International Low Temperature Plasma Community

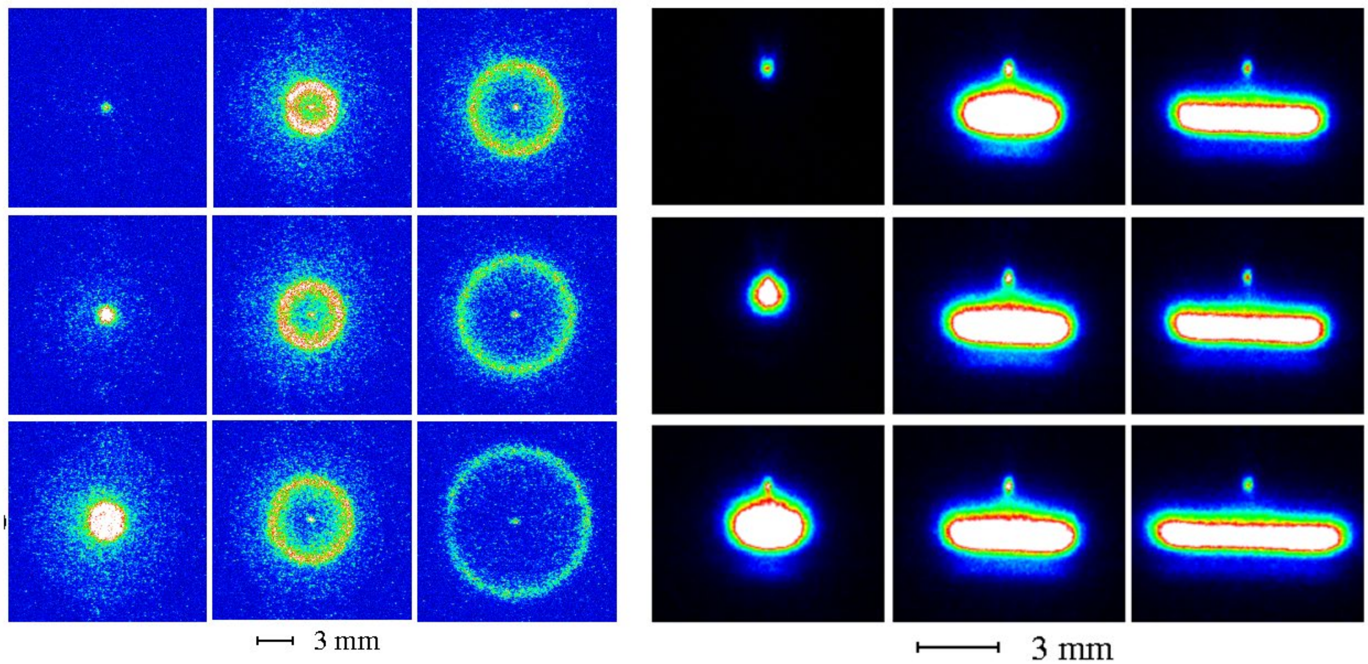
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 12

7 April 2021

Images to Excite and Inspire!

Thank you for submitting your images, some of which are shown here. Those images already submitted will appear in later Newsletters. Please do send your images (with a short description or source) to iltpc-central@umich.edu. The recommended image format is JPG or PNG; the minimum file width is 800 px.



Imaging of Atmospheric Pressure Glow Discharges in Helium:

Needle-plane audio-frequency discharge data were obtained in a flow of pure helium slightly above atmospheric pressure. The upper stainless steel needle high-voltage electrode had a precisely machined (40 µm) radius. The low-potential electrode was (A) a 1-mm-thick borosilicate glass plate with a conducting, transparent coating [indium tin oxide (ITO)] on its bottom surface, to permit observation and photographic imaging of the entire discharge zone; or (B) a 1.6-mm–thick Al_2O_3 ceramic plate, metallized on the bottom. The imaging system used here was an intensified charge coupled device (ICCD) digital camera (Roper Scientific PI-MAX 512RB). The images above are short-exposure (τ_{exp} = 2.5 ns) ICCD images (left) parallel and (right) perpendicular to the d = 3.0-mm needle-plane gap for a f = 10 kHz discharge with the applied voltage being $V_{p\text{-}p} \sim 2$ kV. The images are at times after initiation of (left) 0.05 µs to 15 µs and (right) 0.05 µs to 6 µs.

Contact:

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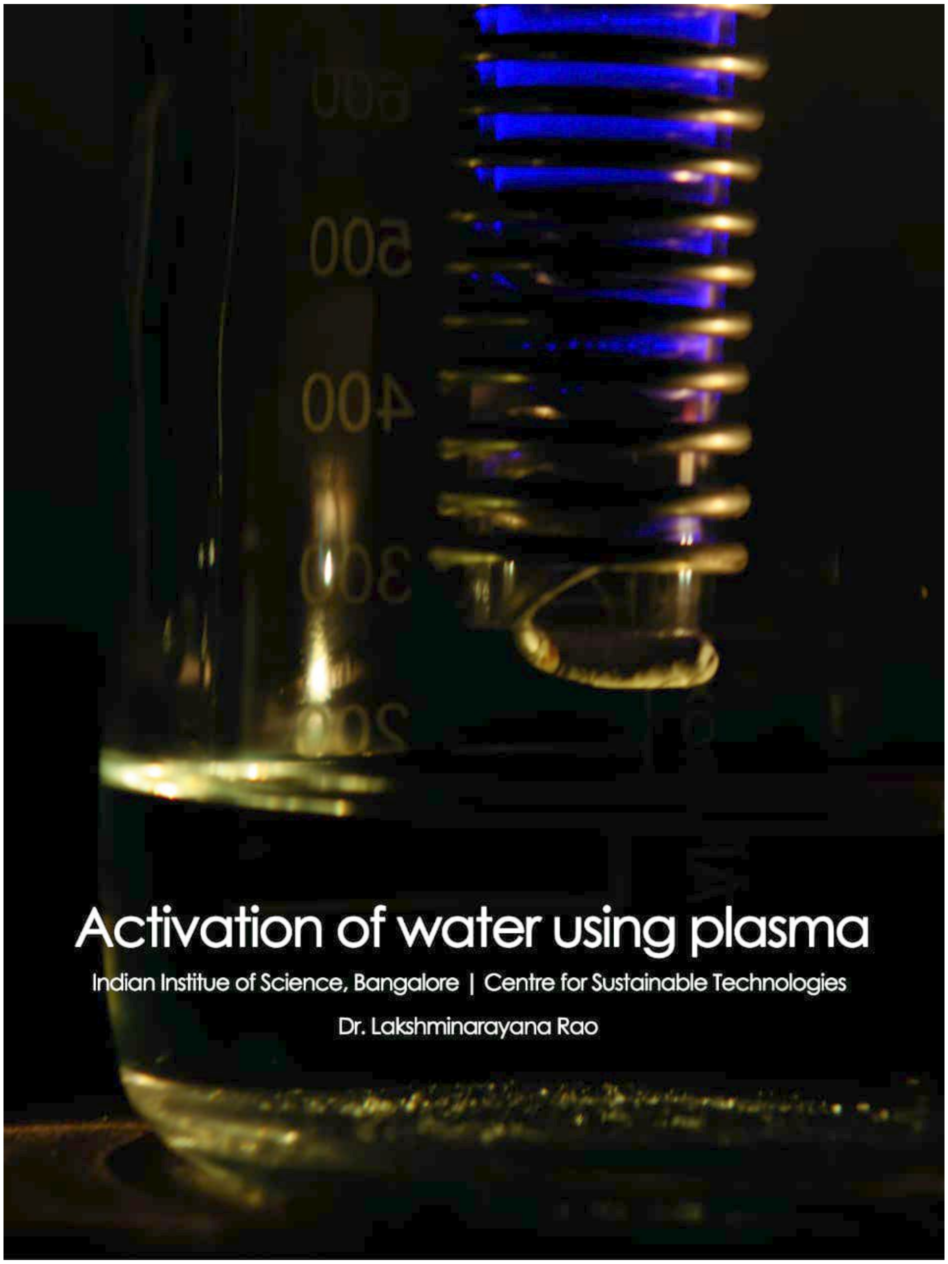

A Simple Process for Generating a Greener Fertilizer

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Source:
https://doi.org/10.1063/5.0039253

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Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **April 30, 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.

LTP Perspectives: Policy, Opportunities, Challenges

Plasma Agriculture – An Actively Growing Multidisciplinary Field

The United Nations Food and Agriculture Organization (FAO) estimates that around 11% of the world's population is suffering from chronic undernourishment and that this percentage is on the rise. Therefore, one of the Sustained Development Goals (SDG) defined for the period of 2015-2030 is "*End hunger, achieve food security and improve nutrition, and promote sustainable agriculture*".

We have seen that Atmospheric Pressure Plasmas (APPs) are effective in medical applications and this field has made several impressive leaps in the last few decades. At the same time as these early plasma medicine investigations, several solitary studies were performed on plasma treatment of plant seeds or calli. (Calli are growing masses of unorganized plant cells.) These early plasma plant treatments obtained positive results. The germination percentage of the seeds and the mass yield of the plant calli increased by significant percentages with plasma treatment. Since then, we have learned a great deal about APPs and how to best design them for application to plants and seeds; about reactive oxygen and nitrogen species, plant development, seed dormancy, liquid fertilization and many more terms used in variety of fields. Today, Plasma Agriculture (PA) is a highly multidisciplinary field that is rapidly developing. PA contains numerous plasma applications, starting with seed and plant treatments, decontamination of fresh food produce, production of Plasma Activated Water (PAW) for liquid fertilization and many more. We have certainly not taken advantage of all of the opportunities in PA that are before us. Of course, with these opportunities and new ideas, there are setbacks and obstacles that must be overcome, and this is our challenge.

As an example, pathogen free seeds that will produce healthy plants or will be added to animal feed resulting in toxin free milk are great. The challenge is how to plasma treat tons and tons of such seeds. We all know that APPs are usually small in volume and surface coverage, and different seeds have different properties. So designing a system for mass production of tons of arbitrary seeds is a big challenge. Apart from PA being a fresh new multidisciplinary science, we also need to adapt our thinking in ways that may be new for scientists focused on only fundamental science: scaling up, legislative public policy, marketing etc. In my opinion we can achieve this as a multidisciplinary community. Maybe not all applications and plasma devices will end up in the fields, green houses or food processing plants. However, there will be enough examples of them that we can say that plasma is an important player solving the problems of hunger and food security. We should be optimists. After all, where would humanity be now without plasma etching?

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Tribute: Dr. Oleg I. Zatsarinny

With deep sadness, we inform the scientific community that Oleg Zatsarinny, a Senior Researcher at Drake University, passed away on 2 March 2021.

Oleg Ivanovich Zatsarinny was born in the city of Uzhgorod, Ukraine, on November 4, 1953. He entered the Moscow Institute of Physics and Technology in 1971. After graduating with an MSc degree in 1977, Oleg obtained a position at Uzhgorod University, first in the Department of Physical and Quantum Electronics and then in Theoretical Physics. There he specialized in calculations for atomic physics. He obtained a PhD degree in 1985 and was soon appointed Head of the Theoretical Physics Division, Laboratory of Electron Collision Physics, Uzhgorod State University. Upon completing and defending his DSc dissertation, he became a Senior Research Associate at the Institute of Electron Physics of the Ukrainian Academy of Science, a position he held from 1993 – 2001.

When the Soviet Union collapsed in 1991, Oleg was successful in getting support from the International Science Foundation, the European Union, and the Open Society Foundations, all of which promoted cooperation between scientists from Western Europe and the independent states of the former Soviet Union. With that support, Oleg started a collaboration with Werner Mehlhorn at the University of Freiburg in Germany.

Charlotte Froese Fischer invited Oleg to Vanderbilt University in 1997. In May 2000, together with his wife Tatyana, Oleg immigrated to the US. After working with Swaraj Tayal at Clark Atlanta University and Thomas Gorczyca at Western Michigan University, Oleg joined the group of Klaus Bartschat at Drake University in October 2003 as a Senior Researcher. He stayed there until the end of his life on March 2, 2021.

In 2006 Oleg published the first version of his suite of computer codes "BSR: B-spline atomic R-matrix codes". This program uses the R-matrix method to calculate electron–atom and electron–ion collision processes, as well as structure data (energy levels and oscillator strengths) and photoionization processes. The latest versions of his codes are freely available at https://github.com/zatsaroi and are being preserved through the Atomic and Molecular Physics Gateway (https://ampgateway.org), where the source code as well as many sample input files and run scripts for test cases are available. Until the very end of his life, Oleg continued to work on the programs and applied them to many cases of interest for the plasma-modeling community. He also made his data freely available to everybody who asked individually and to the general public via the LXCat database https://nl.lxcat.net/home/. In the words of one of his colleagues: "Oleg did something useful!"

Oleg was awarded Fellowship in the American Physical Society in 2008. In later years, he also became an educator. He introduced computational physics courses into the curriculum at Drake University and trained a number of post-doctoral researchers and international visitors in the use of his codes. Oleg published over 200 papers in peer-reviewed journals, which have been cited over 5,000 times, and his data have been downloaded more than 11,000 time from LXCat. His work will continue influencing fundamental atomic physics, as well as its many applications, for decades.

Oleg will be sadly missed by his family and his many friends and colleagues.

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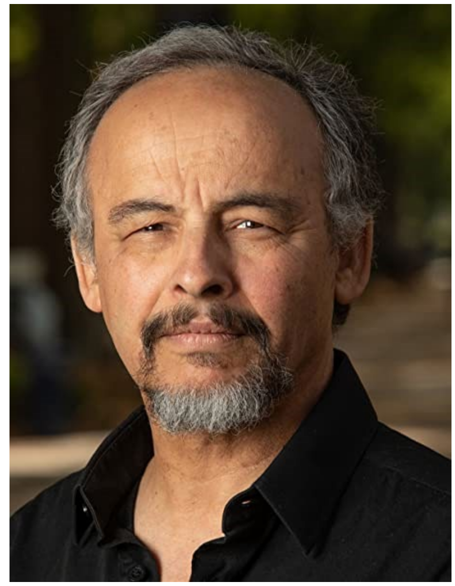
Professor Mounir Laroussi – Pioneer of Plasma Bioengineering



Mounir Laroussi is a Professor in the Electrical & Computer Engineering Department at Old Dominion University and Director of Plasma Engineering and Medicine Institute. Mounir Laroussi is one of early pioneers and promoters of low temperature plasma applications in bioengineering. Mounir was involved in research on the biomedical applications of low temperature plasmas, which is now known as “Plasma Medicine”, starting in the 1990s by focusing on low temperature atmospheric pressure plasma decontamination. This is the scientific direction that by the early 2000s started to grow exponentially. Today, biomedical applications of low temperature plasmas involve wound healing, blood coagulation, cancer therapy, dentistry and many other applications.

Mounir Laroussi’s own research focuses on a number of important aspects of low temperature plasmas including the generation of large volume low temperature plasmas, the interaction of microwaves with plasmas, and the biomedical application of cold plasmas including cancer therapy. Mounir’s best known invention in the low temperature plasma field is the cold atmospheric plasma device known as plasma pencil. This is plasma device that is now widely used worldwide in its various modifications. Mounir’s device can generate long plumes or jets of cold plasmas that can be used in various biomedical applications. To this end, Mounir’s team was one of the first to characterize plasma jet physics and propose mechanisms for jet propagation now known as plasma bullets.

Mounir is a strong advocate of low temperature plasma application in the biomedical field. He is the organizer and editor of numerous special issues focused on plasma medicine in various applied physics and plasma journals. He has written many insightful reviews combining both historical perspective and modern state of the art. Such types of reviews are extremely valuable for educating new generations of researchers in our field. He has published several books, including the recent “Nonequilibrium Atmospheric Pressure Plasma Jets”.

Mounir is a force behind establishing many new initiatives, conferences and workshops. For instance, several years ago he proposed and co-organized a very successful International Workshop on Plasma for Cancer Therapy (IWPCT). Recently, Mounir has been the driving force behind the new MDPI journal Plasma. Mounir is a Fellow of the IEEE and received the IEEE-Nuclear and Plasma Science Society Merit Award, among other distinctions.

During the ongoing pandemic Mounir took the initiative to partially remedy the sad reality of cancellation of many conferences by proposing a high-quality online seminar series, the Online Low Temperature Plama Seminar (https://mipse.umich.edu/ltp_seminars.php). Started in May 2020, this initiative in low temperature plasma has become a very popular forum attracting many colleagues and new graduate students worldwide.

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General Interest Announcements

- **National Science Foundation Plasma Physics Program Semi-Annual Webinar**

The NSF Plasma Physics Program (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503252) will be holding its semi-annual webinar **on Friday, April 9th, 3:00pm – 4:30pm Eastern Time** (US and Canada). All are welcome to attend; please, circulate this invitation to your potentially interested colleagues, postdocs, and students. ***Pre-registration for the webinar is required using information below.***

Webinar Agenda:

1) NSF and Plasma Physics program news and updates
2) New funding opportunities with particular focus on broadening participation and engaging the next generation of scientists from underrepresented groups (see below)
3) Extensive Q&A

Webinar Zoom Information:
When: **April 9, 2021 03:00 PM – 4:30 PM Eastern Time** (US and Canada)
Register in advance for this webinar:
https://nsf.zoomgov.com/webinar/register/WN_kiqlAz1CRt-Z6T337NDhzQ

After registering, you will receive a confirmation email containing information about joining the webinar.

Contact:
Dr. Vyacheslav (Slava) Lukin
Program Director, Plasma Physics
Division of Physics, National Science Foundation

- **National Science Foundation New Funding Opportunities (USA)**

NSF 21-570, Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences (LEAPS-MPS)

https://www.nsf.gov/pubs/2021/nsf21570/nsf21570.htm

Proposal Deadline: **June 14, 2021**

With emphasis in helping to launch the careers of pre-tenure faculty in Mathematical and Physical Sciences (MPS) fields at minority-serving institutions (MSIs), predominantly undergraduate institutions (PUIs), and Carnegie Research 2 (R2) universities, and with the goal of achieving excellence through diversity, the Directorate for Mathematical and Physical Sciences hereby announces a call for Launching Early-Career Academic Pathways (LEAPS-MPS) proposals. This LEAPS-MPS call also aims to broaden participation to include members from groups underrepresented in the Mathematical and Physical Sciences, including Blacks and African Americans, Hispanics, Native Americans, Alaska Natives, and Native Hawaiians, and other Pacific Islanders.

These grants are intended to support MPS principal investigators in initiating their research programs early in their careers, particularly at the aforementioned institutions. By providing this funding opportunity, MPS intends to help initiate viable independent research programs for researchers attempting to launch their research careers such that LEAPS-MPS awards are followed by competitive CAREER or individual-investigator grant submissions that build upon the research launched through this mechanism. This LEAPS-MPS solicitation welcomes proposals from principal investigators who share NSF's commitment to diversity.

Awards are for 24 months and are up to $250,000 total costs (direct plus indirect). Principal Investigators must be U.S. citizens or lawfully admitted U.S. permanent residents at the time of proposal submission; visa-holders are not eligible.

NSF 21-573, Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowships (MPS-Ascend)

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505879

Proposal Deadline: **June 15, 2021**

The purpose of the Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowship (MPS-Ascend) program is to support postdoctoral Fellows who will broaden the participation of groups that are underrepresented in MPS fields in the U.S. including Blacks or African Americans, Hispanics, Latinos, and Native Americans (to include Alaska Natives, Native Hawaiians or other Native Pacific Islanders) as future leaders in MPS fields. The program is intended to recognize beginning investigators of significant potential and provide them with experience in research that will broaden perspectives, facilitate interdisciplinary interactions and help broadening participation within MPS fields. The program funds postdoctoral Fellows in postdoctoral research environments that will have maximal impact on their future scientific development and facilitates their transition into a faculty appointment. Awards will support research in any scientific area within the purview of the five MPS Divisions. Fellowships are awards to individuals, not institutions, and are administered by the Fellows.

The duration of a Fellowship award is up to 36 months, during which stipend support is provided for between 12 to 36 months. The Fellowship amount of $100,000 per year for up to three years consists of two separate payments:

1. A monthly stipend of up to $70,000 annually for full-time support paid directly to the Fellow.
2. A total allowance of $30,000 annually for: a) expenses directly related to the conduct of the research, and/or b) support of fringe benefits, including health insurance provided through either a group plan offered by the host organization or an individual plan secured by the Fellow, dental and/or vision insurance, disability insurance, retirement, dependent care, and moving expenses.

NSF 21-574, Engineering Research Initiation (ERI)

https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=505888&org

The National Science Foundation (NSF) Directorate for Engineering (ENG) seeks to build engineering research capacity across the nation by investing in new academic investigators who have yet to receive research funding from Federal Agencies. The Engineering Research Initiation (ERI) program aims to support new investigators as they initiate their research programs and advance in their careers as researchers, educators, and innovators. This funding opportunity also aims to broaden the base of investigators involved in engineering research and therefore is limited to investigators that are not affiliated with "very high research activity" R1 institutions (according to the Carnegie Classification https://carnegieclassifications.iu.edu/).

The ERI award, including indirect costs, must not exceed $200,000 for a duration of 24 months. The award funds may be used for research expenses, graduate and/or undergraduate student support and Principal Investigator (PI) salary and may include modest equipment cost necessary for the successful conduct of the proposed research.

Meetings and Online Seminars

- **Online LTP Seminar (OLTP)**

  The updated Online Low Temperature Plasma (OLTP) Seminar series schedule for January – June 2021 is available at: https://mipse.umich.edu/ltp_seminars.php. The next seminars in the new series will be presented by Prof. Gerard van Rooij (**April 27, 2021**); and Dr. Gerjan Hagelaar (**May 11, 2021**).

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

  The International Online Plasma Seminar (IOPS) is a non-profit international seminar on low temperature plasma science with bi-weekly sessions via Zoom. The main purpose of the seminar is to make high quality research results in low temperature plasma science available to our community to foster scientific discussion. Based on the speaker's written consent, presentations will be recorded and will be made available for on-demand download. IOPS speakers can be nominated by anybody and are selected by the IOPS committee. The program for IOPS is available at: https://mipse.umich.edu/online_seminars.php. Nominations for speakers for July – December 2021 can also be made from this page.

  The next seminars will be given by Dr. Martin Rudolph and Prof. Ken Hara (**April 22, 2021**); and Dr. Dirk Hegemann (**May 6, 2021**).

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

- **MIPSE (Michigan Institute for Plasma Science and Engineering) Seminar Series**

  The MIPSE seminar series, usually held as an in-person event, is totally virtual this Winter. The seminars during Winter 2021 are covering the full range of plasma topics (not only LTP). The seminars are held on Wednesdays at 3:30 pm (US East Coast Time). The schedule and abstracts can be viewed at https://mipse.umich.edu/seminars_2021.php. Please send a request for the Zoom link to view the seminars to mipse-central@umich.edu. Seminars will be recorded and posted (with slides) at the same website.

  The last MIPSE seminar of the current series will be by Prof. Andrei Smolyakov on **14 April 2021**.

  Past MIPSE seminars (recordings and slides) can be viewed from: https://mipse.umich.edu/seminars.php.

  Interviews of past seminar speakers can be viewed from: https://mipse.umich.edu/life_overview.php.

  Contact:
  MIPSE Central
  mipse-central@umich.edu

- **Atomic and Molecular Data Needs for Plasma Applications Workshop**

The Atomic and Molecular Data Needs for Plasma Applications workshop is to take place on Tuesday to Thursday 13-15 April 2021, with the main programm from 13.00 to 17.00 GMT+1 each day and more informal discussions in the mornings. The workshop is jointly sponsored by the High End Computing (HEC) Consortium UK-AMOR and Collaborative Computational Projects CCPQ and CCP-Plasma

The meeting will focus on both state-of-the-art atomic and molecular data, and practical applications of this data to plasma applications including nuclear fusion. The key objectives will be to:

- Discuss advances in the AMO data that is/will be available
- Expose where plasma applications have the strongest needs to improve this data
- Identify priorities for future work of shared interest.

The workshop also aims to boost effective communications between the communities and to strengthen interdisciplinary links and collaborations.

The workshop is FREE to attend, please read more and register at https://web.cvent.com/event/dbbd439b-6382-48ea-8fc8-fc53f868b001/summary. The registration page also includes opportunities to suggest topics for additional discussion and to register poster contributions which will be displayed electronically throughout the meeting.

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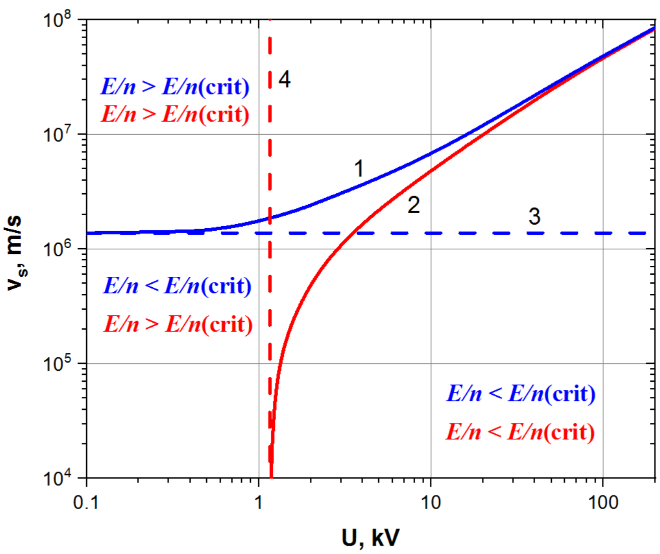
Community Initiatives and Special Issues

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

Limits to Propagation and Deceleration of Positive Streamers



Regions of runaway electron formation at the streamer head in $v_S - U$ space for negative (curve 1, blue) and positive (curve 2, red) polarities. Curve 3 is the asymptotic velocity of negative streamers at low potential of the head. Curve 4 is the minimum potential of the head for positive streamers, allowing their development without formation of runaway electrons. Isolines E/n = 3 kTd are shown.

It was shown that positive and negative streamers behave differently during deceleration and eventual stopping. In both cases, deceleration begins with the loss of a significant portion of the applied potential as a voltage drop across the lengthening channel, which leaves less voltage for the head of the streamer. A positive streamer cannot respond with forward electron drift with this decreasing the head potential, which reduces ionization and photoelectron production rates in front of the head. The only advancement mechanism for a positive streamer is to decrease the effective head radius leading to a local increase in the electric field. This allows the streamer to continue to develop. However, the decrease in the head radius dramatically reduces the photoionization efficiency. This forces the streamer to increase the electric field even more. Estimates show that such a locally enhanced electric field becomes larger than the critical field corresponding to the transition of electrons to the runaway mode when the potential of the head decreases to ~1.2 kV (Figure). A pulsed beam of runaway electrons directed into the channel of the decelerating positive streamer is generated. This mechanism accompanying positive streamer deceleration may explain the recorded bursts of X-ray radiation during the propagation of streamers in long discharge gaps and in the atmosphere.

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Source:
A. Yu. Starikovskiy, N. L. Aleksandrov and M. N. Shneider, J. Appl. Phys. **129**, 063301 (2021). https://doi.org/10.1063/5.0037669

Downsizing Magneto-plasma-dynamic (MPD) Thrusters

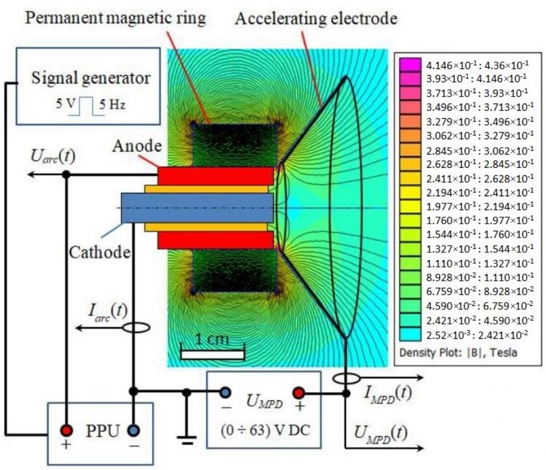

Fig. 1. Schematic of a two-stage μCAT-MPD thruster

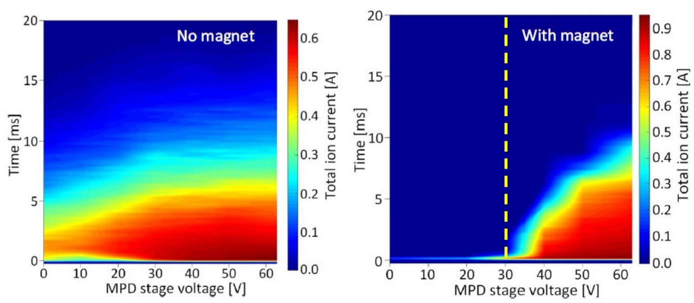

Fig. 2. Ion current exhausting from μCAT-MPD thruster without magnet (left) and with magnetic field (right). Magnetic field ensures the onset of the second stage after certain MPD stage voltage (yellow dashed line).

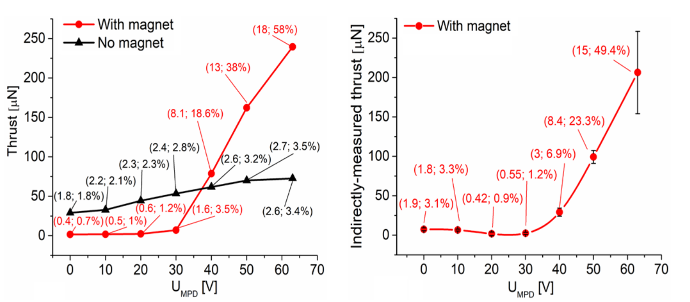

Fig. 3. Estimated thrust (left) of the μCAT-MPD thruster in 'with magnet' and 'no magnet' configurations, and indirectly-measured thrust (right) using the thrust stand in configuration 'with magnet'. The first numbers in brackets mean the thrust-to-power ratio (in μN/W), and the second ones with percent signs mean efficiency, for the respective data points. All values drastically grow after a threshold voltage on the second stage.

Magneto-plasma-dynamic (MPD) thrusters are typically powerful (with an average power within the range of kW to hundreds of kW), high-thrust propulsion engines with an electromagnetic Lorentz force $J \times B$ that accelerates and expels plasma creating the thrust. We propose an ambitious idea to scale down in power and size the applied-field MPD thruster to fit inside a small satellite. This can be done with a two-stage pulsed (up to ms pulse length), cm-sized, low-power (1–30 W) MPD thruster, with the low-power (~several W) first stage based on microcathode arc thruster (μCAT). In such μCAT-MPD configuration, the magnetized vacuum arc discharge demonstrates an interesting threshold behavior. Parameters such as thrust and the thrust-to-power ratio rapidly jump after a certain dc voltage (~30 V) applied on the accelerating electrode. It was demonstrated that such effect improves the thruster performance by increasing the thrust (from ~2 to ~210 μN), efficiency (from ~1% to 50%), and thrust-to-power ratio (from ~0.5 to ~18 μN/W).

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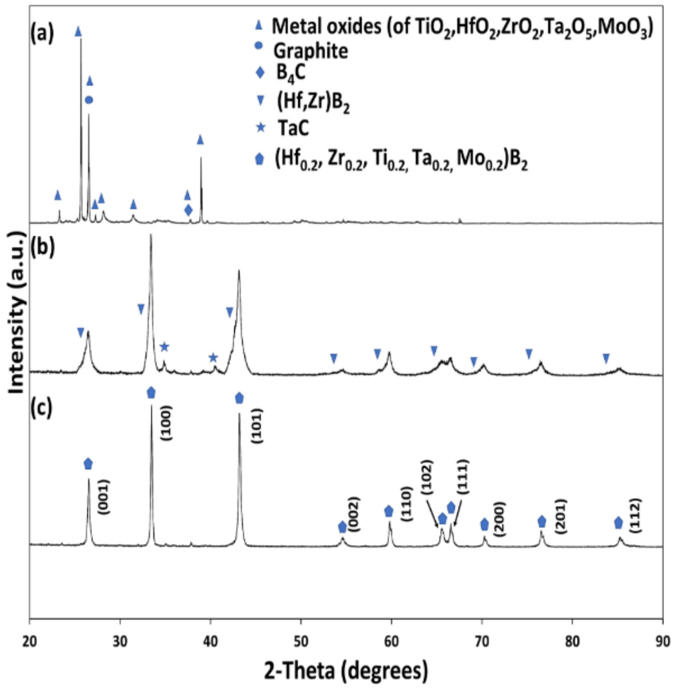
Source:
Phys. Rev. E **102**, No. 2 (2020).
https://doi.org/10.1103/PhysRevE.102.021203

More information:
https://mpnl.seas.gwu.edu/research/propulsion/

Microwave Plasma Synthesis of High Entropy Transition Metal Diborides



XRD of (a) the starting precursor mixture of 5-metal oxides + graphite + B_4C, and of the MW-plasma samples processed at (b) 1800 °C and (c) 2000 °C.

This study explores the boro-carbothermal reduction synthesis of high entropy transition metal diborides via microwave plasma. High entropy diborides are promising materials due to high hardness and resistance to high-temperature oxidation. The use of microwave plasma is a novel approach for high entropy diboride formation that capitalizes on its ability to transfer thermal energy for chemical reactions enabled by low-temperature plasma. Aiming to produce a five-component equimolar diboride, the starting powders consist of metal oxides (HfO_2, TiO_2, ZrO_2, Ta_2O_5, MoO_3) with carbon black blended by high energy ball milling and combined with boron carbide. By annealing the sample using microwave plasma, boro-carbothermal reduction becomes efficient and leads to a single-phase high entropy diboride ($Hf_{0.2}$, $Zr_{0.2}$, $Ti_{0.2}$, $Ta_{0.2}$, $Mo_{0.2}$)B_2 within a single 1hr plasma process.

Future work includes investigating the role that microwave plasma has in the thermal reduction process and to find ways to achieve the high entropy diboride at lower substrate temperature. This will be done by exploring other plasma feed-gas mixtures, substrate biasing, and by varying initial particle size (via milling). Analysis will focus on microstructure, high-temperature oxidation resistance, and hardness.

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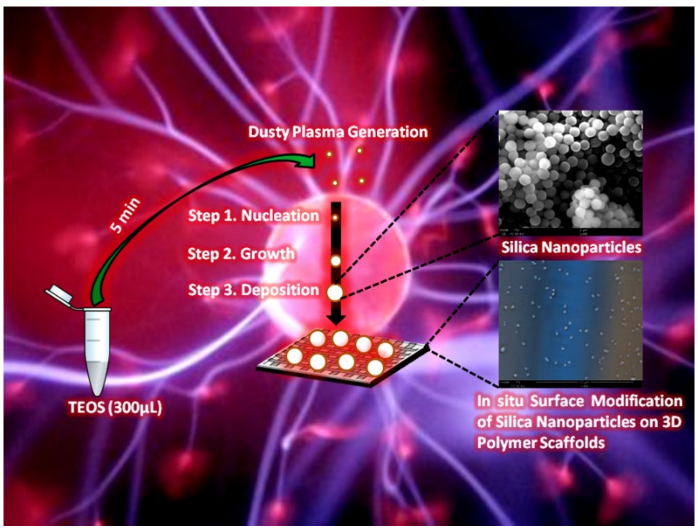
Plasma Enhanced Oxidation (PEO) and Plasma Enhanced Reduction (PER) Toward Surface Engineering of Tissue Scaffolds and Flexible Bioelectronic Materials



An interdisciplinary team at the University of Alabama at Birmingham has developed a new method of surface engineering polymer soft-materials and textiles that has potential to help accelerate bio-integration in tissue scaffolds, applications in plasmonic bioelectronics, and decontaminating personnel protective equipment. The team has utilized *plasma enhanced oxidation (PEO)* and *plasma enhanced reduction (PER)* to oxidize/reduce the precursors in the plasma-phase onto the surface of substrate, irrespective of its nature as metallic/nonmetallic. This is a rapid method for the synthesis of silica nanoparticles (SiNp) from a liquid precursor by PEO into dusty plasma before being deposited as nano-particles onto a 3D-printed polymer. Plasma-enhanced CVD of small amount of a liquid precursor, organosilane, for a short exposure time resulted in the generation of dusty plasma of SiNp with a narrow size distribution.

The team has successfully utilized non-thermal plasma for making super-hydrophilic and blood-friendly material's surfaces. The process described has advantages over existing methods, in that it is a single-step, greener, and more cost-effective process. In addition, the RF reactor can be an ideal scalable technology that industries can use to produce and modify the surface of various biomedical scaffolds or devices with SiNp. This method can also simultaneously modify the 3D printed PLA scaffolds with SiNp for biomedical applications such as bone-tissue engineering and sterilize them. The team is currently investigating functionalization and attachment of plasmonic metal nanoparticles and titania nanoparticles in the plasma phase onto substrates for flexible bioelectronics and anti-microbial surfaces as well as devising strategies for preparation nanoparticles and 1D nanowires and 2D nanosheets.

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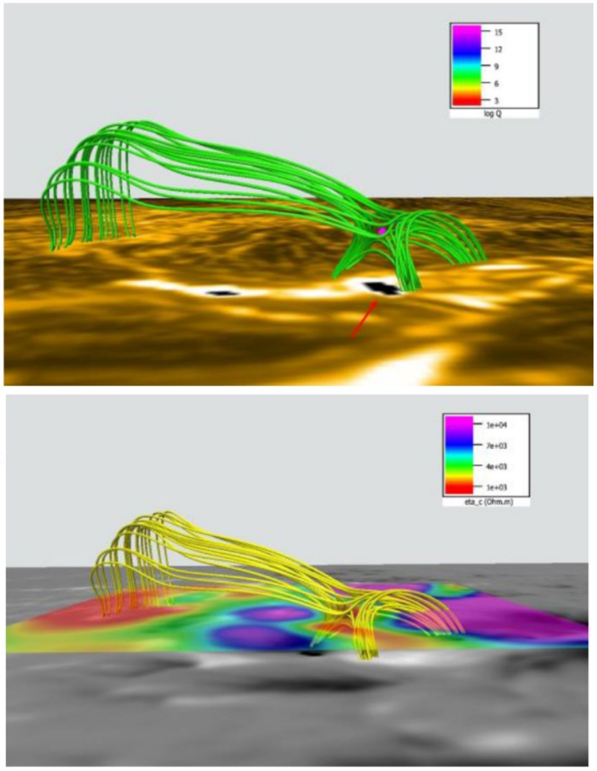
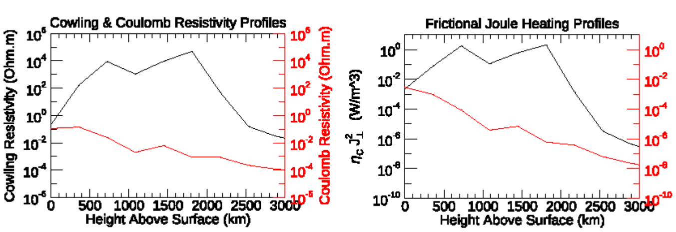
Sources:
V. Vijayan, ACS Appl. Nano Matls. **3**, 7392 (2020).
B. Tucker, Current Op. Biomed. Engr., 100259 (2021).
V. Vijayan, J. Matls. Chem. B **8** (14), 2814 (2020).

Effects of Cowling Resistivity in the Weakly Ionized Chromosphere



(top) Side view of a 3D null point with its spine- fan topology superimposed on an extreme ultraviolet channel 171 Å image from SDO/AIA at 2011 March 10T14:23:36 UT corresponding to a C2.0 flare (indicated by the red arrow). The squashing factor (log Q) contours are shown at the location of the 3D null point, which is at a height of ~1.9 Mm above photosphere. (bottom) Side view of the magnetic field configuration superimposed on an SDO/HMI magnetogram showing AR 11166 at 2011 March 10T14:24 UT and the Cowling resistivity distribution just below the null point. The C.2.0 flare location is at (326,255) arcsec or (N15.34, W20.46) degrees.



Variations of (left) the maximum values of Coulomb and Cowling resistivity profiles with height, and (right) the maximum values of corresponding frictional Joule heating profiles with height at 2011 March 7 T06:00:29 UT.

The physics of the solar chromosphere is complex from both theoretical and modeling perspectives. The plasma temperature from the photosphere to corona increases from ~5,000 K to ~1 million K over a distance of only 10,000 km from the chromosphere and the transition region. Certain regions of the solar atmosphere have sufficiently low temperature and ionization rates to be considered as weakly-ionized. In particular, this is true at the lower chromosphere. As a result, the Cowling resistivity is orders of magnitude greater than the Coulomb resistivity. Ohm's law therefore includes anisotropic dissipation of currents perpendicular and parallel to the magnetic field lines.

To evaluate the Cowling resistivity, we need to know the external magnetic field strength and need to estimate the neutral fraction as a function of the bulk plasma density and temperature. In this study, we determined the magnetic field topology applying the non-force-free field (NFFF) extrapolation technique to SDO/HMI SHARP vector magnetogram data, and the stratified density and temperature profiles from the Maltby-M umbral core model for sunspots.

We investigated the effects of Cowling resistivity on heating and magnetic reconnection in the chromosphere as the flare-producing active region (AR) 11166 evolves. We analyzed a C2.0 flare emerging from AR 11166 and found a normalized reconnection rate of 0.051, in good agreement with observational and numerical results. We also found a significantly thicker reconnection current sheet of 37 km. The heating due to dissipation of currents by Cowling resistivity is 6-8 orders of magnitude greater than heating due to the dissipation of currents by Coulomb resistivity. Cowling resistivity can be used to trace the time evolution of AR features due to its strong dependence on magnetic field strength ($\eta_C \propto B^2$).

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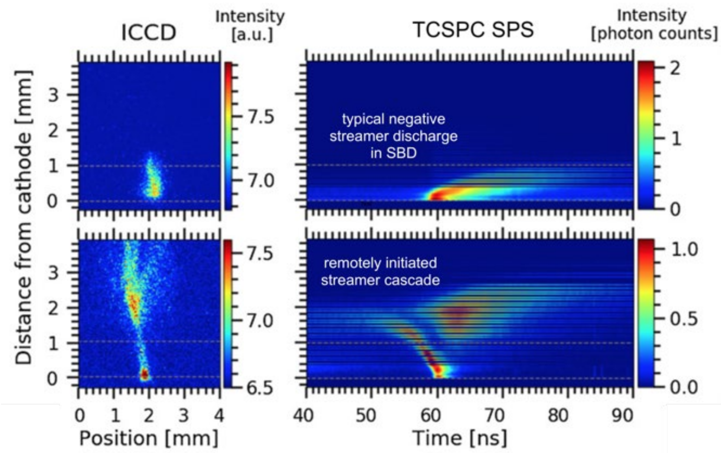
Source:

M. S. Yalim *et al*., Astrophys. J. Lett. **899**, L4 (2020).
https://doi.org/10.3847/2041-8213/aba69a

Ultra-Fast Processes in Surface Barrier Discharges



The ICCD images and results of the TCSPC spatial scans for N_2 second positive system (SPS) for the negative half-period discharges. The bottom images are recorded microseconds later than the top images. For the TCSPC spatiotemporal recordings, the intensity is given in thousands of counted photons, but not scaled as different discharge events have different statistics. Some of the axial coordinates were not scanned, thus the black horizontal lines in the spatiotemporal distributions.

Surface barrier discharges (SBD) are widely used sources of non-equilibrium plasma in many applications: plasma-assisted combustion, flow control or surface treatment, to name a few. In this study, we investigated the origin of filamentary patterns in a sinusoidally driven surface barrier discharge at high over-voltage in atmospheric pressure air. Using time-correlated single-photon counting (TCSPC) based optical emission spectroscopy, we revealed ultrafast processes within generated discharges with both polarities of the applied voltage. For negative polarity, we observed initiation of a complex streamer cascade which emerges far from the bare cathode. This event is responsible for long filamentary structure detected by an intensified CCD camera imaging and transfers an exceptionally large electrical charge. It constitutes another, previously unknown, mechanism contributing to the charge-transfer equilibrium in studied periodic discharges. The event is dominated by long positive streamers propagating towards the cathode. It leads to the formation of an intense cathode spot, a critical condition for plasma-transition into a highly ionized state. Our belief is that these measurements and proposed mechanism also help to clarify the issue of initiation of hot-filaments in high-pressure high over-voltage repetitive-pulsed SBDs used for air-flow control or in the field of plasma-assisted combustion.

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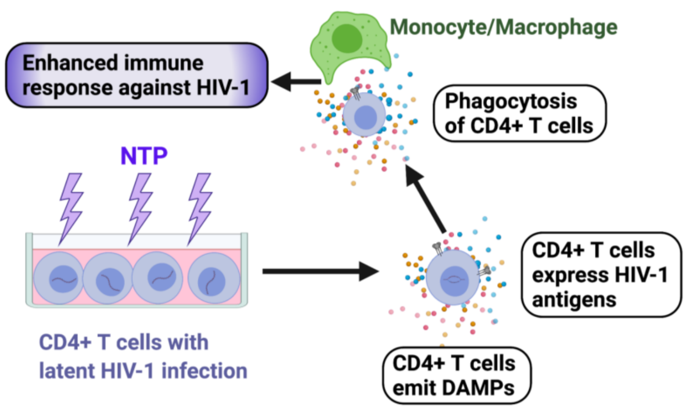
Source:
Plasma Sources Sci. Technol. **30**, 03LT02 (2021). https://doi.org/10.1088/1361-6595/abe4e2

Non-thermal Plasma Modulates Cellular Markers Associated with Immunogenicity in a Model of Latent HIV-1 Infection



In this study we investigated non-thermal plasma (NTP) as the basis for an immunotherapy for patients who continue to harbor HIV-1 as latently infected cells despite effective virus suppression by anti-retroviral therapy (ART). If ART is withdrawn, the infection and accompanying disease symptoms reemerge due, in part, to failures of innate and cytotoxic T lymphocyte responses to clear infected cells. Control of HIV-1 infection without ART may be possible if the suboptimal immune responses can be boosted. Our studies demonstrated that application of NTP to J-Lat cells (a model for latently HIV-1 infected T lymphocytes) stimulated viral gene expression, altered the array of peptides displayed on NTP-exposed cells, and increased the cell surface presence of MHC I and co-stimulatory molecules. These effects are vital steps that promote the recognition of infected cells by the host immune system.

NTP exposure of J-Lat cells also stimulated emission of damage-associated molecular patterns (DAMPs), which increase their immunogenicity. DAMPs emitted by NTP-exposed cells included pro-inflammatory interleukin-1β (IL-1β) and interferon-γ (IFN-γ), as well as pro-phagocytic markers calreticulin (CRT) and heat shock proteins (HSP) 70 and 90. The functional relevance of these DAMPs was evident in the enhanced phagocytosis of NTP-exposed J-Lat cells by macrophages. These effects should facilitate a more effective adaptive immune response *in vivo*. Implementation of our proposed immunotherapeutic method for controlling HIV-1 would rely on *ex vivo* application of NTP to the patient's own HIV-1 infected cells to increase their immunogenicity. The cells would then be injected back into the patient as a "personalized vaccine" to stimulate innate immune responses and a robust cytotoxic T lymphocyte response. The envisioned approach would prevent reemergence of infection without the need for ART.

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Source: https://doi.org/10.1371/journal.pone.0247125

Generation of Large Volume Plasma Jet in Atmospheric Pressure Air Plasma Torch Implementing Plasma Thruster Action

Air plasma torch operating at just 22 kW discharging a plasma jet of length more than 600 mm though implementation of plasma thruster action.

One of the most important weaknesses of thermal plasma technology is its energy intensive nature. In spite of numerous unique advantages, easy availability of competing technologies at lower cost has caused many thermal plasma industries to shut down permanently. To make these industries competitive and more economic, there is an intensive thrust in the area to develop low cost thermal plasma devices that produce large volume high temperature plasma while consuming low electrical power.

The present development contributes towards this goal by developing a large volume self-propagating plasma jet implementing plasma thruster action in the external plasma jet itself. Specific design features of the torch ensure arc current extension in the external jet that automatically occurs in the thruster action in the tail region through interaction of transverse arc current with the magnetic field produced by the adjacent longitudinal current component. The torch operates with hafnium insert cathode and copper anode. A small compressor takes air from atmosphere into the torch at a flow rate of just 30 slpm to form the large plasma jet. Featured operation at low current (< 200A) and high arc voltage (>150V) avoids use of thick current cables and allows easier handling. The device, currently being used in solid waste management, has tremendous potential in the waste to energy sector.

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Source:
S. Ghorui, IEEE Transactions on Plasma Science **49**, 578-596 (2021). doi:10.1109/TPS.2020.3006023.

Analytical and Experimental Studies of Plasma Thermal-Chemical Instability

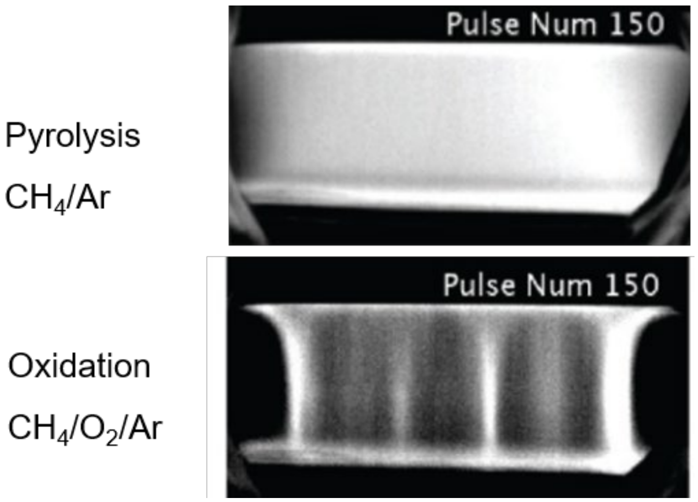

Figure 1. CMOS images of a single burst of the plasma discharge. The fuel and oxygen mole fractions are held constant (6.66% CH_4, 13.34% O_2) with argon added to fill the remaining mole fraction when a mixture component is removed. Intensities are not to scale, for the pyrolysis case camera gain is reduced to prevent saturation.

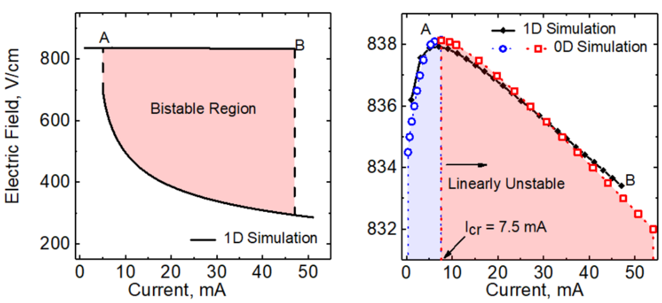

Figure 2. Left: An example current–voltage characteristics using the one-dimensional simulation in a N_2–O_2 mixture. p = 70 Torr and T_0 = 400 K. Convective time scale τ = 1 ms. Right: the comparison of the homogeneous branch of the current–voltage characteristics using zero-dimensional and one-dimensional simulation under the same condition. The linearly stable (in blue) and unstable (in red) region are separated by the stability boundary. The critical current in this case is 7.5 mA.

The control of instabilities in weakly ionized plasma is of great importance in plasma-assisted combustion, fuel reforming, catalysis, and material synthesis. High speed videos of single bursts of a CH_4-containing nanosecond pulsed dielectric barrier discharge plasma were captured with and without oxidizer in a transverse gas flow (Fig. 1). The plasma uniformity was significantly modified by fuel oxidation as compared to fuel pyrolysis. A possible thermal-chemical instability (TCI) mechanism was proposed to account for the rapid formation of streamers from an originally uniform discharge in a chemically reactive flow. An analytical criterion for the on-set of TCI was developed, suggesting the impact of plasma aided chemical reactions on the formation of instability. This thermal-chemical instability was further investigated with quasi-neutral plasma modeling, stability analysis and thermal-chemical mode analysis (TCMA).

The stability analysis indicates that chemical kinetics will modify the bifurcation point and the hysteresis region of the original thermal-ionization mechanism in the current-voltage curve (CVC) (An example of CVC of air is shown in Fig. 2). From chemical mode analysis, a variety of time scales from millisecond to sub-microsecond and their related kinetics are involved for triggering such instabilities. Kinetic pathways and chemical modes of the fuel oxidation by vibrational and electronically excited species were important during the formation of this thermal-chemical instability. These investigations provide insights and guidance for controlling plasma instability using chemical kinetics.

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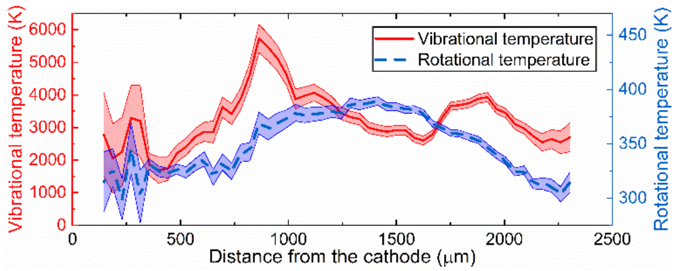
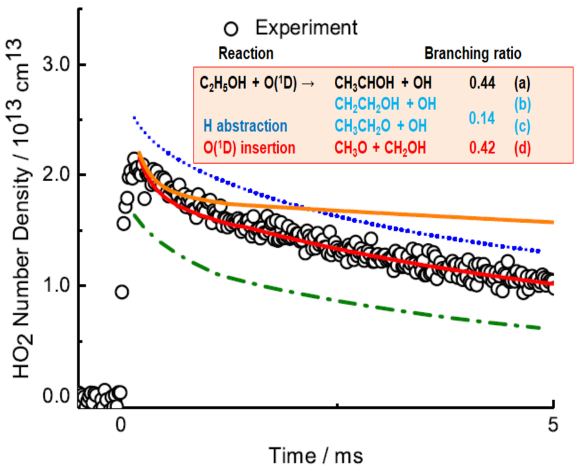
Sources:
A. C. Rousso, Plasma Sources Sci. Technol. (2020). https://doi.org/10.1088/1361-6595/abb7be
H. Zhong *et al.*, J. Phys. D: Appl. Phys. (2019). https://doi.org/10.1088/1361-6463/ab3d69
H. Zhong *et al.,* Plasma Sources Sci. Technol. (2021). https://doi.org/10.1088/1361-6595/abde1c

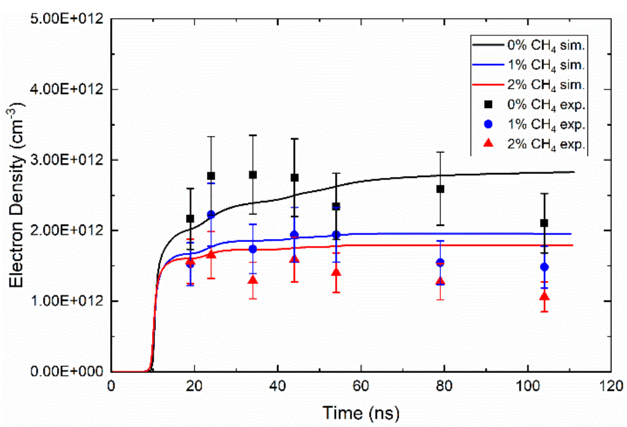
Time-resolved Laser Diagnostics for Studying Non-equilibrium Plasma Chemistry and Dynamics



a)



b)



c)

(a) Spatial distribution of the rotation and vibrational temperature of N_2 in a pulsed CH_4/N_2 plasma. **(b)** Time-resolved HO_2 measurement with 50 kHz time resolution and the measured branching ratios of $O(^1D)$ reaction with ethanol by fitting experimental data. **(c)** Thomson scattering measurements and numerical model predictions of the electron number density in a He nanosecond-pulsed dielectric barrier discharge for varying CH_4 concentration.

The time-evolution of rotation-vibration non-equilibrium, electron density and temperature, and radical species concentrations are critical for understanding plasma chemistry. Here, we highlight our recent work in measuring these parameters using in situ laser diagnostics. First, spatially resolved 1-D imaging of both rotational and vibrational temperatures was simultaneously performed using pure rotational hybrid femtosecond/picosecond coherent anti-Stokes Raman scattering (fs/ps CARS). This enables measurement of rotation-vibration non-equilibrium with high temporal and spatial resolution near surfaces such as in plasma catalysis (Fig. a).

Next, in plasma chemistry, $O(^1D)$ and HO_2 are important intermediate species but their reaction kinetics are not well-explored due to spectral interferences. Here we used Faraday rotation spectroscopy for selective and sensitive HO_2 measurements, which further enables direct measurements of the reaction kinetics of $O(^1D)$ with hydrocarbons and oxygenated fuels (Fig. b). Lastly, we have used laser Thomson scattering recently and studied how the electron density and temperature change with CH_4 addition to a He nanosecond-pulsed discharge. This data was then compared with numerical simulations which reproduced the non-linear trend in electron properties with CH_4 concentration (Fig. c).

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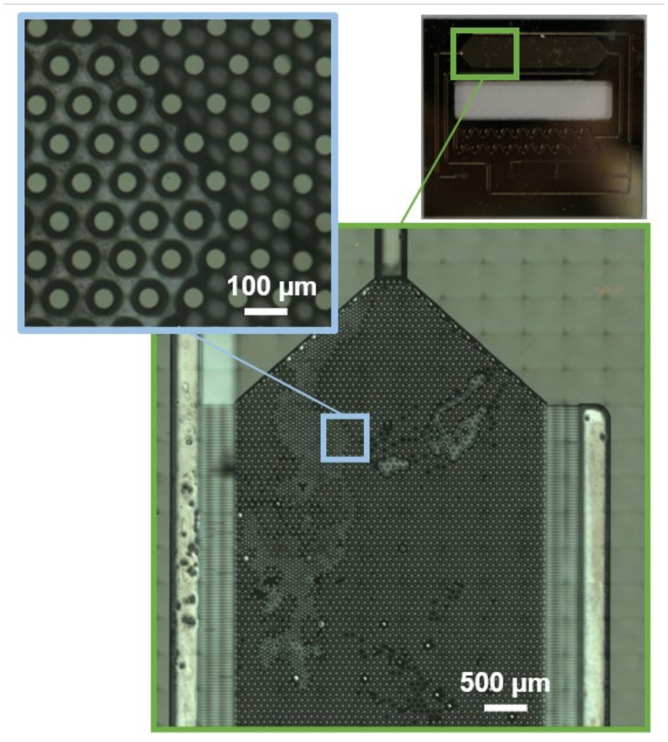
Sources:

https://doi.org/10.1364/OL.394122
https://doi.org/10.1364/OE.413063
https://doi.org/10.1088/1361-6463/ab0598
https://doi.org/10.1002/kin.21474
https://doi.org/10.1016/j.combustflame.2019.10.034

A Counter-current Membrane, Micro-packed-bed Dielectric-barrier-discharge Plasmatron



A counter-current membrane, micro-packed-bed dielectric-barrier-discharge plasmatron was designed and characterized. The µ-plasmatron was then applied to study flash chemistry with atmospheric nonthermal plasma.
Gas-liquid two-phase flows within the µ-reactor were described by residence time distribution modeling, to ascertain the extent that axial dispersion would have on the measurement of reaction kinetics with the microplasmas. Microscope images of 2D multiphase flows in the packed bed microplasmatron were also obtained and pieced together, to visualize gas-liquid interfaces in the packed-bed region. Successful formation of methyl radicals was verified in-situ by optical emission spectroscopy, which creates a new experimental method for the study of plasma catalytic reactions.

Direct addition of methyl radicals to the metal center of a homogeneous cobalt catalyst was confirmed by characteristic Raman shifts. These findings underpin the exciting prospects of methane plasmas in organometallic synthesis, which remains a vastly unexplored area of chemical catalysis. In the context plasma physics, our results demonstrate that "flash chemistry", or reactions that occur in short time scales, can be studied with multiphase microplasmatrons, where transport limitations in conventional reactor designs could be expected to influence the overall rate of reaction.

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Source:
J. Phys. D. Appl. Phys. **54**, 194003 (2021).
https://doi.org/10.1088/1361-6463/abe488

More information: https://wp.nyu.edu/hartmanlab/

Sustainable Gas Conversion by Gliding Arc Plasmas: A New Modelling Approach for Reactor Design Improvement

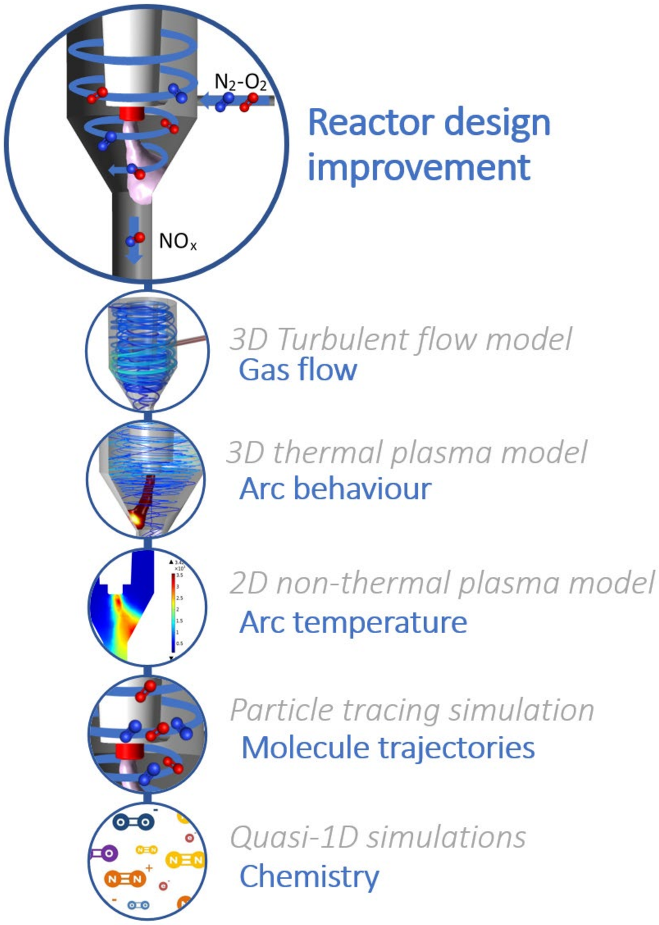

Illustration of the modelling approach, consisting to five complementary models, for describing plasma-based NO_x production in a rotating gliding arc plasma reactor.

Plasma technology is gaining increasing interest for sustainable gas conversion applications. In this paper, we presented a new modelling approach for the design of a gliding arc plasma reactor, revealing the fluid dynamics, arc behavior and plasma chemistry by solving a combination of five complementary models. This approach allows one to efficiently evaluate the performance of a plasma reactor and indicate possible design improvements before actually building it. We demonstrate the capabilities of this method for plasma-based NO_x formation in a rotating gliding arc reactor. The model demonstrates the importance of the vortex flow and the presence of a recirculation zone in the reactor, as well as the formation of hot spots in the plasma near the cathode pin and the anode wall that are responsible for most of the NO_x formation. The model also reveals the underlying plasma chemistry and the vibrational non-equilibrium that exists due to the fast cooling during each arc rotation. Good agreement is reached with experimental measurements.

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Source:
Sustain. Energy Fuels **5**, 1786-1800 (2021).
https://doi.org/10.1039/D0SE01782E

Transport of Gaseous Hydrogen Peroxide and Ozone into Bulk Water vs. Electrosprayed Aerosol

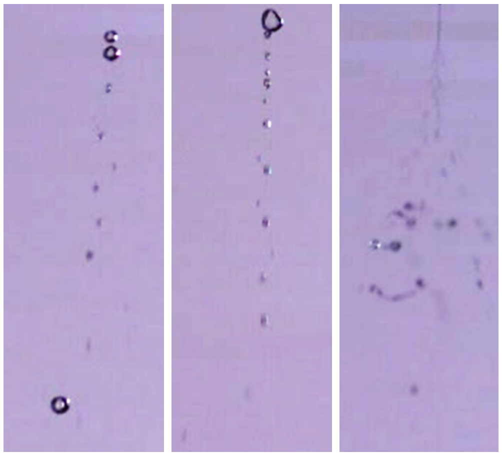

Figure 1. Examples of electrosprayed water droplets with high speed imaging for 300 μL/min water flow rate and different voltages: (left) 9 kV; (middle) 11 kV; (right) 13 kV.

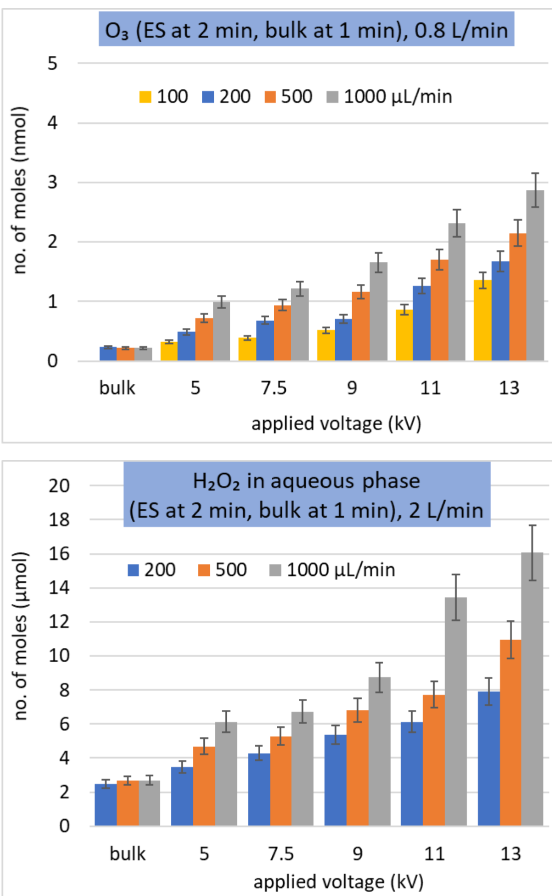

Figure 2. Solvation of O_3 and H_2O_2 from 450 ppm or 110 ppm of O_3 or H_2O_2 in an airflow. Different water flow rates (μL/min) during different treatment times (min) in electrospray (ES) and bulk water solvation.

Production and transport of reactive species through plasma–liquid interfaces play a significant role in multiple applications in biomedicine, environment, and agriculture. Experimental investigations of the transport mechanisms of typical air plasma reactive species: hydrogen peroxide (H_2O_2) and ozone (O_3) into water are presented. Solvation of gaseous H_2O_2 and O_3 from an airflow into water bulk vs. electrosprayed microdroplets was compared, while changing the water flow rate and applied voltage, during different treatment times and gas flow rates. The solvation rate of H_2O_2 and O_3 increased with the treatment time and the gas–liquid interface area. The total surface area of the electrosprayed microdroplets was larger than that of the bulk, but their lifetime was much shorter.

We estimated that only microdroplets with diameters below ~40 μm could achieve saturation by O_3 during their lifetime. The saturation by H_2O_2 was unreachable due to its fast depletion from air. In addition to the short-lived flying electrosprayed microdroplets, the longer-lived microdroplets collecting at the reactor bottom and walls substantially contributed to H_2O_2 and O_3 solvation in water. The experimental results were compared with simple theoretical considerations. We experimentally demonstrated and theoretically explained that Henry′s law coefficient is not the only important parameter determining the solvation of highly and lowly soluble (H_2O_2 and O_3) gaseous species into the water. This study contributes to a better understanding of the gaseous H_2O_2 and O_3 transport into water and will potentially lead to design optimization of the water spray and plasma-liquid interaction systems.

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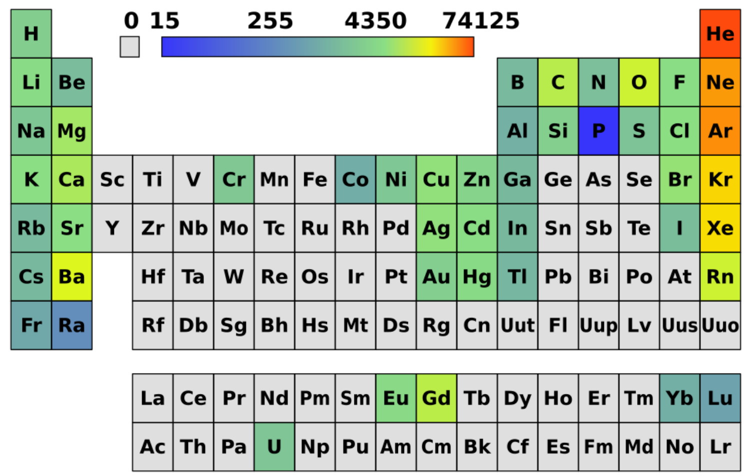
Source:
Water **13**, 182 (2021).
https://doi.org/10.3390/w13020182

New Resources

- **A Tutorial Review on the LXCat Project: Status and Perspectives**

Non-equilibrium low temperature plasma (LTP) modeling requires very large amounts of data. Accessibility, sourcing, traceability and evaluation of data are therefore key components for reliable and reproducible modeling of LTP. In a recently published, open-access, tutorial review [1], an overview is given of the data types present in the various datasets curated by contributors to the LXCat project (www.lxcat.net) and available tools on the website. A brief history of the LXCat project and its current status are given. The review is mainly focused on the electron component of plasmas for LTP modeling; best practices are given for accessing data on the LXCat website and referencing it; and some of the common pitfalls in data usage for plasma modeling are discussed. Properly referencing the data is also critical for traceability as well as for the survival of open-access data sharing projects. The policy for data reuse and referencing is described with some additional new details for more clarity. This review should be useful for new users as well as more experienced users. A YouTube video tutorial (www.lxcat.net/tutorial) for first-time users of LXCat is provided complimentary to the paper.



Heatmap of the number of records on the LXCat website listed by atomic elements showing the variety of elements and species being currently recorded in the databases of the LXCat project [1].

A (successful) database is not only about the data but also about the tools that are provided for analyzing the data and how the data is interfaced with a website or online calculation tools. The LXCat team appreciates very much the feedback from the LTP community and always seeks new contributions/contributors (e.g. data, tools,…). The present design and implementation of LXCat have served the community well for many years. However, as the complexity of the datasets has grown, it has become clear that further improvements to the backend may substantially improve the LXCat user experience. In particular, ongoing work is focused on enabling more timely improvements and additions to LXCat. In the past year the LXCat team has identified several bottlenecks, extracted a set of specifications for a new version of LXCat, and prototyped these ideas. In this paper, a flavor of the results from this work is provided. Feedback and involvement from members of the LTP community are critical for the next steps of the project and we look forward to new input!

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[1] Carbone, E., Graef, W., Hagelaar, G., Boer, D., Hopkins, M. M., Stephens, J. C., Yee, B. T., Pancheshnyi, S., van Dijk, J.; Pitchford, L., "Data Needs for Modeling Low-Temperature Non-Equilibrium Plasmas: The LXCat Project, History, Perspectives and a Tutorial", Atoms **9**, 16 (2021). https://doi.org/10.3390/atoms9010016

- **PhD candidate, Ghent University, Photonics Research Group and Research Unit Plasma Technology: On-Chip Integrated UV Microplasma Sources (Ghent, Belgium)**

We are looking for PhD candidate to develop and study on-chip micro plasma sources for biological applications in joint project between Research Unit Plasma Technology and Photonics team of the Ghent University (Belgium).

GHENT UNIVERSITY

UV light has strong potential for biological and medical investigations but still has a limited application. One of the main bottlenecks is the lack of efficient UV light sources. To tackle this issue, the Photonic Research Group (PRG) and the Research Unit Plasma Technology (RUPT) have launched an interdisciplinary activity consisting in coupling UV photonic integrated circuits with micro plasmas emitting at UV wavelengths. By combining their respective expertise, PRG and RUPT expect major breakthroughs in the fields of UV spectroscopy on chip.

The PhD position will mainly focus on engineering and studying on-chip micro-plasmas by fast imaging methods, spectroscopy techniques and modelling. The student will work in close cooperation with world leading team of Photonics from Ghent University. We are looking for candidates with a MSc degree in electrical engineering or applied physics. A good background in photonics or plasma physics, spectroscopy, or good experimental skills are desirable. The PhD student will be able to gain experience in areas such as chip design, clean room processing, plasma physics, plasma generation, optical imaging, and UV spectroscopy.

Work for an interdisciplinary project on cutting edge of science; international team; competitive scholarship (1900-2300 EUR); access to the state of the art equipment!

The Research Unit Plasma Technology (RUPT), founded by Prof. C. Leys, has built up an internationally recognized expertise in the field of cold atmospheric pressure plasmas. The successful development of different plasma generation concepts has launched RUPT into numerous interdisciplinary collaborations exploring a wide range of applications in environmental technology and materials science. Micro-photonic applications are considered a strategic extension for RUPT to explore new plasma physics. The different research tools, such as Xray photoelectron spectroscopy (XPS), atomic force microscope (AFM), plasma chambers, various power generators, optical imaging systems and UV spectrometers are available at RUPT.

Apply through the contact person:
Dr. Anton Nikiforov
Ghent University
Anton.Nikiforov@UGent.be

- **Computational Plasma Physicist, Applied Materials, Inc. (Santa Clara, CA, USA)**

A career opportunity in computational plasmas physics is available at Applied Materials. Requires in-depth knowledge and experience in computational plasma physics, computational electromagnetics (EM), or related areas. Additional knowledge of plasma materials processing and computational methods is valuable but not essential. The successful candidate will use best practices and technical knowledge to improve design and understanding of semiconductor processing equipment.

Key Responsibilities:

- Perform plasma and/or electromagnetics (EM) modeling of plasma chambers to provide better understanding of plasma/EM behavior during concept & feasibility, design and development of the semiconductor processing equipment.
- Develop, modify and test internal plasma, EM, and related codes as needed.

- Perform engineering analysis. Recommend design modifications to improve Plasma/EM behavior to address technical/business needs.
- Apply internal and/or external codes to address plasma/EM related problems as needed.
- Present modeling results and recommendations to product development team.
- Provide technical expertise in plasma physics and/or EM as valuable resource.

Problem Solving:

- Solves complex plasma physics and/or EM problems; judiciously interprets results; provides recommendation based on analysis.

Interpersonal Skills and Qualifications:

- Explains difficult information; works in a team environment.
- Education: Masters or PhD with 0 – 3 Years of relevant experience.

Contact:
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- **Plasma Polymer Deposition Scientist at General Atomics (San Diego, CA, USA)**

We currently have an exciting opportunity for an experienced Thin Film Scientist within our Inertial Fusion Technology (IFT) group. This position participates in the development, production, characterization and analysis of novel materials required for laser driven fusion research. The ideal candidate under general supervision with limited review, is responsible for determining and developing effective approaches for resolving a wide range of Plasma Enhanced Chemical Vapor Deposition (PECVD) coating challenges, employing techniques to build complex targets with minimum defects. Assignments are normally outlined in terms of overall objectives, customer specifications, and anticipated delivery dates. Deliveries typically involve the physical targets, comprehensive metrology data packages and shipping documents.

- Translate customer specifications into practical fabrication plan with best product quality while minimizing production cost.
- Perform PECVD coatings, including rate check, composition optimization, stress optimization, and contamination control. Deposition of plasma polymer coatings utilizing Glow Discharge Plasma CVD is an integral component of this position.
- Perform characterization of coating defects, composition, films stress, and substrate roughness by using Atomic Force Microscopy, Dark Field Microscopy, Xray fluorescence, and Interferometry.
- Explore new scientific methods and adapt to the production and characterization of targets.
- Pursue research projects under the direction of senior staff and management. Work with and provide support to the wider IFT team and national laboratory collaborators in the above topic areas.
- Work with a high degree of independence in project management while incorporating inputs and constraints from others in a team environment.
- Develop new deposition techniques for advanced multilayer coatings.
- Perform failure analysis, implement and carry out mitigation plans in timely manner.
- Perform equipment maintenance, repair and upgrade. Maintain safe, clean and organized coating laboratories.
- Document findings, communicates results to scientific staff and makes technical presentations as required. Publish in recognized scientific journals, present work at conferences.
- Performs other duties as assigned or required.

We recognize and appreciate the value and contributions of individuals with diverse backgrounds and experiences and welcome all qualified individuals to apply.

Job Qualifications:

- Typically requires a Bachelor's degree, Master's degree or PhD in a scientific or related technical field in the physical sciences and progressively complex scientific experience.
- Prior hands-on experience in coating equipment and PECVD/PVD coating processes highly desired.
- Experience with experimental design and analysis, including statistically driven methods and software tools (e.g., DOE, JMP, or similar tools) is highly desired.
- Prior experience working in a cleanroom environment is helpful.
- Software experience can be helpful, such as LabVIEW, SolidWork, AutoCAD.
- Ability to obtain and maintain a DOE security clearance is highly desired.

Contact:
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- **Product Specialist – Plasma, Comsol, Inc. (Burlington, Massachusetts, USA)**

COMSOL, Inc. is seeking a specialist to strengthen the development team in its Burlington, MA office. We are seeking an individual with a strong background in plasma simulations. The primary responsibility of this position is to enhance the capability of the Plasma Module, an add-on product to COMSOL Multiphysics®. In this position you will identify and create new key features for the Plasma modeling toolset. You will create new example models relevant for industrial plasma applications. You will write detailed technical specification and documentation for new functionality. You will support our Plasma Module customers by providing guidance, advice, and modeling assistance.

Requirements:

- At least 4 to 6 years of combined academic and professional experience in plasma physics (Ph.D. with 0+ years of experience, or M.Sc. with 4+ years of experience).
- Demonstrated expertise in plasma simulations using fluid-type models.
- Solid background in plasma physics.
- Strong written and verbal communication skills.

Meriting Skills and Experiences:

- Solid background in physics areas relevant to plasma physics: chemical reacting flow, electromagnetism, heat transfer, surface chemistry, and kinetic theory.
- Familiarity with COMSOL Multiphysics®.
- Experience with user interface design.

COMSOL Offers:

- A challenging opportunity to expand your knowledge in a wide variety of physics application areas and to work on problems spanning multiple engineering fields.
- Highly creative and qualified teams with a diversity of experience.
- Great career opportunities at a fast-paced, high-tech software company.
- Casual atmosphere in a spacious office, with free access to gym.

Apply at: https://www.comsol.com/company/careers/job/5491/

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Collaborative Opportunities

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