The Newsletter of the International Low Temperature Plasma Community (ILTPC)

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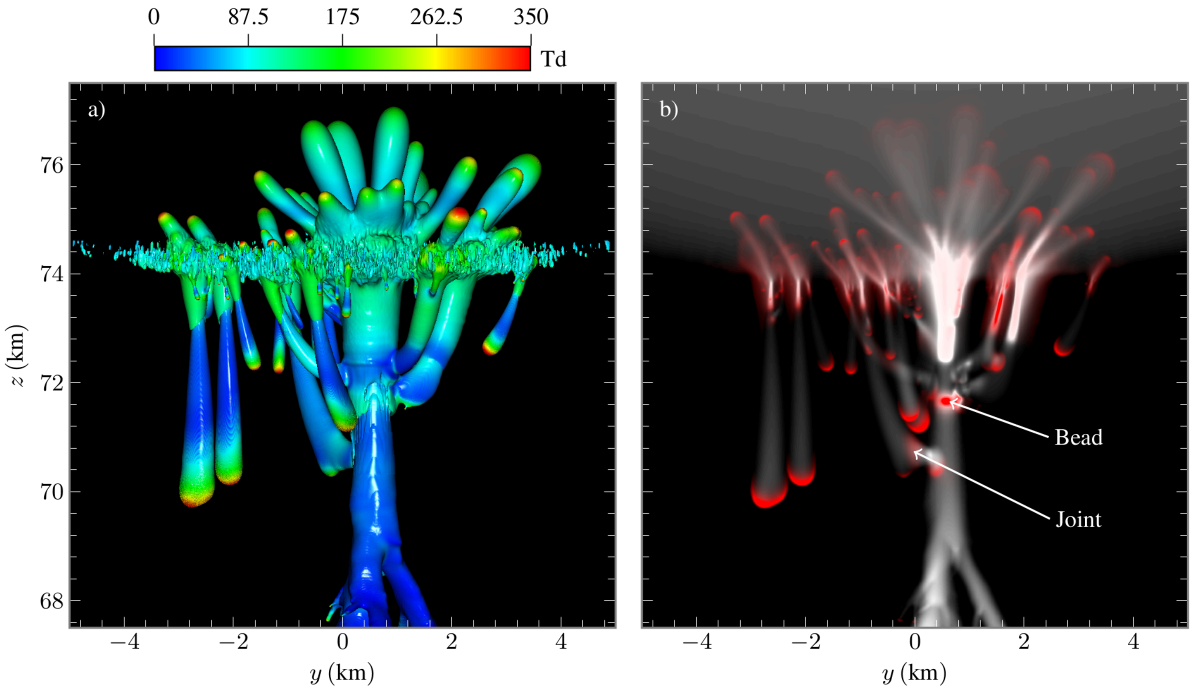
Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to **editor@iltpcnewsletter.org** by June 7th, 2024. Please send contributions as MS-Word files (***.docx**) if possible. In particular, please send Research Highlights and Breakthroughs using **this template**. You can also directly download the template in docx format **here**. (Please do **not** send files in doc format.)

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 The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related.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

Images to Excite and Inspire

Please send your images (with a short description) to editor@iltpcnewsletter.org. The recommended image format is TIF, JPG, or PNG. The minimum file width is 800 px.



A 3D supercomputer simulation of the emergence of an atmospheric sprite. Figure a) shows the field distribution in the sprite streamers and figure b) shows the associated optical emissions from the first positive system of molecular nitrogen. White colors indicate accumulated emissions and red colors show instantaneous emissions. In the computer simulation the sprite streamers emerge spontaneously at the bottom of a large 40-km wide sprite halo. Positive streamers propagate downward and negative streamers propagate upward into the halo. As the positive streamers descend in the atmosphere, they leave behind optical signatures that are experimentally well known, such as streamer reconnections, beads, branching, and column glows.

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Source:
R. Marskar, Plasma Sources Sci. Technol. 33, 025024 (2024)
https://doi.org/10.1088/1361-6595/ad29c0

LTP Perspectives: Policy, Opportunities, Challenges

Please submit your notices for LTP Perspectives to editor@iltpcnewsletter.org.

About LIF and TALIF techniques. Historical retrospective and perspectives.

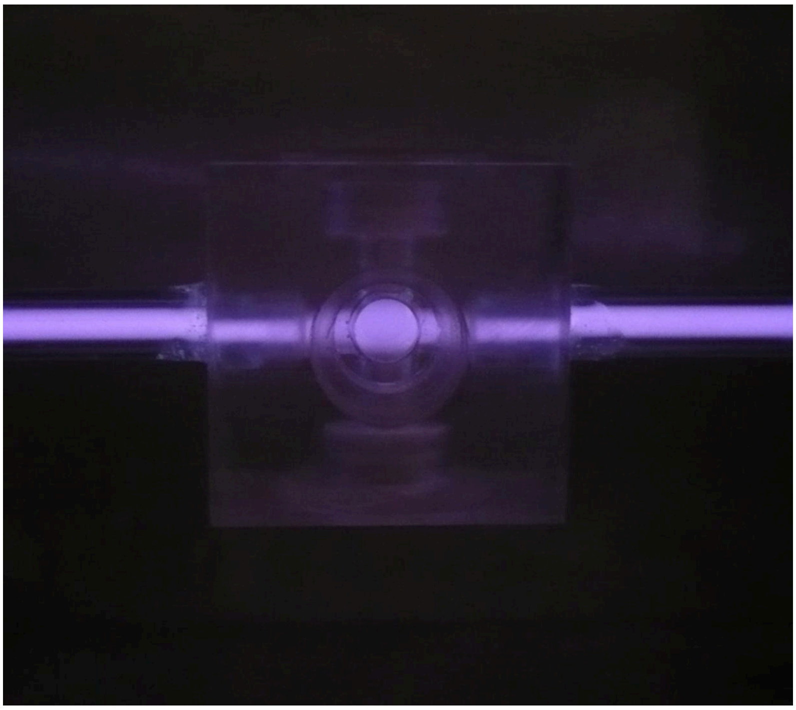
Pioneering laser techniques for measuring chemically active intermediate species, laser-induced fluorescence (LIF) emerged in combustion research in the 1970s, being developed for sub-atmospheric and higher pressures. Simultaneously, microelectronics advancement in the 1980s spurred the development of two-photon absorption laser-induced fluorescence (TALIF) for low-pressure plasma (10^{-2}-10^{-1} mBar).

Both LIF/TALIF methods measure time-resolved, space-resolved density of radicals/atoms. They rely on exciting selected levels from the ground state of the species of interest and detecting resulting fluorescence. Popular species tested include OH, CH_3, CH_2O or C_2H_2 in combustion by LIF [1], while TALIF measures atoms are mainly O, N, H [2].

The introduction of a new absolute calibration method in the early 2000s revolutionized TALIF [3,4]. Calibration used inert gases “similar” to the atoms of interest to get the absolute values, notably in combination O/Xe, N/Kr, and H/Kr. Still, both LIF/TALIF require accounting for side processes like photolysis important at high laser energies and fluorescence quenching particularly crucial in rapidly changing high pressure mixtures.

Efforts to address these challenges have been ongoing, with a focus on using picosecond and femtosecond lasers to eliminate quenching [5]. However, calibration contains open questions even in nanosecond systems. Recent inquiries have arisen regarding the accuracy of calibration [3,4], with proposed adjustments of approximately a factor of 2 for Xe/O two-photon excitation cross-section ratio. Revisiting measurements of two-photon absorption cross-section for Xe [6] confirmed a possible validity of suspicions: if combining the obtained value for Xe with a cross section for O atoms from the literature, the density of O atoms measured by the TALIF method in all 20-years long research should have been halved.

This detective story continued by suggesting a new approach for TALIF calibration [7]. A difference with [3,4] is that no calibration by another technique was needed: a “self-calibration” was provided by using specially developed nanosecond discharge, providing 100% dissociation of molecular oxygen at sub-hydrodynamic and sub-diffusion times. A few mixtures have been tested and it has been shown that the calibration suggested by [3,4] is correct within the accuracy of the experiment. The obtained ratio of Xe/O two-photon excitation cross-sections was equal to 1.8 [7] instead of 1.9 [4].



Capillary discharge similar to used in [7] for absolute TALIF calibration

But the question of calibration persists: simple passage to quenching-free picosecond and femtosecond systems does not guarantee that using the same ratio of cross-sections is correct. A very recent publication [8] suggests, on the basis of TALIF in DC discharge in Xe with small additions of H_2, that the ratio of two-photon absorption cross-sections Kr/H is almost 20 times lower for femtosecond lasers comparing to nanosecond laser systems.
To summarize: picosecond and femtosecond TALIF offer potent tools for high-pressure chemical media, necessitating absolute calibration and potential collaboration between the plasma and the combustion community.

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[2] Stancu G D 2020 Plasma Sources Sci. Technol. 29 054001 DOI 10.1088/1361-6595/ab85d0
[3] Niemi K, Schulz-Von Der Gathen V and Döbele H 2001 J. Phys. D: Appl. Phys. 34 2330 DOI 10.1088/0022-3727/34/15/312
[4] Niemi K, Schulz-Von Der Gathen V and Döbele H 2005 Plasma Sources Sci. Technol. 14 375 DOI 10.1088/0963-0252/14/2/021
[5] M Hay, P Parajuli, WD Kulatilaka, 2022, Proc. Comb. Inst. 39(1), 1435-1444, DOI 10.1016/j.proci.2022.08.090
[6] Blondel C, Alkhoury J, Jannaud T and Drag C 2020 The generalized two-photon excitation cross-section of Xe evisited J. Phys.: Conf. Ser. 1412 142012 DOI 10.1088/1742-6596/1412/14/142012
[7] Shu Z, Popov N A and Starikovskaia S M, 2024 Plasma Sources Sci. Technol. 33, 025019 DOI 10.1088/1361-6595/ad270f
[8] Starikovskiy A and Dogariu A, 2024, AIAA 2024-2786, DOI 10.2514/6.2024-2786

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Leaders of the LTP Community: Career Profiles

Cristina Canal - The right path to Plasma Medicine

With a background in chemistry, Cristina Canal started her research using low-temperature plasma in the textile field, working on the surface modification of fabrics for the substitution of conventional finishing processes. After obtaining her PhD with honors by Universitat Politècnica de Catalunya (UPC) in 2006, she moved to the Laboratoire des Plasmas et Conversion d'Énergie (CNRS-UPS, France) for her first postdoc. The following year, she moved back to Barcelona where she had other research experiences in the field of pharmacy (2007, Universitat de Barcelona) and materials science (2010, UPC) thanks to consecutive competitive postdoctoral fellowships, and she reoriented her investigation towards biomedical materials and applications.

Her expertise and multidisciplinary background between chemistry, engineering and biomedicine led her to consolidate her position in the Biomaterials, Biomechanics and Tissue Engineering group at the Department of Materials Science and Engineering (UPC), where she is an associate professor and serves as the head of the Plasmas for BioMedical Applications laboratory (PlasmaMED lab), a dynamic and multidisciplinary group with people coming from all over the world.

Throughout her career, she has dedicated her efforts to advancing low-temperature plasma technology within the biomedical field. This includes not only enhancing the physicochemical properties of biomaterials through surface modification, but also exploring new therapeutic potential of low-temperature plasmas in various applications like wound healing processes and cancer therapies.

Cristina has participated in and led various research and technology-transfer projects in the areas of biomaterials and low-temperature plasma. Among her most significant achievements, and as a turning point in her career, she obtained a European Research Council (ERC) Starting Grant in 2017, allowing her to set up her own research group

Supported by the results obtained during the ERC Starting, Grant she subsequently obtained an ERC Proof of Concept project to assess the transfer to the market of the solutions and technology she is developing together with her team.

In addition to her main work as a researcher, professor, mother and many other administrative positions, she currently leads the PlasTHER COST Action. This project aims at establishing a synergistic network connecting researchers, medical doctors, industry, and patient associations to enhance Europe's leadership in the field of plasma medicine.

In the last years, Cristina has become a globally recognized figure in the field of plasma medicine, and has emerged as a strong advocate for women in science. Her outstanding research has been recognized with various awards, including the L'Oreal-UNESCO "For Young Women in Science" fellowship (2012) and the prestigious Early Career Award in Plasma Medicine 2018 by the International Society for Plasma Medicine. Cristina has always been engaged in science communication, participating in events, releasing interviews and writing articles aimed at sharing and explaining the methods and results of science to a non-academic audience and fighting fake news.

Last, but not least, her modern vision of teaching and research has enabled her to create and lead the PlasmaMED lab group, promoting equality, career development, teamwork, transparency, and empathy within the competitive, demanding, and rigorous field of scientific research.

Dr. Francesco Tampieri
Dr. Cédric Labay
Dr. Albert Espona-Noguera
Universitat Politècnica de Catalunya, Barcelona, Spain.

General Interest Announcements

Please submit your notices for General Interest Announcements to editor@iltpcnewsletter.org.

Meetings, Online Seminars, and Schools

Please submit your notices for Meetings and Online Seminars to editor@iltpcnewsletter.org.

2024 Gaseous Electronics Conference

The 77th Gaseous Electronics Conference (GEC) will be held from **September 30 – October 4, 2024**, in San Diego, California, USA.
The GEC is a leader in providing a venue for the exchange of ideas and reporting research in low-temperature plasma science and technology. The areas of emphasis are the science of plasma sources, diagnostics, modeling, plasma chemistry, basic phenomena, and atomic

and molecular collision processes. GEC is often at the forefront of reporting on emergent areas of plasma-based technologies, including microelectronics, propulsion, biotechnology, plasma medicine, multiphase plasmas, environmental applications, and atmospheric-pressure plasma systems. Complete details about the 2024 GEC can be found on the conference website (https://www.apsgec.org/gec2024/index.php).

The 2024 GEC will feature the Will Allis Prize talk by Prof. Vincent Donnelly (University of Houston, USA), invited talks from leaders in plasma and collision science, and 5 workshops and tutorials.

Please note that the deadline for abstract submission, Student Award for Excellence nomination, and student travel grant application is June 3, 2024.

Contact: **Shahid Rauf**, GEC Chair, shahid_rauf@amat.com
Venkattraman Ayyaswamy, GEC Secretary, vayyaswamy@ucmerced.edu

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Online Low-Temperature Plasma (OLTP) Seminar Series

The schedule for OLTP seminars and more information on the program, including links to past seminars, can be found at the OLTP website. The seminars are held on Tuesdays at 10:00 am EDT or EST via Zoom and are free to access.

Co-Chairs:
Dr. Ana Borras
CSIC, University of Seville, Spain
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Dr. Mohan Sankaran
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IOPS Online Seminars

The International Online Plasma Seminar (IOPS) is continuing to provide the international community with regular opportunities to hear from leading researchers in the field.
The program of the IOPS (and links to past seminars) can be found at the IOPS website.

Chair:
Prof. Quan-Zhi Zhang
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Community Initiatives and Special Issues

Please submit your notices for Community Initiatives and Special Issues to editor@iltpcnewsletter.org.

Special Issue in Journal Physics D: Applied Physics - Plasma in Liquids for Materials

Plasmas in Liquids for Materials is a rapidly developing field, where the intimate coupling between an intense plasma above and/or inside a liquid is coupled with the species chemistry of an electrolyte, including the solvent and species dissolved in that electrolyte or with solids next to the plasma. The materials synthesis and modification is most often driven by the liquid chemistry and/or the presence of large quantities of solvated electrons. Many of theses processes are being explored application driven such as:

- formation of nanoparticles
- functionalizing surfaces
- micromachining surfaces
- polishing surfaces

The fundamental understanding from the plasma physics in these complex multiphase systems to the electrochemistry involving plasma-excited species, however, remains limited. This special issue aims at bridging this gap between fundamental plasma science and electrochemistry in these activated media with a focus on materials applications. We hope this collection will showcase advances in modelling and diagnostics of plasmas in liquids for materials applications, including electrochemistry, (electro)catalysis, nanoparticle formation and renewable energy applications in general.

Guest editors
Achim von Keudell, Ruhr University Bochum, Germany
Mohan Sankaran, University of Illinois at Urbana Champaign, USA
Thierry Belmonte, Université de Lorraine, France
Albert K. Engstfeld, Ulm University, Germany

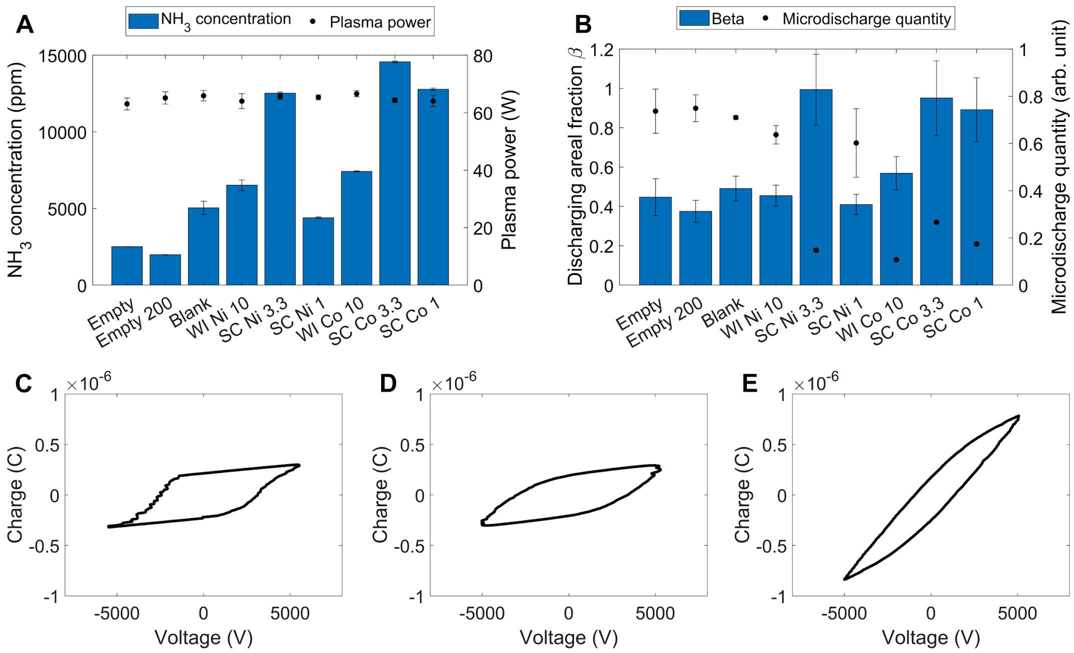
The announcement of the collection can also be found at
https://iopscience.iop.org/collections/jpd-240116-464

Research Highlights and Breakthroughs

Please submit your notices for Research Highlight and Breakthroughs to editor@iltpcnewsletter.org.

Importance of plasma discharge characteristics in plasma catalysis: Dry reforming of methane vs. ammonia synthesis

Plasma catalysis is a promising technology, but the relevant processes governing the overall performance are poorly understood. For example, when observing changes in performance, it is often difficult to distinguish between contributions from surface reactions and from the gas-phase plasma chemistry.



A: NH_3 outflow concentration and measured plasma power for a N_2:H_2 ratio of 1:1. B: Discharging areal fraction β and microdischarge quantity for a N_2:H_2 ratio of 1:1. The DBD plasma discharge characteristics have a significant impact on the overall performance, despite employing similar catalytic materials. C-E: Illustrative charge-voltage diagrams (also called Lissajous figures) from NH3 synthesis experiments with a N_2:H_2 ratio of 1:1 with blank Al_2O_3 (C), WI Co 10 wt% catalysts (D), and SC Co 3.3 wt% catalysts (E). The packing material/catalyst can drastically affect the plasma discharge.

In this work, we synthesized wet impregnated (WI) and spray-coated (SC) catalysts, either Ni or Co, supported on γ-Al_2O_3 spheres. The WI catalysts exhibit metal nanoparticles (10 wt%) distributed throughout the spheres, while for the SC catalysts, the metal (1 or 3.3 wt%) is concentrated at the surface of the spheres. These catalysts were used in a packed-bed DBD for dry reforming of methane and ammonia synthesis. Firstly, we found that the plasma discharge can be affected heavily by the catalysts. In this altered plasma, the microdischarges were strongly reduced, and a higher discharging areal fraction β was attained. Secondly, this altered discharge proved strongly beneficial for ammonia synthesis, while dry reforming of methane performed better in the more typical highly filamentary discharge.

Our work highlights the significant contribution of the gas-phase chemistry in plasma catalysis. These results stress the need for detailed plasma discharge analyses and reporting, in order to further our understanding of the underlying mechanisms.

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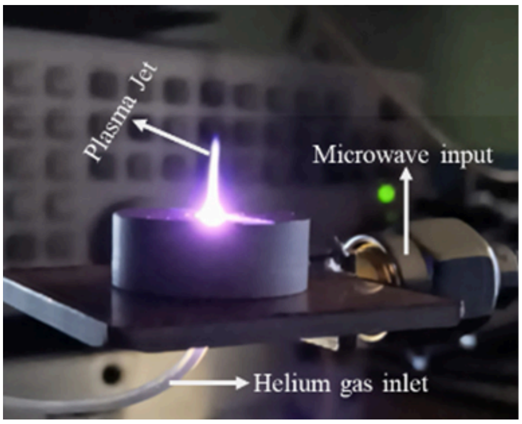
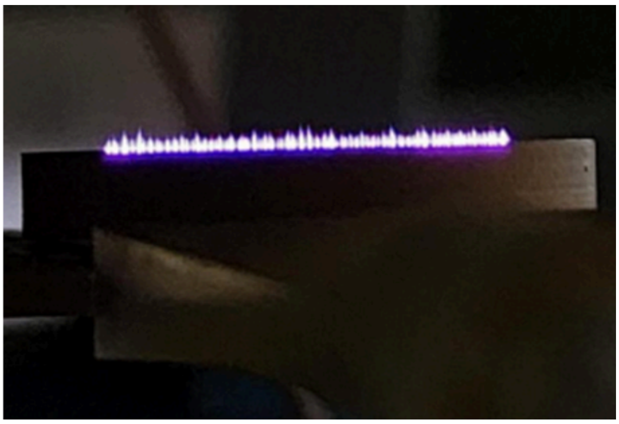
Source:
R. De Meyer, Y. Gorbanev, R. Ciocarlan, P. Cool, S. Bals, A. Bogaerts
Chemical Engineering Journal, 488, 150838 (2024)
https://doi.org/10.1016/j.cej.2024.150838

Efficient and Cost-Effective Plasma Jets Based on Electromagnetic Anapole Technology

We have realized efficient atmospheric pressure plasma needle/line jets using an artificially engineered dielectric structure compatible with PCB fabrication based on Anapole physics. Anapole, an electromagnetic mode, operates in contrast to conventional antennas, as it fully traps electromagnetic energy within a resonator without radiating it. Radiation suppression is achieved by inducing anti-phase electric dipoles over the metallic and dielectric parts of the device, which are developed from commercially available PCB laminate without the need for metallic enclosures, typical of cavities.





Anapole-based low-power plasma jet (left) and line (right).

The anapole plasma jet source operates on significant input power, typically around 1 W for the needle jet and around 5 W for the line jet of 2 cm with helium gas flow. Also, the device is highly compact in the shape of a cylindrical disk of 1.1 cm × 0.38 cm at 2.45 GHz for the needle jet and 2.8 cm × 0.38 cm for the 900 MHz line jet. Moreover, by achieving frequency tuning in these plasma jets, we are unlocking the potential to explore the frequency-dependent properties of these plasmas.

The electron density achieved with anapole jets is on the order of 10^{16} cm^{-3}, among the highest reported so far. Also, It was observed to generate higher reactive species as desired for bio-medical applications compared to other conventional microwave plasma jet technologies. Moreover, this plasma line technology is a low-cost solution to the existing highly controlled plasma sources in semiconductor processing and particle accelerator fields.

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Source:
M. R. Akram and A. Semnani. "A Microwave Anapole Source Based on Electric Dipole Interactions Over a Low-Index Dielectric." (2023)
arXiv:2308.15554 [physics.app-ph]
https://doi.org/10.48550/arXiv.2308.15554
M. R. Akram and A. Semnani. "Non-Radiating Resonances: Anapoles Enabling Highly-Efficient Plasma Jets within Dielectric Structures."
arXiv:2311.00572 [physics.plasm-ph]
https://doi.org/10.48550/arXiv.2311.00572

New Resources

Please submit your notices for New Resources to editor@iltpcnewsletter.org.

Noteworthy Papers

This new section is intended to feature new noteworthy publications in the field of low-temperature plasma science that have appeared in **journals outside the standard reading repertoire of the ILTP community.**

Please submit your notices for Noteworthy Papers to editor@iltpcnewsletter.org.

Career Opportunities

Please submit your notices for Career Opportunities to editor@iltpcnewsletter.org.

Collaborative Opportunities

Please submit your notices for Collaborative Opportunities to editor@iltpcnewsletter.org.

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