International Low Temperature Plasma Community

https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 34

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Images to Excite and Inspire!

Please send your images (with a short description) to iltpc-central@umich.edu. The recommended image format is TIF, JPG, or PNG. The minimum file width is 800 px.

High-speed photograph of a rotating atmospheric pressure plasma filament: This mm-scale argon/silane RF plasma appears diffuse to the eye and in normal photography, but high-speed imaging reveals its filament-like structure. This constriction may provide conditions such as localized species densities and energy fluxes that allow production of crystalline nanomaterials even at low power and atmospheric pressure. Studying this constriction can offer important insights into how researchers can control the properties of miniaturized plasma reactors for use in nanomanufacturing of a diverse set of materials. **Cameron Papson** (papsonca@msu.edu) and **Prof. Rebecca Anthony** (ranthony@msu.edu), Michigan State University, USA.

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Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **September 22, 2023.** Please send contributions as MS-Word files if possible – and **avoid sending contributions as PDF files**.

In particular, please send **Research Highlights and Breakthroughs** using this ***template:*** https://mipse.umich.edu/iltpc/highlight_template_v05.docx. The highlight consists of an image and up to 200 words of text; please also send your image as a separate file (the recommended image format is JPG or PNG; the minimum file width is 800 px). The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related. Please see the *Research Highlights and Breakthroughs* for examples.

Products for Energy and Environmental Applications are High Volume and Low Value

Atmospheric carbon dioxide remains a persistent environmental challenge. A recent development is the plummeting cost of electricity produced with low CO_2 emission. This backdrop has thrust nonequilibrium plasma-chemical processing into the spotlight as a method to decarbonize the economy. Amidst this excitement, and burgeoning academic publications, it is worthwhile to review the orders of magnitude required to have an impact.

A common motivation for research is to decarbonize some commodity X by developing a less CO_2 intensive method to manufacture X; or alternatively, develop some new commodity Y that is functionally similar but less CO_2 intensive than commodity X. For example, we might be interested in decarbonizing the commodity chemical acrylonitrile by finding a less CO_2-intensive manufacturing method when compared to the Standard Oil of Ohio (SOHIO) process. As another example, we might be interested in developing a less-energy intensive means to produce H_2 without CO_2 emission, with the idea being that H_2 could become a major transportation fuel. There is a tremendous amount of research being conducted with these implicit goals.

Figure 1. Photograph of a demonstration scale updraft moving bed gasifier at Sotacarbo SpA. The reactor has an inner diameter of 1.3 m and is capable of gasifying 10,000 tons per year of solid waste carbon (e.g. coal, biomass and/or plastic). Photo courtesy of Hamilton Maurer International.

The scale of the CO_2 emission problem is huge. Energy-related anthropogenic CO_2 emission is 37 billion tons per year (see International Energy Agency). To impact global CO_2 emissions, we must shift towards decarbonization with mass flows on the scale of billions of tons per year. Like voting in a democratic society, many small industrial developments can add up to something impactful. What constitutes a small but relevant manufacturing scale?

Chemicals of relevance to reducing CO_2 emissions are high volume and low value (approximately $1,000 per ton). The minimum production rate for economic viability is expected to be on the order 10,000 tons per year. If there is an intrinsic limitation to a proposed nonequilibrium plasma process or operating at 10,000 tons per year cannot be envisioned for some other reason, then full stop. Game over.

What does a reactor that can produce 10,000 tons per year look like? They are big. For example, in Figure 1 is a photograph of an updraft moving bed gasifier at Sotacarbo SpA that can convert 10,000 tons per year of waste coal, biomass and plastic into synthesis gas. The inner diameter of the reactor is 1.3 meters. That is the *minimum* size of an economically relevant reactor.

To the junior researchers reading this article, think bigger. To the senior nonequilibrium plasma researchers, it is time to recognize that we need to rethink our approach. The production rate required to impact CO_2 emissions is many orders of magnitude larger than the production rate required to impact the semiconductor industry, and the specific value of products relevant to energy is orders of magnitude smaller than semiconductor products. Products of relevance to energy are high volume and low value.

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Leaders of the LTP Community: Career Profiles

Professor Edward Thomas, Jr. – Pioneer of Magnetized Plasma and Driver of Social Change

As a physics professor and the current Dean of the College of Sciences and Mathematics at Auburn University (USA), Dr. Edward Thomas, Jr. has demonstrated that excellence in science and leadership can not only coexist, but also boost each other. Dr. Thomas has conducted impactful research in almost every sub-field of plasmas, with important contributions to fusion, complex low temperature plasmas, laboratory space and astrophysics, and fundamental plasma phenomena. In the LTP community, Dr. Thomas is known for his work on transport processes and the thermodynamic properties of complex plasmas, and laboratory simulations of shear flow driven waves in the ionosphere and magnetosphere. Dr. Thomas is also the head of the Magnetized Plasma Research Laboratory (MPRL, https://mprl.auburn.edu), which hosts the Magnetized Dusty Plasma Experiment (MDPX) incorporating a LTP inside the field of a 4-Tesla, multi-configuration, superconducting magnet. Dr. Thomas's MPDX work has provided foundational knowledge of the interaction between LTPs and magnetic fields with important applications to plasma technology and phenomena in space. During his career, Dr. Thomas has produced over 80 peer-reviewed publications and over 300 scientific presentations, has advised/co-advised 14 PhD students, and has mentored over 40 undergraduate researchers.

In addition to his highly impactful research, Dr. Thomas has been dedicated to broadening participation and improving diversity in plasma fields. Dr. Thomas's MPRL operates as a collaborative research facility under the Department of Energy (DOE) Plasma Science Facility Program with additional support from the National Science Foundation (NSF), NSF Established Program to Stimulate Competitive Research (EPSCoR) and NASA. The MPRL team supports the work of early-career scientists (often students) who otherwise may not have access to a major laboratory facility. Dr. Thomas is also an enthusiastic supporter of the MagNetUS community (https://sites.google.com/view/frontier-science-magnetus/magnetus), which aims to foster a diverse plasma workforce, coordinate communications among collaborative/user facilities, and build a welcoming ecosystem for colleagues interested in magnetized plasma research. Dr. Thomas has also been the Auburn leader of two state-wide NSF EPSCoR grants aiming to advance LTP science and technology across the state of Alabama. These two projects involve working with HBCUs (Historically Black Colleges and Universities) in Alabama, including Alabama State University, Tuskegee University, and Alabama A&M University.

Beyond Auburn University and Alabama, Dr. Thomas has served on various advisory committees for national and international science agencies. Several notable examples include service to the DOE Fusion Energy Sciences Advisory Committee, the National Research Council Plasma Sciences Committee, and the European Space Agency PK-4 Facility Science Team. His current service includes membership on the NSF Mathematics and Physical Sciences Advisory Committee and the National Academies of Sciences Board on Physics and Astronomy. He is also the Chair-Elect of the American Physical Society Division of Plasma Physics (APS DPP) – to become Chair next year. Dr. Thomas has worked with the APS Committee on Minorities, the non-profit organization Quality Education for Minorities, which provides proposal development training for faculty as MSIs, and the APS DPP DEI (Diversity, Equity and Inclusion) Organizing Collective Committee as we seek to create a more welcoming environment in our field.

Dr. Thomas is an exceptional example of a scientist and leader whose work and personality have permeated the plasma community. He continues to be an inspiration to a whole generation of LTP scientists and leaders.

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General Interest Announcements

Please send you General Interest Announcements to iltpc-central@umich.edu.

Meetings and Online Seminars

- **15th Frontiers in Low Temperature Plasma Diagnostics (April 28-May 2, 2024), Castle Hotel Liblice near Prague, Czech Republic**

  We invite you to attend the **15th Frontiers in Low Temperature Plasma Diagnostics** (April 28-May 2, 2024) at the Conference Centre of the Academy of Sciences of the Czech Republic in Castle Hotel Liblice near Prague.

  

  The main goal of the workshop is to enable an intensive meeting of experts in low-temperature plasma diagnostics and to present the latest developments in the use of a whole range of diagnostics for investigating both the basic properties and various applications of low-temperature plasmas. It also provides a unique opportunity for a new generation of researchers to discuss the current state-of-the-art and future prospects of the field with leading scientists. The program traditionally consists of expert presentations by invited speakers, presentations by selected topical speakers and poster presentations.

  More information coming soon on the website: https://www.fltpd2024.cz/.

  FLTPD XV is organized by the Department of Pulsed Plasma Systems of the Institute of Plasma Physics Prague, Academy of Sciences of the Czech Republic.

  Contact:
  Dr. Milan Šimek
  Institute of Plasma Physics of the Czech Academy of Sciences, Czech Republic
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- **The Online Low-Temperature Plasma (OLTP) Seminar Series**

  The schedule for OLTP seminars and more information on the program, including links to past seminars, can be found at the OLTP website:

  https://theory.pppl.gov/news/seminars.php?scid=17&n=oltp-seminar-series

  The seminars are held on Tuesdays at 10:00 am EDT or EST via Zoom and are free to access.

  Co-Chairs:

  Dr. Mikhail Shneider, Princeton University, USA, shneyder@princeton.edu
  Prof. Dr. Vasco Guerra, University of Lisboa, Portugal, vguerra@tecnico.ulisboa.pt

- **IOPS Online Seminars**

The *International Online Plasma Seminar (IOPS)* is continuing to provide the international community with regular opportunities to hear from leading researchers in the field. The program of the IOPS (and links to past seminars) can be found at: http://www.apsgec.org/main/iops.php.

Chair:
Prof. Quan-Zhi Zhang, Dalian University of Technology, China, qzzhang@dlut.edu.cn

Community Initiatives and Special Issues

- **The PlasTHER COST Action**

The objective of the **PlasTHER COST Action** is to unify the known physical and biochemical mechanisms of plasma to allow for unprecedented advancement of plasma technology in biomedical applications.

In this context, we want to create a database to consolidate the existing information on the characterization of plasma medicine devices and the associated operational conditions used in anti-microbial activity, tissue regeneration/wound healing, and cancer treatment (WG1-5). The resulting database will be freely available to the plasma community via the PlasTHER COST Action website to accelerate the development of suitable therapies for patients and society at large.

We invite you to contribute to this initiative by uploading the information of your publications using the following Google form:

https://docs.google.com/forms/d/e/1FAIpQLSeL_D_uwAIK3L1PHjGjIL5D-iH-ZlkD0Wc8WjtCUGF6Qqzyzpw/viewform

You can find a video tutorial on how to fill in the form here:

https://www.plasther.eu/tutorials/

When filling in the form, please consider the following:

- If more than 1 answer, please separate with ","
- Please do not include units
- Questions marked with a red "*" are mandatory
- If more than 1 device is used in the publication, please fill in the form once per device
- Please do not include work with plasma-treated liquids. At this moment, we are collecting information only on the plasma devices

We understand that this database may not encompass all the different features of plasma devices and treatment, yet we see this a starting point for the unification of our field. Should you have any comments or questions regarding this initiative, please reach us out, we will be happy to help you.

Thank you in advance for your contribution! And we are looking forward to see the result of this collective work.

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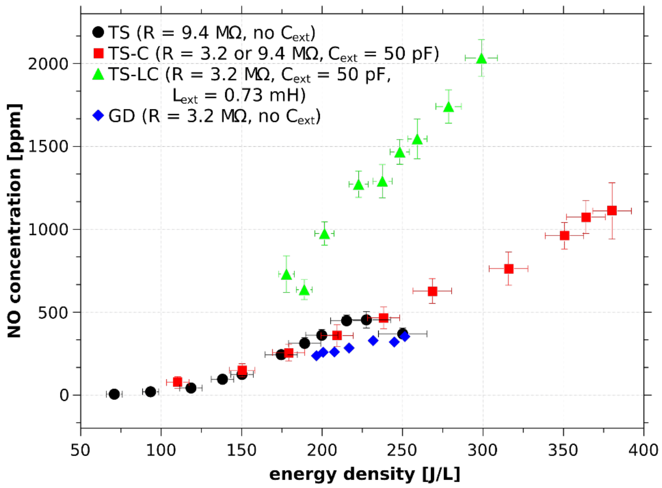
Nitrogen Fixation Using Spark Discharges



The green points show the efficiency of nitrogen oxide production in an atmospheric transient spark discharge is doubled by modifying the driving circuit.

The efficiency of nitrogen fixation in an atmospheric pressure discharge is doubled by simple modification the driving electrical circuit. A capacitor is charged through a load resistor, connected to a spark gap. At breakdown voltage a transient spark is generated as the capacitor discharges.

Modifications to the driving circuit by tuning the capacitance and adding an inductor give enhanced NO production in the discharge. The concentration of NO produced in air by the discharge as a function of 'energy density', which is the energy delivered per litre of air.

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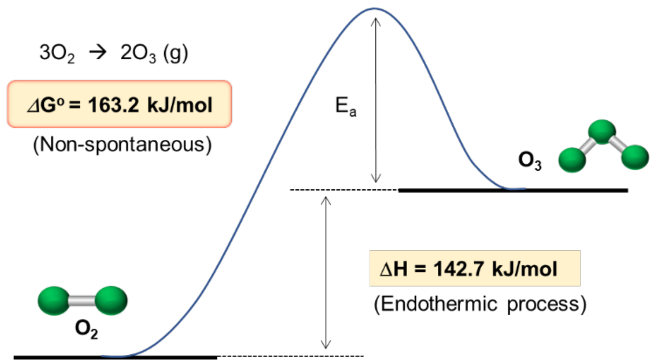
Source:
J. Phys. D (2023). https://iopscience.iop.org/article/10.1088/1361-6463/ace634

Thermodynamics of Ozone Generation in Dielectric Barrier Discharges



Thermodynamic consideration of ozone formation from oxygen. The Gibbs free energy of O_3 formation is endergonic (ΔG^0 = 163.2 kJ mol^{-1}), indicating that it is a nonspontaneous process. However, DBD plasma replace the highly endothermic process by the energetic electronic pathway, enabling the successful generation of ozone despite the thermodynamic limitations.

This review places particular focus on the thermodynamic aspect of ozone formation in dielectric barrier discharge (DBD), which is fundamental but puzzling to newcomers in plasma chemistry. DBD production of ozone connects two independent endothermic and exothermic processes with different time scales, allowing for the endothermic process even at low temperature conditions. By utilizing energetic electron-driven processes, the highly endothermic process is transformed into a quasi-exothermic process which can proceed spontaneously. This elaborate coupling of non-equilibrium with equilibrium processes, as well as exothermic and endothermic processes, makes the DBD reactor an efficient and effective method for O_3 formation against the thermodynamic limits. This review aims to provide valuable insights into the thermodynamic mechanisms behind ozone formation and some noticeable applications of ozone, assisting newcomers in plasma chemistry to grasp the underlying principles of this crucial process.

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http://ijpest.com/Contents/17/2/e02004.html

New Resources

Please submit your notices for New Resources to iltpc-central@umich.edu.

Career Opportunities (for other career opportunities, see: https://mipse.umich.edu/jobs.php)

- **Post-doctoral Research Scholar – Experimental RF ICP Ion Source, FPAC LAB, North Carolina State University, USA**

  The FPAC LAB at North Carolina State University is seeking an early career scientist to develop a radio-frequency (RF), inductively-coupled ion source for application in neutral beam fusion heating systems. This includes the design, procurement, installation and operation of vacuum, gas handling and high-power RF systems. Opportunities exist to interact closely with a group of distinguished national and international collaborators working on all aspects of neutral beam heating systems. The position is under the supervision of **Dr. Florian Laggner** (FPAC LAB lead) and will be based at the Department of Nuclear Engineering in Raleigh, North Carolina, USA.

  Key responsibilities:

  - Coordinate the RF ion source project: Create and manage CAD drawings of vacuum and RF components and support the procurement.
  - Lead the RF ion source assembly.
  - Implement safety systems and design control logics.

  Required skills:

  - Demonstrated success in at least some aspect of designing, building, and operating plasma setups or diagnostics.
  - Basic knowledge or willingness to learn CAD and control software tools, methodologies, and best practices.
  - Scientific research ability demonstrated by peer-reviewed publications and presentations at technical conferences.

  How to apply: https://jobs.ncsu.edu/postings/188409

  Contact:
  Dr. Florian M. Laggner
  Department of Nuclear Engineering, North Carolina State University, USA
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- **Post-doc or Scientist in the Field of Non-equilibrium Plasma Chemical Processes, Swiss Federal Laboratories for Materials Science and Technology, Switzerland**

  Materials science and technology are our passion. With our cutting-edge research, Empa's around 1,100 employees make essential contributions to the well-being of society for a future worth living. Empa is a research institution of the ETH Domain (https://www.empa.ch/).

  Non-equilibrium plasma chemical processes efficiently utilize energies in the plasma to activate chemical bonds at low temperatures, offering great potential for plasma-based gas conversion beyond purely thermal activation.

  Your tasks: The research includes, but is not limited to, in-depth studies of plasma physical and chemical processes to achieve high control over the plasma activation, dissociation and formation of intermediates as well as the selective formation of stable gaseous and solid products. The work comprises the set-up of a novel plasma reactor with suitable diagnostics, building on the extensive experience and leading know-how of the group. We are aiming for an improved fundamental understanding of non-equilibrium plasma processes, contributing to the important field of chemical transformation of carbon-containing matter.

  Desired qualifications: You have a Ph.D. in chemistry, physics, materials science or similar. Ideally, you bring sound knowledge in non-thermal plasma technology with a strong physical or chemical background. Creation of own ideas and strong self-motivation is highly desired. Candidates with demonstrated research skills and good publication records will be considered. Fluency in English is required, further knowledge of

German (or another language spoken in Switzerland) is a plus. To be considered as a scientist, prior experience of 2-3 years as Post-doc is necessary.

You will work in an ambitious team combining strong experience in plasma technology, basic research, and established industry contacts. You should be interested to develop and strengthen your academic record as well as your industrial network.

Our offer:

Empa's Group Plasma & Coating in St. Gallen, Switzerland, is offering a position for 2 years. We live a culture of inclusion and respect. We welcome all people who are interested in innovative, sustainable and meaningful activities. That's what counts - not age, gender, origin, religion, sexual orientation, etc.

We look forward to receiving your complete online application including a letter of motivation, your CV, a list of publications, diplomas with transcripts, and names of academic referees. Please submit these exclusively via our job portal: https://apply.refline.ch/673276/1819/pub/1/index.html.

Contact:
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- **Post-doctoral Position in Plasma Science and Engineering, University of Minnesota, USA**

This position is to participate in research focused on plasma enabled conversion of methane and plasma catalysis. We are looking for a post-doctoral researcher with a recent Ph.D. degree in plasma science / engineering, chemical engineering, catalysis or closely related field. Experience in plasma source design and diagnostics is preferred. The post-doctoral researcher should have excellent oral and written communication skills and the ability and desire to collaborate with a team of multidisciplinary researchers. For more information about the research group, please visit the group website: https://bruggeman.umn.edu/.

Applicants should send a cover letter (including the date applicant is available), CV, and reprints of 3 representative publications to the contact.

Contact:
Prof. Peter Bruggeman
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Collaborative Opportunities

Please submit your notices for Collaborative Opportunities to iltpc-central@umich.edu.

Disclaimer

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