CLAIMS

1. A drive circuit for a dielectric barrier discharge device, the circuit comprising:

a power supply connectable across a dielectric discharge gap, the dielectric discharge gap providing a capacitance; and

an inductance between the power supply and the dielectric discharge gap when connected thereby establishing a resonant tank;

an inverter between the power supply and the tank, the inverter being configured to modulate supply of power to the tank from the power supply, wherein

power is provided to the tank in pulse-trains and only during a pulse-train, a pulse frequency of each pulse-train being tuneable to a resonant frequency of the tank, power provided by each pulse-train charging and maintaining the tank to a threshold at which discharge ignition occurs; and

a power storage device connected across the power supply and configured to accept and store power discharge from the tank after each pulse-train, discharge ignition events per pulse-train being limited to a maximum number based on the drive circuit being configured to shift the phase of the pulse-train by 180 degrees (°) after the maximum number of discharge ignition events has occurred prohibiting each pulse-train transferring power to the resonant tank after the maximum number has occurred.

2. The drive circuit according to claim 1, wherein the maximum number of discharge ignition events is between 1 and 5 events.

3. The drive circuit according to claim 1 or claim 2, further comprising a phase meter in communication with the tank and configured to identify a phase shift in power provided to the tank during each pulse-train, the phase shift corresponding to occurrence of discharge ignition events, and wherein the drive circuit is further configured to determine when the maximum number of discharge ignition events has occurred based on the number of pulses in the respective pulse-train since each respective discharge ignition event.

4. The drive circuit according to any one of the preceding claims, wherein the inverter is an H-bridge or half bridge.

5. The drive circuit according to any one of the preceding claims, wherein each switch of the inverter is a silicon carbide switch.

6. The drive circuit according to any one of the preceding claims, wherein the pulse frequency of each pulse-train is a zero voltage switching frequency.

7. The drive circuit according to any one of the preceding claims, further comprising a transformer, secondary windings of which form part of the resonant tank, the transformer being a step-up transformer.

8. The drive circuit according to claim 7, wherein the circuit is configured to short the primary transformer winding after each pulse-train.

9. The drive circuit according to claim 8 as dependent on claim 4, wherein the primary transformer winding is shorted by switching on a low side or high side of the inverter.

10. The drive circuit according to any one of claims 7 to 9, wherein at least a part of the inductance is provided by the transformer.

11. The drive circuit according to claim 10, wherein the inductance provided by the transformer is leakage inductance of the transformer.

12. The drive circuit according to claim 10 or claim 11, wherein the transformer is an air-core transformer.

13. The drive circuit according to claim 12, wherein the air-core transformer has up to 60% magnetic coupling between windings.

14. The drive circuit according to any one of claims 7 to 13, wherein the transformer has a step up ratio of primary transformer windings to secondary transformer winding of 1:1 to 1:10.

15. The drive circuit according to any one of the preceding claims, wherein at least a part of the inductance is provided by an inductor.

16. A system for providing dielectric barrier discharge, the system comprising:

a dielectric barrier discharge device having at least two electrodes with a gap for fluid therebetween defining a dielectric discharge gap, a dielectric layer being located between the at least two electrodes; and

a drive circuit according to any one of the preceding claims, the power supply of the drive circuit being connected across the dielectric discharge gap.

17. The system according to claim 16, wherein a sub-macroscopic structure is mounted on at least one electrode.

18. The system according to claim 17, wherein the sub-macroscopic structure is a nanostructure.

19. The system according to claim 16 or claim 18, wherein the dielectric layer is connected to a first electrode and the sub-macroscopic structure is connected to a second electrode.

20. The system according to any one of claims 16 to 19, further comprising a controller connected to the drive circuit, the controller being configured to adjust the power supplied to the tank of the drive circuit based on input provided to the controller.

21. The system according to claim 20, wherein the controller is configured to adjust the pulse frequency, and/or the pulse-train repetition frequency, and/or the number of pulse-trains, and/or the number of pulses in a pulse-train.

22. The system according to claim 20 or claim 21, wherein the input includes voltage and current at an output of the drive circuit.

23. The system according to claim 22, wherein the drive circuit comprising an inverter between a power supply and a resonant tank of the drive circuit, the voltage and current being provided from an output of the inverter.

24. The system according to claim 22 or claim 23, wherein the controller is configured to determine phase difference between the voltage and current.

25. The system according to any one of claims 20 to 24, wherein the controller is further connected to the dielectric barrier discharge device, the input including one or more properties of fluid passing through the device.

26. The system according to any one of claims 16 to 25, wherein the system comprises a plurality of dielectric barrier discharge devices and a plurality of drive circuits, each drive circuit being connected across the dielectric discharge gap of one or more dielectric barrier discharge devices.

27. The system according to claim 26, wherein there is only a single power supply configured to provide the power supply for all the drive circuits.

28. A method of controlling discharge in a dielectric discharge device, the method comprising:

providing power to a resonant tank with a series of electrical pulse-trains, the pulse frequency of each pulse-train being tuned to a resonance frequency of the tank, the resonant tank being connected across a gap between electrodes in a dielectric discharge device, a capacitance of the tank being provided by the dielectric discharge device, power provided by each pulse-train charging and maintaining the tank to a threshold at which discharge ignition occurs;

providing a maximum number of discharge ignition events per pulse-train by prohibiting each pulse-train transferring power to the resonant tank after the maximum number of discharge ignition events has occurred;

discharging the resonant tank after the maximum number of discharge ignition events has occurred, the tank being discharged by changing the phase of the power provided by the respective pulse-train by 180°,

prohibiting power transfer to the tank between pulse-trains; and

storing energy passed out of the resonant tank by the discharge.

29. The method according to claim 28, wherein the maximum number of discharge ignition events is between 1 and 5 events.

30. The method according to claim 28 or claim 29, further comprising:

identifying a phase shift in power provided to the tank during each pulse-train, the phase shift corresponding to occurrence of discharge ignition events; and

determining when the maximum number of discharge ignition events has occurred based on the number of pulses since each respective discharge ignition event.

31. The method according to any one of claims 28 to 30, wherein each electrical pulse-train is a voltage pulse-train.

32. The method according to any one of claims 28 to 31, further comprising modulating the pulse frequency, and/or frequency of pulse-trains, and/or number of pulse-trains in the series of electrical pulse-trains, and/or number of pulses in each pulse-train.

33. The method according to claim 32, wherein the modulation is based on a phase difference in properties of the power provided to the resonant tank and/or one or more properties of fluid passing through the device.

34. The method according to any one of claims 28 to 33, wherein power is provided to the resonant tank via a transformer, the method further comprising shorting the transformer primary winding between pulses-trains.

35. The method according to any one of claims 28 to 34, wherein the pulse frequency of each pulse-train provided to the resonant tank is set by switching in a circuit between a power supply and the resonant tank.