Nanosecond Pulser with Variable Pulse Width and PRF for Biomedical Research

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EAGLE HARBOR TECHNOLOGIES

Introduction

Eagle Harbor Technologies (EHT), Inc. is producing commercially available Nanosecond Pulsers which allow for independently, user-adjustable output voltage (0 – 30 kV), pulse width (20 – 500 ns), and pulse repetition frequency (0 – 100 kHz) with several versions allowing different classes of average output power levels. EHT Nanosecond pulsers are currently being used at universities, medical start-ups, and government laboratories to conduct research in biomedical, sterilization and decontamination, clean combustion applications. Examples and results will be presented.

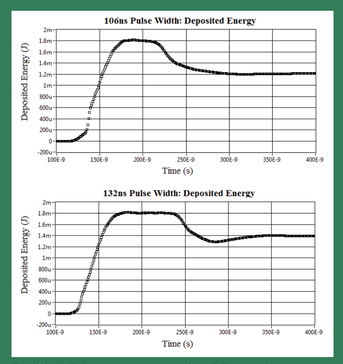
EHT Nanosecond Pulsers

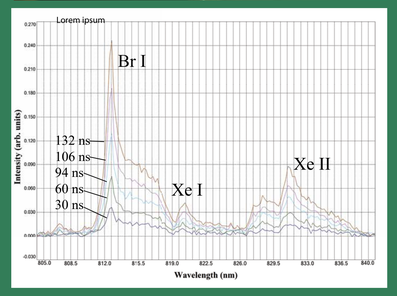
EHT has product line of versatile high voltage nanosecond pulsers with independently adjustable output voltage, pulse width, and pulse repetition frequency for producing non-equilibrium plasmas like pseudosparks, dielectric barrier discharges, atmospheric pressure plasma jets, and other cold atmospheric plasmas.

- Maximum output voltage: 5, 10, 20, or 30 kV
- Pulse width: 30 - 250 ns or 40 - 500 ns
- Pulse repetition frequency: Single Pulse - 200 kHz (CW)
- Rise time: 20 ns (load dependent)
- Power: 30 W - 7.5 kW

High Pressure Xenon-Bromine DBD

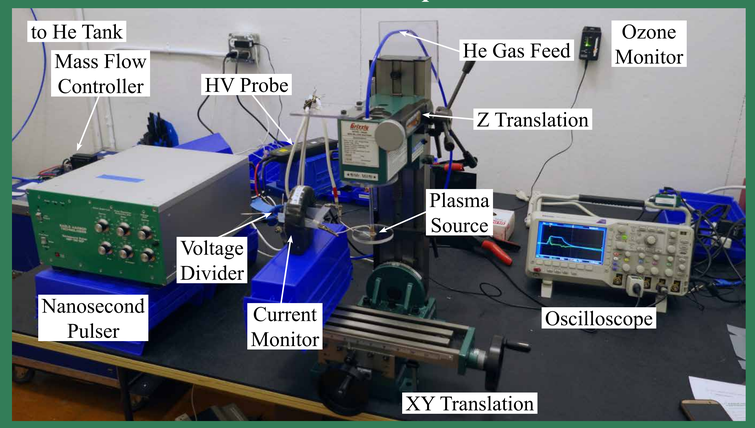
The DBD consisted of a sealed mixture of xenon and bromine at 7 atm inside a 1 cm diameter quartz tube. 20 kV pulses at 1 kHz were applied between an internal tungsten electrode and an external copper electrode. Varying pulse width changed spectral line intensity and total energy deposited in the plasma.

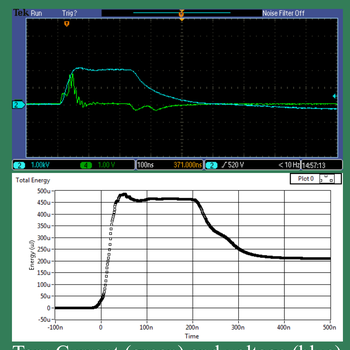




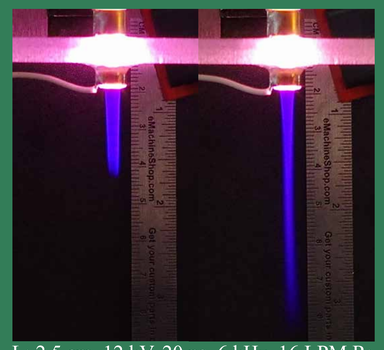
Left: 106 ns (top) and 132 ns (bottom) pulses deposited 1.2 mJ and 1.4 mJ into the plasma, respectively. Right: While increases in the blackbody radiation were modest, Br I, Xe I, and Xe II spectral lines increased dramatically with pulse width. This indicates potential utility of nanosecond pulsers in excimer production

Surface Sterilization of *Bacillus atrophaeus*





Top: Current (green) and voltage (blue) waveforms. Bottom: Energy per pulse.

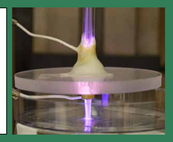


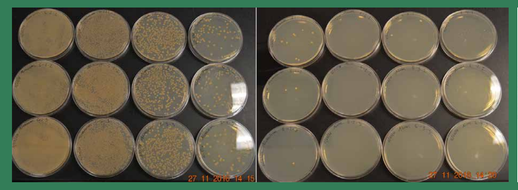
L: 2.5 cm, 12 kV, 20 ns, 6 kHz, 16 LPM R: 6.2 cm, 12 kV, 220 ns, 4 kHz, and 4 LPM

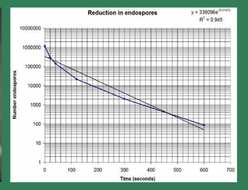
0.1 ml drop of stock *B. atrophaeus* endospore solution containing 2.9 x 10^7 endospores/ml was placed onto Al tape.

Exposed to the APPJ (4 slpm, 50 ns, 4 kHz, 20 kV) for 20 - 600 s. Untreated Al tape with endospores served as a control.

Recovery by dilution series, and calculate killing percentage.





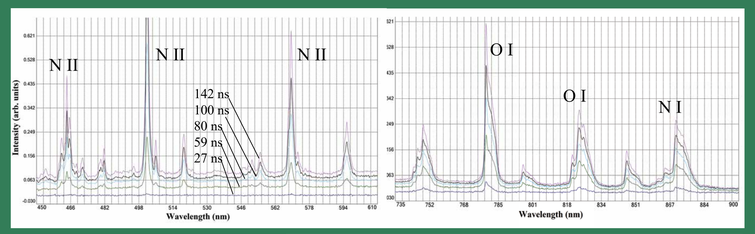


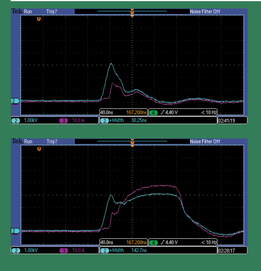
Left: Results of dilution series for control plates (left) and 10-min exposure (right). Columns represent 0.5 ml plated from dilutions of 1:10, 1:100, 1:1,000, and 1:10,000 (left to right). Rows represent triplicate plating of dilution series onto TSA. Plates were incubated for 24 hrs at 35 °C, with no more growth observed after 48-hour incubation.

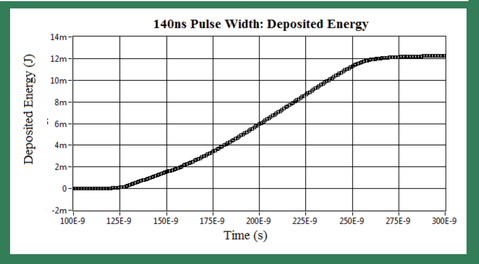
Right: Data yields an average D value of 160 s under these conditions on an Al surface. D values are typically considered to be linear, the killing pattern here was faster initially, with a D value of <60 seconds for the first log reduction, ~120 seconds for the second log reduction, and closer to 180 seconds for the third and fourth log reductions.

Atmospheric Arc

An arc was created between copper electrodes with a 1 mm spacing with 15 kV nanosecond pulses 1 kHz and a variety of pulse widths. The results indicated that varying the pulse width allows for isolation of various arc phases, and therefore selecting for relative intensities of different spectral lines. Arc nanosecond plasmas have been used for water treatment, nitrogen fertilizer production, and enhanced combustion.







Left: Voltage (blue) & current (purple) waveforms of 30 (top) and 143 ns (bottom) 15 kV pulse. Right: Energy deposited into the arc with respect to time is consistent with the expectation of a constant power, and helps validate other power measurements.

Conclusion

EHT has developed versatile high voltage nanosecond pulsers that have been used for in the development of medical devices, water treatment, sterilization processes, in-situ fertilizer production, and many other applications.

EHT Nanosecond Pulsers are designed in both low-power bench-top units, which are ideal for research labs investigating plasma chemistry, as well as high-power rack units that can operate at average powers up to 7.5 kW for larger industrial applications. Theses pulsers allow researchers to investigate a wide range of pulse parameters and tailor the pulse waveform to the specific application.

More information: https://www.eagleharbortech.com