
	Heat Transfer Coefficient Characterization for Stagnation Temperature Probe (R02-4348042)	Air Force / AEDC	April 19, 2013 – March 1, 2014	$50,000	0
Murray, George	Development of Polymer for Detection of Chlorate (R02-4419024)	Raptor Detection, Inc.	January 10, 2012– January 31, 2013	$248,318	$126,751
	Molecularly Imprinted Polymer Films for the Determination of Fatty Acid Methylesters (R02-4419025)	AlphaSense, Inc.	June 21, 2012– December 21, 2012	$20,000	$20,000
Parigger, Christian	Analysis and Presentation of AlO Flame Experiments (R02-4334021)	Sandia National Laboratory	April 10, 2012 – October 5, 2012	$5,000	$3,085
	Analysis of Broadbank Thermal Emission Data in Aluminum Solid Propellant Combustion (R02-4334022)	Sandia National Laboratory	March 12, 2013 – May 31, 2013	$5,000	$4,932