applied sciences

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Editorial

The Applications of Plasma Techniques II

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1. Introduction

This Special Issue "The Applications of Plasma Techniques II" in the section "Optics and Lasers" of the journal *Applied Sciences* is intended to provide a description of devices and processes related to plasma applications in the broad sense. Plasma is called the fourth state of matter because its properties differ significantly from those of gas. Plasma can be defined as a conductive medium generated by the ionization of gas. Thus, it occurs as a mixture of photons, electrons, and ions, but it can also contain neutral atoms and molecules. The concept of plasma includes media with very different properties. Densities and kinetic energies of plasma components differ for various types of plasma by several or even more orders of magnitude. Hence, plasmas can have very different applications. Nowadays, plasma is very common in everyday life—from ubiquitous discharge lamps to plasma TVs. In technology, plasma is used in areas as diverse as gas purification, production of chemical compounds, surface treatment of materials, synthesis of nanoparticles, and deactivation of bacteria, viruses, and cancer cells. Readers interested in this modern field of science and technology are invited to enjoy this collection of articles, which will certainly excite the curiosity of both scientists, engineers and medics interested in plasma applications. As a guest editor of this Special Issue I wish you a pleasant reading.

2. Results

As a guest editor of this Special Issue of "The Applications of Plasma Techniques II" in the "Optics and Lasers" section of the journal "*Applied Sciences*", invited to write an *Editorial*, below I briefly discuss the results of all articles published in this Special Issue.

2.1. Dual-Frequency Microwave Plasma Source

Chi Chen et al. in [1] presented a dual-frequency microwave plasma source based on microwave coaxial transmission line, and 915 and 2450 MHz microwaves were used in this study. Two waves were delivered from two ports into the plasma reactor. One of these waves was used to excite the plasma and the other to regulate the plasma characteristics. In this system, the electron density and electron temperature of plasma can be controlled by feeding in different frequencies from the second port. In this way, different frequencies can selectively drive the plasma characteristics. The OES (optical emission spectroscopy) results confirmed that the particles with different energy levels showed different responses at different frequencies. The comparison of the characteristics was carried out between the single-frequency microwave plasma and the dual-frequency microwave plasma in the same device. The presented device is interesting because it allows to some extent to regulate such plasma parameters as electron density and electron temperature. The range of these parameters can be extended by using microwave sources with adjustable power and frequency.

2.2. Cold Plasma Treatment of Melanoma Cells

Yun-Hsuan Chen et al. in [2] showed the results of application of cold atmospheric pressure plasma for treatment of melanoma (B16F10)-skin cancer cells (with and without catalase enzyme in vitro). The generated cold plasma was characterized electrically and

Citation: Jasiński, M. The Applications of Plasma Techniques II. *Appl. Sci.* **2022**, *12*, 3683. https://doi.org/10.3390/app12073683

Received: 29 March 2022
Accepted: 31 March 2022
Published: 6 April 2022

spectroscopically. Biological data showed that the plasma inactivated cancer cells but not non-malignant cells. The authors state that the presence of the CAT enzyme confirmed that the reactive oxygen and nitrogen species (RONS) play key roles in inactivating the melanoma cancer cells. The authors conclude that the cold atmospheric plasma is a promising tool to overcome certain cancerous and precancerous conditions in dermatology, and that detailed investigation is still needed to understand the mechanisms underlying the presented results. Humanity has been fighting cancer for a long time with a limited success, so the presented cancer-fighting technique seems to be important.

2.3. Vortex Breakdown Control by the Plasma Swirl Injector

Gang Li et al. in [3] proposed and tested the concept of using the plasma swirler to control vortex breakdown. The presented plasma swirler with a helical shape was adopted to control the vortex breakdown. The plasma swirler with the electrode placed in the streamwise direction was designed by the authors. The plasma actuation, in affecting the onset and development of the vortex breakdown was captured and analyzed using particle image velocimetry (PIV) technique. The flow field measurement demonstrated that the plasma actuation was effective in controlling the development of vortex. The authors conclude that the method being proposed here may represent an attractive way of controlling vortex breakdown using a small amount of energy input without a moving or intrusive part, and the plasma actuation offers great flexibility in flow and combustion control.

2.4. Influence of Ag Electrodes Asymmetry Arrangement on Their Erosion Wear and Nanoparticle Synthesis in Spark Discharge

Kirill Khabarov et al. in [4] investigated the effect of the asymmetry arrangement of Ag electrodes on them erosive wear and presented the synthesis of nanoparticles (NPs) during a spark discharge. The two types of discharge current pulses were studied: oscillation-damped, in which the electrodes changed their polarities during a single discharge, and unipolar, in which the electrodes had a given polarity during the discharge. The used electrodes in the form of rods, one of which had a gas supply hole, were installed coaxially. The authors demonstrated that it is possible to control the size and concentration of synthesized nanoparticles by changing the degree of the electrodes asymmetry by setting their end faces at a certain angle. With an increase in the degree of the electrodes asymmetry, larger nanoparticles (with sizes greater than 40 nm) appeared in the aerosol composition and their agglomeration increased. The results presented in this article can help spark discharge users to optimize the placement of discharge electrodes.

2.5. Impact of the Samples Surface State on the Glow Discharge Stability in the Metals Treatment and Welding Processes

Maksym Bolotov et al. in [5] presented the results of a study of the effect of sample surface condition on the stability of glow discharge in metalworking and welding processes. The main objective of this study was to investigate the effect of cathode macro and micro relief on the existence of stable glow discharge in metalworking and diffusion welding processes. It was determined analytically and supported experimentally that the stability of the glow discharge is mainly affected by the generated sharp protrusions on the cathode surface due to the pretreatment of the samples by machining before welding. It was found that the increasing the cathode surface roughness from 10–15 μm to 60–80 μm led to the rapid decreasing the region of the limiting pressure of the stable glow discharge from 1.33–13.3 kPa to 1.33–5.3 kPa. The results presented in this article may be helpful for glow discharge researchers to optimize the working gas pressure and surface roughness of discharge electrodes.

2.6. Surface Discharge Mechanism on Epoxy Resin in Electronegative Gases and Its Application

Herie Park et al. in [6] presented a work on the mechanism of surface discharge on epoxy resin in electronegative gases and its application. The authors showed the characteristics of surface discharges in compressed insulating gases, including sulfur hexafluoride (SF_6), dry air and N_2 under a non-uniform electric field. The experiments were conducted with the gas pressure from 0.1 to 0.6 MPa using samples of epoxy dielectrics under an AC voltage. The experimental results showed that the surface insulation performance improved significantly using insulating gases containing electronegative gases, such as SF_6 and dry air. Among the various gases, SF_6 and dry air, which are electronegative gases, showed better insulating properties compared to N_2 due to their electron attachment capacity. The influence of electronegative gases on the surface ignition voltages, which vary with the pressure in these gases, has been analyzed in detail through the processes of electron attachment and detachment. The authors conclude that the physical information obtained from the results of this study can be used to provide improved surface insulation performance by using an insulating gas mixing technique in the design of SF_6-free HV equipment surface insulation.

3. Conclusions

The collection of articles discussed above covers various types of discharges and various processes. The discharges presented include, for example, microwave, spark, glow, or surface discharges. The characterizations of the sources of these discharges, the parameters of the generated plasmas, as well as the applications of these plasmas are discussed. The applications include, for example, the synthesis of nanoparticles or the treatment of skin cancer cells. I hope that the presented articles will be valuable for readers representing the world of science, medicine, and technology.

Acknowledgments: Thank you to all the authors and reviewers for their valuable contributions to this Special Issue (The Applications of Plasma Techniques II) of Applied Sciences. Congratulations to the management and all MDPI staff for the editorial support that contributed to the success of this project. I would especially like to thank Seraina Shi (Menaging Editor from MDPI Branch Office, Tianjin) for direct cooperation and assistance.

Conflicts of Interest: The authors declare no conflict of interest.

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