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NEXT GENERATION OF UNIVERSAL PULSE RESONANCE ATMOSPHERIC PLASMA SYSTEMS

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Abstract. New generation of atmospheric plasma generator was designed to create atmospheric plasma discharge between 2 electrodes with gap which is useable in food industry for plasma treatment of food or for any low conductive material in industry. Design was leaded to reach parameters of plasma which are unique on the market to simplify application of plasma treatment in real industry. System allow to create plasma discharge in gap from 5 to 60 mm in space of hundreds of cm2. The plasma source is based on a pulse resonance circuit which allow create high voltage pulses with ability to control and reduce a current of the plasma discharge. This ability allows to keep a temperature of the treated sample's (organic or inorganic) material at the room temperature.

1. INTRODUCTION

New plasma system was designed to fulfil needs of researchers from academic area with ability to transfer plasma treatment from academic laboratory to industry area. In last several decades, in many papers, impact of the plasma technologies to a surface structure and functionality are studied (Park et al. 2000, Abourayana et al. 2016). In most cases the plasma systems were operated at a low pressure (i.e. vacuum) and they are used for treatment of inorganic materials (Milosavljević and Cullen 2015). There are also available plasma systems which are able to create plasma discharge in atmospheric pressure known as plasma jet or microwave plasma (Cullen and Milosavljević 2015). The main disadvantage of all those systems is, they are able to create only small (local) atmospheric plasma discharge. Therefore, unavailability of such plasma systems to generate atmospheric plasma discharge in volume of thousands cm^3 with possibility to control energy of discharge to keep temperature of treated material low, makes a big obstacle for those systems to be used in food industry.

New pulse resonance atmospheric plasma systems were designed and manufactured to increase possibility of study of plasma treatment impact on sensitive organic and inorganic materials.

2. EXPERIMENTAL SETUP

The plasma system is based on tuned pulse resonance circuit which allows reaching high voltage on electrodes and reducing current via plasma to keep temperature of treated material low. A special new design of pulsing plasma power generator allows setting parameters of plasma which help to tune requested plasma treatment applying to different materials. Our plasma system allows to increase the surface-plasma interaction selectivity and to reduce plasma induced damages to the surface.

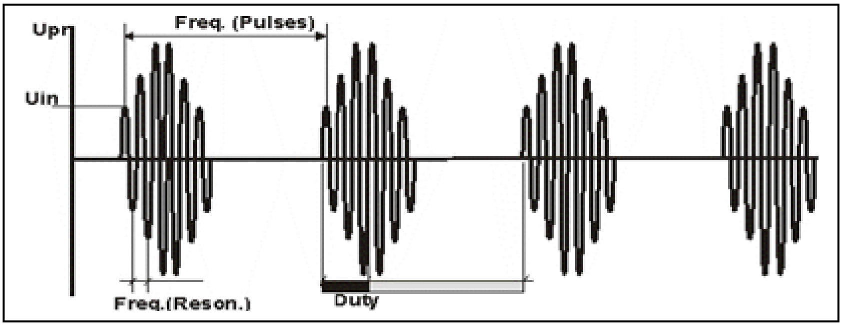

Figure 1: Pulse resonance pulses.

All parameters showed on Fig.1 can be changed. Namely, resonance frequency (Freq.(Reson.)) can be set from 30 kHz to 120 kHz and depend on configuration of the HV transformer and plasma electrodes. Currently used HV transformers are used with frequency about 55kHz. Correct setting of resonance frequency increase output voltage of HV transformer. Pulse frequency (Freq.(Pulses)) can be set from 100 Hz to 3000 Hz, and increasing this frequency would lead to increase the power of plasma discharge. Duty cycle influences current-power of each discharge. Input voltage is set following dielectric barrier between electrodes. Output power of system depends on the configuration of all mentioned parameters and can be set from 30W to 700W. Maximum power is limited also by dimension of electrodes. Maximum power for tested electrode with dimension about 12cm x 17cm is up to 400W.

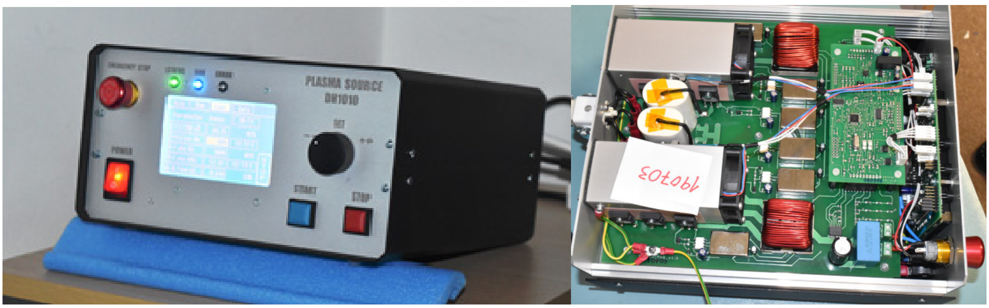

Figure 2: Plasma power supply unit.

The plasma generator (Fig.2) is designed to operate with the customize pin electrode such serves as a HV electrode, and ambient air such serves as a dielectric barrier. No additional dielectric material is required. This pin electrode is used together with flat electrode which is connected to ground. This configuration of electrodes allows to reach gap up to 65 mm between the flat electrode and the pins. Output voltage can go up to 80kVpp (depends on the air gap). On Fig.3 the parallel plate electrodes configuration is presented.

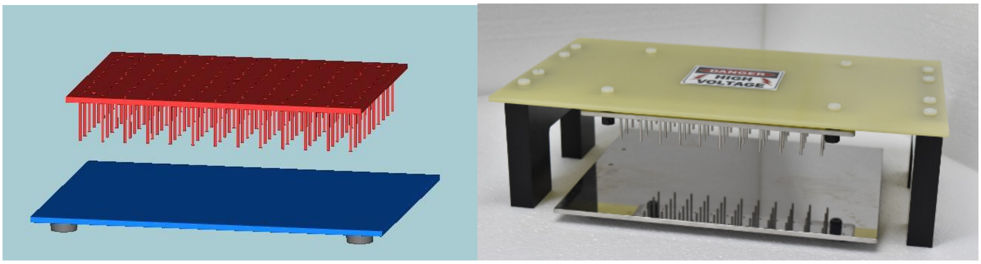

Figure 3: Pin electrodes

In Fig.4 is shown plasma discharge between electrodes. This plasma generator is used to study influence of plasma treatment on organic materials and to find the optimum plasma parameters which would give the best performance of those biological samples at the minimal plasma power (W/cm^2). With increasing the plasma power over a threshold point for the bio-surface activation, the plasma effectiveness stagnate or decrease.

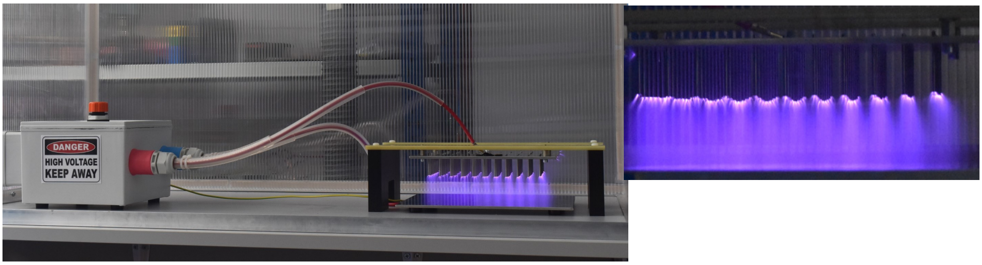

Figure 4: HV Transformer and electrodes with plasma discharge

3. RESULTS AND DISCUSSION

Measured dependence minimum output voltage (peak to peak) in kV to start discharge and number of pins used in top electrode with air gap from 1cm to 6cm between pin and flat electrode is showed on Fig 5. Fig.6 shows max Voltage (peak to peak) in kV before local discharge.

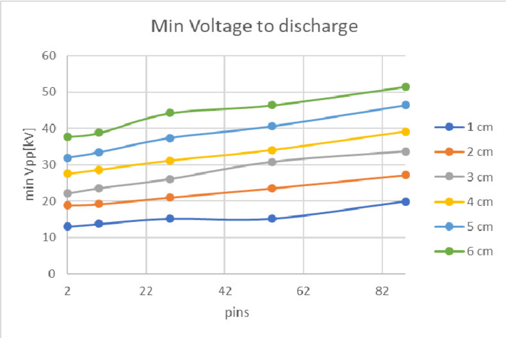

Figure 5: Min. voltage to discharge

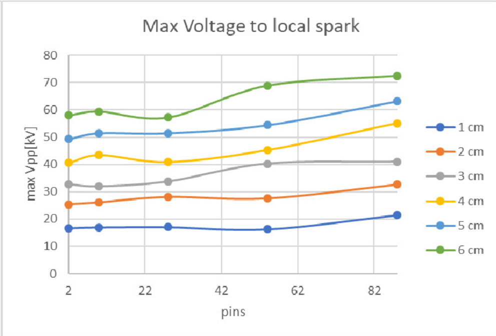

Figure 6: Max. voltage to discharge

4. CONCLUSIONS

The new pulse resonance plasma system, with pins electrode, allows much greater gap between electrodes, and give a possibility to be applied in food industry. Moreover, dielectric material necessary for today's DBD technology, is not required for this system. Therefore there are not issues with sterilization or decontamination of our plasma tool, on the contrary to systems which have thermally and chemical unusable dielectric (e.g. DBD).

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