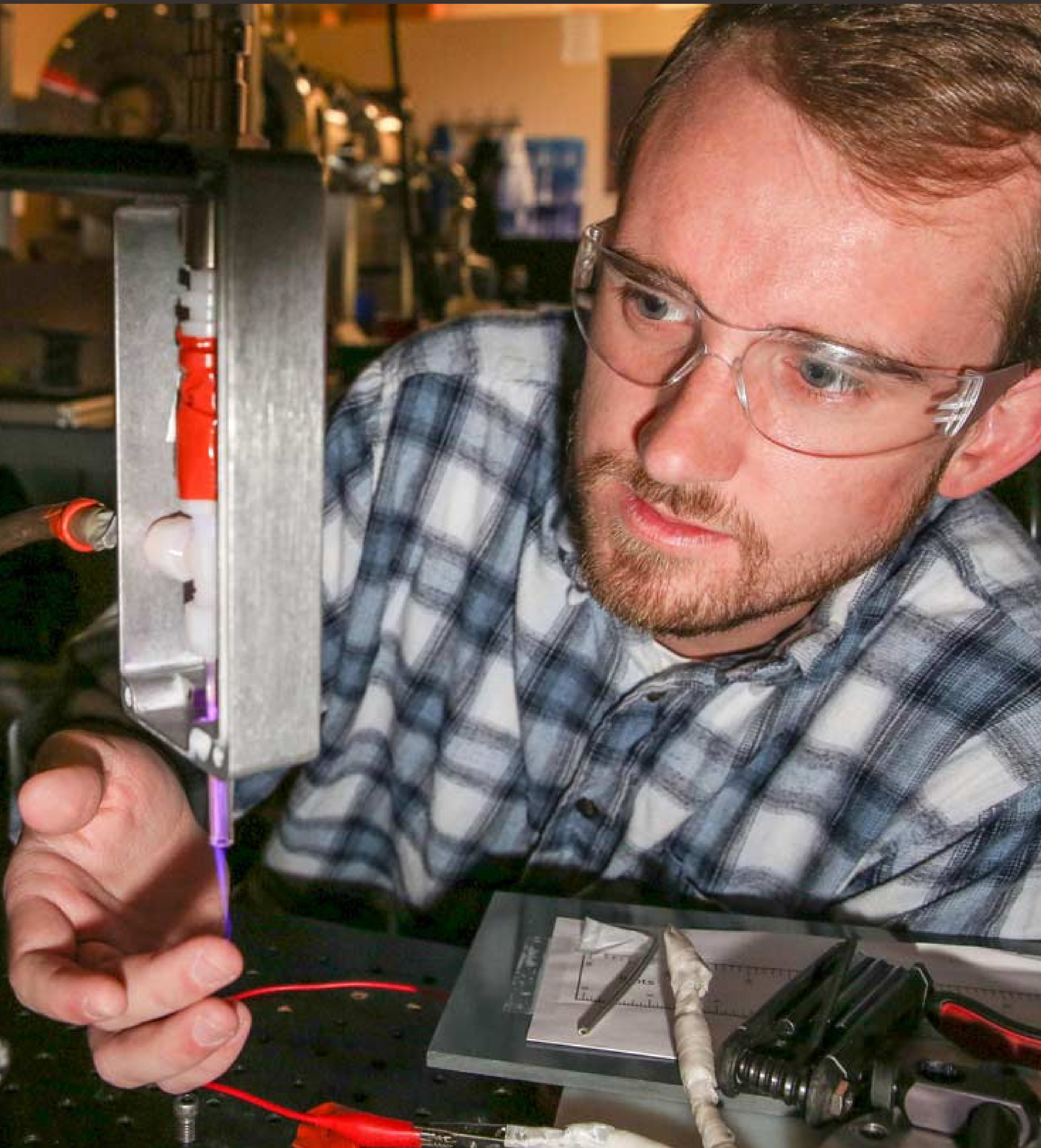

WITHIN THE PLASMA UNIVERSE

ISSUE NO. 01 | FALL 2018

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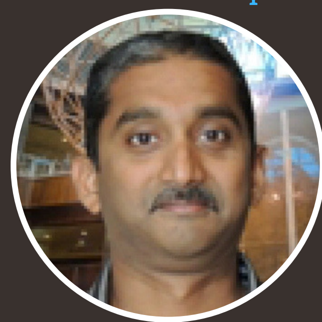

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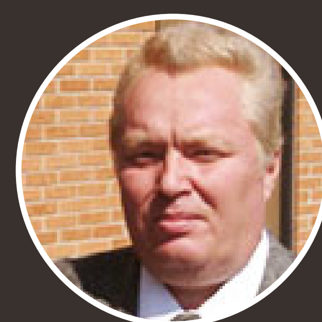

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SiO2 Medical Products, Inc.

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ABOUT

Plasma is a state of matter consisting of a collection of ionized particles, electrically neutral atoms, and molecules. It makes up more than 90% of the observable universe and underpins several high-tech manufacturing industries. Familiar forms of plasma include the sun, stars, lightning, neon signs, television screen displays, welder's torches, and rocket exhaust..

The NSF EPSCoR CPU2AL project seeks to understand, predict, and control plasma processes and interactions in low-temperature plasma (LTP) environments. This knowledge can be used to develop new technologies for aerospace, manufacturing, medicine, agriculture, and food safety. Research thrusts include investigating the basic physical properties and modeling of complex low-temperature plasma in both naturally occurring and commercial and industrial settings, and the prediction and preparation of novel materials that have unique physical and biological properties. Potential applications include superhard materials, prosthetics, and food disinfection. The project shares resources and leverage partnerships among Alabama institutions and industries to strengthen the research capacity and to build and train an inclusive workforce in plasma science and technology.

RESEARCH THRUST 1: PARTICLE KINETICS IN LOW-TEMPERATURE PLASMA

A partially ionized plasma is a collection of charged (electrons and ions) and neutral particles (atoms, molecules, and photons) collectively interacting with electromagnetic fields. The goal of this thrust is to develop theoretical and computational models to describe particle transport in low-temperature plasma, coupling electron transport with electromagnetics, plasma chemistry, and plasma interactions with boundaries and interfaces. The research challenges are associated with identifying correct criteria for selecting appropriate models for electrons, ions, and neutral species, coupling kinetic and fluid solvers at interfaces, resolving multi-scale challenges, and developing computational tools for plasma engineering on modern computing systems. Particle transport can be described by either kinetic or hydrodynamic (fluid) models. Kinetic models are based on Boltzmann, Vlasov, and Fokker-Planck kinetic equations. Fluid models express conservation laws for density, mean velocity, and temperature of plasma species.

Another goal of this thrust is to develop electric and optical diagnostics of low-temperature plasma. Electric diagnostics include Langmuir probes for measuring electron energy distribution functions, electron density, temperature and electric potential, as well as emissive and impedance probes. Optical diagnostics include high-speed imaging, particle tracking velocimetry, particle image velocimetry, and laser-induced fluorescence and emission spectroscopy.

This thrust provides theoretical, computational, and experimental methodologies and techniques for studying the fundamental properties of low-temperature plasma, its interactions with boundaries and interfaces, and practical applications in modern technologies.

RESEARCH THRUST 2: ELECTRON INTERACTIONS WITH ELECTROMAGNETIC FIELDS AND COLLECTIVE PHENOMENA

One of the unique properties of plasma is the ability of charged particles to self-assemble into ordered patterns. These patterns are believed to arise from microscopic processes that occur due to the interactions of the charged particles in the plasma with electric and magnetic fields and mutual interactions among the particles themselves. These microscopic processes then grow into the large-scale, self-organized patterns that are shown in these photographs.

In the CPU2AL projects, an important goal for our researchers is to understand how to control and manipulate these processes. In some cases, for example, when plasmas are used for manufacturing, we want to avoid the formation of these ordered patterns because we want to have large, uniform, stable plasmas. In other cases, such as studying how structures like Saturn's rings are formed, we want to be able to form these self-assembled patterns in the laboratory. We use both experimental and theoretical studies to understand pattern formation in plasmas.

RESEARCH THRUST 3: PLASMA INTERFACES (SOLID, LIQUID, BIO-MATTER)

One research area is the synthesis and processing of novel superhard materials using a microwave plasma chemical vapor deposition technique. The focus is on first and second row elements (C, N, O, and B) that form dense covalent and ionic solids in three-dimensional network structures which are extremely hard and exhibit unique electronic and optical properties. Also, graphitic carbon is being harvested from renewable waste sources for incorporation into composites after plasma treatment. Various boron carbides, boron nitrides, and carbon-boron-nitrogen compounds are being synthesized that survive heat better than diamonds and also have a diamond-like hardness. The gas phase chemistry is studied by a variety of plasma spectroscopy techniques and is utilized for identifying critical growth species required for synthesis of novel superhard materials.

This research thrust also focuses on understanding the effects of low-temperature plasma on biomaterials, plants, seeds, and agricultural products and the fundamental processes responsible for their bioactivity. Plant seeds treated with plasma have been shown to produce increased crop yields and nutritional content. Low-temperature plasma offers potential for chemical-free means of disinfection of fresh agricultural produce including poultry meats and eggs. There is also significant research activity in low-temperature plasma treatment of biostable and biodegradable tissue engineered biomaterials. The plasma treatment of biomaterials is being investigated to promote adhesion/conjugation of biomolecules and proteins that accelerate the proliferation of cells onto them, and drug molecules for controlled release or cellular growth factors to promote biointegration.

DIRECTOR'S MESSAGE

Dr. Gary P. Zank,
Department Chair, Space Science Department
Director, Center for Space Plasma and Aeronomic Research

DIRECTOR'S MESSAGE

Dear Friends & Colleagues,

Welcome to the first Newsletter from the NSF EPSCoR RII-Track-1 project, Connecting the Plasma Universe to Plasma Technology in AL: The Science and Technology of Low-Temperature Plasma, also known by the acronym CPU2AL. The Newsletter has several important themes running through it. The first is in educating a broader community about an apparently little-known discipline that nonetheless impacts our lives every day in profound and sometimes life-changing ways. This is the subject of low-temperature plasma (LTP), which has a pervasive influence on almost every aspect of our lives today; LTP underpins the $1 trillion semi-conductor industry in the US, LTP enables the development of efficient, emission-reducing engines and lighting, materials for alternative-energy sources such as solar cells, and the discovery, manufacture, and deployment of advanced materials, LTP impacts life sciences through the development of biocompatible surfaces, micro-plasma arrays for sterilization and disinfection, and helps the agricultural sector by improving crop yields, food safety, and is at the nexus of food, energy, and water. This collaborative project brings theory, modeling, and experimental validation to industrial applications of plasma to realize the extraordinary potential of LTP science, and we showcase some of our team, including researchers, students, management, and our advisory bodies.

The second theme is who we are. CPU2AL is a new program and a statewide collaborative consortium led by the University of Alabama in Huntsville together with nine Alabama universities including Auburn University , the University of Alabama at Birmingham, Tuskegee University , the University of Alabama , Alabama A&M University , the University of South Alabama, Alabama State University , and Oakwood University together with an industrial partner, Computational Fluid Dynamics Research Corporation. The collaborative project brings theory, modeling, and experimental validation to industrial applications of plasma to realize the extraordinary potential of LTP science, and we showcase some of our team, including researchers, students, management, and our advisory bodies.

DIRECTOR'S MESSAGE

Of course, exposing some of our science, workforce development, and outreach engagement activities to a wider audience forms a critical third theme. We have highlighted exciting work that we're doing in agriculture and in developing and applying novel exceptionally hard materials to medical devices. Both applications may someday impact many of our lives. Indeed, as part of this focus, and part of a broader narrative, some of the most exciting science is being done by our students and post docs. Our graduate students are investigating how LTP can cleanse contaminated water, whether on the International Space Station or as a cost-effective process for developing countries, or, at the opposite end of the spectrum, developing novel plasma propulsion systems for spacecraft, and exploring the effect of LTP on the sprouting and growth of the turmeric rhizome. Of course, besides these exciting and novel applications of LTP, researchers and students continue to explore the fundamental physics of LTP, utilizing experiments, computer simulations, and theory, much of this being done through multi-campus teams, including the sharing of equipment, resources, and skills.

The final focus of our Newsletter is the extraordinary array of student opportunities that CPU2AL offers, besides the typical support through research assistantships. These include student internships at plasma-related AL industries and companies, an international summer program in space weather that includes 2 weeks in South Africa and Germany, a 10-week plasma physics summer internship that includes a week at Princeton Plasma Physics Laboratory, and research experiences for undergraduate students across the breadth of the AL universities. These programs are proving very successful, with the only drawback being that they are highly oversubscribed and we cannot meet demand!

None of the programs and activities would be possible without the excellent support, engagement, and enthusiasm of the management team, the project manager, the Education & Outreach, and Diversity Coordinator, the assistants across all institutions, and of course the researchers and students. I should particularly like to thank Ms. Dana Waller and her team for generating an excellent newsletter. A huge thank you to everyone!

I trust that after reading the newsletter, you will share my excitement and enthusiasm for CPU2AL!

All the best,

Gary Zank

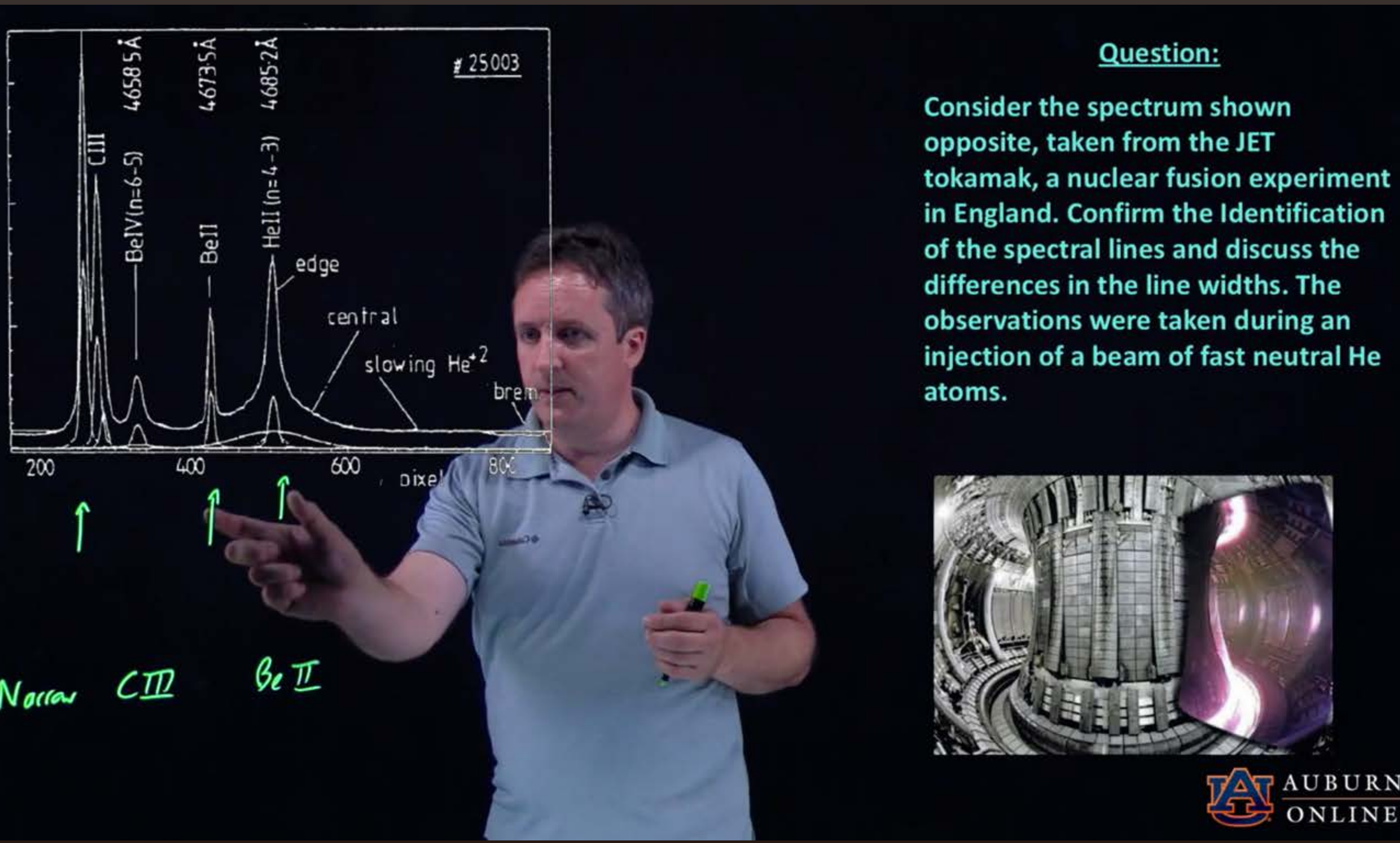
THE SCIENCE

AUBURN UNIVERSITY COURSE SETS IT SIGHTS ON EXPANDING SPECTRAL DIAGNOSTICS FOR CPU2AL MEMBERS

NEW PLASMA TECHNOLOGY COLLABORATION ELEVATES UNDERSTANDING OF BIOMATERIALS SURFACE ENGINEERING

CPU2AL COLLABORATION ON LOW-TEMPERATURE PLASMA EFFECTS OF SEED SANITIZATION AGAINST SEED-BORNE PATHOGENS COULD REVOLUTIONIZE CURRENT AGRICULTURAL PRACTICES

THE SCIENCE



AUBURN UNIVERSITY COURSE SETS IT SIGHTS ON EXPANDING SPECTRAL DIAGNOSTICS FOR CPU2AL MEMBERS

WRITTEN BY TARALYN CAUDLE

Auburn University (AU) is now offering a new online course, "Introduction to Spectral Diagnostics" as a part of the workforce development arm of the CPU2AL research grant. The course was developed, in part, as a response to the observable need for more training in the area of spectral diagnostics, as well as increased exposure to the variety of research conducted by CPU2AL collaborators.

As CPU2AL developed, it became apparent that the areas covered by the grant - plasma, space, bio, and atomic physics, might not be familiar to all participants. So, Dr. N. Ivan Arnold, Post Doctoral Fellow, AU Physics and his colleagues, Dr. Stuart D. Loch, Professor, AU Physics and Dr. Edward E. Thomas, Jr., Associate Dean for Research, COSAM, AU, proposed a series of seminars, lectures, and courses to help fill in the gap, including the "Introduction to Spectral Diagnostics" course.

The course evolved from an existing course, "Astronomical Spectroscopy," taught by Dr. Loch as a one semester special topics class focusing on quantum mechanics and atomic physics. Here, advanced undergraduate and graduate students are introduced to the physics and mathematics required to analyze astronomical spectra and spectroscopic techniques.

Noting that it would be useful for CPU2AL members to have a strong background in spectral diagnostics, given the anticipated non-invasive diagnostics work on the grant, Dr. Loch proposed adapting his course to focus on laboratory plasmas and spectroscopic diagnostics.

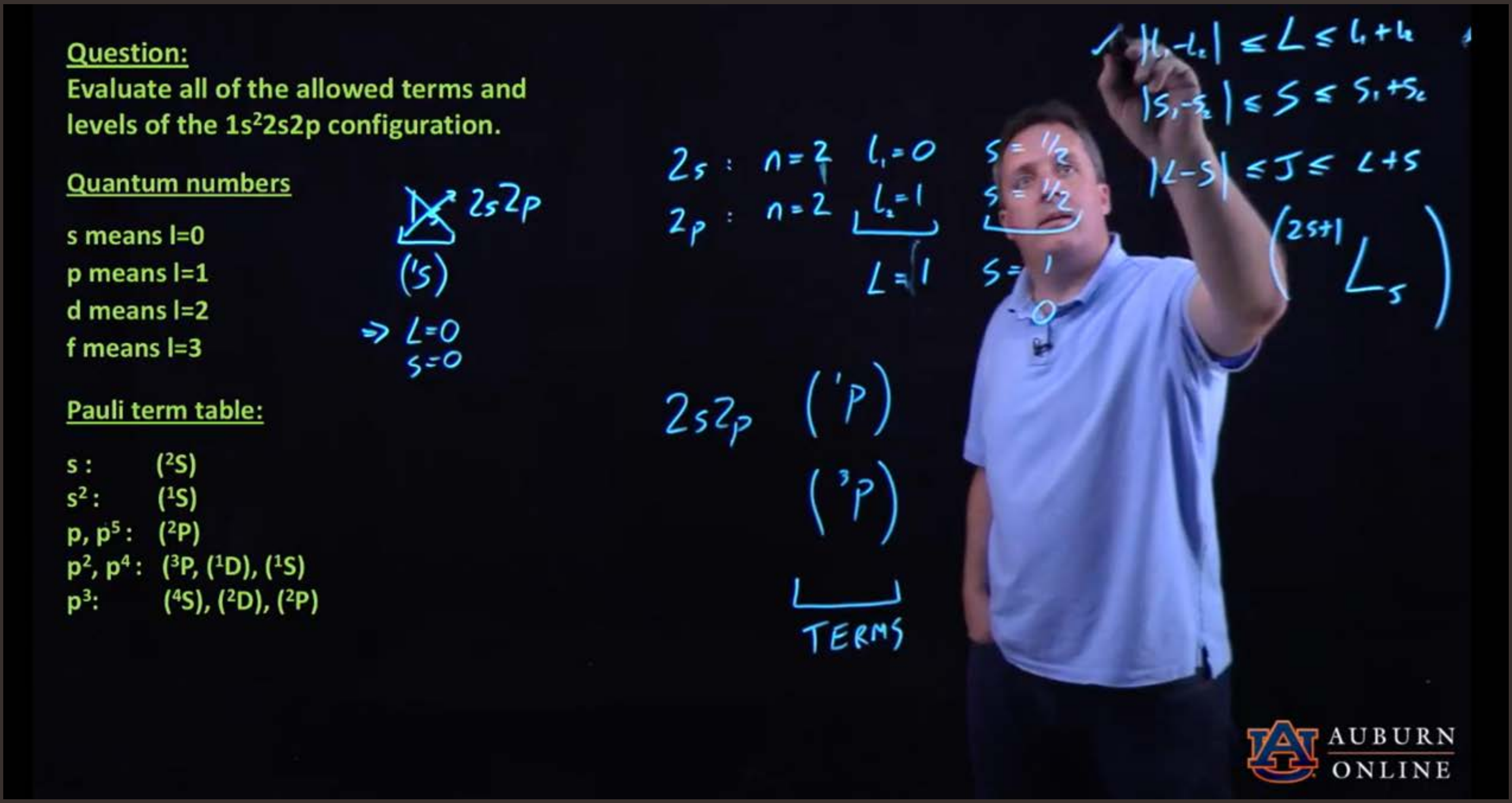
THE SCIENCE

The resulting course attempts to:

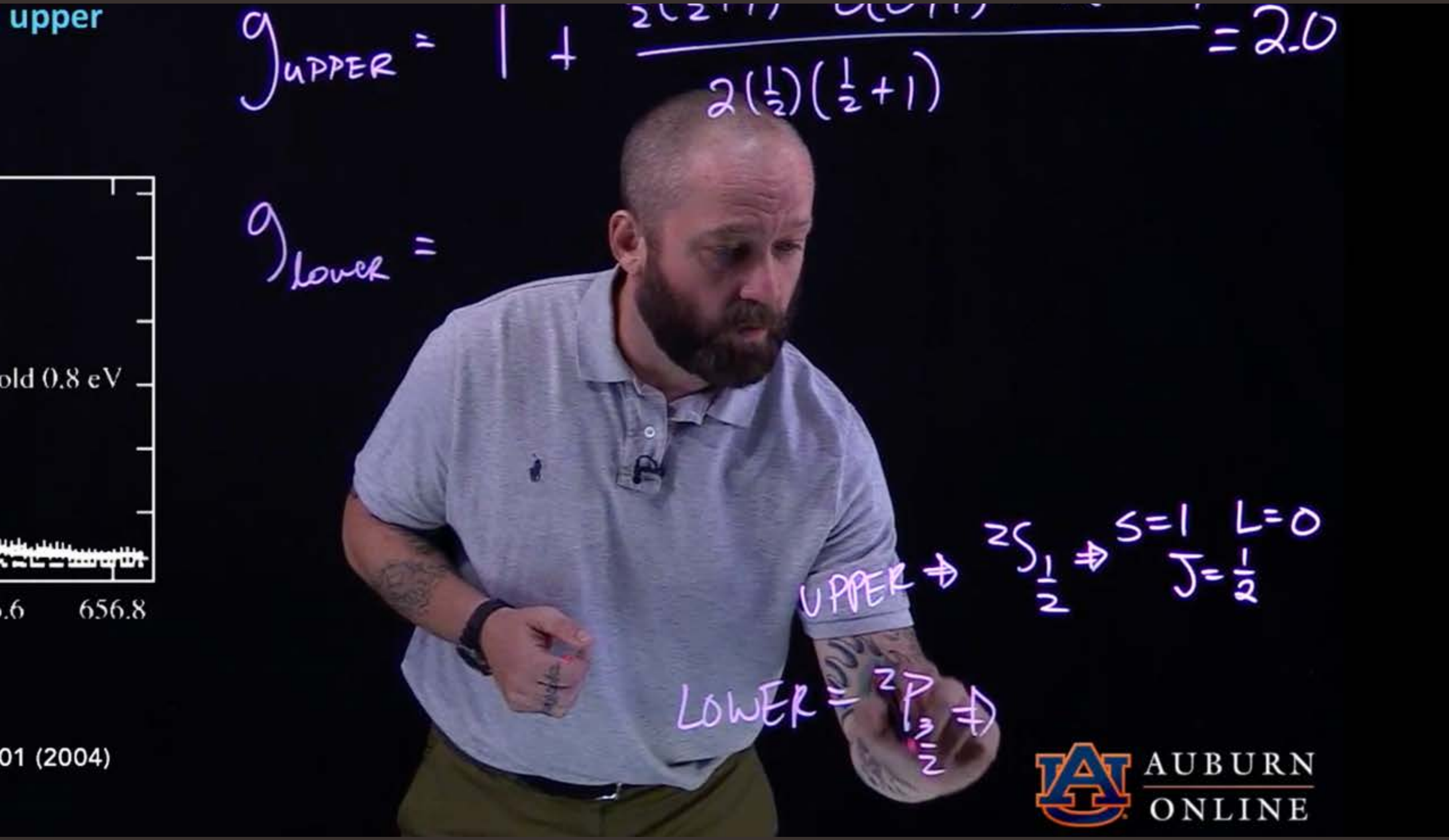
- Give participants the basics to understand atomic processes in low-temperature plasmas that give rise to spectral line emission;
- Provide a basic background in spectrometers and the hardware required to collect spectra;
- Offer an introduction to the techniques required to analyze spectral line profiles and ratios;
- Provide participants with the tools (code) required to analyze spectral data and offer tutorials on how to use them.

Well thought-out and highly curated, the course is designed to be as interactive and self-paced as possible. With 10-12 self-contained modules (and new modules in development), each includes an introduction video, several pages of web content focused on a specific sub-topic, an assessment quiz, and a homework problem designed to help students apply the content covered in the module to a real laboratory situation. Guided video examples are also provided, whenever possible.

In addition, for problems that require data analysis and/or code development, screencasts for auxiliary problems are provided to guide students in the right direction. Several embedded interactive web tools have also been developed to help students see the results of applying these techniques in real time.



T H E   S C I E N C E



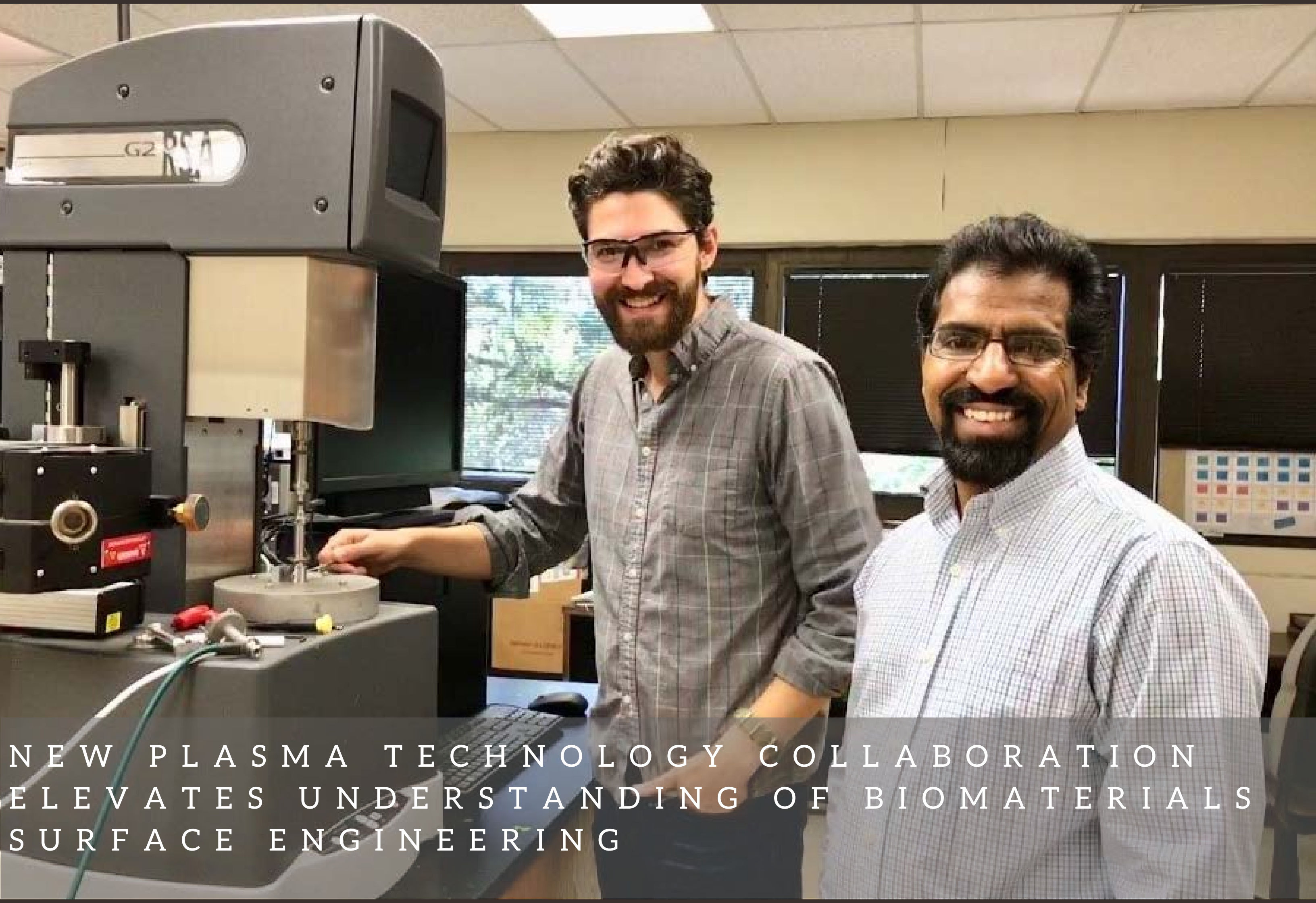
"Basically, our goal with this course is to take someone who has a limited background in spectroscopy and give them the tools to be able to collect and analyze spectral emission from a low-temperature plasma in order to diagnose plasma parameters," says Dr. Arnold. " We also hope that once someone has completed the course, they will have the necessary background to develop more specialized diagnostics tooled to their specific needs."

There has already been some discussion about extending the class to a full-length university course, but focused on low-temperature and laboratory plasmas. In the meantime, ongoing refinement of the current course will continue over the next several months. The long-term goal is to see the course become a full-fledged low-temperature diagnostics course that includes techniques beyond the spectroscopic line ratio and wavelength diagnostics currently covered.

All three professors are very pleased with the course as well as the results from students who have been enrolled in the course, particularly the practical aspect of the modules, where participants gain experience running the modeling and diagnostic codes.

Highlighting the original intent of the course, Dr. Arnold concludes, "It has already been of great benefit to the research on the grant, allowing people interested in plasma spectroscopy to get a background that then makes a collaboration on their spectral observations very productive."

THE SCIENCE



NEW PLASMA TECHNOLOGY COLLABORATION ELEVATES UNDERSTANDING OF BIOMATERIALS SURFACE ENGINEERING

WRITTEN BY TARALYN CAUDLE

A team of researchers from the University of Alabama in Birmingham, including Dr. Vinoy Thomas, Assistant Professor of Materials Science and Engineering; Dr. Paul Baker, Scientist ; Dr. Yogesh Vohra, Professor of Physics and Director of UAB Center for Nanoscale Materials & Biointegration; and UAB graduate student, Bernabe Tucker, in collaboration with Dr. Gabe Xu, Associate Professor of the University of Alabama in Huntsville have successfully demonstrated a convenient and efficient method for inner-surface modification of small-diameter vascular graft tubes. By using cold atmospheric pressure plasma, the bulk mechanical properties of the tubes remain intact, an essential feature for retaining the dynamic flexibility of cardiovascular implants, and ultimately, improved vascular grafts for cardiovascular disease patients.

Currently, there are no synthetic grafts for small-diameter (less than six millimeters) replacement of damaged blood vessels. And while large-diameter vascular grafts have previously been successful in clinical applications, small-diameter vascular grafts have proven less so as a result of incompatibility between the mechanical properties and blood-clotting resistance of the graft and the native blood vessel.

T H E   S C I E N C E

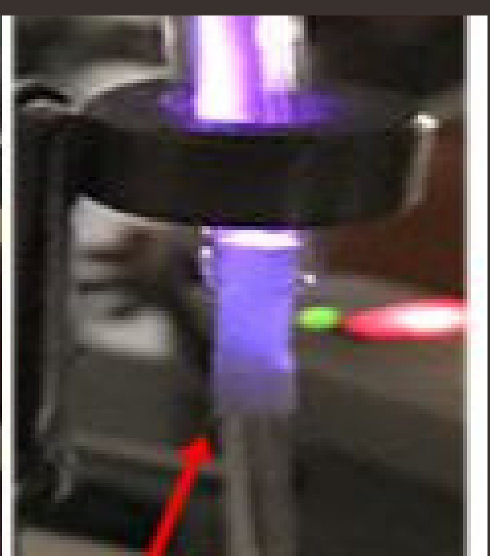
Dr. Thomas' lab at UAB has been using old textile technologies such as electrospinning and wet lay process for fiber-mesh composites in combination with recent additive manufacturing for microfibers to create fibro-porous extra-cellular matrix (ECM) scaffolding, which can mimic the tubular geometry of native blood vessels. The wet-lay system, in particular, has proven highly scalable and allows for fabrication of hybrid fiber systems. This process, as previously described by Dr. Thomas, “uses water and no other organic solvents, in situ hydrogel reinforcements, and cell-micro integration for cell-integrated scaffold constructs,” thus, laying the groundwork for cell-scaffold construct for cardiac and muscle tissue engineering applications.

This new plasma processing, however, with the use of an atmospheric pressure plasma jet, aims to take tissue engineering to the next level by addressing the previous complication of compatibility while also maintaining the flexibility of the graft.
For decades, various plasma methods have been used in other industries, such as agriculture, food processing, and the automotive sector to alter surface properties, and for sterilization and disinfection. Consequently, surface modification is especially useful in biomaterial engineering for obtaining improved biocompatibility or for attaching active molecules or proteins while leaving the bulk properties unaltered. In short, this bioactivity is critical for cell adhesion and growth between artificial and native blood vessels if they are to withstand the pressure exerted by blood flow.

In this latest research, cold atmospheric plasma, which Dr. Thomas has coined, “touchy” plasma is used rather than hot plasma, as the latter would degrade the proteins of the biopolymer blood vessels, which are made of plastic. The purpose of this plasma is to functionalize the inner side of the tube, making it easier for blood to flow and prevent clotting.

In addition, the high energy of the plasma jet prevents any compromised mechanical flexibility of the tube. Further studies are in progress to gauge the effects of plasma-modified surfaces on the growth of human endothelial cells, which is vital knowledge to determine the potential performance of these grafts. And in the next stages, a comparison of various process parameters to control the plasma will allow the researchers to carefully and precisely tune the inner surface properties.





T H E   S C I E N C E

Dr. Thomas further explains that optimizing the inner surface properties of grafts by using these plasma modifications allows for faster growth of the endothelial tissue layer, estimating that the lining should grow within in a couple of weeks of being implanted in the body. The material could then become a bio-integrated structure with inside natural endothelium, known anti-clotting surface, and outside, a mechanically robust fabricated construct. However, in cases where the graft does not attach, small molecules such as nitric oxide (NO) or short peptides (VEGF) conjugated through post-processing will attract endothelial cells to the scaffold construct, again, without changing its functionality and mechanical flexibility.

The implications of this work are critical in addressing the current unmet need of “off-the-shelf” ready to implant small diameter blood vessel substitutes for patients’ care. Approximately 140,000 access grafts are implanted in the United States each year, with the overall annual cost of hemodialysis access to treat end-stage renal disease (ESRD) totaling $23 billion, and projected to increase 3.6% every year.

Ultimately, this research has led to a greater understanding about the impact of plasma on the surface of biomaterials, including changes in surface chemistry that were found to be directly related to the type of ionized gas used in the plasma jet. Just as important, perhaps, are the Alabama university collaborations and graduate research opportunities that have added to the knowledge base of the CPU2AL project.

THE SCIENCE

CPU2AL COLLABORATION ON LOW-TEMPERATURE PLASMA EFFECTS OF SEED SANITIZATION AGAINST SEED-BORNE PATHOGENS COULD REVOLUTIONIZE CURRENT AGRICULTURAL PRACTICES

WRITTEN BY TARALYN CAUDLE

A team of researchers from Alabama A&M University (AAMU), the University of Alabama at Birmingham (UAB), and the University of Alabama in Huntsville are working diligently to expand the knowledge base of low-temperature plasma (LTP) technologies emerging as chemical-free biocides and surface disinfectants of plant seeds and fresh foods.

According to Dr. Rao Mentreddy, Professor of Crop Science (AAMU), most of the current research has been focused on seed germination and seedling growth, with the scientific literature containing information on the evaluation of LTP treatments on seeds of major crop commodities such as wheat, soybean, oilseed rape and rice, but not on common vegetable seeds or rhizomes. Few studies have reported LTP effects on plant growth following a greater percentage of seed germination in grain crops, and furthermore, there is little to no evidence of LTP effects on seed-borne pathogens.

Consequently, Dr. Mentreddy and his AAMU colleagues, Dr. Leopold Nyochembeng and Dr. Ernst Cebert, anticipate that their research on LTP will not only provide an understanding of mechanisms underlying the LTP effects on pathogens and plant growth but also strengthen this area of seed-borne pathogen management.

Most of their research to date has been conducted in collaboration with CPU2AL partner institution, UAB, specifically with cooperation and facilities provided by Dr. Yogesh Vohra and postdoctoral fellow, Dr. Paul Baker.

T H E   S C I E N C E

That research includes a recent study on the effects of low-temperature plasma on bell pepper seeds to disinfect and enhance seed germination. Two separate experiments were conducted using the seeds of bell pepper to determine the optimal conditions for assessing LTP effects on seeds with or without seed-borne pathogen.

In the first experiment, the effects of seed sterilization and plasma on the germination of seed infected with or without bacterial pathogen were determined. And in the second, the effects of plasma or chamber conditions on the germination of seed infected with or without bacterial pathogen were determined. The plasma effects in these two experiments, however, proved inconclusive, prompting the decision to initiate new studies to determine plasma effects on the seed-borne pathogen rather than seed germination.

In response to the latter outcome, Dr. Mentreddy says they are still exploring protocols and fine-tuning specific parameters to determine the most effective procedures for LTP treatment to achieve desired effects on seed-borne pathogen, seed germination, and plant performance. By optimizing plasma source, power (voltage) settings, duration of LTP exposure to organisms and handling of specimens post LTP treatment in future experiments, they hope to see an increase in seed germination and plant resistance, improved plant performance with no deleterious effects, and suppression of plant pathogens in LTP treated seeds.

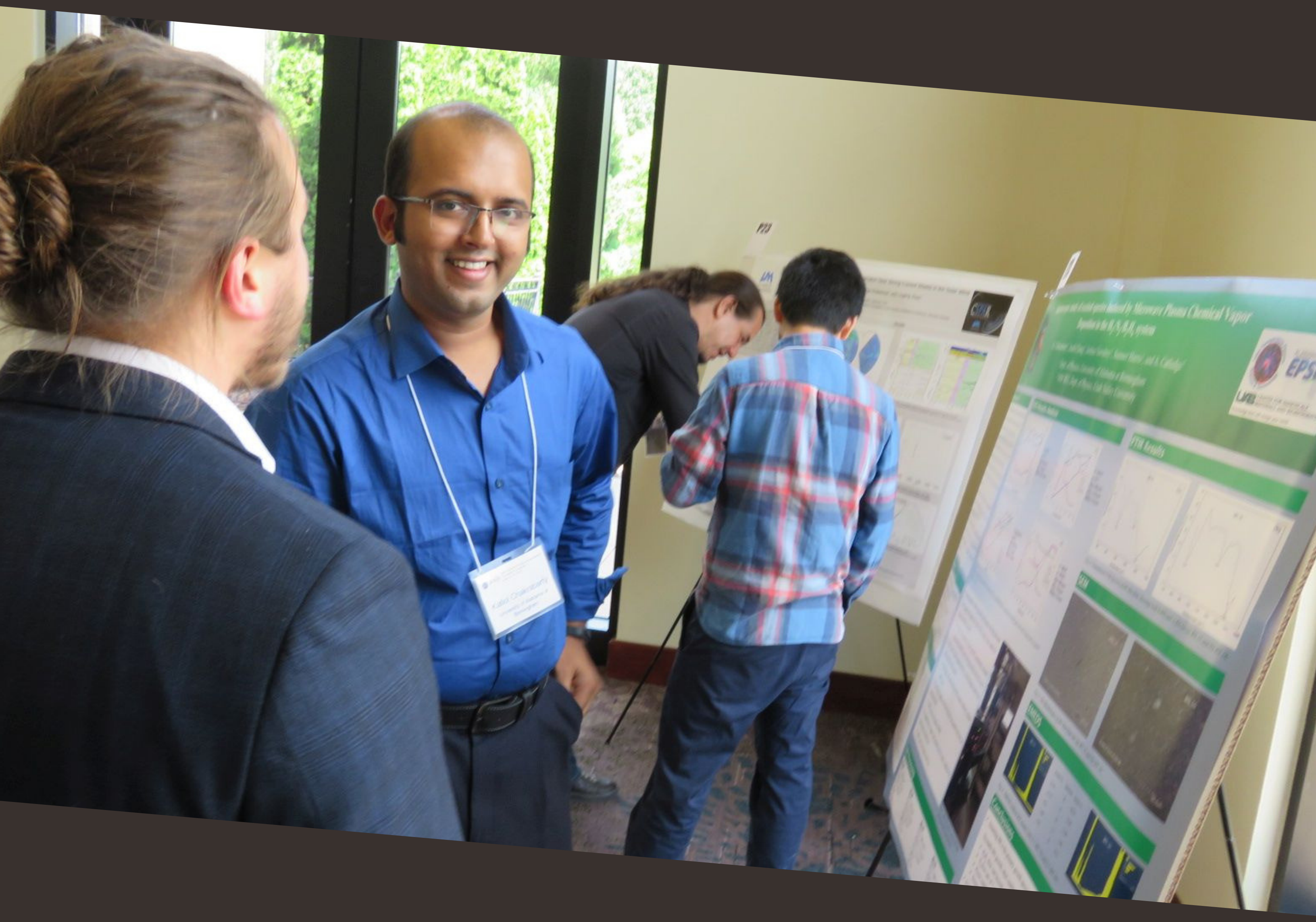
The team has since started another experiment, testing LTP effects on turmeric, which is currently trending as the number one herbal supplement in the United States. Turmeric, primarily propagated by rhizomes (storage roots), suffers from a major limitation in the form of uniform sprouting. This research is a collaboration with Dr. Gabe Xu and his postdoctoral fellow, Dr. Ryan Gott from the University of Alabama in Huntsville, will help in timely planting of uniform plants that could produce a better yield of crop. And Dr. Mentreddy reports that they have already seen highly encouraging results and are planning more experiments to optimize experimental conditions.

THE SCIENCE

The advantages of this research, both economically and environmentally cannot be understated. Seed-borne pathogens can pose serious threats to seedling establishment and plant growth. Currently, only a few options are available (e.g., hot water treatment) to achieve non-chemical sanitization of seeds to manage seed-borne and seed transmitted pathogens. Chemical methods, such as fungicides and antibiotics, used to control seed-borne pathogens are costly and hazardous to the environment. Furthermore, antibiotic resistance, as in the case of bacterial plant pathogens may also occur. The economic advantages of using LTP, on the other hand, include low cost, potential increase in yield, and environmental safety.

Dr. Cebert adds that the team is seeking the participation of industries from the agricultural sector, including poultry processors, seed companies, nurseries, and other food processors. Interaction of leaders from the private sector with scientists who are actively engaged in applied research will allow a seamless transition from the laboratories to industries, ultimately benefiting consumers.

THE STUDENTS



Our goal is to provide training to undergraduate, graduate, and postdoctoral research students that will link academic research activities to the Alabama LTP industry through assistantships and internships.

T H E   S T U D E N T S

CORPORATE INTERNSHIP PROGRAM ON PLASMA TECHNOLOGY APPLICATIONS (CIPPTA)

The Alabama NSF EPSCoR CPU2AL project sponsors a 10-week Corporate Internship Program on Plasma Technology Applications (CIPPTA) for students pursuing degrees in science, technology, engineering, and mathematics. The program provides students at CPU2AL partner institutions with quality experiences on plasma technology applications at private companies and allows students the opportunity to establish connections with industry and university professionals. It is open to undergraduate and graduate students in a broad spectrum of disciplines. The ultimate goal of the program is to engage a diverse, educated, and skilled pool of scientists and engineers to promote long-term relationships between students, academia, and industry to enhance the Alabama workforce.

GRADUATE RESEARCH ASSISTANTSHIPS

There are different avenues that students can pursue to receive financial support through a graduate research assistantship.

CERIF GRA

The NSF EPSCoR CPU2AL project has a Central Education, Recruitment, and Impact Fund (CERIF) to award GRAs to selected students involved in research on LTP. These GRAs provide financial support for up to three years to selected graduate students at CPU2AL partner institutions.

GRADUATE RESEARCH SCHOLARS PROGRAM

The Alabama Established Program to Stimulate Competitive Research (ALEPSCoR) Graduate Research Scholars Program (GRSP) was established in 2006 by the Alabama State Legislature. This program provides financial support to selected graduate students for up to three years. The proposed research must be directly related to a current EPSCoR federally funded project and the GRSP advisor must currently be receiving federal EPSCoR funds. Most investigators in the NSF EPSCoR CPU2AL project are eligible to become GRSP advisors.

INSTITUTIONAL GRAS

CPU2AL partner institutions continuously seek good students that are interested in research on LTP.

THE STUDENTS

ALABAMA PLASMA INTERNSHIP PROGRAM (ALPIP)

The Alabama Plasma Internship Program (ALPIP) is a 10-week summer internship program for undergraduate students enrolled at institutions across the southeastern U.S. (Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia, the U.S. Virgin Islands, and Puerto Rico). The ultimate goal of the program is to promote long-term relationships between students in the southeastern U.S. with investigators in Alabama. ALPIP students will become involved in a summer research project at a CPU2AL institution for nine weeks. The program will also involve an intensive one-week training activity participating in lectures, laboratory experiments, and short classes in plasma science given by Princeton Plasma Physics Laboratory (PPPL). This week will take place concurrently with the Department of Energy (DOE) Summer Undergraduate Laboratory Internship (SULI) program. In this way, ALPIP students will be part of a larger, national plasma science student cohort, learn about opportunities in plasma science, and be exposed to the research environment of the national laboratory for plasma physics.

ALABAMA RESEARCH EXPERIENCES FOR UNDERGRADUATES (ALREU)

The Alabama Research Experiences for Undergraduates (ALREU) program is a 10-week summer internship program for undergraduate students enrolled at HBCU institutions that are part of the CPU2AL project. The program provides students with quality research experiences at CPU2AL partner institutions in a broad spectrum of disciplines. The ultimate goal of the program is to engage a diverse, educated, and skilled pool of scientists and engineers to promote long-term relationships between students and investigators to enhance the Alabama workforce.

THE STUDENTS

PLASMA-BASED TECHNOLOGY MAY BRING CLARITY TO CHALLENGES POSED BY CONTAMINATED WATER

WRITTEN BY DIANA LACHANCE

The availability of clean, potable water is a concern for everyone, from residents here on Earth to astronauts in space. To address the issue, researchers have recently begun studying plasma-based technologies as a cost-effective method to purify water. The process, simply stated, involves removing pollutants from water by turning air bubbles into a plasma, or ionized gas, state and then releasing the chemicals produced inside those bubbles back into the liquid. The problem, however, is executing this process at scale. "Plasma at atmospheric pressures likes to stay as small as possible in small volumes," says Dr. Gabriel Xu, an associate professor in the Department of Mechanical and Aerospace Engineering at The University of Alabama in Huntsville (UAH). "So getting it larger is a challenge."

Helping Dr. Xu tackle that challenge is Ph.D. candidate Ryan Gott. The pair had worked together previously, with Dr. Xu serving as Gott's advisor for his master's thesis on using plasma-based technology for satellite propulsion. And it was Dr. Xu who encouraged Gott to continue building on that experience for his doctoral research. "He showed me a list of projects to choose from, and water purification using plasma-based technology was one of them," says Gott. "I thought the idea was really cool, and because it was related to the work we had already been doing, I knew we had the technology to make an impact on it. It was serendipitous."

So, too, was the timing. That fall, UAH was selected as the lead institution on a $20 million, five-year grant from the National Science Foundation's Experimental Program to Stimulate

Competitive Research (EPSCoR) to fund the "Connecting the Plasma Universe to Plasma Technology in Alabama: The Science and Technology of Low-Temperature Plasma" (CPU2AL) project.

With its emphasis on plasma processes and interactions in low-temperature plasma environments, the project synched perfectly with Gott's interest in water purification using plasma-based technology, and the pair was able to apply for and receive support for their research. CPU2AL now provides funding for supplies and materials for Dr. Xu's Plasma and Electrodynamics Research Lab, while Gott receives financial support through the Alabama EPSCoR Graduate Research Scholars Program. "I've got a few classes left, which I'm working on concurrently," he says, "but it's basically a full-time job!"

While the CPU2AL project comprises three major research thrusts – Particle Kinetics in Low-Temperature Plasma, Electron Interactions with Electromagnetic Fields and Collective Phenomena, and Plasma Interfaces – it is the latter that most closely aligns with the work that Gott and Dr. Xu are doing.

"Our focus is on developing low-temperature plasma water-purification technology for three applications," says Dr. Xu. "The first is manned space travel, the second is chemical and industrial cleanup, and the third is in developing countries where water sources may be polluted with bacteria."

Key to their research is an atmospheric-pressure plasma jet originally design by Dr. Xu. It works by feeding a propellant gas – typically argon or helium in the lab – through a tube where it is ionized and pushed out as a plasma plume. The electrons from this plume then react with water molecules to produce OH radicals, which drive the purification process.

"I'm still working on improving the design, but we have the basic plasma technology," says Gott. "What we're trying to do now is understand how changing the power operating conditions, gas flow rate, and tube size can affect the size of the plasma plume by studying the production of OH radicals using optical emission spectroscopy."

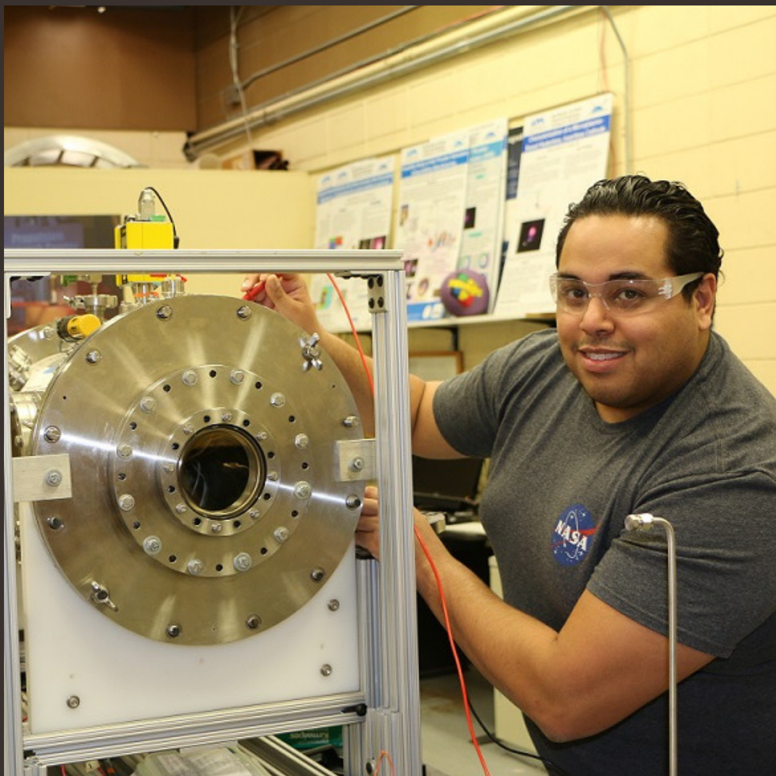
Since presenting their most recent research results at last month's 71st Annual Gaseous Electronics Conference in Portland, Ore., and being recognized by the American Physical Society, their work has focused on fully characterizing their existing plasma jet and increasing the plasma size by experimenting with the jet's design. "We're doing pretty well so far using a 3-D printer to quickly and cheaply test different channels and designs," says Dr. Xu, adding that, at present, they are capable of creating a 2 inch wide and ¾ inch thick "sheet" of plasma. After that, says Gott, "we'll study the interaction between the plasma and the water and the air, and figure out how we can best shape it to suit our needs."

Each step brings them closer to their ultimate goal – a complete understanding of the plasma physics and behavior so as to design better plasma-based water purification methods for the aforementioned applications. "Once we understand the plasma itself," says Dr. Xu, "then we'll have a better idea of how to scale up."

THE STUDENTS

MEET GRADUATE STUDENT ROBERTO DEXTRE, A NEW YORKER INVOLVED IN PLASMA PROPULSION IN ALABAMA.

WRITTEN BY DANA WALLER



Roberto, a graduate student at the University of Alabama in Huntsville (UAH), had humble beginnings in New York City as the only child of a Peruvian hospital café worker and a Dominican sales representative. As a child, Roberto enjoyed Latin dancing, playing basketball, and video games. He first recognized his passion for science at the High school for Environmental Studies in Manhattan, New York. He noticed that he easily understood math and science. "I think it was the physics courses that opened my mind to how science plays into all of our lives every day. It seemed like an obvious choice to pursue engineering so that I can learn to apply science as needed", said Roberto.

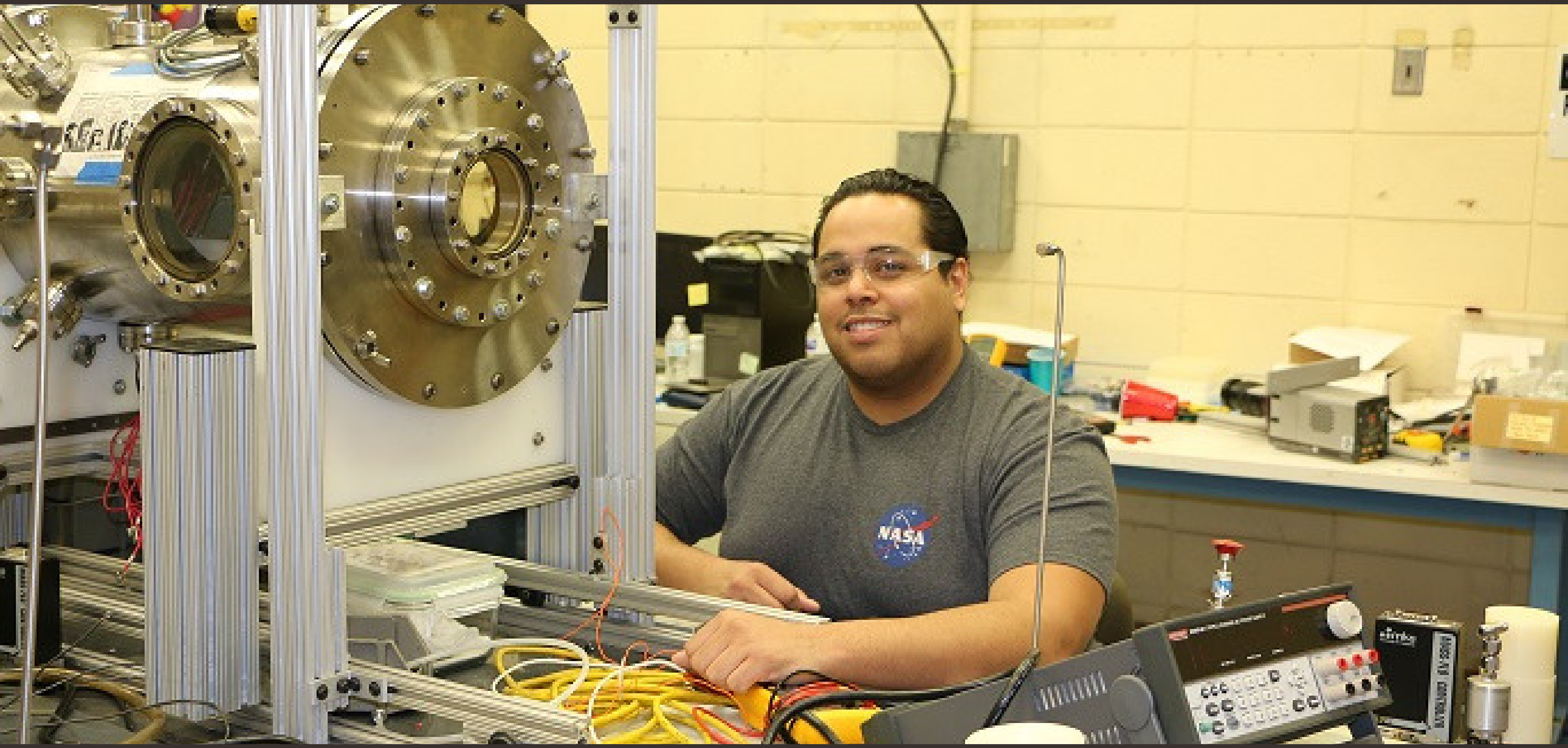
Roberto decided to further his newfound passion at Binghamton University in Binghamton, New York, where he received his bachelor's degree in Mechanical Engineering.

While an undergraduate student, he was offered an internship at Marshall Space Flight Center in Huntsville, Alabama, where he was introduced to rocket propulsion and became very interested in its capabilities. During his internship, he heard about UAH's graduate program and decided to apply, and was accepted shortly afterward.

While attending UAH Roberto received his Master's and Doctorate degrees in Aerospace Engineering.

When he was not working on his degrees, he was a tutor and mentor for the Louis Stokes Alliance for Minority Participation Program (LSAMP). He also became involved in the Society of Hispanic Professional Engineers, and was able to help lead the Salsa Club on campus.

STUDENTS



Roberto received financial support from the UAH Adriel D. Johnson, Sr. Fellowship and NASA for his graduate studies and was recently awarded a graduate research assistantship (GRA) through the Central Education, Recruitment, and Impact Fund (CERIF) of the NSF EPSCoR CPU2AL project.

In Roberto's Ph.D. project, he used concentric split-ring microwave resonators to produce plasmas at vacuum pressures with the goal to understand the characteristics of the generated plasma. Such plasma could find applications in space propulsion and plasma treatment of solid-state materials, biomaterials, plants, seeds, and agricultural products. He computationally modeled the electromagnetic behavior of the resonators and compared it to experimental measurements of the plasma density and electron temperature with Langmuir probes.

After graduation, Roberto started working for Aerojet-Rocketdyne an an engineer with a focus on ballistics.

THE PEOPLE

THE PEOPLE

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N E W S W O R T H Y


Effects of Low Temperature Plasma on Turmeric Rhizome Sprouting and Plant Growth
Turmeric and Basal Research Project
Alabama A&M University
ABSTRACT
MATERIALS AND METHODS
Experiment 1 and 2: Turmeric rhizomes
Treating turmeric rhizomes with LTP at University of Alabama in Huntsville.
Turmeric rhizome varieties VN 12, 18, and 44 planted after LTP treatment
RESULTS
Fig. 1A & B. Variation among varieties for days to 100% sprouting with or without low temperature plasma treatment
RESULTS (cont.'d)
Fig. 2. Variation among varieties for plant height with or without low temperature plasma (Control) treatment
Fig 2A: Days after planting
Fig 2B: Days after planting
ACKNOWLEDGEMENT
This research was supported by NSF EPSCoR RII Track 1 Grant OIA – 1655280.
LAM DUONG
Alabama A&M University

NEWSWORTHY

ASU AWARDED A $500,000 NSF GRANT FOR TISSUE REGENERATION RESEARCH

Associate ASU professor of biology Dr. Komal Vig was awarded a three-year, $500,000 grant from the National Science Foundation's (NSF) Excellence in Research program to conduct tissue regeneration research to help wound victims. Dr. Vig says it will lead to innovative strategies to regenerate tissues after damage, which can help in wound healing.

DIRECTOR TO ADDRESS NSF AS DISTINGUISHED SPEAKER

Dr. Gary Zank will speak on three current space missions of scientific discovery as a distinguished speaker at the National Science Foundation's (NSF) Distinguished Lecture Series in Mathematical and Physical Sciences.

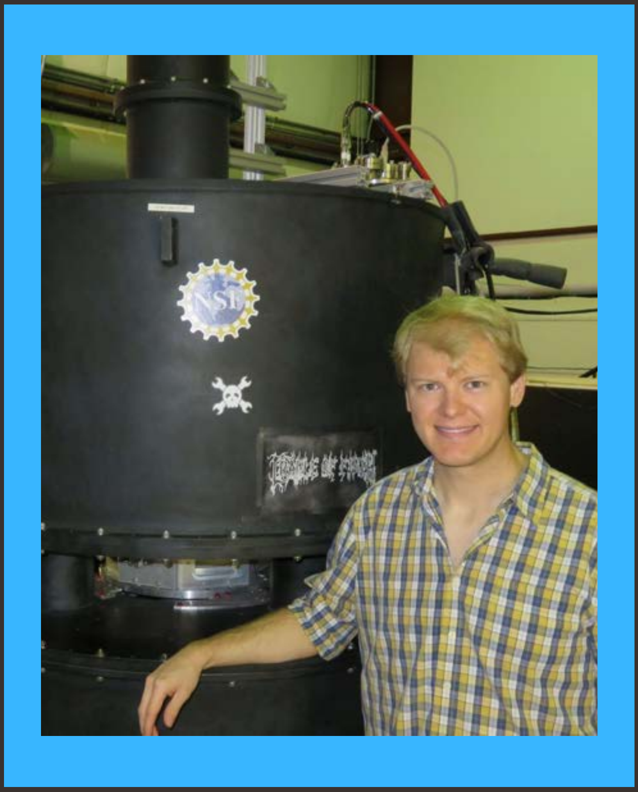
NEWSWORTHY

ARTICLE INVOLVING UAB AND UAH SELECTED AS EDITOR'S PICK OF THE JOURNAL OF VACUUM SCIENCE AND TECHNOLOGY

Congratulations to the team and especially to CERIF GRE awardee Bernabe Tucker for being the first author of this article. The team successfully demonstrated a convenient and efficient method for inner-surface modification of small-diameter vascular graft tubes using cold atmospheric pressure plasma without affecting the bulk mechanical properties, which is paramount for dynamic flexing cardiovascular implants.

ARTICLE BY GRADUATE STUDENT TAYLOR HALL AND THE AUBURN TEAM FEATURED ON THE COVER OF PHYSICS OF PLASMAS

Congratulations are in order to Taylor Hall, Auburn CERIF GRA for having his article, “Methods for the characterization of imposed, ordered structures in MDPX,” featured on the cover of Physics of Plasmas Volume 25 Issue 10.



N E W S W O R T H Y

AUBURN STUDENT GAINS INTERNSHIP AT PLASMA PROCESSES LLC.

"I have accomplished more than I could have ever imagined with a summer internship and have gained the confidence to complete full reports on samples that I know nothing about.This internship has positively impacted the way I see the blue and white collar work force as well as how I see myself in my future job".

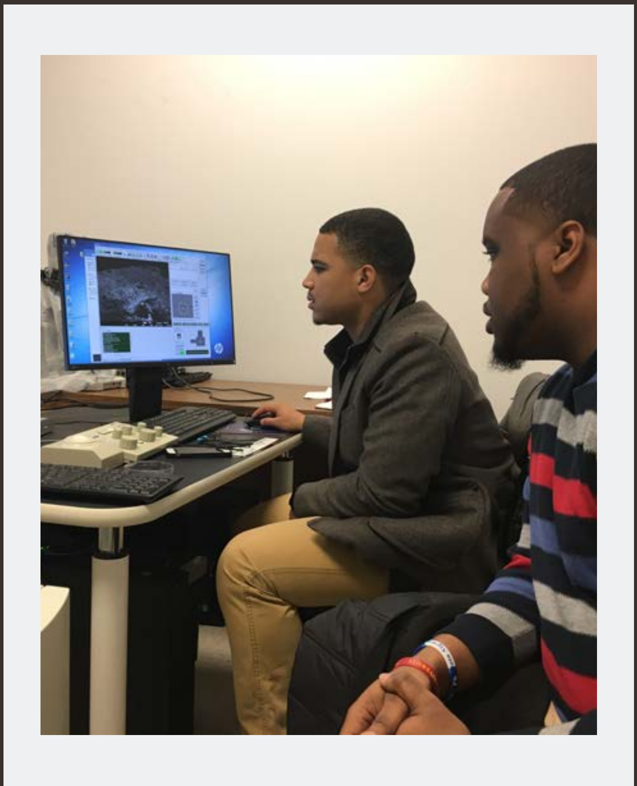
Ashley Roman, Auburn University

UNIVERSITY OF ALABAMA IN HUNTSVILLE STUDENT GAINS INTERNSHIP AT EVONIK

" I am so glad to be a part of the wonderful internship opportunity offered to me by UAH, NSF under CIPPTA, and Evonik Corporation. I have had a fun, exciting, and educational summer at Evonik corporation".

Jay Chokshi, The University of Alabama in Huntsville

N E W S W O R T H Y



N S F A W A R D E D $ 4 , 0 0 0 , 0 0 0 T O T U S K E G E E U N I V E R S I T Y

Congratulations to the Tuskegee Team on this accomplishment. The TU team is in partnership with University of Nebraska-Lincoln to research Multiferroic Polymer Nanocomposites. Tuskegee NSF-PREM project is co-funded with NSF EPSCoR began September 1, 2018.

C P U 2 A L D I R E C T O R T O H E A D D E C A D A L S U R V E Y F O R P L A S M A P H Y S I C S

Dr. Gary Zank has been named by the National Academy of Sciences to co-chair a committee performing a decadal survey for plasma physics. Dr. E. Thomas, Auburn co-PI has also been named to participate as a committee member.

T H E   E V E N T S

Auburn graduate student Eleanor Williamson inspiring middle school students at the Science and Technology Open House in Montgomery.

Congratulations to the Auburn Team for successfully leading most hands-on K-12 events, including Tech Trek in Huntsville, Destination STEM and Science Matters in Auburn, The Science and Technology Open House in Montgomery, and the DPP Plasma Expo in Portland, OR.

THE EVENTS

PAST EVENTS

2018 CPU2AL ANNUAL MEETING

The CPU2AL Annual Meeting was held on June 13 -15, 2018, in Huntsville, Alabama.

The 2018 NSF EPSCoR CPU2AL Annual Meeting allowed CPU2AL participants to showcase and discuss their research activities. Students and postdocs had the opportunity to develop their presentation skills and witness role models in action and exposed them to possible careers in academia, research facilities, or the private sector.

THE EVENTS

PAST EVENTS

2018 CPU2AL SCIENCE AND TECHNOLOGY OPEN HOUSE HOSTED BY TUSKEGEE UNIVERSITY

The CPU2AL Science and Technology Open House was held on September 7 - 8, 2018, in Montgomery, Alabama. On Friday, September 7, over 100 Alabama college students and postdocs filled the conference center eager to present their research.

The K-12 outreach event on Saturday, September 8, brought in upwards 60 local students. These students were able to engage in hands on science demonstrations and participate in science and motivational talks.

2018 Science and Technology Open House Poster Awardees

Undergraduate Level

Natalie Simpkins, University of Alabama at Birmingham
Stimulation of medium spiny neurons in the nucleus accumbenselicits place preference and goal-directed behavior

Yiming Zhang, University of Alabama at Birmingham
Unfolded Protein Response (UPR) Initiated Intercellular Stress Communication between Epithelial Cells and Fibroblasts

Pratheek Bobba, University of Alabama at Birmingham
Nitric Oxide Releasing Bionanomatrix Coating to Improve Endothelialization on Left Atrial Appendage Closure Devices

Masters Level

Mohammad Al Ahsan, Tuskegee University
Investigation on the compressive properties of carbon/glass/epoxy composites reinforced with graphene nanoplatelets

Nikhil Reddy Mettupally, The University of Alabama in Huntsville
Comprehensive Parking Study at the University of Alabama in Huntsville using Airborne sensors

Natalie Simpkins, University of Alabama at Birmingham
Stimulation of medium spiny neurons in the nucleus accumbenselicits place preference and goal-directed behavior

Biological Sciences: Ph.D. Level

Mohammed Majrashi, Auburn University
Designer Drugs (TFMPP-Derivatives) Can Increase the Risk for Dementia

Yuan Tian, Auburn University
Novel Peptide Combinations Support Dynamic Adhesion of Endothelial Colony Forming Cells

Lam Duong, Alabama A&M University
Effects of Low-Temperature Plasma on Turmeric Rhizome Sprouting and Basil Seed Germination

2018 Science and Technology Open House
Poster Awardees

Physical Sciences: Ph.D. Level

Jafar Orangi, Auburn University
Assembling 3D Ordered Structures of 2D MXenes for Energy Storage Applications

Morgan Ellis, Auburn University
Production of Engineered Heart Tissues Using Patient-Derived Stem Cells to Study Congenital Heart Disease

Zaheeruddin Mohammed, Tuskegee University
Effect of Graphene nanoplatelets and Montmorillonite nanoclay on mechanical and thermal properties of DGBA epoxy matrix

THE EVENTS

UPCOMING EVENTS

NSF EPSCOR REGIONAL OUTREACH: ALL ABOUT RESEARCH CENTER PROGRAMS

The NSF EPSCoR Regional Outreach: All About Research Center Programs meeting will be held on April 2, 2019, in Mobile, Alabama.

This event will be attended by up to five NSF Center Program Officers and two to three Center Directors who will provide extensive information about the various Centers sponsored by the NSF. The event will also feature breakout sessions where attendees can ask questions about Centers and speak with the attending Program Officers and Center Directors.

2019 CPU2AL SCIENCE AND TECHNOLOGY OPEN HOUSE

The Science and Technology Open House will be held on April 3-4, 2019, in Mobile, Alabama.

Middle school teachers and students are also invited to participate in a one-of-a-kind STEM experience. The K-12 open house held at the Gulf Coast Exploreum Science Center will include full access to the Exploreum including IMAX presentations and hands-on science demonstrations.

Undergraduate and graduate students and post-docs will present their research posters and awards will be given to the top three student posters in physical and biological science at each academic level.

2019 CPU2AL ANNUAL MEETING

The CPU2AL Annual Meeting will be held on April 4 - 5, 2019, in Mobile, Alabama.

The 2019 NSF EPSCoR CPU2AL Annual Meeting will allows CPU2AL participants to showcase and discuss their research activities.

Designed and edited by Dana Waller
Education, Outreach, Diversity Coordinator