Experimental study and sterilizing application of non-thermal plasma technology

G. M. El-Aragi
Plasma Physics and Nuclear Fusion Dept., Nuclear Research Center, AEA, PO 13759 Cairo, Egypt
e-mail: elaragi@gmail.com

Résumé

Non-thermal dielectric barrier discharge has been constructed that can be operated at atmospheric pressure consists of two parallel electrodes, one of which covered by a dielectric material. An ultra-short pulsed dielectric barrier discharge is employed to inactivate microorganisms in contaminated water. Experimental results indicate that after 180 s pulsed plasma discharges killing the targeted microorganisms in the water sample that contains some pathogenic microorganisms including Heterotrophic Plate Count (HPC) more greater than 210 CFU/ml and coliform bacilli greater than +240/100ml. The water sample was collected from River Nile in Cairo, Egypt.

Dielectric barrier discharges DBD or silent discharge plasmas are such that one or both of the electrodes are covered with dielectric layers. In conventional atmospheric pressure discharges, arcing results in localized heating and non-uniform processing of the gas. In DBD, however, the dielectric surfaces serve the role of a capacitor in series with the plasma. The plasma in DBD consists of a "forest" of micro-streamers.

Fig. 1 shows the schematic diagram of the pulsed power generator used in this paper. The generator is consisting of a negative dc source, a Blumlein-type pulse-forming network (E-PFN), and a dynamic spark gap switch. A triggered spark gap switch was used as a closing switch of E-PFN. E-PFN had 4 stages of LC ladder, which were composed of 5 nF of capacitor and 3 μH of inductor. The characteristic impedance ($2\sqrt{L/C}$) and the pulse width ($2N\sqrt{LC}$) of E-PFN, calculated from capacitance (C) and inductance (L) of the LC ladder, and number (N) of LC ladder stages were approximately 49Ω and 1.0 μs, respectively.

A charging resistance value of 50k Ω is chosen in the present case which corresponds to a charging RC time constant of 1 ms, which is 40 times faster compared to the repetition rate of the pulse.

The charging voltage into E-PFN was varied between 10 kV up to 30 kV. The applied voltage to and the discharge current through the discharge chamber were measured using a voltage divider (Home made), which was connected between the two electrodes, and a current monitor, which can be located upon returning to the ground. The signals from the voltage divider and the current monitor were recorded in a digitizing oscilloscope (Lecroy, USA) with a 200-MHz bandwidth.

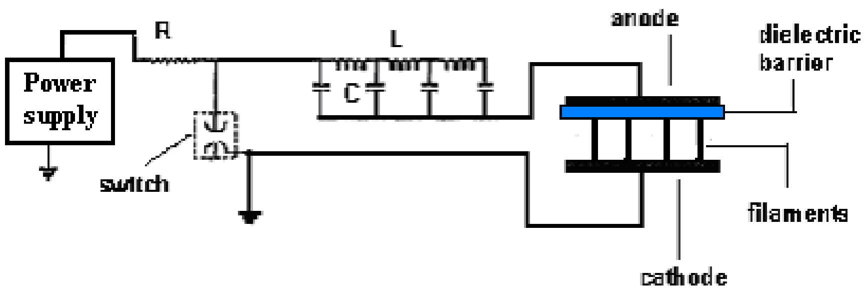

Figure1. Schematic diagram of the pulsed power generator.

Fig. 2 shows the configuration of the two plane parallel electrodes at least one which is covered by dielectric of thickness a few millimeters.

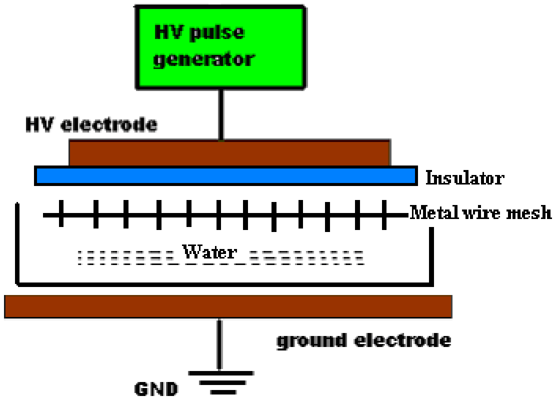

Fig. 2: Geometry of DBD discharge

Fig. 3 shows an exemplary of the waveforms of the applied voltage to and discharge current through the discharge chamber with 10-kV (a), these measurements allowed the determination of the power (b). The width of filaments lies between 15 – 20 ns and the period of filaments about 30 ns.

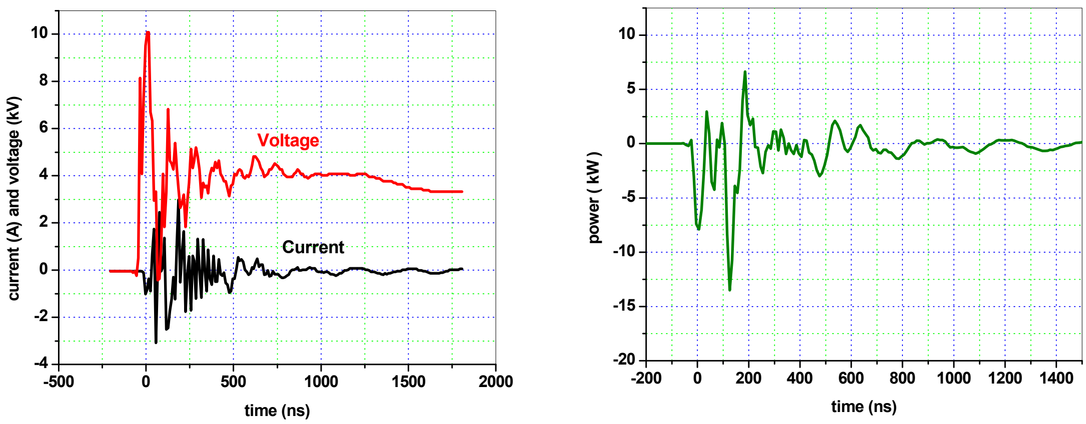

Fig. 3: The current, the voltage (a) and power waveform (b) of the DBD device

By using a gas flow the discharge is capable of changing into a homogeneous pattern. Figure 4 indicate that the filamentary discharge with air at atmospheric pressure and the homogeneous discharge using argon gas with flow rate 60 lpm, the discharge with more filaments.

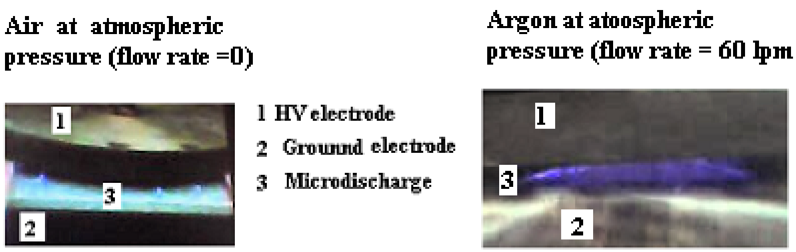

Fig. 4: Photograph of micro-discharges pattern in a 2 mm air gap (a) the filamentary discharge
(b) the homogeneous looking discharge.