# International Low Temperature Plasma Community

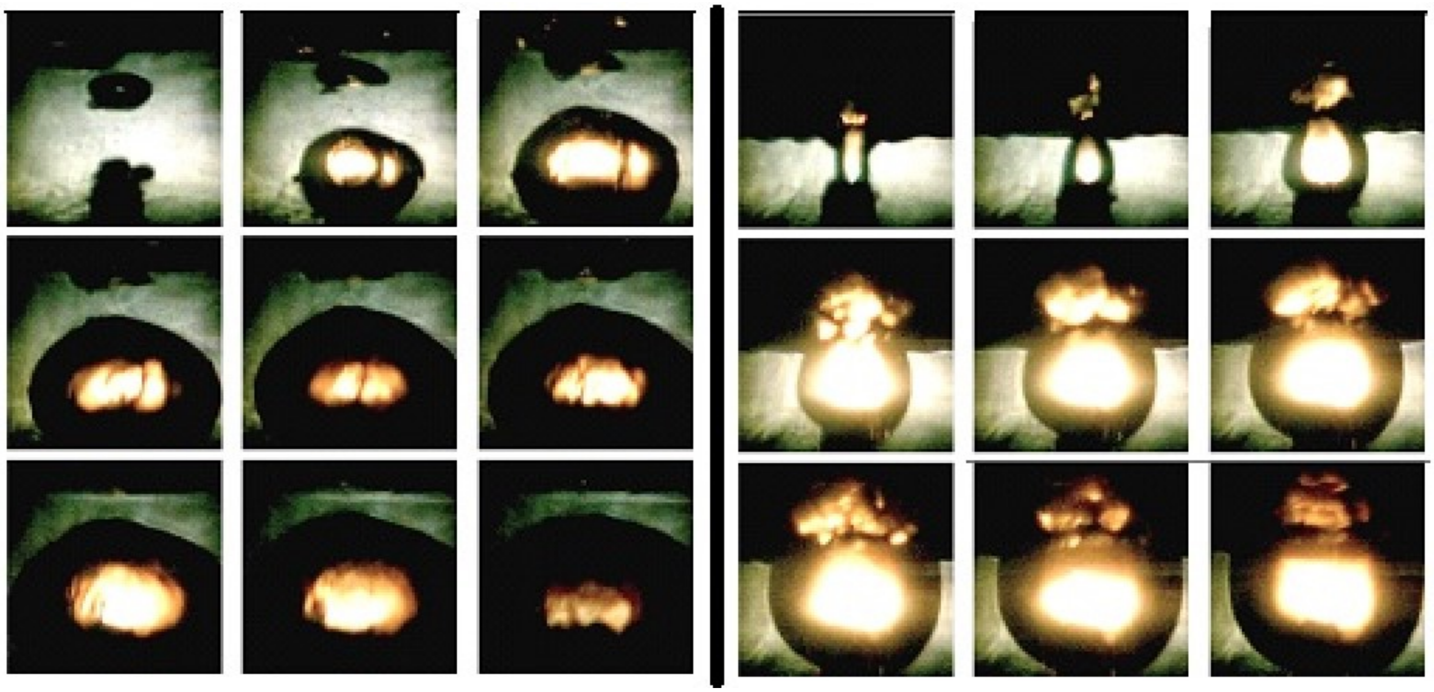
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

# Newsletter 18

3 November 2021
(amended)

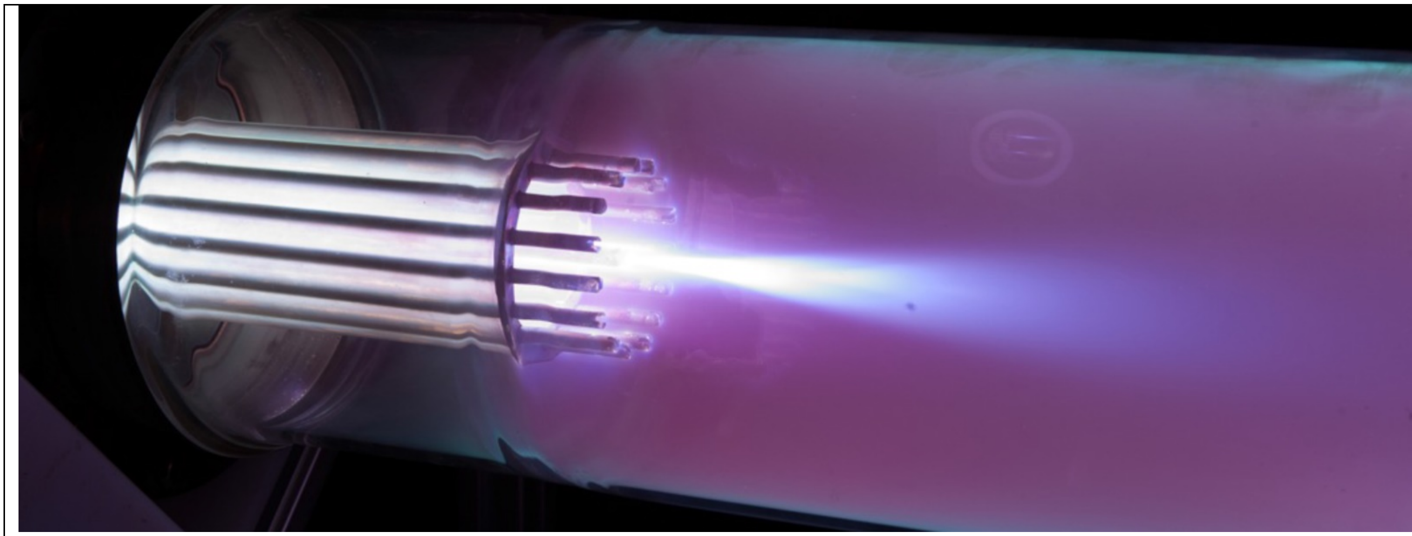
## Images to Excite and Inspire!

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



**Microwave discharges in liquid hydrocarbons** are one of the least studied discharges (Yu. A. Lebedev, Polymers **13,** 1678 (2021)). Usually, they are generated at the end of a microwave antenna immersed in a liquid. Additional gases can be supplied through a channel in the antenna to the discharge region. The shadow photographs show the stages of discharge development in a petroleum solvent (a mixture of light hydrocarbons with a boiling point from +33 to 205°C) when supplying argon through a channel in the antenna at a flow rate of 0.1 cm/s. The incident microwave (2.45 GHz) power is 250 W and there atmospheric pressure above the surface of the liquid. The discharge was visualized with a high-speed video camera Phantom MIRO M 310 (exposure time 0.9 μs with an interval between frames of 1 ms). The discharge is a sequence of micro-discharges. Images from nine images on the left show the development of the discharge during the first ignition and on the right during the re-ignition of the discharge 50 ms after the first. The first frame shows an antenna tip and a floating gas bubble. The glowing areas in the dark part of the frame are reflections of the discharge in the liquid.

*Contact:* **Prof. Yuri Lebedev,** Laboratory of Plasma Chemistry and Physical Chemistry of Pulse Processes, Topchiev Institute of Petrochemical Synthesis of the Russian Academy of Sciences, Moscow, Russia, lebedev@ips.ac.ru.



**A Hydromagnetic Plasma Thruster** - Long (~ 1 s) broadband exposure (self-emission) captures the firing of a hydromagnetic plasma thruster. The plasma jet that forms at the exit plane of the thruster results from a quasi-steady magneto-deflagration mode whereby plasma expands from a region of high magnetic pressure. This operational mode is able to generate Alfvénic axial velocities (up to ~ 100 km/s) and maintain stability due to the presence of shear flow around the central plasma jet.

**Prof. Thomas Underwood**, University of Texas at Austin, USA, thomas.underwood@utexas.edu.



## Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **December 10, 2021.**

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.

**Machine Learning and Artificial Intelligence: New Tools for Plasma Science**

Data-driven science has been a subdiscipline of statistics and information science for many decades and various techniques to analyze a large amount of data have been developed up to today. With the availability of inexpensive high-power computation, these techniques are found to be extremely useful to analyze every aspect of our lives, from politics to commerce to culture, including science and technologies. In science, unlike the first-principles-based analyses, data-based analyses typically give you a “large picture” of the phenomena of your interest. They may even help you discover something you might have overlooked (maybe just like Newton discovered the theory of gravity by seeing a falling apple; if this episode is true).

In plasma science, unlike some scientific disciplines where people are distressed when they discover a disagreement in the 12th digit, large error bars seem to be common in daily life. We often take them for granted because we know plasmas are, by nature, extremely complex. Now, thanks to the latest development of machine learning (ML) and artificial intelligence (AI), we may have access to new tools to obtain additional information from such complexity, if not to disentangle it.

For some applications, we may have a large amount of data to analyze just statistically, but for others, we do not. In the latter cases, combining some knowledge of physics with a limited amount of available data in analyses can provide a needed solution to the problem of interest.

Recently my colleagues and I have worked on the prediction of sputtering yields of single-element materials subject to single-element ion impact, using ML with a large amount of existing sputtering yield data. The results are posted on the web page: http://www.camt.eng.osaka-u.ac.jp/hamaguchi/SY/

We plan to extend it to multi-element materials, such as alloys and oxides, with more complex molecular ions.

To promote the application of ML and AI to plasma research, we have been running online seminars since April 2020, titled *Physics informed Artificial Intelligence in Plasma Science (PiAI) Seminars.*

http://www.ppl.eng.osaka-u.ac.jp/JSPS_Core/seminars.html

If you are interested, please send a message to core@ppl.eng.osaka-u.ac.jp to register. (No registration fee.) If you do not live in a convenient time zone, future seminars will be recorded.

We also organize international meetings on this topic. Most recently we held the *3rd International Conference on Data Driven Plasma Science* online as

http://www.ppl.eng.osaka-u.ac.jp/ICDDPS3/

The next meeting, *4th ICDDPS*, is now scheduled to be held from 6 to 10 June, 2022, at Princeton Plasma Physics Laboratory (Princeton, New Jersey, USA), pending the US Department of Energy’s approval due to the Covid-19 travel restrictions. For the latest information, please contact me or send a message to icddps4@ppl.eng.osaka-u.ac.jp.

**Prof. Satoshi Hamaguchi**
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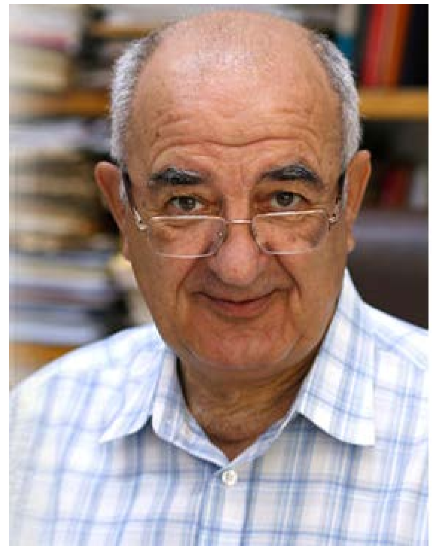
### Gheorghe Popa – From Excellence in Plasma Physics to Education and Research Management



Gheorghe Popa is a Romanian physicist and *professor emeritus* at Alexandru Ioan Cuza University of Iași, Romania. He entered the university in 1961 as freshman student in the Faculty of Mathematics and Physics and then built a half century university career within the Faculty of Physics. In the late 1960s, he worked on plasma polymerization in dc and rf discharges and on plasma diagnostics of ion sources. In the 1970s, he studied Kelvin-Helmholtz, ion space charge and ion-acoustic instabilities, as well as ionization waves, at the Institute of Physics - Czech Academy of Sciences (in the laboratory of Dr. L. Pekarek) and at the Institute of Theoretical Physics, University of Innsbruck. In the early 1980s, Prof. Popa obtained an outstanding result – a bi-potential structure created in a double plasma machine, having a continuously tuneable reflexion coefficient, from zero (lack of reflection) to 1 (total reflection), for ion-acoustic waves and solitons. His findings related to plasma waves and instabilities are recognized and cited as pioneering works in the field.

In the late 1980s, Prof. Popa developed his own research team, working on two major directions: plasma technology and plasma fundamentals. In collaboration with industrial partners, he worked on ion plasma nitriding, electron beam welding, metallization of plastic foils using thermal evaporation or magnetron sputtering, plasma treatment of polymers and fibres. Fundamental studies were carried out on the role of secondary electron emission in the negative glow, the origin and mechanism of anodic instabilities, double layers, plasma diagnostics of low and atmospheric pressure discharges.

In addition to his scientific and teaching activities, Prof. Popa was involved in education and research management, as Rector of the university (1992-2000) and Secretary of Research within the Ministry of Education, Research and Youth (2003-2005). A dominant element of his managerial activity was to offer the Romanian researchers access to international research and collaborations. Today, many of Prof. Popa's students are working in or even leading plasma physics laboratories all around the world. He placed Alexandru Ioan Cuza University of Iași on the map of high energy physics and fusion related research. He founded ANELIS PLUS, an association facilitating access to scientific literature, which he coordinated even after retirement.

For his prolific scientific activity, Prof. Popa received numerous awards and distinctions, among them the Constantin Miculescu Award of the Romanian Academy and L'ordre des Palmes Academiques. He is Officer of the National Order "Star of Romania", Honorary Professor of Shizuoka University Japan, and member of the European Academy of Sciences and Arts.

Prof. Gheorghe Popa was and still is an influential leader of the Romanian plasma physics community, a reputed scientist and memorable teacher. We are pleased to meet him regularly at conferences and other occasions.

**Dr. Ionuț Topală**
**Dr. Claudiu Costin**
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## General Interest Announcements

- **2022 EPS Plasma Innovation Prize – Call for Nominations**

The Plasma Physics Division of the European Physical Society (EPS) is seeking nominations for the "2022 EPS Plasma Physics Innovation Prize".

The EPS Innovation Prize was established in 2008 in order to recognize and promote the wider benefits to society that arise from the applications of plasma physics research. The works recognized by the Prize in previous years are diverse. Nominations are welcome from all areas of technology, industry, society or more. Recent awards have included applications in medicine and materials processing.

The prize is awarded for proven applications that can go beyond, but are derived from, plasma physics research. Joint Innovation Prizes are also possible and can be awarded to a group of up to three individuals.

The deadline for the next round of nominations for the 2022 EPS Plasma Physics Innovation Prize is: **February 1st, 2022**.

Details can be found here: http://plasma.ciemat.es/eps/awards/innovation-award/

*Contact:*
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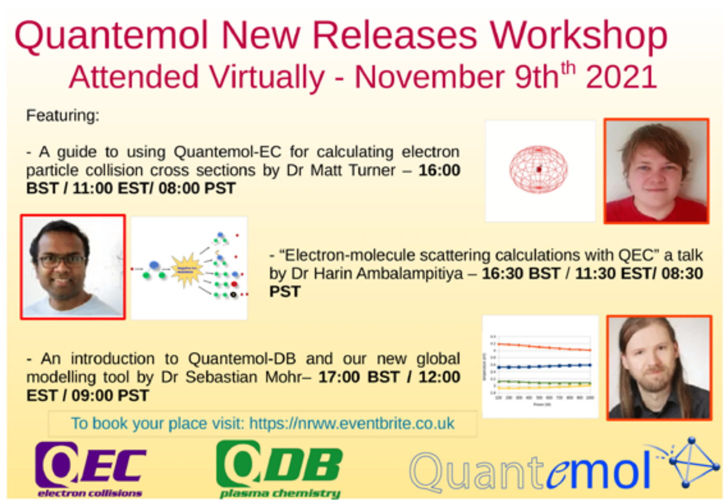
- **Quantemol Workshop – New Releases**

Quantemol is holding a workshop on the 9th of November to showcase our new releases for calculating electron scattering and plasma properties. Featuring:




- A guide to using Quantemol-EC for calculating electron particle collision cross sections by Dr. Matt Turner – 16:00 BST / 11:00 EST / 08:00 PST
- "Electron-molecule scattering calculations with QEC" a talk by Dr. Harin Ambalampitiya – 16:30 BST / 11:30 EST / 08:30 PST
- An introduction to Quantemol-DB and our new global modelling tool by Dr. Sebastian Mohr – 17:00 BST / 12:00 EST / 09:00 PST

To sign up visit: https://nrww.eventbrite.co.uk. We hope to see you there!

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- **Open Solicitation of Collaborative Research Proposals on Low Temperature Plasma at Department of Energy User Facilities (Experiment and Computations)**

  The Princeton Collaborative Research Facility (PCRF) at the Princeton Plasma Physics Laboratory (PPPL), http://pcrf.pppl.gov (New Jersey, USA), and the Sandia Plasma Research Facility (PRF) at the Sandia National Laboratories (SNL), http://www.sandia.gov/prf/ (Albuquerque, New Mexico, USA), are now soliciting collaborative research proposals on low temperature plasma and applications. Collaborative research opportunities are available using the experimental facilities and computational capabilities at these Department of Energy funded laboratories. Please consult the websites of each facility for an overview of their experimental and computational capabilities. Collaborative research can be performed onsite at the PCRF and PRF or remotely, and is open to the international community. The schedule for this year's call is:

  - Call for proposals opens: October 12th, 2021
  - Call for proposals closes: December 17th, 2021
  - External Review: ~1 month
  - Notification of Principal Investigators: by February 4, 2022

  For inquiries on PCRF, contact Yevgeny Raitses: yraitses@pppl.gov.
  For inquiries on Sandia PRF, contact Shane M. Sickafoose: smsicka@sandia.gov.

  The PPPL PCRF is supported by the US Department of Energy, Office of Science, Fusion Energy Sciences, under contract DE-AC02-09CH11466.

  The SNL PRF is supported by the US Department of Energy, Office of Science, Fusion Energy Sciences. SNL is managed and operated by NTESS under DOE NNSA contract DE-NA0003525.

  *Contacts:*
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  **Dr. Shane M. Sickafoose**, Sandia National Laboratory, USA, smsicka@sandia.gov

## Meetings and Online Seminars

- **International Online Plasma Seminar (IOPS)**

  The International Online Plasma Seminar (IOPS) is a seminar series on low temperature plasma science (LTPS). The seminars are presented bi-weekly via Zoom. The current program and information about IOPS can be found here: https://mipse.umich.edu/online_seminars.php. Nominations for future speakers can also be made from this page.

  The next IOPS (3:00 pm Central Europe Time) will be given by Prof. Vasco Guerra and Prof. John Foster (**November 11, 2021**); and Dr. David Pai (**November 25, 2021**).

  To attend IOPS, use the following Zoom link:
  https://ruhr-uni-bochum.zoom.us/j/93889931395?pwd=bFN5dU14RHRMYU5ySW40V1gvbDJpZz09

- **Online LTP Seminar (OLTP)**

  The schedule of the Online Low Temperature Plasma (OLTP) Seminar series is available at: https://mipse.umich.edu/ltp_seminars.php. The next seminars (9:00 am US Eastern Standard Time) will be presented by Dr. Pascal Chabert (**November 16, 2021**) and Prof. Holger Kersten (**November 30, 2021**). To obtain the Zoom link to attend the seminars, contact Dr. Yevgeny Raitses (yraitses@pppl.gov) and/or Prof. Michael Keidar (keidar@gwu.edu).

- **Merger of the OLTP and IOPS Online Seminar Series**

  Over the past few years, we have had the fortune of benefiting from two online LTP seminars where excellent lectures on plasma science and applications have been delivered. *The International Online Plasma Seminar* (IOPS - https://mipse.umich.edu/online_seminars.php) is now in its fourth year. *The Online LTP Seminar* (OLTP - https://mipse.umich.edu/ltp_seminars.php ) series was started in May 2020 with the goal of remedying the lack of in-person conferences/workshops due to the COVID-19 pandemic.

  The leadership of IOPS and OLTP have agreed to merge the two seminar series to enable better coordination and ultimately bigger impact. This merger is planned to occur in two stages. In the first stage, from January to June 2022, IOPS and OLTP will continue to be run as they are now, but will be managed under the umbrella of the Gaseous Electrons Conference (GEC). There will be joint talks between the IOPS and OLTP, and the seminars will be announced as *OLTP-IOPS Seminars*. The current archive of past seminars (presentations and videos) will be moved from their current location on the MIPSE website to the GEC website. During this period a committee will work on the final format and organization details for the merged seminar series, including the future speaker selection process. Starting July 2022, the seminars will formally merge and will be run under the auspices of the GEC with the tentative name of *Online Plasma Science Seminar* (OPSS). More details will be forthcoming as we get closer to the merging date.

  *Contacts:*
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  **Dr. Julian Schulze** and **Dr. Kallol Bera**, IOPS Co-Chairs
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- **Collaborative Workshop on Transient Atmospheric Pressure Plasmas: Bridging the Pandemic - Reigniting Cooperation on Plasma Research**

  160 years ago, the Japanese government and Prussia signed the first treaty addressing diplomatic, commercial, and cultural exchange, which was the start of a long history of official relations between Japan and Germany. The 160th anniversary is now being celebrated. The goal of this workshop on *Transient Atmospheric Pressure Plasmas*, is to revitalize relations between Japan and Germany in low-temperature plasma science, which have been hit hard by the pandemic lockdown.

  Research on topics generally related to the CRC1316 (Transient Atmospheric Pressure Plasmas: From Plasmas to Liquids to Solids [https://sfb1316.rub.de/index.php/en/]) at Ruhr University Bochum (RUB) is the focus of the workshop. The schedule of the workshop is distributed over seven days within six weeks, from 29 October 2021 to 3 December 2021.

  In addition to speakers from RUB, there will be speakers from the following Japanese universities and institutes: AIST (National Institute of Industrial Science and Technology), Hokkaido University, Iwate University, Keio University, Kyushu University, Nagoya University, Osaka University, Tohoku University, Tokyo Institute of Technology, Tokyo Metropolitan University, University of Tokyo. The schedule and registration information (please ignore deadline on website) are at: https://www.ep5.ruhr-uni-bochum.de/index.php/en/japan-rub-workshop.

  *Contact:*
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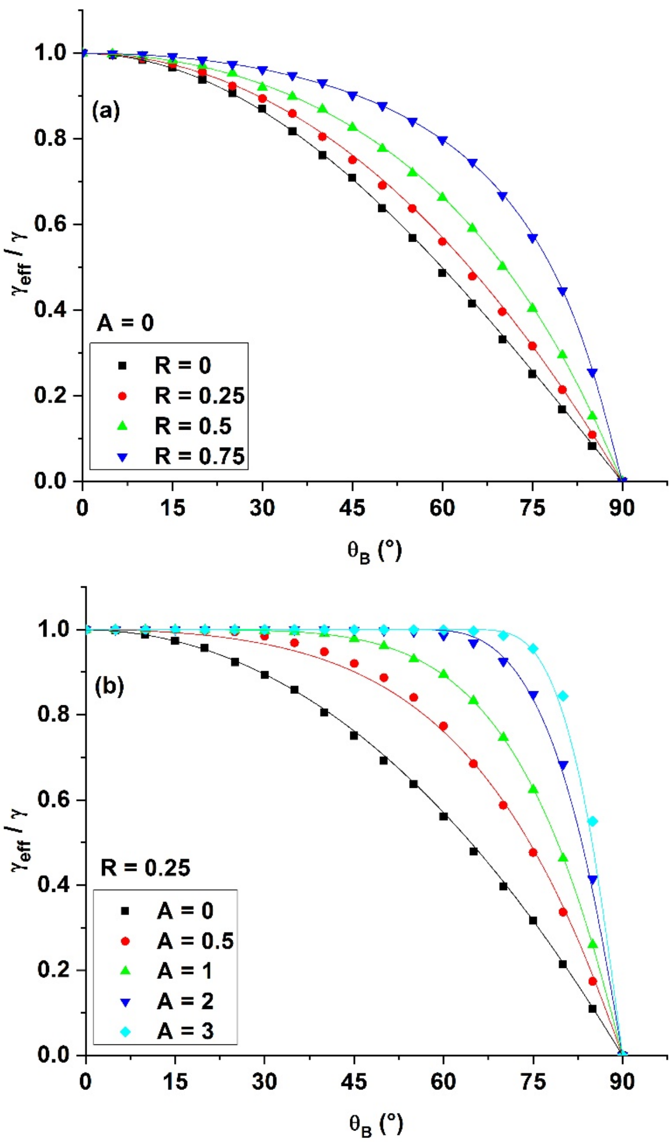
## Community Initiatives and Special Issues

Please submit your announcement for Community Initiatives and Special Issues to iltpc-central@umich.edu.

## Efficiency of Secondary Electron Emission Under Magnetic Constraint




Efficiency of the SEE as a function of the magnetic field tilt $\theta_B$, for different values of the reflection coefficient (a) $R$ and (b) of the parameter $A$. Symbols correspond to MC simulations, full lines correspond to the analytical solution.

The secondary electron emission (SEE) process is a key factor for plasma-surface interactions. It is essential for the optimal operation of plasma-based applications, from laboratory experiments to fusion reactors or high-energy accelerators. In magnetized discharges, secondary electrons are forced to move on helical trajectories, some of them being returned to the emissive surface. In such a case, the SEE process is quantified by an effective yield $\gamma_{eff}$ that includes only the electrons that are relevant to the discharge.

A three-dimensional Monte Carlo (MC) simulation method has been used to study the role of a magnetic field $B$ on the SEE process, including a set of other relevant parameters: the magnetic field tilt with respect to surface normal, $\theta_B$, the electron reflection coefficient on the surface, $R$, the most probable speed of the secondary electrons, $v_S$, and the electric field in front of the surface, $E$. The secondary electrons have been emitted with a cosine angular distribution having a Maxwellian distribution in energy. Electrons transport in a low background pressure, on collisionless trajectories.

As a result of the numerical simulations, an analytical solution has been proposed for the effective SEE yield, $\gamma_{eff} = \gamma \frac{cos\theta_{BE}}{1-R(1-cos\theta_{BE})}$, where $\gamma$ is the SEE yield without magnetic field, $\theta_{BE} = \theta_B(1 - Acos\theta_B)$, and $A = \frac{2E}{Bv_S}$. The efficiency of the SEE process is defined as the ratio between $\gamma_{eff}$ and $\gamma$ and it may be severely reduced by the presence of a magnetic field. Very good agreement has been found between the MC simulations and the analytical formula.

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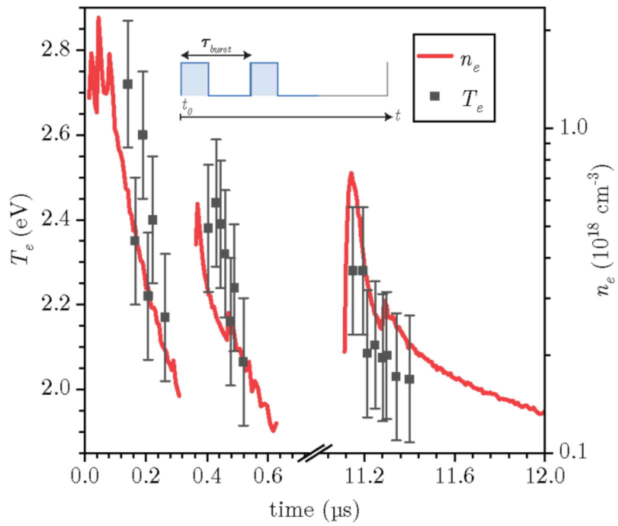
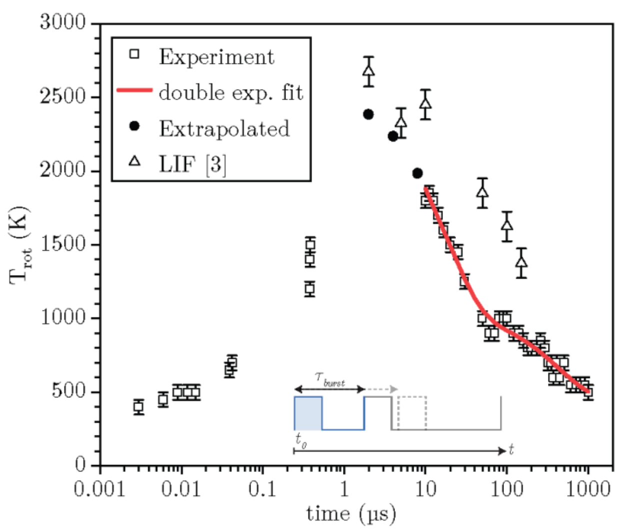
*Source:*
C. Costin, Scientific Reports **11**, 1874, 2021
https://doi.org/10.1038/s41598-021-81345-x

## Time-resolved Optical Emission Spectroscopy in $CO_2$ Nanosecond Pulsed Discharges




Electron density ($n_e$) and electron temperature ($T_e$) extracted from Stark broadening and $C^+/C^{++}$ line ratio respectively in a 2-pulse burst discharge in pure $CO_2$ feed gas.




Gas temperature evolution in the first pulse of a burst sequence and its decay, as measured from the $N_2$ SPS (0,0) band that is visible under electron impact. Varying the inter-pulse time ($\tau_{burst}$) allows probing of the temperature with a subsequent pulse. Results improve upon earlier work using LIF thermometry under the assumption of rotational relaxation.

Non-thermal discharges are promising to achieve plasma(-catalytic) conversion of $CO_2$ into value-added compounds. The non-equilibrium conditions unlock thermodynamically unfavorable reaction pathways. While commonly investigated in air-like mixtures, atmospheric pressure nanosecond repetitively pulsed (NRP) discharges are an attractive candidate for such research, showcasing high conversion rates and good conversion efficiencies, which are further improved operating in burst mode.

Previous work on NRP's in $CO_2$ did focus on conditions and conversion just after a pulse or burst sequence. This new manuscript details research using time-resolved optical emission spectroscopy that investigated conditions during the pulses of a burst itself, further developing an understanding of the evolution of NRP $CO_2$ discharges and the altered behavior due to the burst pattern.

The Stark broadening of an oxygen emission line allowed the electron density to be estimated, while the $N_2$ Second Positive System was used to determine the gas temperature. Emission from $C^+$ and $C^{++}$, due to electron impact, allowed us to estimate the electron temperature.

The overall picture from these observations is of a highly ionized spark discharge in quasi-local thermodynamic equilibrium instead of the thermal spark encountered in air-like mixtures. Based on time-resolved spectra, it appears that $CO_2$ dissociation and $O_2$ formation are both processes that occur over longer (>1 us) timescales and only occur after a delay, implying that other processes than electron impact play a role.

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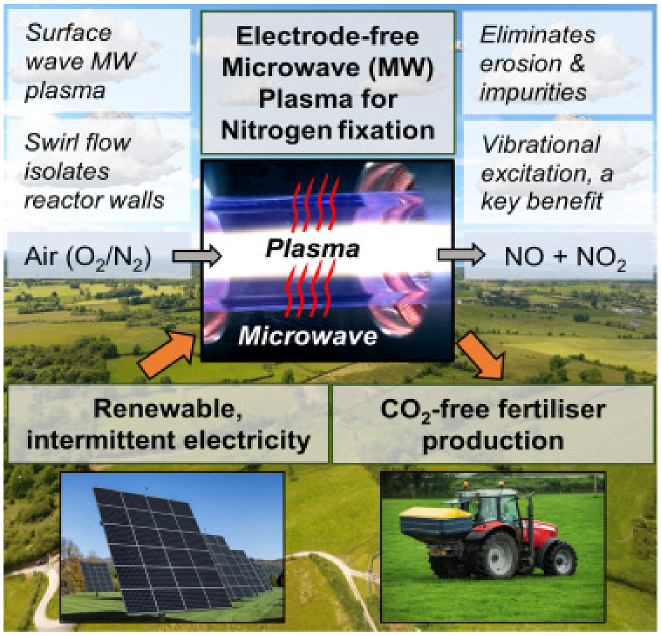
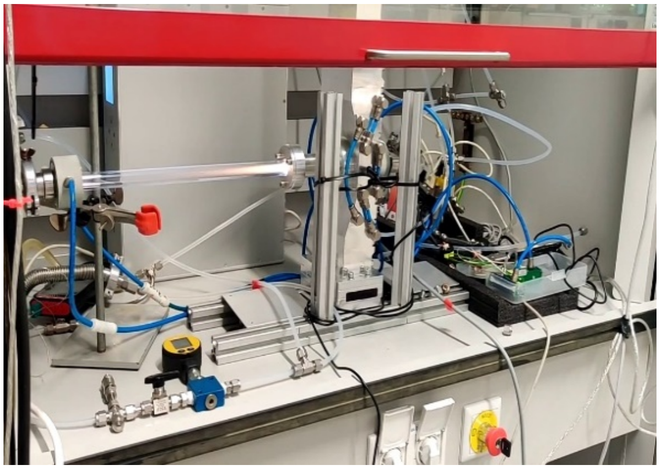
*Source:*

Plasma Sources Sci. Technol. (2021)
https://iopscience.iop.org/article/10.1088/1361-6595/ac2411

## Nitrogen Fixation in an Electrode-free Microwave Plasma



(**Top**) Graphical abstract and (**bottom**) image of reactor operating an atmospheric pressure air plasma.

In this work, we demonstrate energy-efficient $NO_x$ formation from air and $N_2/O_2$ mixtures, in a plasma filament isolated at the center of a quartz tube operating at atmospheric pressure, using a swirl gas flow. The electrode-free ignition provides a significant advantage, given the reduced energy losses to the walls, which limits damage, especially at higher powers, with the key benefits of a prolonged reactor lifetime and no metal contamination (which is potentially detrimental to soil and ecosystems in agriculture applications). $NO_x$ production, via an enhanced Zeldovich mechanism, is found to scale efficiently with gas flow rate and power. For relatively high flow rates (i.e., 20 L/min), increasing MW power (up to ~1 kW) leads to the highest $NO_x$ production (~3.8%), as well as minimum energy cost (~2 MJ/mol), giving the best cost-conversion metric for this work. This energy cost is the lowest reported up to now in literature for atmospheric pressure plasmas. The experiments are supported by chemical kinetics modeling, which reveals that the higher flow rate reduces the time available for the back reactions, explaining the better performance.

This study is published in: Joule **5**, 11 (2021).

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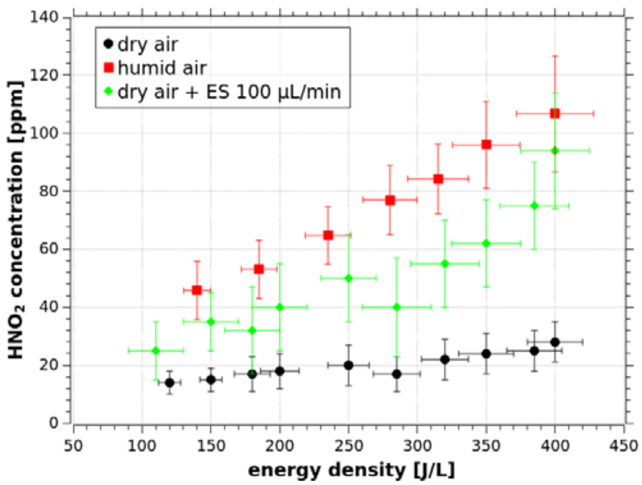
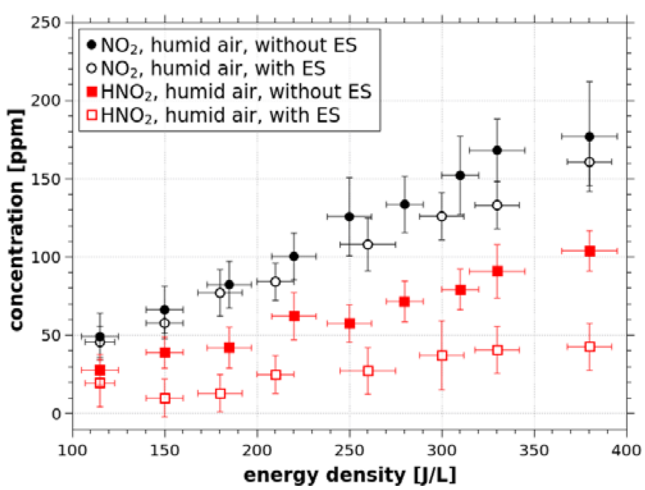
*Source:*
https://www.cell.com/joule/fulltext/S2542-4351(21)00437-2

# The Role of $HNO_2$ in the Generation of Plasma-Activated Water by Air Transient Spark Discharge




$HNO_2$ concentration as a function of the TS input energy density in dry/humid air and dry air with water electrospray, measured by UV-Vis absorption technique, 1-stage system (TS and ES generated together in one reactor).




Comparison of $NO_2$ and $HNO_2$ concentrations generated by TS with and without post discharge electrospray treatment, measured by UV-Vis absorption technique, 2-stage system (TS in the first reactor, followed by water ES in the second reactor).

Transient spark (TS), a DC-driven self-pulsing discharge generating highly reactive atmospheric pressure air plasma, was employed as a rich source of $NO_x$. In dry air, TS generates high concentrations of NO and $NO_2$, increasing approximately linearly with increasing input energy density ($E_d$), reaching 1200 and 180 ppm of NO and $NO_2$, at $E_d$ = 400 J/L, respectively. In humid air, the concentration of $NO_2$ decreased down to 120 ppm in favor of $HNO_2$ that reached approximately 100 ppm at $E_d$ = 400 J/L. The advantage of TS is its capability of simultaneous generation of the plasma and the formation of microdroplets by the electrospray (ES) of water directly inside the discharge zone. The TS discharge can thus efficiently generate plasma activated water (PAW) with high concentration of $H_2O_2$ $_{(aq)}$, $NO_2^-{}_{(aq)}$ and $NO_3^-{}_{(aq)}$, because water microdroplets significantly increase the plasma-liquid interaction interface. This enables a fast transfer of plasma generated nitrogen species such as NO, $NO_2$, and $HNO_2$ from the gas into water. In this study, we compare TS with water electrospray in a one stage system and TS operated in dry or humid air followed by water ES in a two-stage system. We show that **gaseous $HNO_2$, rather than NO or $NO_2$, plays a major role in the formation of $NO_2^-{}_{(aq)}$ in PAW** that reached the concentration up to 2.7 mM.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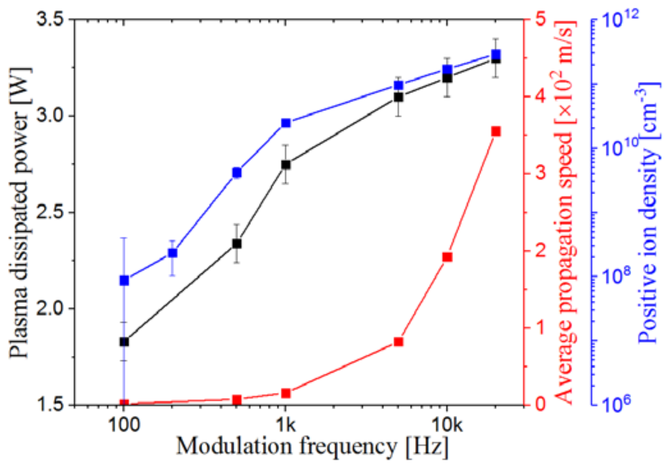
*Source:*
Appl. Sci. **11**, 7053 (2021).
https://doi.org/10.3390/app11157053

## Ion Dynamics and Pre-ionization Effects in an Ar-$O_2$ Modulated RF-driven Atmospheric Pressure Plasma Jet




Time-averaged plasma dissipated power, plasma plume propagation speed as obtained by ICCD imaging and the positive ion density at the end of the modulation cycle as a function of the RF modulation frequency for a plasma jet plume with a maximum length of 8 mm.

We reported (absolute) ion fluxes impinging on substrates as produced by a modulated RF-driven atmospheric pressure plasma jet operating in a homogenous gas environment (Ar+1% $O_2$) using molecular beam mass spectrometry (MBMS). The influence of the RF modulation frequency (100 Hz-20 kHz) upon the ion fluxes was investigated by time-resolved measurements, and lifetimes of the dominant ions, $O_2^+$, $NO^+$, $O^-$, $O_2^-$ and $O_3^-$, were found to be 28±2 µs, 117±8 µs, 7.3±0.4 µs, 17±1 µs, and 23±2 µs, respectively. The absolute ion densities in the near afterglow region were found to be on the order of $10^{11}$ $cm^{-3}$. Significant differences in the dynamics of the positive and negative ions were found and explained by large electron densities in the afterglow produced by electron detachment reactions from negative ions due to the large concentrations of atomic oxygen and singlet delta oxygen. Transitions in ion flux dynamics for different modulation frequencies and at the startup of the plasma were analyzed together with ICCD images recording the plasma propagation, to assess the dynamics of plasma plume propagation and how it is impacted by "memory effects" caused by the remaining volumetric charged species. The results highlight the tremendous impact of pre-ionization on plasma propagation and the range of densities required for these memory effects.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*Source:*
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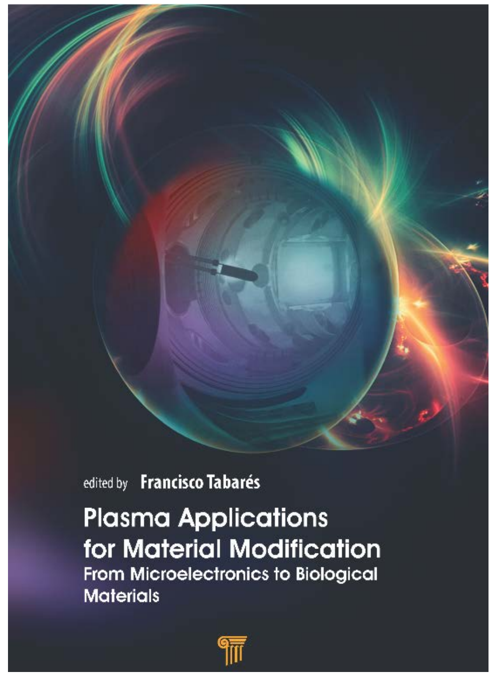
## New Resources

- **New Book - *Plasma Applications for Material Modification From Microelectronics to Biological Materials,* Francisco Tabarés (editor)**

The first time the word 'plasma' appeared in print in a scientific text related to the study of electrical discharges in gases was 1928, when Irving Langmuir published his article 'Oscillations in Ionized Gases'. This new book, *Plasma Applications for Material Modification From Microelectronics to Biological Materials*, is an up-to-date review of the most important plasma-based techniques for material modification, from microelectronics to biological materials and from fusion plasmas to atmospheric ones. Each of its technical chapters is written by a long-experienced, internationally recognized researcher. The book provides a deep and comprehensive insight into plasma technology and its associated elemental processes and is illustrated throughout with excellent figures and references to complement each section. Although some of the topics covered can be traced back several decades, care has been taken to emphasize the most recent findings and expected evolution.




- Covers current research on an outstanding, unique broad field of the uses of plasma technology for surface modification and provides a deep and comprehensive insight into the associated elemental processes
- Includes contributions from researchers who have more than 30 years of experience in laboratory work and teaching on specific topics and who are authors of previous books on their respective specialties
- Is illustrated throughout with excellent figures and references to accompany each section

More information at:

https://www.jennystanford.com/9789814877350/plasma-applications-for-material-modification/

*Contact:*
**Dr. Francisco Tabares Vazquez**
Centro Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain
paco.tabares@ciemat.es

## Career Opportunities

- **Assistant Professor, Aerosol Science and Engineering, Washington University St. Louis, USA**

  The McKelvey School of Engineering at Washington University in St. Louis, USA invites applications and nominations for tenure-track faculty position(s) in the Department of Energy, Environmental & Chemical Engineering (https://eece.wustl.edu/index.html). Joint appointments with other departments (e.g. Earth and Planetary Sciences) may be possible for suitably qualified candidates.

  The faculty search is open to all areas of aerosol science and engineering, with a preferred emphasis on identifying individuals with expertise in two distinct areas: atmospheric aerosol processes. Special consideration will be given to research involving a transdisciplinary approach e.g. in studies of atmosphere-biosphere interactions; and gas-phase synthesis of functional materials, including plasma methods, and/or characterization for application e.g. in chemical catalysis or photonics and optoelectronics. Special consideration will be given to research involving metastable phases including application-oriented characterization. More information and application directions: https://apply.interfolio.com/96041.

  *Contact:*
  **Prof. Elijah Thimsen**
  Washington University in Saint Louis, USA
  elijah.thimsen@seas.wustl.edu

- **Faculty Position, Experimental Plasma Physics, University of California at Los Angeles, USA**

  The Department of Physics and Astronomy at the University of California, Los Angeles (UCLA) invites applications for a full time faculty position at the assistant professor level in the area of experimental plasma physics. The Department is seeking outstanding candidates with the potential for exceptional research, the capacity for excellence in teaching, and a clear commitment to enhancing the diversity of the ment. Individuals with a history of and commitment to mentoring students from underrepresented minorities are encouraged to apply. The successful candidate is expected to contribute to the teaching mission of the department at both the undergraduate and graduate levels and to establish a vigorous, externally funded research program. Applicants must have a Ph.D. or equivalent degree prior to the anticipated start date, which is July 1, 2022. Salary will be commensurate with education and experience.

  The UCLA Department of Physics and Astronomy has active research programs in theoretical, computational, and experimental plasma physics which include particle-in-cell simulation, turbulence and transport in magnetized plasmas, the nonlinear optics of plasmas, intense laser and beam plasma interactions, plasma-based acceleration, magnetic reconnection, inertial and magnetic confinement fusion energy, high-energy density plasmas, and space plasmas. Outstanding candidates are sought with expertise in plasma experiment and research interests in frontier areas of plasma physics.

  Initial review will start on November 29, 2021 and for full consideration, applications should be received by **January 3, 2022**, however applications will be accepted after that date and until the search is closed.

  Apply online via the UCLA Academic Recruit website: https://recruit.apo.ucla.edu/apply/JPF06939. Candidates should please submit: a cover letter; a curriculum vita; a statement of research accomplishments, interests and plans; a list of publications; a statement of teaching experience or interest; and a statement on the candidate's past, present, or planned contribution to equity, diversity and inclusion. Please arrange through this website to have 3-5 letters of recommendation submitted as well.

  *Contact:*
  **Prof. Troy Carter**
  University of California at Los Angeles, USA
  tcarter@physics.ucla.edu

- **PhD/Postdoc Position, Numerical Modeling of Plasmas for Methane Conversion, Maastricht University, The Netherlands**

  We are part of the newly created Department of Circular Chemical Engineering in the Faculty of Science and Engineering at Maastricht University. Our research group is uniquely situated in the heart of the Dutch chemical industry at the Brightlands Chemelot campus, 20 km north of Maastricht. We seek a PhD student/postdoc to work on methane conversion using plasma. The research will be primarily based on numerical modeling and simulation - the candidate will perform analysis of chemical reaction pathways and transport in synergy with state-of-the art laser diagnostics at Maastricht University to develop a comprehensive understanding of the underlying physical and chemical processes occurring in the plasma.

  You will join a small team working on experiments and numerical models. We expect that you will regularly discuss, share, and present your work with fellow team members, colleagues, and wider audiences at international conferences. We expect you will write a number of high-quality scientific articles. For the PhD position, such articles shall ultimately culminate in your PhD thesis.

  ***For the PhD position:*** We seek motivated and highly talented candidates with a Master degree (or an equivalent diploma giving access to doctoral studies) in Physics or Chemistry. We offer a full-time employment contract as a PhD candidate. The employment contract will be for a period of 1 year and will be extended for another 3 years after positive evaluation. The applicant should have, general knowledge of low temperature plasmas, knowledge of computational modelling, good programming skills (e.g., Fortran, C, C++) are essential and good communication skills in English (both written and spoken).

  ***For the postdoc position:*** The applicant should have a PhD in physics or chemistry or computational science and experience in low temperature plasma modeling preferably with a focus on plasma chemistry. Preference will be given to candidates with demonstrated experience in the development and use of computer simulation codes and who have qualifying experience in a scientific research institute. Very good programming skills (e.g. Fortran, C, C++) are essential as well as good verbal and written communication skills in English are mandatory. We offer a 3 year *full-time* fixed-term employment contract as postdoc. Intended start date is **as soon as possible.**

  *More information on this vacancy can be obtained from:*
  **Dr. Paola Diomede**
  Maastricht University, The Netherlands
  p.diomede@maastrichtuniversity.nl

- **Tenure Track Faculty Position (Assistant or Associate Professor), Nonequilibrium Thermodynamics Laboratory, Department of Mechanical and Aerospace Engineering, Ohio State University, USA**

  The Department of Mechanical and Aerospace Engineering is one of the largest departments in the College of Engineering at The Ohio State University (USA). We are the home to nearly 80 faculty and over 35 dedicated staff members. Approximately 1900 undergraduates are pursuing a degree in either Mechanical or Aerospace Engineering through rigorous programs that feature hands-on, project-based learning. Nearly 300 graduate students are seeking a degree in either Mechanical, Aerospace, or Nuclear Engineering.

  The Department of Mechanical and Aerospace Engineering invites applications for a tenure-track faculty position in the interdisciplinary fields of nonequilibrium hypersonic flows, high-enthalpy reacting flows, low-temperature plasmas, and advanced laser diagnostics. The successful candidate is expected to augment the experimental capabilities of the Nonequilibrium Thermodynamics Laboratories, develop a highly visible research program, and expand the collaboration with the Aerospace Research Center, Turbulence and Combustion Research Laboratory, and High-Fidelity Computational Multi-Physics

Laboratory. Forging collaboration with the research groups in the fields of Physical Chemistry (Department of Chemistry and Biochemistry) and Atomic, Molecular, and Optical Physics (Department of Physics) is of particular importance. The successful candidate will teach a range of undergraduate and graduate courses in the areas of thermofluids and optical diagnostics, and mentor students in Mechanical & Aerospace Engineering and potentially other graduate programs.

Applicants are required to hold a doctoral degree in aerospace or mechanical engineering, or in a closely related field, or have equivalent experience.

Interested applicants should submit an application in Academic Jobs Online: https://academicjobsonline.org/ajo/jobs/19735.

*Contact:*
**Prof. Igor Adamovich**
Ohio State University, USA
adamovich.1@osu.edu

- **Postdoc Position, Plasma Decomposition of $CO_2$, IPFN, IST, University of Lisbon, Portugal**

Applications are invited for a Postdoctoral Research position within the N-Prime group (http://nprime.tecnico.ulisboa.pt/) of IPFN (https://www.ipfn.tecnico.ulisboa.pt/), Instituto Superior Técnico, Universidade de Lisboa, Portugal, in the framework of project PARADiSE (https://www.ipfn.tecnico.ulisboa.pt/paradise/).

PARADiSE consists of a thorough theoretical, modelling and experimental investigation of plasma decomposition of $CO_2$. It builds on the results of the previous project PREMiERE (https://nukutawhiti.wixsite.com/premiere) and explores three research lines: extension of the prior results to plasma sources widely used for technological applications; fundamental studies on the influence of impurities and industrial gases; and study of plasma-surface interactions and product separation. The work will be done in close collaboration with several foreign laboratories that will conduct a series of measurement campaigns tailored to the needs of the project. By its end the investigation will unveil the mechanisms underlying plasma $CO_2$ dissociation, identify the optimal conditions for a plasma reactor to operate and produce a proof-of-concept prototype, paving the PlasmA RoAD to Solar fuEls (PARADiSE).

The post is offered on a full-time basis, for 1 year, with a possibility for extension up to 3 years. The start of the position is January/February 2022, but can be flexible up to April 2022. There will be excellent flexibility within the post to investigate various aspects of $CO_2$ plasma conversion.

The person should have a PhD in plasma physics, engineering physics, materials engineering, or similar fields. It is desirable that the person has experience in plasma modelling, or a demonstrated aptitude for learning new fields of research. Additionally, a strong track record of high-quality journal publications is an advantage. Expression of interest to be sent by the **end of November 2021**.

*Contact:*
**Prof. Vasco Guerra**
Instituto de Plasmas e Fusão Nuclear, Portugal
vguerra@tecnico.ulisboa.pt

- **Postdoc and Graduate Student Research Opportunities, Experimental Low-temperature Plasma Science, University of Texas at Austin, USA**

  The Underwood Group in the Department of Aerospace Engineering and Engineering Mechanics University of Texas at Austin (USA) invites applications for postdoctoral research fellows or students who wish to pursue a Ph.D. Our group is just beginning funded projects (from AFOSR and DOE) spanning experimental low-temperature plasma science including: (1) interfacial catalysis, (2) surface science, (3) plasma photonics, and (4) air-breathing space propulsion. Our group prides itself on being multi-disciplinary and enabling students to pursue research at the interface of plasma physics, fluid mechanics, optics, and chemistry. We are, for example, presently interested in developing novel optical diagnostics to probe chemical interfaces and new propulsion shames to harvest and capture air as a propellant source.

  Technical responsibilities will be to oversee project advancement in the laboratory, the training of graduate students, and the publishing of manuscripts. A strong background in analytical chemistry, optical diagnostics, or plasma physics is preferred, although not essential. It is expected for postdoctoral candidates to have an expertise in one of these areas and to develop expertise in the others during their stay. Finally, it is expected candidates will travel to and participate in conferences to highlight their research progress.

  Review of applications will begin immediately, and the positions will remain open until filled **with immediate availability**. Interested candidates should send a curriculum vitae, two letters of recommendation, and a brief statement of research interests to **Professor Thomas Underwood** (thomas.underwood@utexas.edu).

  *Contact:*
  **Prof. Thomas Underwood**
  University of Texas at Austin, USA
  thomas.underwood@utexas.edu

- **Faculty Positions, School of Aeronautics and Astronautics, Purdue University, USA**

  The School of Aeronautics and Astronautics at Purdue University, Indiana, USA invites applications for multiple tenured/tenure track positions at all ranks, seeking to attract exceptional candidates with interests and expertise in spacecraft engineering. The following areas are of particular interest: spacecraft instrumentation and communication - including data and information systems, in-space propulsion - including nuclear propulsion, spacecraft attitude control, on-orbit servicing & rendezvous, and spacecraft systems design & integration.

  The School of Aeronautics and Astronautics at Purdue University is consistently recognized as an international leader in the quality of its educational programs, along with the innovation and depth of its graduate research program and its technology and workforce impact on the aerospace industry. With nearly 1,050 undergraduate students, 600 graduate students, and 41 faculty members, the School is among the top six programs in the US. Additional information is available at https://engineering.purdue.edu/AAE. Applications must be submitted electronically via this site:
  https://career8.successfactors.com/sfcareer/jobreqcareer?jobId=15929&company=purdueuniv.

  For information/questions regarding applications contact the Office of Academic Affairs, College of Engineering, at coeacademicaffairs@purdue.edu. Review of applications will begin on October 1, 2021 and will continue until the position is filled. A background check is required for employment in this position.

  *Contact:*
  **Prof. Alexey Shashurin**
  Purdue University, USA
  ashashur@purdue.edu

- **Postdoc Position, Plasma Physics, West Virginia University, USA**


The plasma physics group headed by **Professor Earl Scime** (escime@wvu.edu) at West Virginia University, USA, invites applications for a Postdoctoral Research Associate position as part of the Center for KINETIC Plasma Physics (https://kineticplasma.wvu.edu/). The primary responsibilities of the position involve the performance of experiments focused on magnetic reconnection, magnetized sheaths, and thermal anisotropy driven instabilities in the PHAse Space MApping (PHASMA) facility. A PhD in physics or other relevant field and a strong experimental background and/or experience with low temperature plasma sources, plasma diagnostics, vacuum systems, and spectroscopy are required. The salary and benefits are competitive and the successful applicant will have opportunities to develop new research ideas, participate in proposal development, lead collaborations with other research groups, and mentor graduate and undergraduate students. Morgantown is regularly listed among the top ten small cities on the east coast of the USA and is located approximately 70 miles south of Pittsburgh, PA and 200 miles east of Washington, DC. The university has an enrollment of 25,000 students and the Department of Physics and Astronomy has strong research programs in plasma physics, condensed matter physics, physics education research, and astronomy. For a complete job description and to apply for this position (a CV, cover letter, and three letters of reference are required), please visit https://careers.wvu.edu/career-opportunities and click on the “View Open WVURC Positions” link to find Position #18037.

*Contact:*
**Prof. Earl Scime**
West Virginia University
escime@wvu.edu

- **Postdoc Position, Phased-Array Antenna Development, University of Wisconsin, USA**

At the University of Wisconsin (Madison, WI, USA), we are currently looking to fill a post-doctoral researcher position in the area of applied electromagnetics with emphasis on phased-array antenna design and development. ***The desired technical qualifications include:***

1. Ph.D. in Electrical Engineering or related field, with emphasis on Applied Electromagnetics, Microwaves, or related fields.
2. Experience with the design, fabrication, and characterization of antennas, microwave circuits, or enough background to quickly climb the learning curve.
3. Familiarity with modeling, simulation, fabrication, and measurement of antennas or microwave structures and circuits.

Candidates should have the ability to work independently and work well both individually and as part of a larger team. While all candidates will be considered for this position, candidates who are already in the United States and have the appropriate authorization to work (U.S. citizens, permanent residents, or foreign nationals who can legally work in the U.S.) are highly encouraged to apply. Interested applicants should send their latest CV with the names and contact information of at least three references to either **Professor Nader Behdad** (behdad@wisc.edu) or **Professor John Booske** (jhbooske@wisc.edu) via email.

*Contact:*
**Prof. John Booske**
University of Wisconsin, USA
jhbooske@wisc.edu

- **Computational Scientist, Plasma-Surface Interaction and Plasma Physics, Applied Materials Inc., Santa Clara, CA, USA**

  Applied Materials is the world leader in materials engineering solutions used to produce virtually every new chip and advanced display in the world. Our expertise in modifying materials at the atomic scale and on an industrial scale is a key enabler behind the advances in most electronics technologies. We have an opportunity for a computational plasma physicist or chemist to help design the next generation of plasma processing equipment. This position requires in-depth knowledge and experience in computational physics or chemistry, computational plasma physics, computational surface science, or related areas. Additional knowledge of plasma materials processing and the semiconductor industry is valuable but not essential.

  ***Key responsibilities include:***

  - Develop and test mechanisms for plasma interaction with surfaces and implement in feature scale etch and deposition models.
  - Perform plasma physics and/or plasma chemistry modeling of plasma processing systems to provide a better understanding of plasma behavior during concept & feasibility, design, and development of plasma processing systems.
  - Perform feature scale and molecular dynamics modeling of plasma etch and deposition processes for emerging applications.
  - Develop, modify, and test internal plasma, feature scale, and related codes as needed.
  - Perform engineering analysis. Recommend design modifications to improve plasma and process behavior to address technical/business needs.
  - Apply internal and/or external codes to address plasma and plasma–surface interaction problems.
  - Work in a team environment. Present modeling results to the product development teams.
  - Provide technical expertise in plasma physics and plasma chemistry to management.

  ***Education and experience:***

  Masters or PhD with 0 – 3 years of relevant experience. Position suitable for new PhDs or postdocs.

  *Contact:*
  **Dr. Shahid Rauf**
  Applied Materials Inc., USA
  shahid_rauf@amat.com

- **PhD Position, Plasma-fluid Mechanics, Leibniz Institute for Plasma Science and Technology (INP) Greifswald, Germany**

We seek candidates for a PhD position in plasma-fluid mechanics in the research group plasma source concepts at the Leibniz Institute for Plasma Science and Technology (INP) Greifswald, Germany. To advance towards a deeper understanding of the complex interaction between cold atmospheric plasma discharges (e.g. for medical application) and the surrounding fluid(s) as well as potential medical flows in general, the INP is going to build up a new gas flow test-rig. Initially, an older setup has to be modified into a versatile, stand-alone test setup for complex flow regimes. Primary focus of the test-rig are optical measurement techniques (such as 2D-2C PIV and spectroscopy). However, more common measurement techniques (pressure, volume flow, temperature) are going to be implemented as well. With an integral approach in mind, additional CFD simulations will go in parallel to the experiment. Using proven in-house plasma sources, the test rig is iteratively adapted to answer first questions regarding plasma-jet / fluid interaction. We offer a project position in Karlsburg near Greifswald, starting on 1st January 2022 for 3 years (26,67 h/week).

***Key responsibilities include:***

- You design and built a gas flow test facility with integrated control-loops and adaptable interfaces for multiple experiments.
- You do CFD simulations for the test facility and evaluate them with experimental data.
- You use your setup to take the first step into a deeper understanding of plasma discharge / fluid interaction using proven in-house plasma sources.
- You get familiar with top-notch measurement techniques, such as PIV, Fast-framing, robotics and control.
- You interact with an interdisciplinary team from physicists to medical staff.
- You present your results at scientific conferences and publish in peer reviewed journals.

***Your profile:***

- Very good university-level qualification (Master of Science degree) in mechanical engineering or comparable subject areas.
- Experienced with computational tools such as CAD, CFD.
- Experienced with CAM manufacturing tools (milling machine, lathe) and rapid prototyping.
- Advanced programming skills in Python for data processing.
- Fluent English, advanced German.

Please apply with the common documents (cover letter, CV, references) giving the keyword "0441 PhD Position Plasma-Fluid Mechanics"- preferably via our online application form (https://www.inp-greifswald.de/en/career/ ) - until **end of November 2021**.

*Contact:*
**Dr.-Ing. Philipp Mattern**
Post Doc Plasma Source Concepts, INP, Germany
philipp.mattern@inp-greifswald.de

## Collaborative Opportunities

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

***Disclaimer***

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