SAPP XXII

22nd Symposium on Application of Plasma Processes and 11th EU-Japan Joint Symposium on Plasma Processing

Book of Contributed Papers

Štrbské Pleso, Slovakia
18-24 January, 2019

Edited by V. Medvecká, J. Országh, P. Papp, Š. Matejčík

Book of Contributed Papers: 22nd Symposium on Application of Plasma Processes and 11th EU-Japan Joint Symposium on Plasma Processing, Štrbské Pleso, Slovakia, 18-24 January 2019.

Symposium organised by Department of Experimental Physics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava and Society for Plasma Research and Applications in hotel SOREA TRIGAN***, Štrbské Pleso, Slovakia, 18-24 January 2019.

Editors: V. Medvecká. J. Országh, P. Papp, Š. Matejčík

Publisher: Department of Experimental Physics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava; Society for Plasma Research and Applications in cooperation with Library and Publishing Centre CU, Bratislava, Slovakia

Issued: January 2019, Bratislava, first issue

Number of pages: 386

URL: http://neon.dpp.fmph.uniba.sk/sapp/

Local Organizers

Department of Experimental Physics
Faculty of Mathematics, Physics and Informatics
Comenius University in Bratislava
Mlynská dolina F2
842 48 Bratislava, Slovakia
URL: http://www.fmph.uniba.sk/
Tel.: +421 2 602 95 686
Fax: +421 2 654 29 980

Society for plasma research and applications
Faculty of Mathematics, Physics and Informatics
Comenius University Bratislava
Mlynská dolina F2
842 48 Bratislava, Slovakia
URL: https://spvap.eu/
E-mail: spvap@neon.dpp.fmph.uniba.sk
Tel.: +421 2 602 95 686

Local Organizing Committee

Štefan Matejčík (chair)
František Krčma
Peter Papp
Juraj Országh
Veronika Medvecká
Ladislav Moravský

International Scientific Committee

22nd Symposium on Application of Plasma Processes

Prof. J. Benedikt	Christian-Albrechts-University, Kiel, Germany
Dr. R. Brandenburg	INP, Greifswald, Germany
Dr. Z. Donkó	Hungarian Academy of Sciences, Budapest, Hungary
Dr. T. Field	Queen's University, Belfast, United Kingdom
Prof. S. Hamaguchi	Osaka University, Japan
Prof. F. Krčma	Brno University of Technology, Brno, Czech Republic
Prof. N. Mason	University of Kent, United Kingdom
Prof. Š. Matejčík	Comenius University in Bratislava, Slovakia
Prof. J. Pawlat	University of Technology, Lublin, Poland
Prof. M. Radmilović-Radjenović	Institute of Physics, Belgrade, Serbia
Prof. P. Scheier	Leopold-Franzens University, Innsbruck, Austria

11th EU-Japan Joint Symposium on Plasma Processing

Prof. S. Hamaguchi	Osaka University, Japan
Prof. N. Mason	University of Kent, United Kingdom
Prof. Z. Petrović	Institute of Physics, Belgrade, Serbia

Reading Committee

Prof. Š. Matejčík	Comenius University in Bratislava, Slovakia
Prof. F. Krčma	Brno University of Technology, Brno, Czech Republic
Prof. N. Mason	University of Kent, United Kingdom
Dr. P. Papp	Comenius University in Bratislava, Slovakia
Dr. J. Országh	Comenius University in Bratislava, Slovakia
Dr. V. Medvecká	Comenius University in Bratislava, Slovakia

Conference Topics

1. Electrical discharges and other plasma sources
2. Elementary processes and plasma chemical reactions
3. Plasma-surface interactions
4. Plasma treatment of polymer and biological materials
5. Nanometer-scaled plasma technology
6. Ion mobility spectrometry

Table of Content

DIAGNOSTICS OF ATMOSPHERIC PRESSURE PLASMAS AND THEIR APPLICATION IN AGRICULTURE

N. Puač[1], N. Škoro[1], D. Maletić[1], S. Živković[2], N. Selaković[1], G. Malović[1] and Z.Lj. Petrović[1,3]

[1]*Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia*
[2]*Institute for Biological Research "Siniša Stanković", University of Belgrade, Bul. despota Stefana 142, 11000 Belgrade, Serbia*
[3]*Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000 Belgrade, Serbia*
E-mail: nevena@ipb.ac.rs

Atmospheric pressure plasmas (APPs) have been intensively studied in the last decade due to their high potential in the applications in medicine, biology and, lately, in agriculture [1, 2]. They are generated in plasma sources of various geometries and configurations and with different electrode material in order to make them efficient for large variety of applications. The types of sources used are mainly atmospheric pressure plasma jets (APPJs), but since some applications require large areas to be treated plan parallel dielectric barrier discharges [3-6] are also utilized. Typical configurations of APPJs consist of a tube for conducting the flow of the buffer gas and set of electrodes where powered one can be in the contact with the plasma or covered by dielectric. The power supplies that are most commonly used can be divided by the type of signal as continuous or pulsed and they can operate in the large range of frequencies (from several kHz to GHz). The choice of the geometry as well as the type of the power supply used is governed by the application of the APP. Regardless of the system choice and configuration, one needs to perform detailed diagnostics of the plasma system to obtain the data that could be linked to the processes significant for the particular treatment. Then, the efficiency of desired application can be assessed and, which is also important in many cases, there is an opportunity up to some extent to compare the achieved effects with the other systems used for the same application. At the same time, the detailed diagnostics allows the studies of fundamental questions of APP behaviour. For instance, in the case of APPJs an interesting feature of formation of pulsed atmospheric-pressure streamers (PAPS) was observed and investigated. The fast ICCD imaging of this phenomena revealed that PAPS have a speed of several kilometres per second and their formation and propagation still needs to be explained in more detail.

However, from the point of applications the most important feature of the APP is that they create chemically highly active media (both in gas and liquid) with the properties that can be generally tuned according to the application's demands. The active chemistry of the plasma's gas phase can directly modify the treated surface or activate specific mechanisms inside the treated target, e.g. plasma treatment of cells leading to the improved differentiation or cancer cell death [7, 8]. Also, since APP can operate in direct contact with a liquid, the chemically active environment produced in the gas phase above the liquid can modify the physical and chemical properties of the treated liquid [9-11]. Extensive research in this type of experimental configurations has led to the development of the applications of APP in the field of agriculture. Two examples of such applications are direct treatment of seeds and treatment of water in order to create plasma activated water. It was shown that in both cases plasma treatment induces higher germination percentage, less contamination of the seedlings, higher water uptake and faster plant development. These and other observed effects are the result of the interaction of plasma formed reactive oxygen and nitrogen species (RONS) with the seed and plant cells. RONS can trigger various biochemical mechanisms that can be observed also at molecular level through the activity of enzymes or hormones in the seeds and plants.

Here we will try to give the overview of the detailed characterization of the APP systems that were used for both medical applications and applications in agriculture. Results of time-resolved plasma imaging using fast ICCD camera will show the development of plasma structure within one period of the power signal and provide an insight in kinetic effects such as PAPS. Moreover, by using optical emission spectroscopy spectra of excited species in the gas phase will be obtained allowing the qualitative assessment of excited species above the treated liquid. The results of electrical measurements of APP sources, as another important diagnostics tool, will be presented. Comparison of the two different APP (in electrode geometry and applied voltage frequency) will be done by comparing both the results of plasma diagnostics and the response of the biological system treated by these plasma sources. Also, investigations of the applications of APP in the agriculture will be shown featuring the idea of plasma decontamination of water polluted by pesticides and its influence on germination of commercial plants.

Acknowledgments: This research has been supported by the Ministry of Education and Science Serbia, project III41011 and ON171037.

References

[1] Adamovich I. *et al. J. Phys. D. Appl. Phys.* 2017 **50** 323001.
[2] Puač N, Gherardi M and Shiratani M 2017 *Plasma Process Polym.* e1700174.
[3] Stoffels E, Flikweert A J, Stoffels W W and Kroesen G M W 2002 *Plasma Sources Sci. Technol.* **11** 383–8.
[4] Winter J, Brandenburg R and Weltmann K-D 2015 *Plasma Sources Sci. Technol.* **24** 064001.
[5] Maletić D, Puač N, Selaković N, Lazović S, Malović G, Đorđević A and Petrović Z L 2015 *Plasma Sources Sci. Technol.* **24** 025006.
[6] Čech J, Brablec A, Černák M, Puač N, Selaković N and Petrović Z L 2017 *Eur. Phys. J. D* **71** 27.
[7] Miletić M, Mojsilović S, Okić Đorđević I, Maletić D, Puač N, Lazović S, Malović G, Milenković P, Petrović Z L and Bugarski D 2013 *J. Phys. D. Appl. Phys.* **46** 345401
[8] Hirst A M, Frame F M, Maitland N J and O'Connell D 2014 *Biomed Res. Int.* **2014** 878319
[9] Bruggeman P J et al 2016 *Plasma Sources Sci. Technol.* **25** 053002.
[10] Škoro N, Puač N, Živković S, Krstić-Milošević D, Cvelbar U, Malović G, Petrović Z. Lj. 2018 *Eur. Phys. J. D* **72** 2.
[11] Puač N, Miletić M, Mojović M, Popović-Bijelić A, Vuković D, Miličić B, Maletić D, Lazović S, Malović G, Petrović Z. Lj. 2015 *Open Chemistry* **13**(1) 332.