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RF-POWERED ATMOSPHERIC PRESSURE PLASMA JET FOR SURFACE TREATMENT

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Atmospheric pressure plasma jet (APPJ) was developed for decontamination purposes. Features of the device are ability to work with various feed-gases at the atmospheric pressure in several gas flow, frequency and current- voltage regimes. LabVIEW based TGAs virtual measurement sub-system for monitoring and measurement process through subsequent setting of electrical and gas-flow parameters (digital control of flow-meters), conditioning and amplification of electrical signals and collection of the data from peripheral measuring devices was applied.

1. Introduction

Plasma and Advanced Oxidation Processes (AOPs) are well known of excellent efficiency towards variety of chemical and biological contaminants [1-4].
Many research groups concentrate on the efforts of designing plasma sterilizing device working in the ambient conditions [5-17] using variety of methods such as barrier discharges, corona reactors or plasma jets. The main objective of this research was development of operator- and environmental- friendly low temperature atmospheric pressure plasma decontamination device, which should have operation cycle length at least the same as traditional set-ups, should be applicable toward broad range of materials and surfaces without damaging them irreversibly.

2. Experimental set-up

Experimental set-up, consisted of the following sub-systems:

- gas and liquid dosing sub-system,
- electrical discharge generating sub-system
- control and data acquisition sub-system
- chemical and biological analyzing sub-system

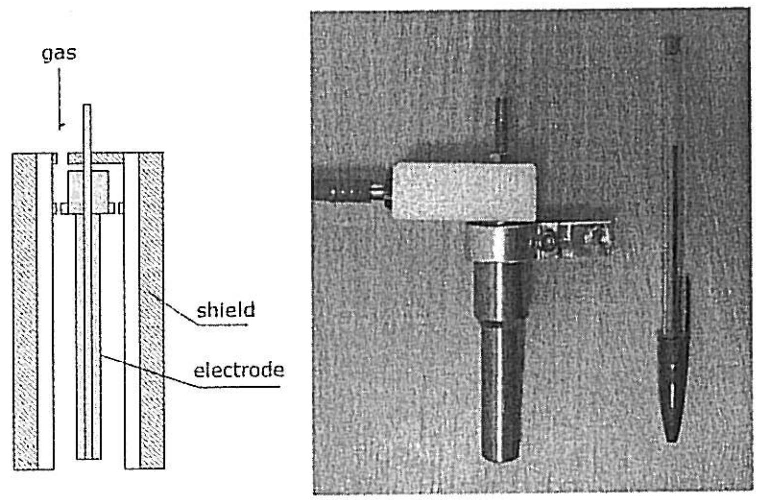

Fig.1. Schema and photo of atmospheric pressure plasma jet.

The main part of the device, which is presented in Fig. 1. was RF-powered changeable rod electrode of tungsten or acid-proof stainless steel. 3 types of electrode shapes: flat surface, screw-type

3. Results and discussion

Current/voltage characteristics on the primary and secondary side are presented in Fig. 4. Discharge homogeneity changed in dependence on all tested parameters: feed gas, gas flow rate, power supply parameters. The most homogenous plasma was generated in gas mixtures containing argon and helium and at gas flow rates exceeding 7,5 l/min. This is in a good accordance with literature data. From the discharge homogeneity point of view, the most beneficial were flat and turtle shape tungsten electrodes.

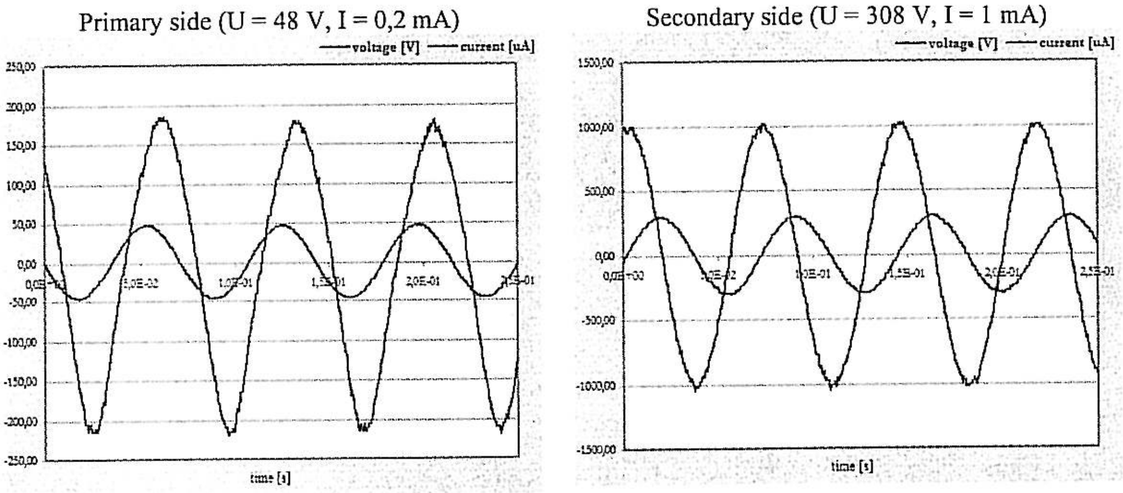

Fig. 4. Voltage/current characteristics

From the RF generator point of view, the most stable operation, which resulted in the lowest ratio of reflected power was achieved at frequency range 12-15 MHz (depending on the feedgas type). Examples of the discharge regimes in feed gas mixtures oxygen/argon and oxygen/helium (30/70%) with the current/voltage characteristics on secondary side are shown in Fig.5.

In dependence on the gas flow rate, discharge plasma sizing from 10 to 20 mm and 5-15 mm in diameter and length was produced. It is possible to achieve temperatures below 40°C compromising applied power, frequency and gas flow-rate.

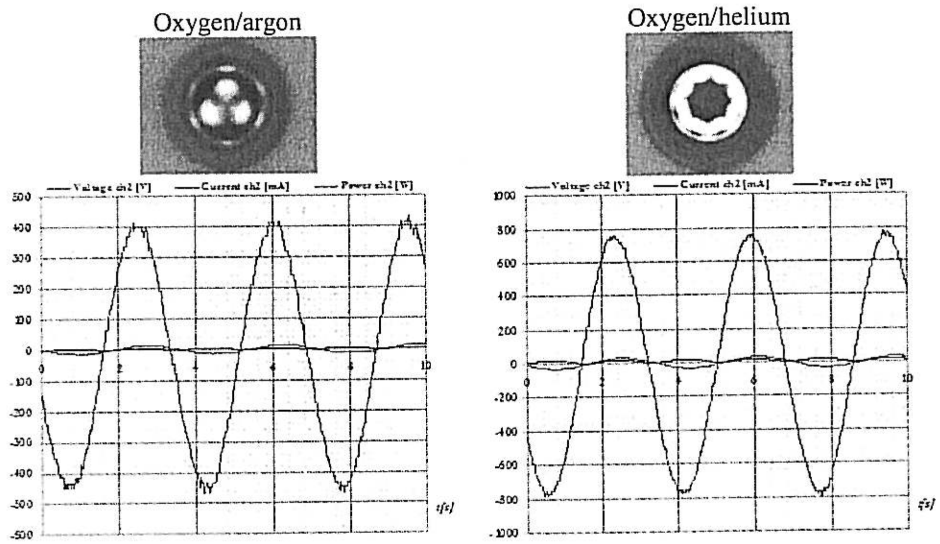

Fig. 5. Examples of discharge regimes obtained in APPJ.

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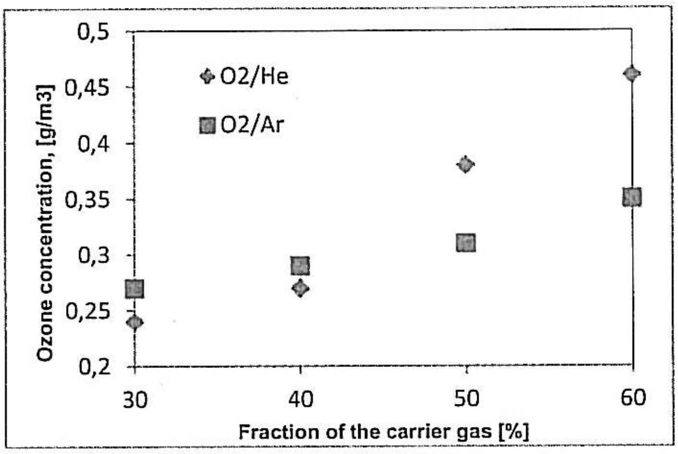

Fig. 6. Ozone concentration in dependence on the fraction of carrier gas: helium or argon. Process gas: oxygen, total flowrate: 10 l/min, P= 55 W, f=14,05 MHz.

Ozone concentration was measured in dependence on the gas type, gas flow rate, power and the type of electrode. Comparison of ozone concentration depending on the fraction of the argon and helium as a carrier gas added to oxygen, at 5 mm diameter, flat-surface electrode condition is presented in Fig. 6. Achieved ozone concentrations were low and ranged 0,82 g/m^3.

4. Conclusions

Compact device: atmospheric pressure plasma jet for decontamination purposes was developed. Achieved temperatures of the working gas in the outlet vicinity depended on the discharge conditions-mainly on the gas flow rate and it was possible lower temperature below 40 °C. Device may be applied for the treatment of the heat-sensitive surfaces in the future.

5. References

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and turtle-type surface of diameters ranging from 4 to 6 mm were tested. The electrode was powered by a regulated RF supply (AG 1021 RF generator, T&C Power Conversion) via impedance matching network. It was possible to power plasma reactor with frequencies from 10 kHz to 20 MHz. The schema of electrical supply is depicted in Fig. 2.

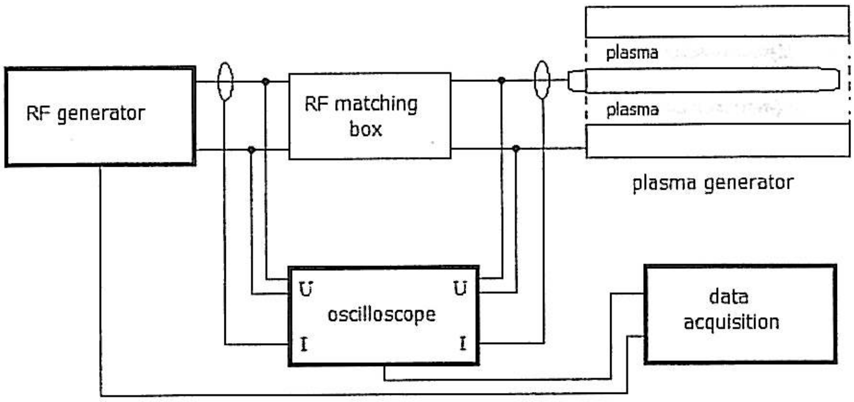

Fig.2. Electrical supply of APPJ.

LabVIEW based TGAs virtual measurement sub-system was developed for the purpose of this project. Main screen of the system, presented in Fig.3, enables whole monitoring and measurement process through subsequent setting of electrical and gas-flow parameters (digital control of flowmeters), conditioning and amplification of electrical signals. TGAs also automatically collects the data from Tektronix TDS2024B oscilloscope, voltage and current probes.

Elaborated application was divided into 4 modules: data acquisition, digital signal processing, reporting and flow-rate control. Main loop consists of decision events and event handler. Change of the settings on the front panel by user leads to direct communication and data streaming to generator, oscilloscope and flow meters. Application also uses functions defined in external module- report, which enables creating of reports in MS Office documents. Basic operations on discrete sequence representing measured signal are performed in the main loop. It is a data set of constant number of elements (2500 for each channel). Whole TGAs system represents integrated virtual environment communicating with devices using built-in communication tools for management of devices' work parameters and for data acquisition. Physically those tasks are realized via RS232 port or USB port.

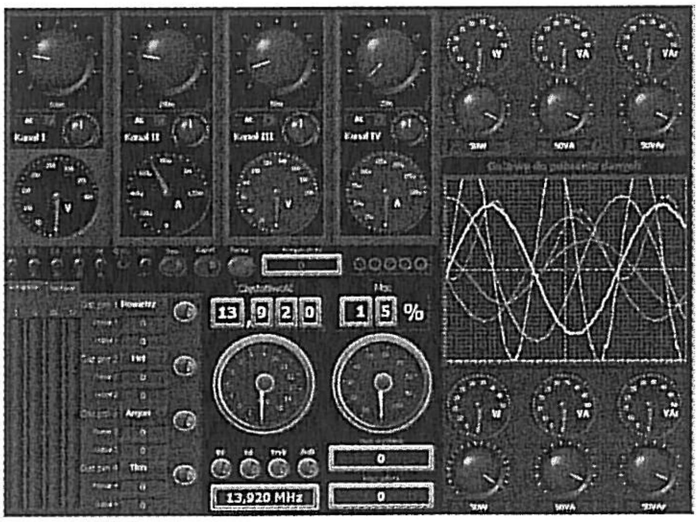

Fig. 3. Developed TGAs subsystem for control of gas flow and electrical parameters.