International Low Temperature Plasma Community

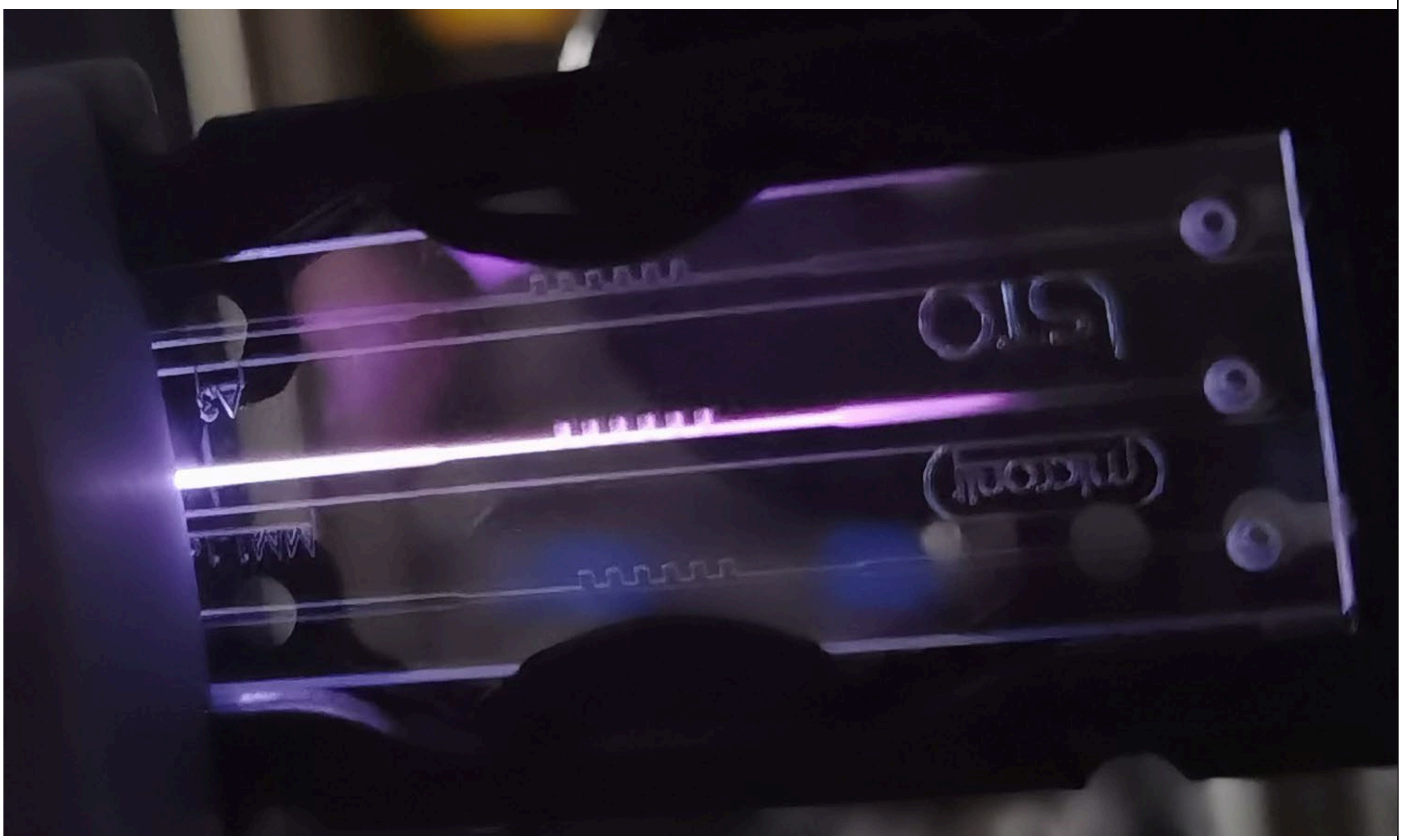
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 27

9 November 2022

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.



Helium plasma jet in a micro-channel: A plasma jet works in noble gas such as helium and is able to generate a plasma that propagates away from the electrode confinement into the ambient air or into a microchannel as shown in this picture. Plasma has the ability to modify the wettability of the channel wall. In geosciences, micro-channels are used to mimic the porous structure of aquifers, soils, or reservoir rocks. The ability of plasma to control the wettability of the channel walls is used to make it similar to natural porous media. Such a device contributes to understanding the complex phenomena of CO_2 sequestration in-geological reservoirs.
Viktor Gredicak (viktor.gredicak@cnrs-orleans.fr), **Dr. Sophie Roman** (sophie.roman@univ-orleans.fr), **Dr. Arnaud Stolz** (arnaud.stolz@univ-orleans.fr) and **Dr. Claire Douat** (claire.douat@univ-orleans.fr), Université d'Orléans.

Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **December 16, 2022.** 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 The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related.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.

The Role of Computations in Atomic and Molecular Collision Physics

"Charged-particle collisions with atoms, ions, molecules, and surfaces are critically important to the understanding and the modeling of laboratory plasmas, astrophysical processes, lasers, and planetary atmospheres." Statements like this can be found in many papers, grant proposals, and conference talks. If you are a producer of such data, you will also frequently be approached by data users and asked to provide the numbers you have already and likely be given a list of many more that would be highly desirable.

In light of the increased sophistication of current plasma models, especially those of interest for the international low-temperature plasma community (ILPTC), it is no longer sufficient to determine a few angle-integrated quantities, e.g., the low-energy elastic or momentum transfer cross section, directly via transmission through scattering cells or indirectly via swarm experiments. Instead, excitation and ionization cross sections, not just from the ground state but also from excited states (especially metastables) are required. Furthermore, some of these input cross sections are wanted angle-resolved to obtain the maximum information from the plasma model.

While the need for the many data seems to be accepted universally, it is not so clear how to fulfill that need. Experiments remain important to provide benchmarks for testing theory, provided they can be performed with sufficient accuracy. The latter requirement is by no means trivial, especially if absolute numbers are to be extracted from crossed-beam setups, where normalization can be a serious challenge. Furthermore, funding for such experiments has decreased substantially over the past 20-30 years, with many laboratories being retired together with the person(s) who built them. While guessing the needed numbers still remains a last resort, performing calculations has become increasingly important for data production. For some targets, like atomic hydrogen, helium, other light quasi-one- and quasi-two electron targets, and even molecules like H_2, theory and the associated computer programs (often run on supercomputers) have made enormous progress over the past decades – to the extent that for H and He calculated datasets are not only more comprehensive than what is available experimentally but, at least by some, are also regarded to be more reliable and overall consistent.

However, the situation is by no means clear for more complex systems, such as open-shell targets near the center and the bottom of the periodic system, heavy atoms and ions, and certainly most molecules. These systems present major challenges to an accurate computational treatment, and hence exciting scientific progress is still to be expected. Also, photo-driven processes, such as ionization by continuous or ultrashort intense pulsed radiation over a wide wavelength range by synchrotrons, high-harmonic sources, and free-electron lasers involve scattering of the ejected electron from the residual ion. Hence, in order to go beyond relatively simple and thus often severely limited single-active-electron approximations, expertise in the treatment of electron collisions remains in high demand. Positron and heavy-particle collisions are very important as well, for both fundamental studies (often involving rearrangement collisions) and their increasing importance for medical applications, particularly imaging as well as cancer diagnosis and treatment.

The ILTPC and other modelling communities, as well as industry, should go beyond expressing their gratitude to the data producers, but also help getting the message across to those who can provide monetary funds as well as computational facilities. One cannot just hope that all the data needed will be produced somehow and provided voluntarily. Instead, systematic funding of data production needs to be assured. Those who want the numbers will likely have to pay for them, just as they do for other services. As long as the funding is there, the field will continue to blossom.

Prof. Klaus Bartschat
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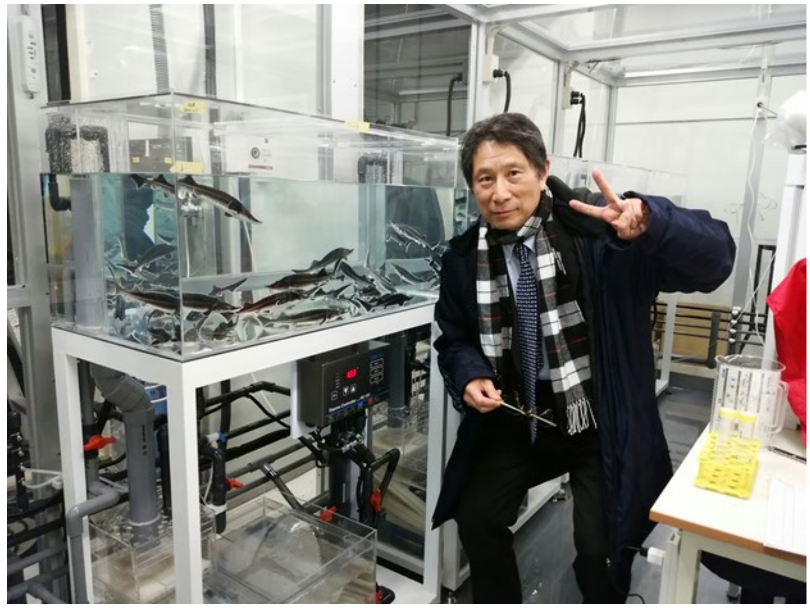
Professor Masaru Hori: An Inspiration Across Many Fields



Professor Masaru Hori is a fantastic professor with excellent creativity who keeps coming up with new ideas like a fountain. He has an extraordinary ability to foresee the future as a leading researcher of the LTP community in many fields. He has focused on physico-chemical measurements of reactive species in processing plasmas with newly developed instruments, enabling comprehensive understanding of LTP reactions in gaseous, aqueous, and solid phases. He has aimed to develop each application field based on the perspective of radical reactions. His achievements include the development of autonomously controlled equipment for plasma processing technology and being a leader in the establishment of plasma medical science. His approach to research is always very serious and rigorous. Research meetings held in his group take up an entire day, and discussions with colleagues at the meetings often heat up. And yet, he is usually very friendly and values friendships with his colleagues and students. After the meeting, he frequently had a dinner together with colleagues after the discussions before the pandemic. This friendship makes him an attractive professor. If you get stuck and have problems in your research, we encourage you to discuss your research with Prof. Hori, and we are sure he will have a positive influence on you.

Prof. Hori has authored more than 650 journal articles, 1,843 papers/presentations in international conferences (351 invited talks including 69 of plenary and keynote lectures), presentations in domestic conferences (1,307 including 285 invited talks), 31 books, 216 Patents Granted, 369 Patent Applications, 63 Doctoral Degrees as a principal professor and 26 awards in his lifetime achievements. He served as chair of the organizing committee and achieved great success in the joint conference of the 7th International Conference on Reactive Plasmas (ICRP) and the 63rd Gaseous Electronic Conference in Paris in 2010. Very recently, he received the Reactive Plasma Award, in October 2022.

For over 30 years, he has been an outstanding scientist who devoted himself wholeheartedly to the establishment of plasma process science. In 1992, he proposed carbon film as an etching mask, discovered the high plasma durability of the carbon masks, and demonstrated for the first time that carbon masks can be applied to plasma etching of various materials. In today's semiconductor industry, this carbon mask technology has become essential. He demonstrated the autonomously controlled plasma equipment based on a feed-back system of plasma diagnostics data, named "Radical Controlled Plasma Processing" technology, and invented a compact device to measure the vacuum ultraviolet absorptions of atomic species (H, O, N, C, F, etc.) in reactive plasmas. In 2004, he and Prof. Hiramatsu discovered growth of Carbon Nanowalls (vertically standing nanographene) on a substrate without any catalysts and has developed their many applications (28 patents granted). In 2008, he extended his research in atmospheric pressure plasma and developed a source that generates high density electrons of the order of 10^{16} cm^{-3}. In 2010, he discovered a selective killing effect of ovarian cancer cells against normal cells when a cell culture medium was irradiated by the developed source. From this discovery, he found out an essential part of the killing effect, that is, plasma irradiation of the media, and established a concept of Plasma Activated Medium (PAM). Thereafter, cell culture media were replaced by intravenous drip and his research moved to the Plasma Activated Lactate (PAL). Even now, biochemical and biological mechanisms are still being studied in vitro and in vivo to realize plasma cancer therapy. He received the Plasma Medicine Award in 2018 and edited the book, Plasma Medical Science (2018). His strong and sincere attitude towards the establishment of plasma process science, including semiconductor devices, material processes, and plasma-bio research, and highly original researches continues unabated.

Prof. Kenji Ishikawa, Nagoya University, Japan, ishikawa@plasma.engg.nagoya-u.ac.jp
Prof. Keigo Takeda, Meijo University, Japan, ktakeda@meijo-u.ac.jp
Prof. Masafumi Ito, Meijo University, Japan, ito@meijo-u.ac.jp

General Interest Announcements

- **Princeton Collaborative Low Temperature Plasma Research Facility (PCRF) and Sandia Plasma Research Facility (PRF): Call for Collaborative User Proposals**

The Princeton Collaborative Low Temperature Plasma Research Facility and the Sandia Plasma Research Facility (PRF) have opened their fourth round of solicitations for collaborative research proposals from the scientific community. The schedule for this year's call is:

Call for proposals opens: Now open!
Call for proposals closes: **December 16, 2022**
External Review: ~1 month
Notification of Principal Investigators: February 3, 2023

You can learn more about both collaborative low temperature plasma facilities at their websites:

PCRF: https://pcrf.princeton.edu/
PRF: https://www.sandia.gov/prf/

Questions can also be sent directly to the facility directors, listed below.

Contacts:
Dr. Yevgeny Raitses (PCRF), Princeton Plasma Physics Laboratory, USA, yraitses@pppl.gov
Dr. Shane Sickafoose (Sandia PRF), Sandia National Laboratory, USA, smsicka@sandia.gov

- **EPS Plasma Physics Innovation Prize 2023**

The EPS Plasma Physics Innovation Prize was established in 2008 by the EPS Plasma Physics Division to acknowledge and promote the many benefits to society that derive from plasma physics research, such as applications in medicine, waste management, material processing or any other areas of societal, industrial or technological applications. The prize is awarded for scientific achievements in plasma science which have opened breakthroughs in the field of applications. Joint awards can be granted to groups of up to 3 researchers. The closing date for receipt of nominations is **February 15, 2023**.

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

Please contact Prof. Thomas Mussenbrock for the nomination form.

Contact:
Prof. Thomas Mussenbrock
Ruhr University Bochum, Germany
thomas.mussenbrock@rub.de

Meetings and Online Seminars

- **The Online Low-Temperature Plasma (OLTP) Seminar Series**

  We have scheduled the OLTP seminars until December 13, 2022. For more information on the program, including links to past seminars, please refer to 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 from anywhere in the world.

  As the end of 2022 approaches, our term as co-chairs of the 2022 OLTP seminar series comes to an end. The 2023 OLTP seminar series will continue under new chairs to provide the international community with regular opportunities to hear from leading researchers in the field. We are happy to announce that the 2023 OLTP co-chairs will be **Dr. Mikhail Shneider** (Princeton University, shneyder@princeton.edu) and **Prof. Dr. Vasco Guerra** (University of Lisboa, vguerra@tecnico.ulisboa.pt). Together with the OLTP Seminar Committee Members they will be responsible for the 2023 seminar program.

  We would like to thank all the speakers of OLTP seminars and OLTP committee members who helped us set up the program of seminars in 2022. In particular, we would like to thank outgoing members Peter Bruggeman, Sander Bekeschus and Katharina Stapelmann for their commitment to the OLTP committee these last years. For 2023, three new members will join the OLTP committee: Deborah O'Connell, Vasco Guerra and Mikhail Shneider. Finally, we would also like to thank all the attendees of the OLTP seminars in 2022 for their interest in the seminars.

  Dr. Anne Bourdon, Laboratory for Plasma Physics Paris, France, anne.bourdon@lpp.polytechnique.fr
  Dr. Igor Kaganovich, Princeton Plasma Physics Laboratory, USA, ikaganov@pppl.gov
  2022 OLTP Co-Chairs

- **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

  Since the beginning of 2022, six tutorial/review seminars have been jointly organized by the Online Low-Temperature Plasma (OLTP) Seminar Series and the GEC-IOPS. The next jointly organized seminar will be:

  - **Prof. Eray Aydil**, December 13 (10:00 am US-EDT): "The Role of Plasmas in the Electrification and Decarbonization of Chemical Manufacturing"

  Dr. Kallol Bera, IOPS Chair
  Applied Materials
  kallol_bera@amat.com

- **XXXV International Conference on Phenomena in Ionized Gases, Egmond aan Zee, The Netherlands**

We cordially invite you to the XXXV International Conference on Phenomena in Ionized Gases, on 9-14 July 2023, fully in person, on the coast of The Netherlands.

General invited lectures will be given by:

- Annemie Bogaerts, Universiteit Antwerpen, Belgium
- Pascal Chabert, Ecole Polytechnique, Palaiseau, France
- Kenji Ishikawa, Nagoya University, Japan
- Achim von Keudell, Ruhr-Universität Bochum, Germany
- Zdenko Machala, Comenius University in Bratislava, Slovakia
- and the winner of the von Engel and Franklin Prize (not yet known)

Furthermore, the conference will feature topical lectures and oral contributions that will be selected from the submitted abstracts. 4 poster sessions will take place in the early afternoons.

The conference will be located at Hotel Zuiderduin (https://www.zuiderduin.nl/en/) in Egmond aan Zee (https://egmond.nl). Egmond is a former fishermen's village and nowadays a place for beach holidays. Rooms in the conference hotel are available for attractive prices, if booked in time. Air or train travel to the venue would approach Amsterdam airport or Amsterdam station. From there it is about an hour to Egmond by public transport.

Please check the webpage (https://www.icpig2023.com/) for the international scientific committee and the local organizing committee. The second announcement with conference fees and deadlines will be mailed in early January and updated on the webpage.

Contacts:
Prof. Masaharu Shiratani, Chair of the International Scientific Committee
Profs. Ute Ebert and Sander Nijdam, Chair and Co-chair of the Local Organizing Committee
ebert@cwi.nl, s.nijdam@tue.nl, siratani@ed.kyushu-u.ac.jp

- **IWPCT 2023 (International Workshop on Plasma for Cancer Treatment), March 13-15, 2023, Raleigh, North Carolina, USA**

It is our pleasure to host the 8th International Workshop on Plasma for Cancer Treatment (IWPCT 2023) at North Carolina State University in Raleigh on March 13-15, 2023. Originally planned for March 2020, we hope to be able to have a meaningful in-person conference in 2023. Researchers from around the world will attend to discuss their latest developments on plasma for cancer treatment.

The topics of the workshop are as following:

- Plasma sources and plasma equipment used for cancer treatment
- Plasma-cancer interactions: experiments, modeling and simulation
- Destruction of cancer cells by plasmas
- Mechanisms of plasma selectivity towards cancer cells
- Plasma-liquid interaction / plasma chemistry in biological liquids / plasma activated media for cancer applications
- Animal and clinical studies of cancer treatment by plasmas

The call for abstracts is open: www.iwpct2020.org
Abstract deadline: **December 16, 2022**.

Contact:
Prof. Katharina Stapelmann, Conference Chair
North Carolina State University, Raleigh, North Carolina, USA
kstapel@ncsu.edu

- **Plasma Electrochemistry and Catalysis 2 at the Electrochemistry Society Meeting, May 27-June 2, 2023, Boston, USA**

The Electrochemistry Society (ECS) will hold its Annual Meeting in Boston, Massachusetts, USA on May 27-June 2, 2023. The arranged session *D01 - Plasma Electrochemistry and Catalysis 2* invites papers dealing with various aspects of plasma chemistry, plasma-solid and plasma-electrolyte interface dynamics and applications in CO_2 reduction, methane reforming, ammonia formation, and other chemical processing applications. Papers dealing with fundamental concepts-involved plasma chemistry and plasma electrochemistry, atmospheric plasma discharges, scale-up studies and their use in nanomaterials processing are also of interest. For more information and submission instructions, see:

https://www.electrochem.org/ecsnews/243-tcu-plasma-electrochemistry-catalysis/

Submission deadline: **December 2, 2022**.

Contact:
Prof. Davide Mariotti
Ulster University, UK
d.mariotti@ulster.ac.uk

Community Initiatives and Special Issues

- **Special Issue on Plasma Medicine in *Plasma Processes and Polymers***

  We are launching a Special Issue in *Plasma Processes and Polymers* on "Plasma Medicine" (https://onlinelibrary.wiley.com/page/journal/16128869/homepage/2410_SI), guest edited by **Dr. Cristina Canal, Dr. Albert Espona Noguera** and **Dr. Francesco Tampieri** from the PlasmaMedLab in the Dept. of Materials Science and Engineering, Universitat Politècnica de Catalunya, Barcelona, Spain (https://plasmamedlab.upc.edu/en).

  Plasma Processes and Polymers (PPaP) (https://onlinelibrary.wiley.com/journal/16128869) is one of the leading full-paper materials science journals and achieved an impact factor of 3.877 last year. *PPaP* publishes review articles, full papers of original research and feature articles reviewing cutting-edge work from leaders in the field.

  Plasma medicine combines plasma technology with clinical medicine and bioengineering with the final aim to use Cold Atmospheric Plasmas in the clinics for human and veterinary therapeutic applications. The present special issue aims at gathering the latest advances in this exciting and quickly evolving field. In particular, but not restricted to the following areas:

  - Fundamental plasma-biological interaction mechanisms
  - Interaction of plasmas with liquids of biological interest
  - Plasma devices for medicine
  - Disinfection and wound healing
  - Tissue regeneration & cosmetic applications
  - Plasma oncology & immunology

  We would like to invite you to submit an article within these topics for publication in this special issue.

  Submission deadline: **February 2023**.

  Contacts:
  Dr. Cristina Canal, cristina.canal@upc.edu
  Dr. Albert Espona Noguera, albert.espona@upc.edu
  Dr. Francesco Tampieri, francesco.tampieri@upc.edu
  Universitat Politècnica de Catalunya, Barcelona, Spain

- **Special Issue on Plasma Oncology, *MDPI Cancers***

  As collection editors of "Plasma Oncology" in the open-access MDPI journal, *Cancers*, we would like to invite you to submit an original research article of your work related to the topic "Plasma Oncology": https://www.mdpi.com/journal/cancers/topical_collections/plasma_oncology.
  All papers that provide new insights into the mechanisms of plasma oncology based on in vitro, in ovo, and in vivo experiments, clinical studies, as well as by computer modeling, are welcome.

  Would you like to submit a paper? We look forward to hearing from you! Our Topical Collection is ongoing. Contact us if you would like to submit within the next 6 months; in that case, we can offer a discount.

  Contacts:
  Dr. Angela Privat-Maldonado, angela.privatmaldonado@uantwerpen.be
  Dr. Abraham Lin, abraham.lin@uantwerpen.be
  Prof. Dr. Annemie Bogaerts, annemie.bogaerts@uantwerpen.be
  University of Antwerp, Belgium

- **Special Section on Plasma Modeling and Feature Evolution for Semiconductor Fabrication, *JM³ (Journal of Micro/Nanopatterning, Materials and Metrology)***

Plasma modeling and feature profile simulation have made valuable contributions to the advancement of fabrication of microelectronics devices over the past several decades. With the new focus from governments to support and advance microelectronics manufacturing, there is both a new opportunity and a need for plasma modeling and simulation (M&S) to have an industry-changing impact. M&S can potentially help with several key challenges, including (1) expanding the current quantitative predictive capability to a larger range of plasma sources, (2) developing models that include complex plasma chemistries, (3) creating a robust and complete database of fundamental cross sections, reaction probabilities and transport coefficients for gas phase and surface processes, (4) improving profile simulation to be more predictive while including more fundamental processes, (5) leveraging machine learning and artificial intelligence for process development, and (6) bringing M&S of plasma processing into the co-design hierarchy.

A Special Section on *Plasma Modeling and Feature Evolution for Semiconductor Fabrication* in *JM³* (*Journal of Micro/Nanopatterning, Materials and Metrology*) will address these challenges. We invite the submission of papers that discuss investigations contributing to the advancement of plasma modeling and feature simulation for microelectronics device manufacturing. Submissions can include but are not limited to:

- Reactor scale modeling
- Fundamental data
- Feature scale modeling
- Machine learning
- Molecular dynamics
- Model reduction
- Real-time-control
- Validation and verification

More information on the Special Section and submission instructions for the **March 1, 2023** submission window are at:

https://www.spiedigitallibrary.org/journals/journal-of-micro-nanopatterning-materials-and-metrology/call-for-papers#PlasmaModelingandFeatureProfileSimulation

Contact:
Dr. Catherine B. Labelle
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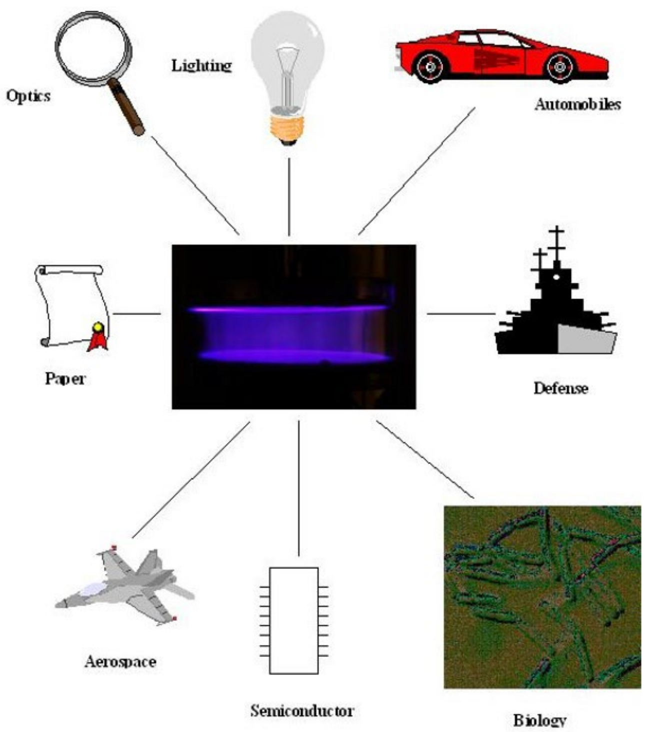
catherine.labelle@intel.com

Grand Challenges in Low Temperature Plasmas



LTP is used in various technological applications.

Low temperature plasmas (LTPs) enable creating a highly reactive environment at or near ambient temperatures due to energetic electrons with typical kinetic energies in the range of 1 to 10 eV (1 eV = 11,600K). These reactive environments are being used in applications ranging from plasma etching of electronic chips to additive manufacturing to plasma-assisted combustion. LTPs are at the core of many technologies and without them many of the conveniences of modern society would simply not exist. New applications of LTPs are continuously proposed but researchers are facing many grand challenges in translating them to practice. This paper discusses the challenges being faced in the field of LTPs, in particular for atmospheric pressure plasmas, with a focus on health, energy and sustainability.

Contact:
Prof. Xinpei Lu
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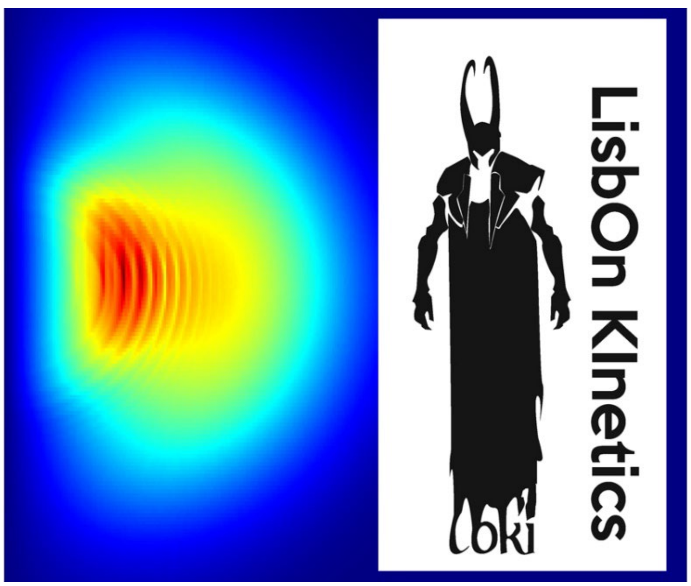
luxinpei@hotmail.com

Source:
X. Lu, P. J. Bruggeman, S. Reuter, G. Naidis, A. Bogaerts, M. Laroussi, M. Keidar, E. Robert, J-M. Pouvesle, D. Liu, K. Ostrikov, "Grand Challenges in Low Temperature Plasmas", Front. Phys. **10**, 1040658, (2022).

https://doi.org/10.3389/fphy.2022.1040658

The LisbOn Kinetics Monte Carlo is Released as Open-Source Code



The group N-Plasmas Reactive: Modelling and Engineering (N-PRiME) (https://www.ipfn.tecnico.ulisboa.pt/nprime/) has been consistently developing simulation tools to describe the electron kinetics and the plasma chemistry in low-temperature plasmas.
This systematic effort started three years ago with the release of the open-source LisbOn Kinetics Boltzmann solver (LoKI-B) (https://github.com/IST-Lisbon/LoKI), and continued with the development of the LisbOn Kinetics (LoKI) (https://nprime.tecnico.ulisboa.pt/loki/) suite, comprising a Boltzmann component (LoKI-B) and a Chemistry component (LoKI-C).

The LoKI tools are now reinforced with the release of a Monte Carlo code for electron kinetics simulations (LoKI-MC) in low-temperature plasmas, excited by uniform DC electric fields from different gas mixtures. LoKI-MC (https://github.com/IST-Lisbon/LoKI-MC) is written in C++, benefiting from a highly efficient object-oriented structure, and was released as open-source code licensed under the GNU general public license.

The code follows the strategy and data organization of the two-term counterpart LoKI-B, since it easily addresses any complex mixture of atomic/molecular species, describing electron collisions with any target state (electronic, vibrational and rotational), characterized by any user-prescribed population. On input, the code requires the working conditions, the gas-mixture composition, the distributions of populations for the levels of the atomic/molecular gases considered, and the relevant sets of electron-scattering cross sections obtained from the open-access website LXCat. On output, it yields the electron energy and velocity distribution functions, the electron swarm parameters, the collision rate-coefficients, and the electron power absorbed from the electric field and transferred to the different collisional channels.

Contact:

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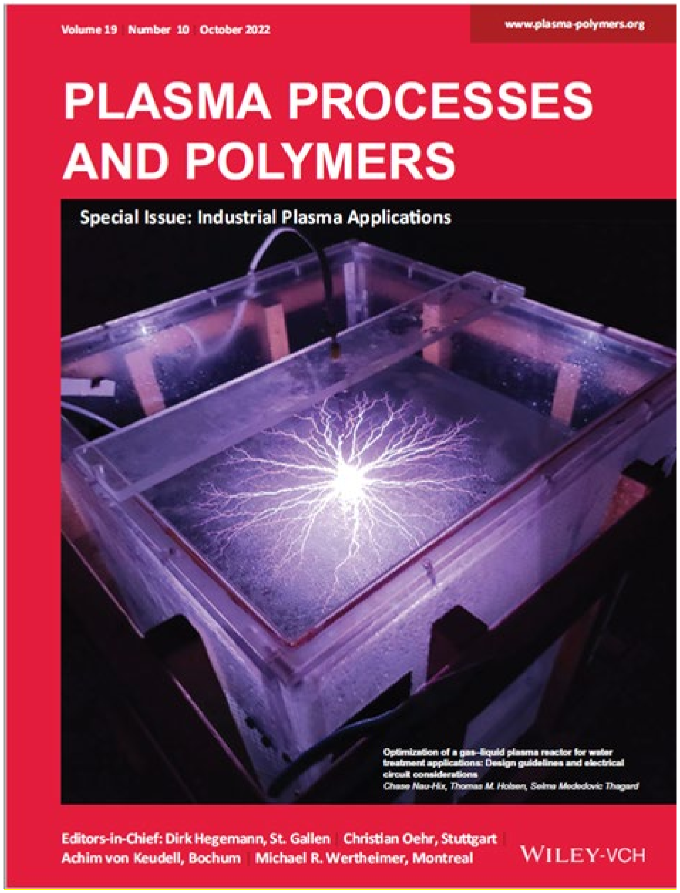
Source: T. C. Dias et al, Comput. Phys. Comm. **282,** 108554 (2022).
https://doi.org/10.1016/j.cpc.2022.108554

Optimization of a Gas–liquid Plasma Reactor for Water Treatment Applications: Design Guidelines and Electrical Circuit Considerations



Large volume plasma-based water treatment: single point electrical discharge in argon contacting the surface of 170L of contaminated water.

Plasma-based treatment (PWT) is a promising technique for the decomposition of persistent aqueous contaminants. As PWT continues to develop, providing guidelines for scaling up plasma reactors and optimizing the plasma-generating network will become paramount in the long-term success of the technology.

This work assessed the influences of discharge energy, grounded electrode size and position, and number of high voltage discharge points on the production of reactive species and the degradation of several organic contaminants in a 1L bench scale gas-liquid electrical discharge plasma reactor. The applicability of bench-scale results to large volume systems was further assessed by performing selected experiments in a 170L upscaled reactor of the same electrode geometry.

For both systems, removal rates of different compounds are controlled by the magnitude of the plasma-liquid contact area and the energy delivery to the reactor. The number of high voltage discharge points has no effect on the plasma area but influences the voltage and the reactive species' production rates. *Bench-scale findings apply directly to large volume systems resulting in the highest contaminant removal rates using a single high voltage electrode and a grounded electrode spanning the entirety of the treatment zone.*

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Clarkson University
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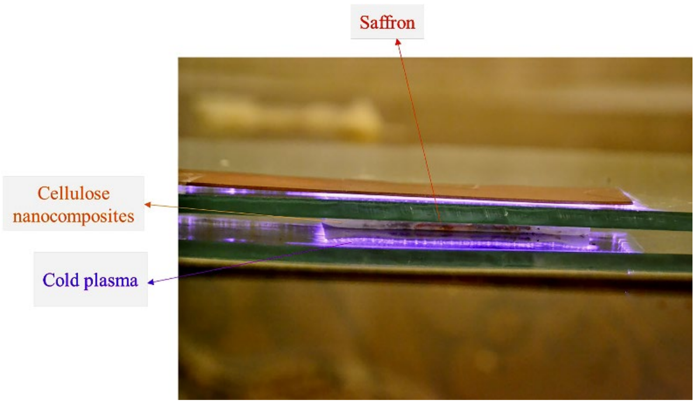
Source:
Plasma Process. Polym., e2200036 (2022).
https://onlinelibrary.wiley.com/doi/10.1002/ppap.202200036

Cold Plasma Decontamination and Cellulose-based Nanocomposite Packaging for Long-term Saffron Preservation



Plasma treatment of saffron within the nanocomposite CNCs packaging.

The ever-increasing demand for the preservation of healthy food products over long periods of time necessitates longer food shelf-life, sterilization of equipment containing microorganisms, and sustainable food processing and packaging technologies. Priorities in saffron preservation include sterilization of saffron packaging and maintenance of the saffron's purity. Common methods of saffron preservation are ineffective, so it is necessary to develop innovative packaging techniques utilizing renewable materials and to eliminate packaging waste.

Using the synergistic application of nanoclay-loaded carboxymethyl cellulose (CMC)/polyvinyl alcohol (PVA) nanocomposites (CNCs) and cold plasmas (CPs), simultaneous decontamination and quality preservation of saffron are proven for the first time. Compared to the single use of CP and CMC/PVA/nano clay, our results indicate the synergies between CP and CMC/PVA/nano clay that result in the total eradication of Escherichia coli germs without significantly altering the quantities of the key saffron components (safranal, crocin, and picrocrocin). Overall, the CP-treated CMC/PVA/nanoclay promote saffron preservation by eliminating contamination and preserving the food product's quality. The synergistic use of CP and CMC/PVA/nanoclay for packaging, sterilization, and preservation of high-value food products is therefore a potential method.

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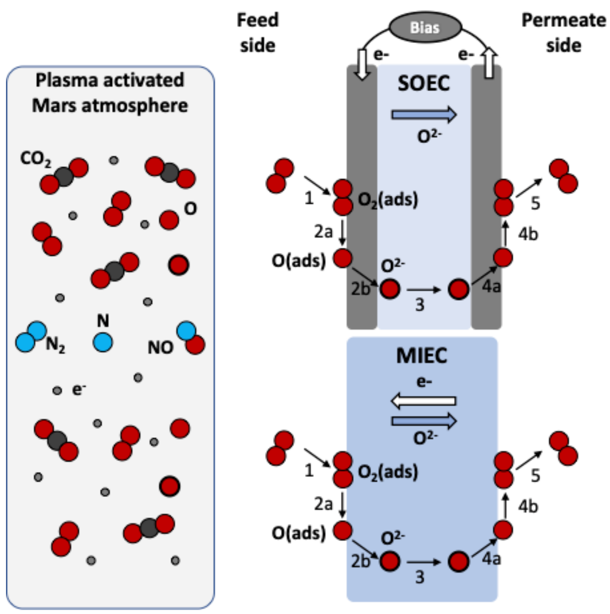
Source:
Sci Rep **12**, 18275 (2022).
https://doi.org/10.1038/s41598-022-23284-9

Plasmas for In Situ Resource Utilization on Mars



Schematic representation of oxygen separation via solid oxide electrolysis cells (SOEC) and mixed ionic-electronic conduction (MIEC) membranes.

This *featured paper* from *Journal of Applied Physics* discusses the potential of coupling non-thermal plasmas and conducting membranes for in situ resource utilization (ISRU) on Mars. By converting different molecules directly from the Martian atmosphere, plasmas can create the necessary feed-stock and base chemicals for processing fuels, breathing oxygen, building materials, and fertilizers. All are essential for future human settlements on Mars.

A synergistic effect between plasma decomposition and oxygen permeation across conducting membranes is anticipated. The emerging technology is versatile, scalable, and has the potential to deliver high rates of production of molecules per kilogram of instrumentation sent to space. Therefore, it will likely play a very relevant role in future ISRU strategies.

The work is a collaboration between teams from the University of Lisbon (IPFN, IST), École Polytechnique (LPP), Technical University of Eindhoven, DIFFER and the MIT.

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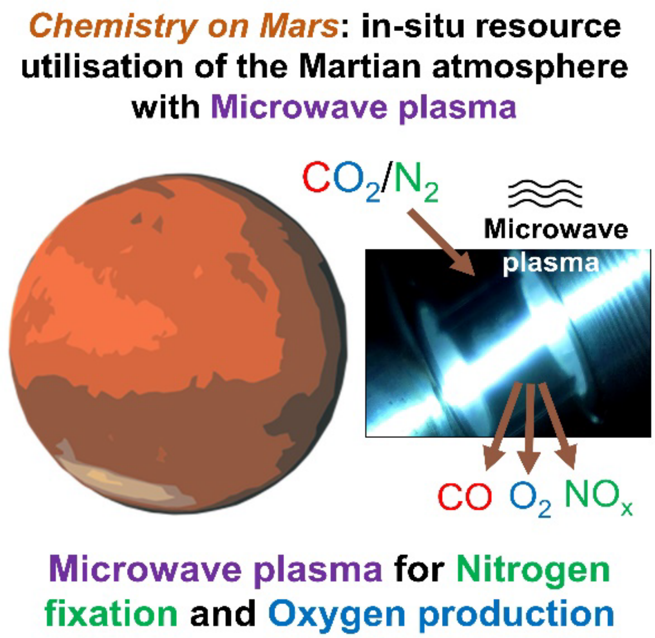
Source:

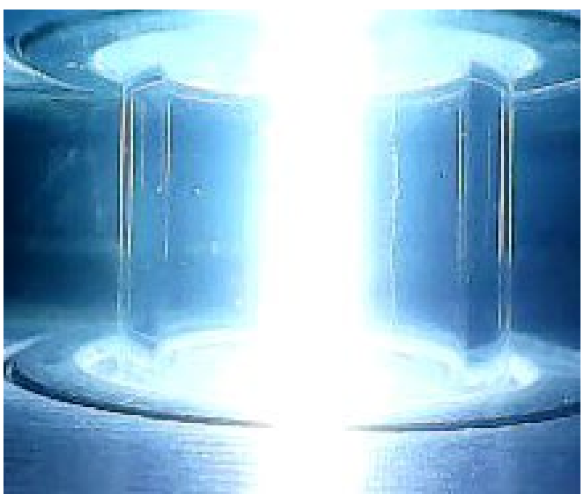
“Plasmas for in situ resource utilization on Mars: Fuels, life support, and agriculture,” J. Appl. Phys **132**, 070902 (2022*)*.
https://doi.org/10.1063/5.0098011

More information:

https://www.science.org/content/article/plasma-reactors-could-create-oxygen-mars

Producing Oxygen and Fertiliser with the Martian Atmosphere using Microwave Plasma





(top) Graphical abstract and (bottom) image of plasma ignited in a Martian atmosphere from inside the wave-guide.

The concept of 'living off the land' is key for future space enterprises to planets like Mars. The prohibitive cost of bringing fuel, oxygen and food greatly motivates exploitation of resources locally, where chemistry must be performed 'in-situ'. In this work, the potential of microwave plasma-based in-situ resource utilization (ISRU) of the Martian atmosphere is explored with focus on the novel possibility of fixing nitrogen (i.e., fertilizer production). Experiments in a plasma ignited with a Martian atmosphere mix (consisting mostly of carbon dioxide with 2% nitrogen) are performed under energy conditions similar to the Mars oxygen in-situ experiment (MOXIE), currently onboard NASA's Perseverance rover. We find that oxygen liberated through carbon dioxide dissociation facilitates the fixation of the nitrogen fraction. This demonstrates a novel process to source a key macronutrient for agriculture. In particular, O_2 production rates are ~30 times higher, with ~10 times lower energy cost, than those demonstrated by MOXIE, while the NO_x production rate represents a ~7% fixation of the N_2 fraction present in the Martian atmosphere.

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Source:
https://doi.org/10.1016/j.chempr.2022.07.015
https://www.cell.com/chem/pdf/S2451-9294(22)00374-6.pdf

New Resources

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

Career Opportunities

- **Research Engineer / Postdoctoral Researcher, Data-driven Modeling of Low-temperature Plasma Dynamics, Stanford University, USA**

The Plasma Dynamics Modeling Laboratory (PDML) in the Department of Aeronautics and Astronautics at Stanford University is seeking a Research Engineer or a Postdoctoral Research Fellow.

The position is focused on development of data-driven models (e.g., machine learning, neural network, state estimation, optimization techniques) to understand the physics and chemistry of low-temperature plasmas (such as plasma-material/surface interaction, collisional and radiative processes, plasma instabilities, plasma turbulence, etc.) in space propulsion and plasma processing systems.

The researcher must have a Ph.D. degree in Physics, Engineering, Applied Mathematics, or similar disciplines, with a particular focus in plasma science, rarefied gas dynamics, computational fluid dynamics, or closely related fields. Highly motivated and hardworking candidates with a strong background in computational plasma and fluid dynamics are encouraged to apply.

More information about the research group is available at https://pdml.stanford.edu/

The initial appointment period is 1 year with a reappointment for 2 or 3 years upon availability of funds and subject to performance.

Applicants are invited to send a resume/CV, including a list of publications, a brief statement of research interests, and contact information of three references to **Prof. Ken Hara**.

Contact:
Prof. Ken Hara
Stanford University, USA
kenhara@stanford.edu

- **Optical Diagnostics of Plasma Experimental Postdoctoral Appointee at Sandia National Laboratories, Albuquerque, NM, USA**

We are seeking a dedicated Postdoctoral Appointee to conduct fundamental research developing active and passive optical diagnostic techniques examining plasmas used in a wide range of applications. The successful candidate will assist in research leading to new scientific insights aiding Sandia in its mission to serve the nation. You will interrogate a variety of plasma systems increasing our ability to understand the process of electrical breakdown and work in collaboration with members of our computational plasma physics team to increase our fundamental knowledge of these systems. Join us to develop creative solutions to unique national security challenges!

On any given day, you may be called on to:

- Establishing new scientific insight on the physical mechanisms underlying low temperature plasma phenomena
- Publication of scientific results and participation in the scientific community
- Collaborating with external partners through Sandia's Low Temperature Plasma Research Facility (https://www.sandia.gov/prf/)
- Use plasma diagnostic tools for new applications

- Developing or otherwise supporting the development of new diagnostic tools for interrogating plasma initiation and steady states
- Verification and validation of plasma simulation tools in collaboration with modelers

Qualifications we require:

- Possess, or are pursuing, a PhD in Physics, Electrical Engineering, Nuclear Engineering, Mechanical Engineering, Chemistry, or relevant STEM field
- Experience in setting up and operating experimental systems to study plasma generation, including complex diagnostics and plasma sources
- Able to acquire and maintain a DOE Q-level security clearance

See Sandia Careers website for full details: https://sandia.jobs/albuquerque-nm/optical-diagnostics-of-plasma-experimental-postdoctoral-appointee/69283E0B3A1344BDA45FE27E6BED6659/job/

Contact:
Dr. Brian Bentz
Sandia National Laboratories, USA
bzbentz@sandia.gov

- **Post-doctoral Position: Implementation of ps–laser and Streak Camera Diagnostics in Reactive Plasmas, Université Sorbonne Paris Nord, France**

A 1-year post-doctoral contract with possibility of extension (+18 months; depending on candidate's performance) is available at the *Process and Material Sciences Laboratory (LSPM)*. Collaboration between *Plasma Surface Interaction and Microplasmas (IPS–MP)* group of *LSPM and Photonique et Nanostructures (PON)* team of the *Laboratory of Laser Physics (LPL) at Université Sorbonne Paris Nord* (Villetaneuse, France).

Duties: The post-doc will perform advanced optical diagnostics at LSPM and enter a wide scientific network involving plasma physicists (experiments and models), research engineers, and material processes experts. He/she will work on the optimization of the advanced laser and detector platforms available in IPS-MP for studying low- (e.g., a microwave hydrogen plasma between 1-300 Pa) and atmospheric-pressure (microplasma jet and/or torch) plasmas by means of ns (fast) and ps (ultrafast) two-photon absorption laser induced fluorescence (TALIF). He/she will particularly focus on the development of ps-TALIF coupled with an ultrafast streak camera for the reliable determination of reactive atom lifetimes and densities (such as H, N and O) in collisional plasmas.

Expected skills:

- PhD in Experimental Physics, Plasma Physics and Diagnostics, Physical Chemistry (combustion), or Lasers.
- Strong background on laser diagnostics (ideally LIF/TALIF), laser/plasma physics and optical diagnostics.
- Strong computer skills and capacity in data analysis using scientific software (Origin®, MATLAB®, Python…).
- Experience with streak cameras and LabVIEW would be an asset.
- Strong organization and methodology, high autonomy, commitment, respect deadlines, flexibility, collaboration, efficient problem solving.
- Supervision of PhD and Master students and cooperation with research engineers.
- High efficiency in preparing research papers and conference presentations.
- Fluent in English and (ideally) in French.

Starting date: Ideally from January 2023.

The candidate should send to the contacts the following files:

- A copy of the PhD diploma (or equivalent).
- A two-page CV.
- A motivation letter (one page).
- Two recommendation letters.

Contacts:
Prof. Guillaume Lombardi, guillaume.lombardi@lspm.cnrs.fr
Dr. Kristaq Gazeli, kristaq.gazeli@lspm.cnrs.fr
Université Sorbonne Paris Nord, France

- **Associate Research Scientist, Diamond Synthesis, Princeton Plasma Physics Laboratory, New Jersey, USA**

The Princeton Plasma Physics Laboratory (PPPL) seeks to fill a post-doctoral research physicist position to perform plasma simulations for the modeling of low-temperature plasma devices for microelectronics and quantum information science. The Associate Research Physicist will join a research team working on this application, comprising experts in experimental and theoretical plasma physics, as well as materials and processing scientists from the PPPL, Princeton University, and the Royal Melbourne Institute of Technology. The candidate will be expected to model the grow of the epitaxial diamond using plasma enhanced chemical vapor deposition (PECVD) reactors. The results of this work will be used for development of new co-doping protocols, recipes, and devices, for diamond quantum sensing applications. The Associate Research Physicist will work in support of a DOE microelectronics grant and may involve collaboration with industry partners. Applicants will have multi-disciplinary experience in material synthesis with proficiency in the fields of plasma physics and chemistry, and computational fluid dynamics (CFD). The applicant will develop a model of a plasma reactor for the chemical vapor deposition (CVD) of diamond. Therefore, experience in modeling of plasma-material interaction with important aspects including plasmas that are not in the state of thermodynamic equilibrium is crucial.

Particularly, experience in developing integrated models of plasma reactors for plasma processing and CVD is crucial. Validation and verification of the code will be facilitated through collaboration with research and industry partners, and the candidate should be adept at managing and maintaining these relationships. Through these collaborations they will be asked to apply these codes to model micro-wave (MW) discharges for diamond CVD. The candidate should be proficient on the physics and chemistry which govern these devices, including the importance of self-consistent plasma formation in MW plasmas and impurity transport. A proven record of collaboration with experimentalists and demonstrated impact on experimental programs is desirable. Previous experience working with industry is beneficial.

Qualifications:

- Must have a PhD in plasma science or engineering, or chemical engineering or other closely related field
- Experience in plasma processing, for example involving deposition or etching is preferred
- Experience with diamond processing is not specifically required

Contact:
Dr. Igor Kaganovich
Princeton Plasma Physics Laboratory, USA
ikaganov@pppl.gov

Collaborative Opportunities

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

Disclaimer

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