International Low Temperature Plasma Community

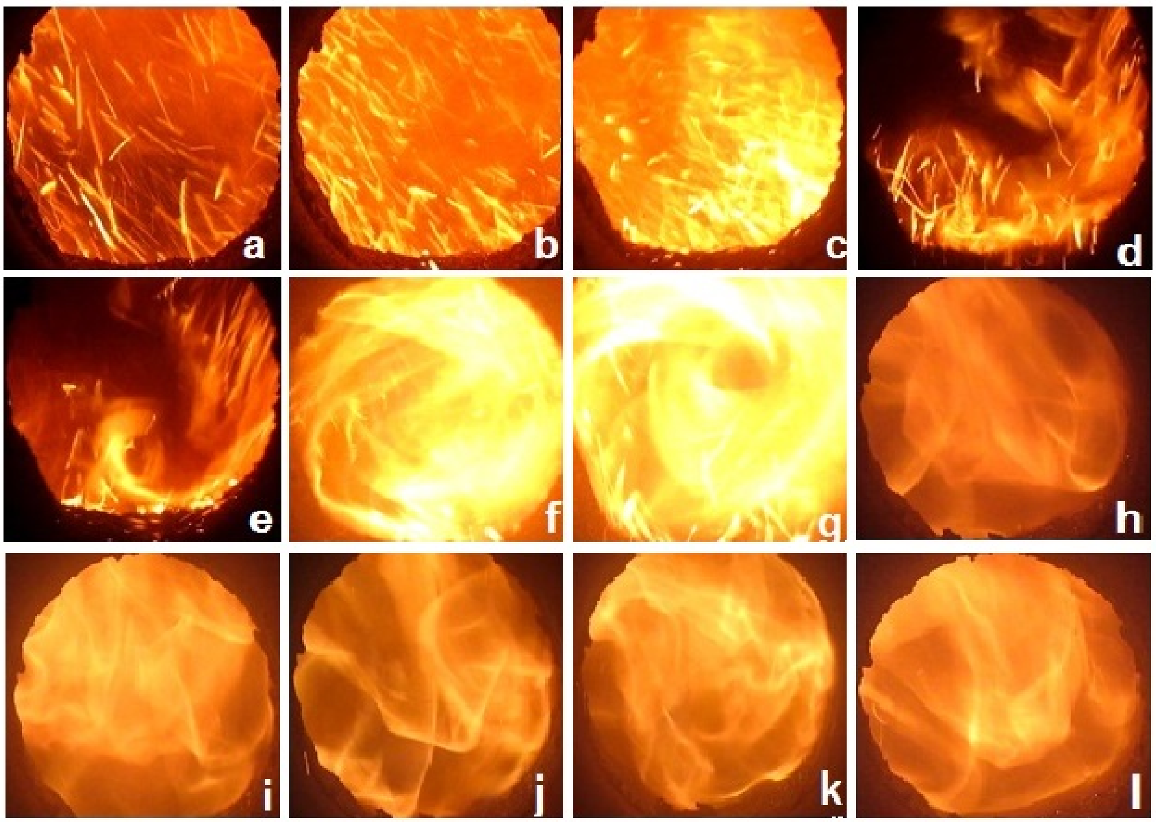
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 15

12 July 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.



Ion exchange resins are composed of polystyrene cross linked by divinylbenzene and are widely used in water treatment. The ction types are used in treatment of water for removal of ions of magnesium, calcium, heavy metals etc., and the anion types are used in removal of contaminants like nitrate, fluoride, sulfate, and arsenic. Mineral scaling, and surface clogging degrade the resins over time and generate tons of spent resin as solid waste, disposal of which is a critical global issue. High temperature incineration is considered as one of the best disposal routes. While it is difficult to handle such resin in normal incinerators, the images exhibit almost instant gasification of resin achieved in a high temperature plasma gasifier of 3 ton per day capacity, recently developed at Thermal Plasma Technologies Section of Laser & Plasma Technology Division, BARC, Mumbai.

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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 **August 13, 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 The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related.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

Management and Science Policy are Essential to Optimize Research Outcomes

Looking at the profiles of the leading figures of our community, it is clear that there are many ways to make an impact on a given research field. Some prefer to investigate new ideas and applications, with a deep curiosity for the interfaces with other disciplines, while others focus on consolidating core knowledge, either by challenging well-established theories, or by revisiting classic experiments with a fresh view and modern diagnostics. The same diversity applies to the resources needed to achieve different research goals. Some researchers manage large teams with many students and post-docs, while others work in smaller groups, often staying with the same few colleagues for their entire career. Some experimental facilities require many years and millions of dollars to become operational, while a theoretician may need only a pencil and modest financial support for travel expenses.

One could suppose that these different career paths are a consequence of individual personalities, and that research diversity and quality result from the sum of these individual talents. However, they are also the result of the specific funding opportunities that are available. It can be challenging to win support from a national research agency (or foundation) to work on subjects identified as “old science”. Likewise, it may be difficult to convince reviewers to endorse a research proposal at the interface between established disciplines.

All of the above emphasises that in order to optimise research outcomes, it is crucial to involve people with substantial research experience in the management of science, and more importantly in the development of research policy. All governments, along with their research agencies, have their own research support strategies and ideas about which fields should be prioritised. These strategies are elaborated with the help of scientists who have opted to dedicate part (sometimes a very large part) of their time to this process. Many scientists prefer to avoid management, choosing to dedicate their time to conducting cutting-edge research and writing important papers. The very process of scientific education tends to select those who prefer to avoid subjective decision-making and conflict management. Nevertheless, the participation of highly experienced researchers in this process is essential. Every senior researcher should therefore ask themselves whether they could contribute more to science by participating in the development of better science policy, rather than by writing one more good paper.

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Françoise Massines – From Homogeneous Dielectric Barrier Discharges to Nanocomposites Coatings by Atmospheric Pressure Plasma

Françoise Massines is a French physicist and research director at the French National Scientific Research Centre (CNRS). She is currently at the Processes, Materials and Solar Energy (PROMES) laboratory located in Perpignan (France) and she is considered as a pioneer in the study and application of homogeneous atmospheric pressure plasmas. Between 1984 and 1989, she worked for the Institut des Matériaux Industriels du National Research Council Canada on the characterization of polymers with ultrasound. She defended her doctoral thesis in applied science on the same subject in 1987. Since she joined the CNRS in 1989 at the Toulouse Electrical Engineering Laboratory (LGET), her research activities have been focused on cold plasmas at atmospheric pressure and their interaction with solids such as polymers or photovoltaic cells. While studying plasma polymer interactions using the corona process, she became convinced that the filamentary regime was not the right path. Prof. Okazaki Satiko, a Japanese colleague, then published an article in which she claimed to have achieved a homogeneous discharge in helium at atmospheric pressure. Dr. Massines decided to reproduce this work, and above all, she decided to focus on the understanding this phenomenon. While working with research director Pierre Ségur, who was developing models for her experiments, she discovered that the time it takes to bring the gas back to equilibrium plays a role: what is called the memory effect. She then tried to transpose this process into nitrogen. She was successful, resulting in the discovery of diffuse atmospheric pressure discharges in nitrogen using a Dielectric Barrier Discharge (DBD).

This discovery has opened the door to many studies worldwide on the physics of diffuse DBDs in nitrogen and their applications. Thanks to the long-lasting and successful collaborations with Pierre Ségur, she demonstrated that the diffuse DBD in nitrogen is a Townsend discharge (like at low pressure). She identified the conditions to obtain this regime and, in particular, the role of the long-live excited species $N_2(A)$. At the same time, she started to work on plasma coating with diffuse DBD to realize homogeneous dense or porous thin films.

In 2007, Dr. Massines joined the PROMES laboratory, opening a new chapter in her career. She oriented her activities to Atmospheric Pressure Plasma Enhanced Chemical Vapor Deposition (AP-PECVD) for photovoltaic applications and played a key role in the development of novel large area plasmas sources. Dr. Massines started to work in argon mixtures with excitation frequencies up to 13.56 MHz. However, she has never stopped studying plasma-surface interactions aimed at optimizing surface treatment and simplifying the process conditions and reactor configuration. She has lately been focusing on the nano-structuring of AP-PECVD thin films.

Dr. Massines' contribution to the field of atmospheric pressure plasma physics and surface treatment is evidenced by numerous invitations to present her work at international conferences and her large number of citations (more than 4000). Her involvement in large industrial collaborations has resulted in more than 10 patents. In 2014, she received the CNRS silver medal for her pioneering work in atmospheric pressure plasma technology. In 2015, she was made Knight of the Legion of Honor.

With more than 70 students since the beginning of her career, Françoise is actively involved in the training of students and young researchers. She has influenced several generations of fellows who now hold prestigious posts in industries and universities around the world. Her main quality is undoubtedly to always bring out the best performance of each and every member of her team.

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Tribute to Prof. Yuri Raizer

With deep sadness we announce that on June 25, 2021 our teacher and colleague Yuri Raizer passed away.

Several generations of gas dynamics and plasma physicists studied from the books he wrote. His ideas have inspired and continue to inspire scientists around the world. His scientific contribution to the physics of a gas discharges, the physics of strong shock waves, and plasma physics for many years determined the development of these fields of science.

Yuri Raizer was born in 1927 in Kharkov, Ukraine. He graduated from the Leningrad Polytechnic Institute in 1949, and become Doctor of Sciences (Physics and Mathematics) in 1959, full professor in 1968, Honored Scientist of the Russian Federation (2002). He was a chief researcher at the Institute for Problems in Mechanics of the Russian Academy of Sciences, and Honored Professor of the Moscow Institute of Physics and Technology (2012).

He worked at the Institute of Physics and Power Engineering (Obninsk), the Institute of Applied Mathematics, the Institute of Chemical Physics, and the Institute of Physics of the Earth of the USSR Academy of Sciences. Since 1965 Yuri Raizer worked at the Institute of Problems of Mechanics of the Russian Academy of Sciences since the foundation of the Institute, and was a head of the Department of Physics of Gas-Dynamic Processes for 34 years.

Yuri Raizer was a specialist in the field of physical gas dynamics and low-temperature plasma. He made an outstanding contribution to the physics of shock waves, strong explosions, optical breakdown and interaction of laser and microwave radiation with plasma, gas discharges, lightning, and high altitude atmospheric electricity phenomena. On the basis of his ideas and theory the process of continuous plasma generation in free space by laser radiation (continuous optical discharge) was discovered. This process created a new type of plasma generators – optical plasmatrons. The new method of organizing the discharge he proposed was used to create a series of high-power technological CO_2-lasers. He was the author of over 200 scientific papers, and 8 books. His monographs “Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena” co-authored with Yakov Zeldovich, and “Physics of a Gas Discharge” are table-top books of many researchers around the world.

Dr. Raizer's sociability and friendliness immediately won everyone's favor. Yuri Raizer was always full of ideas and energy. He lived without reference to age. As a physicist, Raizer's characteristic was his ability to distinguish the important features of a problem and ignore the minor ones. This Riser phenomenon has kept him at the forefront of science. Along with outstanding scientific activity, Yuri Raizer devoted a lot of time to educating young scientists. For many years he was engaged in the pedagogical process, being a professor at Moscow Institute of Physics and Technology.

In recognition of his contributions the fields of physics of shock waves, explosions, gas discharges, interaction of laser radiation with plasma, Yuri Raizer was awarded numerous national and international prizes: Lenin Prize (1966); State Prize of the Russian Federation (1999); International Penning Prize in Ionized Gas Physics (USA, Penning Award Excellence, 1993); American Society of Aeronautics and Astronautics Award (USA, AIAA Plasmadynamics & Lasers Award, 2002); Order of the Badge of Honor (1975); Zeldovich’s Gold Medal (RAS, 2020); “Phystech Star”, MIPT Badge of Honor (2016).

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General Interest Announcements

- **New Coalition for Plasma Science (CPS) Leadership Sets Goals to Address Recommendations of Plasma 2020**

  The recently published NAS report *Decadal Assessment of Plasma Science (Plasma 2020*) identified that plasma science and engineering can significantly benefit from the advancement of interdisciplinary work, improved translation between research and applications, and a strong workforce development plan (https://www.nap.edu/catalog/25802/plasma-science-enabling-technology-sustainability-security-and-exploration). The Coalition for Plasma Science (CPS) has recently elected two new leaders who are eager to pursue the goals of Plasma 2020 through a strong program of outreach in plasma science. Prof. Evdokiya (Eva) Kostadinova (Auburn University) was elected Chair of CPS, replacing Dr. Lee Berry. Dr. Dmitri Orlov (University of California at San Diego) is Vice-Chair, replacing Dr. Richard Temkin.

  The new CPS leadership plans to launch several initiatives, including establishing student awards for interdisciplinary research, preparing resource kits for journalists and congressional staffers, and developing a Plasma Network for Outreach and Workforce (Plasma NOW). To promote these ideas, CPS will organize receptions at upcoming plasma conferences. The Coalition will continue supporting some of its well-established activities, such as sponsoring science fair awards, hosting educational events on Capitol Hill, and organizing programs for K-12 teachers. CPS strongly encourages members of the plasma community to join CPS and contribute to a strong program of outreach and educational activities.

  The CPS team would like to thank Lee Berry and Rick Temkin for their service to the Coalition. The current CPS board members include, in addition to the Chair and Vice-Chair, Paul Rivenberg, CPS Secretary, Steve Dean, CPS Treasurer, Arturo Dominguez, Mark Kushner and Rick Temkin.

  For more information, visit the CPS website: https://www.plasmacoalition.org/

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Meetings and Online Seminars

- **GEC Will Organize and Lead the International Online Plasma Seminar (IOPS)**

  At its recent meeting, the Gaseous Electronics Conference (GEC) Executive Committee has agreed to organize and lead the International Online Plasma Seminar (IOPS) to engage the GEC community throughout the year in addition to the yearly conference. The transition of IOPS to the GEC will take place on January 1, 2022.

  The GEC-IOPS is a non-profit seminar series on low temperature plasma science (LTPS). The seminars are presented bi-weekly via Zoom and attendance is free. The goal of the GEC IOPS is to make high quality research results in LTPS widely available to our community, as well as to foster an interactive scientific discussion. In this way presentations that are usually available at conferences are widely available to anybody - including those who cannot attend classical onsite meetings. Following each presentation questions can be asked by all attendees. With speaker's consent, presentations are recorded and are made available for on-demand viewing. GEC IOPS speakers can be nominated by anybody and are selected by the IOPS committee.

  The current program for IOPS and information about IOPS can be found here: https://mipse.umich.edu/online_seminars.php. Nominations for future speakers can also be made from this page.

  The next IOPS presentations will be given by Dr. Lui Habl and Dr. Laurent Garrigues (**July 22, 2021**); and Dr. Bocong Zheng (**August 5, 2021**).

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

- **Online LTP Seminar (OLTP)**

  The schedule of the Online Low Temperature Plasma (OLTP) Seminar series is available at: https://mipse.umich.edu/ltp_seminars.php. The next seminars will be presented by Prof. Paul Maguire (**July 13, 2021**), Dr. Artem Smirnov (**July 27, 2021**), and Prof. Masaru Hori (**August 10, 2021**).

- **New Dates for the XXXVth ICPIG: July 9-14, 2023**

  The XXXVth ICPIG (International Conference on Phenomena in Ionized Gases) was planned for July 2021. However, due to the Covid-19 pandemic the meeting was postponed to **July 9-14, 2023**. The meeting will be held at a beach hotel in Egmond aan Zee in the Netherlands.
  For details, please refer to https://www.icpig2023.com/icpig2023.

  The ICPIG has been shifted by 2 years to align with the XXVth ESCAMPIG in Paris that has been shifted from July 2020 to July 11-15, 2022.

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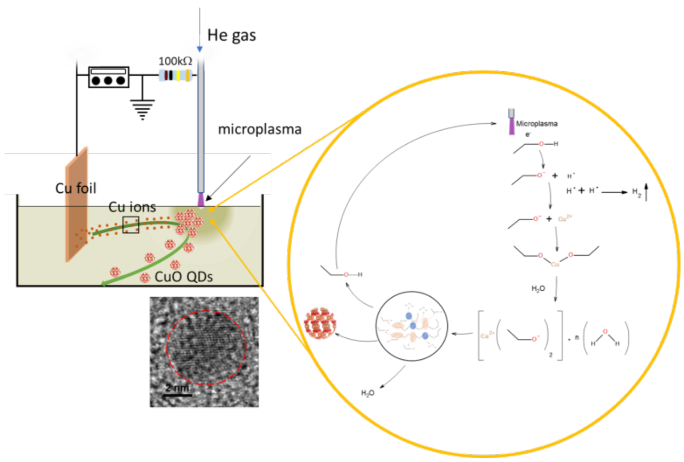
Community Initiatives and Special Issues

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

Understanding Plasma-induced Non-equilibrium Electrochemistry During the Nanoparticle Synthesis



Schematic of plasma-ethanol interaction producing CuO QDs using Cu ions from Cu anode.

Here we present a complete study on the synthesis mechanisms leading to cupric oxide (CuO) quantum dots (QDs) providing a range of experimental evidence that clarifies chemical reaction pathways from plasma interacting with ethanol. For greater understanding on the plasma chemistry, the process was also studied with different electrodes to assess the impact of QDs formation in the overall plasma-ethanol chemistry. We carried out extensive material characterization of the CuO QDs by x-ray photoelectron spectroscopy and transmission electron microscopy. Similarly, the liquid products at different conditions were also studied mainly through Fourier transform infrared spectroscopy, ultraviolet-visible spectroscopy, nuclear magnetic resonance and mass-spectroscopy. This work shows the role of different species in the synthesis of CuO QDs. Some of these chemical pathways may be general and applicable to the formation of other metal oxide QDs in ethanol.

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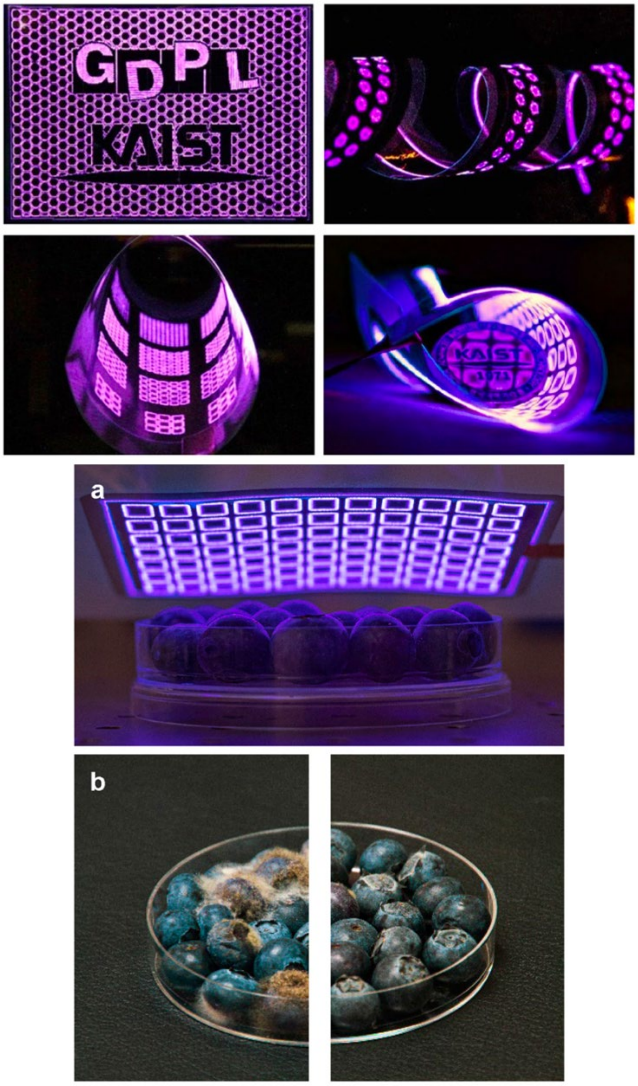
Source:
Green Chem. **23**, 3983-3995 (2021).
https://pubs.rsc.org/en/content/articlelanding/2021/gc/d0gc03291c#!divAbstract

Surface Plasma with an Inkjet-Printed Patterned Electrode for Low-Temperature Applications



Examples of flexible DBD (FXDBD) with different inkjet-printed, patterned electrodes operated in ambient air to demonstrate the flexibility of electrode formation (i.e., a large variety of electrode shapes and sizes) and the flexibility of the substrate. In-package plasma treatment of blueberries, and control and plasma-treated (5 minutes) blueberries after 72 hours of storage.

The global health crisis caused by the recent pandemic has led to increasing social demand for 'new normal' sanitizing and disinfecting facilities to fit our 'new normal' lives. Here, we introduce an inkjet-printed, thin-film plasma source applicable to dry disinfection processes. In contrast to conventional plasma reactors, the merits of plasma produced on a film include disposability, cost-effectiveness, and applicability to high-dimensional objects such as the human body. The developed flexible plasma film can be applied to a wide variety of shapes via origami—remaining plasma stable even when bent. However, electrode degradation has been a practical issue in the long-term operation of inkjet-printed plasma sources, which is troublesome from application perspectives. We focus on making the inkjet-printed electrode more plasma stress-resistant, thereby increasing its lifespan from a few minutes to two hours of continuous operation with optimal inkjet printing and passivation, thus increasing the practicality of the source. Considering the fact that ozone and nitrogen oxides are selectively produced by plasma, we implement a disposable pouch-type plasma source and examine its usefulness in extending the shelf life of food.

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Source:
Scientific Reports **11**, 12206 (2021).
https://www.nature.com/articles/s41598-021-91720-3.pdf

Transient Processes in an Initial Stage of Breakdown in Saline Solution

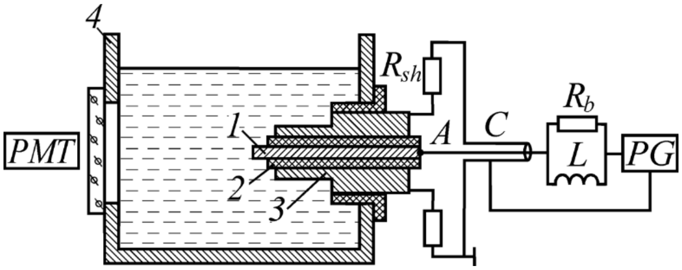
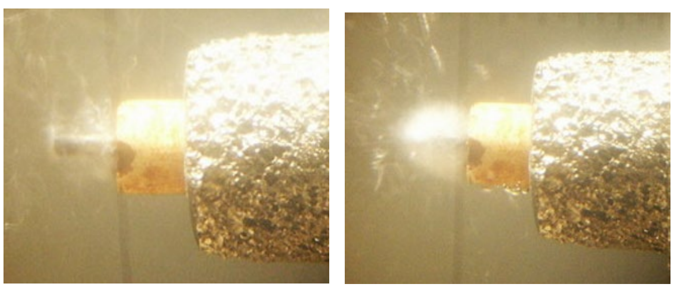
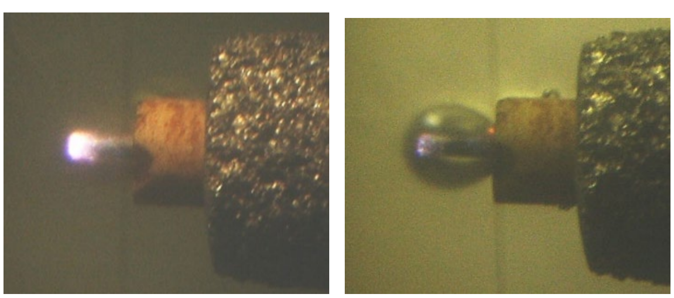


Figure 1. Schematic of experimental arrangement. *1* – active electrode 0.5 mm in diameter, *2* – ceramic insulating tube, *3* – return grounded electrode, *4* – bath with the saline solution, *PG* – pulsed generator with a voltage up to 400 V, pulse duration of 25 μs, and pulse repetition rate of 25 kH.



(a) (b)

Figure 2. Photographs of the microbubbles in absence of the discharge for a voltage lower than the critical value (a) and close to the critical value (b).



(a) (b)

Figure 3. Gas cavities at the active electrode in the case when the discharge is available.
(a) Glow-type discharge in the thin vapor layer.
(b) Microspark discharge in the so-called macrobubble that covers the surface of the active electrode.

We have investigated discharges in saline solution for the conditions typical of the so-called plasma scalpel. The saline solution is an electrolyte, which has a rather high conductivity. As distinct to distilled water, gas cavities in the form of microbubbles and thin layers at the active metal electrode appear at a low voltage at the gap. The experimental arrangement is shown in Fig. 1.

The principal process in the gap at a low voltage is the formation of microbubbles with a characteristic diameter of about 100 μm (Fig. 2). The necessary condition for appearing the discharge is that the electrode surface is completely covered with the microbubbles and the voltage at the gap is high enough to exceed the critical value (about 200 V). In this case, the glow discharge with a typical current of (0.1–0.3 A) arises in the gas cavity. The whole voltage at the gap is close to the voltage drop at the cathode fall region.

The glow discharge is not sustained in a steady-state regime. Its operation is accompanied by the occasional glow-to spark transitions and corresponding spikes in the current with a duration of about 100 ns or less. Such transitions are characteristic of the situation when the voltage pulse has a negative polarity and the metal electrode plays a role of the cathode.

During the discharge operation, plasma exists in the gas cavity. Two types of the cavities are observed in the experiments. These are the thin vapor layer, which is located at the active electrode (Fig. 3a) and the so-called macrobubble, which covers the active electrode (Fig. 3b). The latter case is typical for discharges sustained in the microspark mode.

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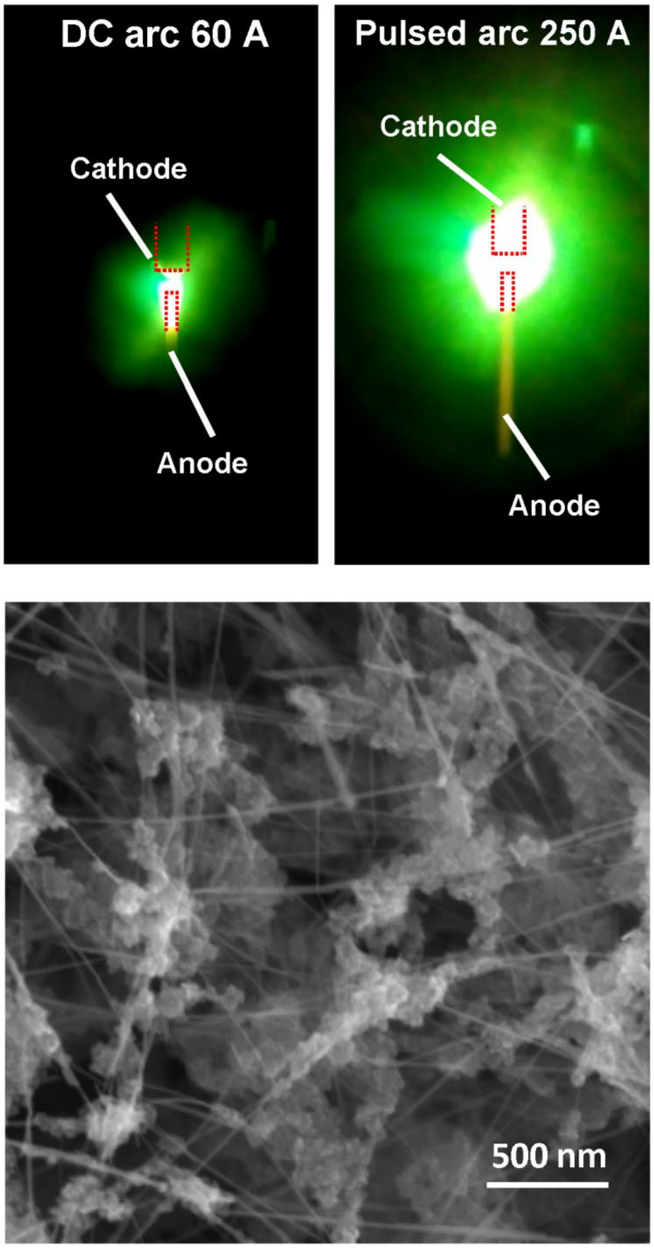
Source:
Y. D. Korolev et al., J. Appl. Phys. **129**, 043304 (2021).
https://doi.org/10.1063/5.0035340

Pulsed Arc Discharge for the Synthesis of Nanomaterials



Top: Filtered images of anodic arcs in DC and pulsed modes. Bottom: Carbon nanotubes deposited onto the cathode surface after pulsed arc operation.

Low-dimensional materials, such as graphene and carbon nanotubes, are present in a wide range of applications thanks to their extreme physical and chemical properties. A major challenge is the controlled synthesis of nanomaterials with high throughput and high quality.

Recently, we demonstrated the growth of carbon and MoS_2 nanostructures by means of an anodic arc discharge in a pulsed mode at low frequency. Single and compound anodes can be ablated by applying short pulses of a few hundred Amps in a non-reactive atmosphere (such as helium). The deposition process has been characterized with spatial-temporal resolution using different diagnostics, and the samples were studied via electron microscopy and Raman spectroscopy. Power management in the pulsed arc processes has proven to be advantageous compared to using a continuous DC arc plasma. In fact, pulsed operation solves the issues of arc instabilities, dust formation, and system overheating.

Pulsed anodic arc methods are a powerful alternative to traditional plasma deposition methods. Fundamental research to better understand this efficient plasma source is planned. Accurate control of the properties of new nanomaterials, which should be adapted to the needs of the final application, is the main goal in this line of research.

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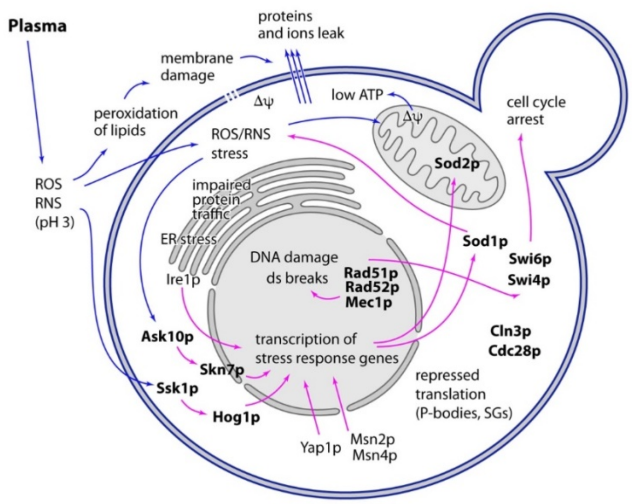
Source:
Phys. Plasmas **27**, 054501 (2020).
https://doi.org/10.1063/5.0002872

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

Effects of Non-Thermal Plasma on Yeast *Saccharomyces cerevisiae*



Summary of cold plasma effects on yeast cell. Treatment of cells with plasma induces multiple types of stress and damage (blue arrows). Cellular stress response pathways (purple arrows) act to protect cell from this damage. Components of these pathways that are known to affect the cell survival (e.g. deletion of genes encoding for these components results in increased sensitivity of cells to the plasma) are shown in bold.

Cold plasmas generated by various electrical discharges can affect cell physiology, induce cell damage, or often result in the loss of viability. Many cold plasma-based technologies have emerged in recent years that are aimed at manipulating the cells within various environments or tissues. These include inactivation of microorganisms for the purpose of sterilization, food processing, induction of seeds germination, but also the treatment of cells in the therapy. Mechanisms that underlie the plasma-cell interactions are, however, still poorly understood. Dissection of cellular pathways or structures affected by plasma using simple eukaryotic models is therefore desirable. Yeast *Saccharomyces cerevisiae* is a traditional model organism with unprecedented impact on our knowledge of processes in eukaryotic cells. As such, is it had been also employed in studies of plasma-cell interactions. This review focuses on the effects of cold plasma on yeast cells.

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Source:
Int. J. Mol. Sci. **22**, 2247 (2021).
https://doi.org/10.3390/ijms22052247

New Resources

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

Career Opportunities

- **PhD and Post-Doc Positions in Environmental/Biomedical Plasma Applications, Comenius University, Bratislava, Slovakia**

Division of Environmental Physics, Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava, Slovakia (http://enviro.fmph.uniba.sk/index.php?lang=english&link=phd) is currently seeking highly qualified applicants for:

4-year PhD program, starting in March 2022
1-year Post-Doctoral position (1) starting in October 2021

Topic: ***Electrical discharges in catalysts. Plasma catalysis for flue gas cleaning.***

Objectives: The main objective is to investigate the mutual interaction of electric discharges generating non-thermal plasma and materials with catalytic properties. Investigation of properties of discharges generated on surfaces, in capillary tubes, cavities and pellets of materials with catalytic properties, using both classical and new electrical and optical diagnostic methods, supplemented with a theoretical analysis.

- Electrical measurements and optical measurements of excited species, spatial distribution of temperature across the catalysts.
- Chemical activity of discharges measured by UV and FTIR spectroscopy. Search for optimal conditions for the generation of high concentrations of various oxidants and other reactive species.
- Removal of selected components of the flue gas, e.g., aromatic or polyaromatic hydrocarbons, cleaning of a real flue gas from the diesel engine.
- Surface analysis of the catalysts. Identification of solid products deposited on the surface by SEM, EDX and ATR FTIR. Regeneration of the catalysts.

For information and application details, contact:
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1-year Post-Doctoral position (2) starting in October 2021

Topic: ***Applications of cold plasmas combined with photo-catalysis for indoor air decontamination.***

Motivation: Actual global pandemic situation with pathogenic aerosols including SARS-CoV-2, and other indoor chemical/microbial contaminants.

Objectives: Addressing fundamental complex questions of the principles of operation and finding synergies of cold atmospheric air plasma and UV-induced photocatalytic processes.

- Investigation of the physical and chemical effects of electrical discharges generating cold plasma on water aerosols. Characterization of with respect to the formation of ozone, NO and NO_2.
- Investigations of the modes of operation of the combined technology of cold plasma and photocatalysis on TiO_2 or other photocatalysts, to achieve the highest possible decontamination efficiency.
- Optimizing the efficiency of the plasma-catalytic systems while eliminating toxic gases at the outlet of the device. Searching for conditions for strengthening the formation of radicals and chemical processes ensuring chemical and antimicrobial activity and subsequent destruction of excess O_3 and NOx.

For information and application details, contact:
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- **Postdoctoral and Graduate Student Research Opportunities in Experimental Plasma Electromagnetics, Department of Mechanical Engineering, Stanford University, USA**

  The Stanford Plasma Physics Laboratory (https://sppl.stanford.edu/) seeks students who are interested in continuing on to either a Ph.D. program or postdoctoral studies in the broader field of Experimental Plasma Electromagnetics.

  Stanford University has been active in the study of the use of gas discharges and laser produced plasmas in applications related to the control of electromagnetic waves. Recently published work addresses the use of non-magnetized as well as magnetized plasmas in photonic crystals and metamaterials to provide a degree of reconfigurability. Our recent award of a Multi-University Research Initiative (commencing 2021) examines an extension of this prior work to exploit the gyrotropic response of magnetized plasmas that when integrated into topological non-trivial and nonreciprocal metastructures provide unique control of surface and bulk electromagnetic wave propagation. We are currently interested in applications such as the demonstration of tunable invisibility cloaks, diffraction-free beamed energy, and optical computing. Motivated and qualified students will also be able to participate in the broader research activities of the laboratory, which include plasma research related to plasma transport, electric propulsion, advanced plasma diagnostics, plasma chemistry, and fusion. Opportunities are also available to students who may qualify for participation in projects collaborating with the DOE Laboratories.

  Students with prior experience in electromagnetics or plasmas is highly desirable. Highly motivated students that are independent, self-starters, and also willing to work with students from our MURI collaborating institutions are encouraged to apply.

  Interested students should send a CV and a brief statement of research interests, together with the names of at least two references to the contact.

  Contact:
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  cap@stanford.edu

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

  We seek a PhD student to work on methane conversion using plasma. The research will be primarily based on numerical modeling and simulation. The candidate will perform analysis of chemical reaction pathways and transport in synergy with state-of-the art laser diagnostics at Maastricht University to develop a comprehensive understanding of the underlying physical and chemical processes occurring in the plasma.

  Background: The chemical industry urgently needs to cut its CO_2 emissions. Electrification will reduce emissions from processes by powering them with renewable electricity in place of fossil fuels. Circular processes will reuse valuable resources (e.g. plastics), and in doing so will cut end-of-life emissions and reduce resource depletion rates. We research novel plasma technologies to facilitate both electrification and circular processes for the chemical industry. In future, industry expects to have an environmentally sustainable source of methane, which can be most effectively valorized via upgrading to ethylene; a crucial feedstock in the production of plastics. Thermal plasma technology is a promising approach for methane to ethylene conversion. Plasma chemistry modelling is extremely challenging due to the high number of species and their reactions and dynamics, which occur over multiple time and length scales. Gas heating, transport, and electromagnetic power coupling also need to be incorporated. Consideration of the non-equilibrium between electrons and other species is critical; requiring specific methodologies to describe electron kinetics. The project aim is to develop a plasma model to simulate plasma driven reforming of methane.

  Job Description: The successful candidate will perform numerical simulations to evaluate chemical and physical processes occurring in methane plasma discharges. You will work independently to develop code, collect, analyze, and evaluate results and compare them with experimental measurements. Code validation and characterization is also an essential part of the job. You will join a small team working on experiments and similar numerical models. We expect that you will regularly discuss, share, and present your work with fellow team members, colleagues, and wider audiences at international conferences. We expect you will write a number of high-quality scientific articles, ultimately culminating in your PhD thesis.

Requirements: We seek motivated and highly talented candidates with a Master degree (or an equivalent diploma giving access to doctoral studies) in Physics or Chemistry. The applicant should have: General knowledge of low temperature plasmas, knowledge of computational modelling, good programming skills (e.g. Fortran, C, C++), good communication skills in English (both written and spoken).

Application: Electronically submit an application letter and full curriculum vitae (including names and e-mail addresses of maximum 3 persons who could act as your references), a grade list and possibly copies of papers to p.diomede@maastrichtuniversity.nl. Please use the following format for your documents:

lastname_applicationletter.pdf, lastname_cv.pdf, lastname_gradelist.pd, lastname_papers.pdf

For more information, please contact:

Dr. Paola Diomede
Maastricht University, The Netherlands
p.diomede@maastrichtuniversity.nl

- **Computational Plasma Physics Software Developer, ESI Group, USA**

ESI Group, a dynamic and diversified company specializing in CAE solutions for virtual manufacturing and prototyping, seeks an expert in the development and implementation of computational models for low temperature technological plasmas. The expert will be a member of the Solver Development Group and participate in the development, support, maintenance, and extension of the plasma physics module in our flagship multi-physics modeling product, the ACE+ Suite. The plasma physics module is continuously being extended and improved for modeling of non-equilibrium low temperature plasmas for virtual reactors, process design, and other applications, as well as validation.

Essential Functions

- Work collaboratively with experienced computational physics R&D staff to advance the state-of-the-art in plasma modeling to make an impact in the semiconductor and other industries.
- Design and develop new algorithms for high performance computation of plasmas and electromagnetics in complex geometries, chemistries, and process conditions using fluid, particle, and hybrid methods.
- Improve existing models and algorithms in the plasma module.
- Create validation and benchmarking problems to test and verify new and existing capabilities.
- Provide guidance, consultation, and support to users on existing and new capabilities.
- Propose, define, and contribute to new research topics to meet users' needs and reflect recent developments in plasma physics.

Education and Skills

- A PhD in plasma physics/engineering or related field with 5 or more years of code development experience. Relevant MS/Mtech degrees with sufficient experience will also be considered.
- Expertise in discretization and computational modeling of plasma governing equations.
- Experience in modeling plasma chemistry, including volumetric and surface reactions.
- Industrial experience in the modeling of low temperature plasmas in the semiconductor industry is highly desired.
- Reactor scale and feature scale modeling knowledge and experience is preferred.
- Knowledge of computational electromagnetics, DSMC, Boltzmann and particle methods is preferred.
- Good skills with Fortran, C, or C++.
- Hands-on experience with parallel programming and optimizing code for high performance computing.

- Understanding of software engineering principles and the development of large multi-physics codes.

Location: Huntsville, AL is preferred, but other ESI Group offices worldwide can be considered.

To apply, please submit your resume on this site: https://esigroup.applicantpro.com/jobs/.

Contact:
Dr. Jun-Chieh Wang
ESI-Group, Software Development Engineer
JWA@esi-group.com

- **Senior Research Engineer-Plasma Science Focus, 3M Inc., St. Paul, Minnesota, USA**

As a **Senior Research Engineer-Plasma Science Focus** you will have the opportunity to tap into your curiosity and collaborate with some of the most innovative and diverse people around the world. Here, you will make an impact by:

- Effectively operating as a critical member of a technology development team
- Identifying and developing new plasma process technologies through experimental and simulation-based approaches
- Driving implementation and scale up of plasma processing technology to impact 3M
- Initiating and contributing to the development of Intellectual Property and IP strategies
- Contributing to sustainability efforts to meet 3M's sustainability goals

For additional information, please visit: https://www.3m.com/3M/en_US/company-us/about-3m/research-development/

Your Skills and Expertise:

To set you up for success in this role from day one, 3M requires (at a minimum) the following qualifications:

- Ph.D. in a science or engineering discipline (completed and verified prior to start) from an accredited institution
- Experience using plasma-based technologies in a private, public, government or military environment
- Experience collaborating effectively within and across scientific disciplines

Additional qualifications that could help you succeed even further in this role include:

- Ph.D. in Chemical Engineering, Chemistry, Mechanical Engineering, Physics, Materials Science or related discipline from an accredited institution
- Experience with plasma modelling and/or simulations
- Experience with model validation
- Experience with fundamental chemical kinetics, transport, computational fluid dynamics, electrodynamics utilizing propriety and/or commercial software (e.g. Aspen Plus, ANSYS, COMSOL, MatLab, OpenFOAM, etc.)
- Proven track record demonstrated by academic publications, conference presentations, and/or published Intellectual Property (IP)
- Excellent technical presentation skills and oral communication skills

To apply: https://3m.wd1.myworkdayjobs.com/en-US/Search/job/US-Minnesota-Maplewood/Senior-Research-Engineer-Plasma-Science-Focus_R01049820-1

For more information, contact:
Dr. Aniruddha A. Upadhye
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Collaborative Opportunities

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

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