Plasma Science and Technology
Room 201 ABCD W - Session PS2-WeA

Atmospheric Plasma

Moderators: Michael Gordon, University of California at Santa Barbara, **Scott Walton**, Naval Research Laboratory

3:00pm **PS2-WeA-4 Investigating the Thermal Behavior of Atmospheric Pressure Plasma Jets on Different Surface Types**, ***Vladimir Milosavljevic,*** School of Physics, Clinical & Optometric Sciences, Technological University Dublin, Ireland & Faculty of Physics, University of Belgrade, Serbia, Ireland; *James Lalor,* School of Physics, Clinical & Optometric Sciences, Technological University Dublin, Ireland

Atmospheric pressure nonthermal plasmas hold great promise for applications in environmental management, energy transformation, and material engineering. Although they operate at room temperature, nonthermal plasmas produce highly reactive species that can modify surfaces at the plasma/surface interface. This study examines the interaction of an Argon atmospheric pressure plasma jet (APPJ) with both insulating and conductive mesh surfaces. The dielectric barrier discharge APPJ functioned at 8 kV and 21 kHz.

Previous research has analyzed how an atmospheric pressure plasma jet behaves when directed perpendicularly onto both dielectric and conductive flat surfaces, revealing that the jet maintains a laminar flow, expanding radially from the impact point. The highest temperature occurs at the central impact zone, with a radial decrease outward due to jet expansion and heat dissipation along the surface.

In contrast, this study introduces a novel method by treating a mesh substrate with 0.8 mm x 0.8 mm openings, allowing partial gas plume penetration. This enables thermal mapping of the interaction between the APPJ and the substrate, offering insights into the jet plume's thermal cross-section. A series of experiments explored how different materials, such as metals and polymers, respond to the APPJ's thermal energy by analyzing temperature rise, heat distribution, and cooling rates. The distance between the APPJ nozzle and the mesh surface (standoff distance) was adjusted from 0 to 70 mm, with thermal profiles recorded to identify the optimal distance for preventing surface overheating. Additionally, treatment time was varied between 0 and 240 seconds at a fixed standoff distance to evaluate thermal effects over different exposure durations.

A FLIR i7 thermal camera with a 140 x 140-pixel resolution was employed to capture precise thermal images, enabling detailed measurement of temperature gradients across treated surfaces. Its high accuracy and sensitivity were crucial for assessing the APPJ's thermal impact on various materials, ensuring reliable data acquisition throughout the study.

This research investigates the thermal behavior of APPJ treatments on metallic and polymeric surfaces, emphasizing the effects of standoff distance and treatment duration. The results indicate that steel, with its high thermal conductivity, heats and cools rapidly, whereas polypropylene retains heat longer due to slower heating. Findings also demonstrate that reduced standoff distances increase energy transfer, with material properties playing a crucial role in temperature distribution.

3:15pm **PS2-WeA-5 Spatiotemporal Analysis of a Submerged Water Plasma Driven with Nanosecond Long Voltage Pulses**, ***Michael Johnson,*** *David Boris, Lina Petrova,* Naval Research Laboratory, USA; *Mackenzie Meyer,* National Research Council; *Scott Walton,* Naval Research Laboratory, USA

Atmospheric pressure plasmas generate a distinct chemical and electrical environment ideal for treating water, making them attractive for applications in wound healing, chemical synthesis, nanomaterial fabrication, and water remediation. These plasmas can operate in a nonequilibrium regime when driven by short pulses of power, lasting tens to hundreds of nanoseconds, that energize electrons but are too short to significantly heat the surrounding gas. This study investigates the impact of pulse width on plasma-water interactions by applying 70–350 ns pulses to an argon plasma submerged in water. Plasma properties are analyzed using optical emission spectroscopy and electrical measurements. Results indicate that within the first 15 ns of the pulse, the plasma fully fills the gap between the electrodes. After this initial stage, the plasma expands to occupy the entire inter-electrode space for the remainder of the pulse, forming an arc-like plasma where current flow is regulated by the power supply. Essentially, pulse width determines how long the plasma remains in this high-current state. Optical emission spectroscopy revealed that argon dominates the emission immediately after plasma formation, but over time, hydrogen emission becomes more prominent as the plasma dissociates water molecules. This results in higher power consumption at longer pulse widths due to increased energy transfer to the water. Spatial emission profiles show uniform hydrogen emission across the reactor, whereas argon emission weakens near the positive electrode. Significant broadening of emission lines was observed during the pulse, with Stark broadening of hydrogen lines used to estimate electron density. Measurements indicate that a substantial electron density persists for several microseconds after the pulse, likely due to residual voltage on the electrodes during power supply neutralization. At the longest tested pulse width (350 ns), the post-pulse current lasted nearly 10 µs, highlighting not only the influence of pulse width on plasma dynamics but also the importance of other system parameters in determining plasma lifetime.

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3:30pm **PS2-WeA-6 Controlling Nitrogen Product Distributions in Plasma Electrolytic Reactors for Microbial Growth**, ***Brandon Kamiyama,*** *Diep Nguyen, Mohammadali Eslamisaray, Emily Gillmore, Angela Tomita, Ting Lu, R. Mohan Sankaran,* University of Illinois at Urbana Champaign

Fixed forms of nitrogen are essential for the growth of plants that enable global food production, and for the growth of microorganisms which power critical processes beyond agriculture such as biomanufacturing and chemical production. Currently, nitrogen fixation is predominantly carried out by industrial processes (e.g., Haber-Bosch, Ostwald processes) that have large physical and environmental footprints. The development of alternative methods that are sustainable and deployable at a small scale for point-of-use production has emerged as one of our critical technological challenges. Among the different approaches being explored, plasmas in contact with liquids have shown great promise, capable of reacting nitrogen in air with water as a source of hydrogen at atmospheric pressure and near room temperature. However, a key challenge is that these processes generate many nitrogen products, including ammonium, nitrate, and nitrite ions, in addition to other products such as hydrogen peroxide.

In this work, we studied a direct-current plasma-based electrolytic reactor and correlated process conditions such as gas feed, pH, and electrode polarity with product yields and selectivity. In particular, molecular oxygen and pH were found to be key for controlling the selectivity between the reductive and oxidative species. These results provided insight into possible reaction mechanisms and enabled us to selectively synthesize nitrogen products as substrates for microbial growth and biosynthesis.

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