1. Name of the Technology

High voltage high-frequency pulse power supply for Dielectric Barrier Discharge- Cold Atmospheric Plasma Torch.

2. One graphical image

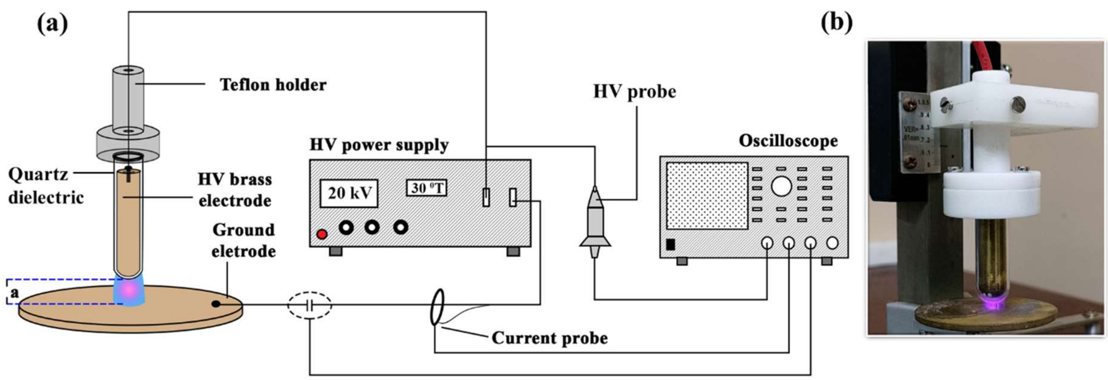

Figure 1. (a) Schematic and (b) image of the DBD-CAP set-up.

3. Brief description of the technology

This technology disclosed two components, **a high-voltage, high-frequency pulse power supply** and a **dielectric barrier discharge (DBD)** setup to generate cold atmospheric plasma (CAP). The CAP is generated by DBD which is powered by high-voltage quasi-sinusoidal signals (kV range) of kHz frequency range (18-30 kHz) by the developed high-voltage high-frequency pulse power supply.

4. Details about the technology

The technology involves a high-voltage high-frequency pulse power supply with a simple electrical design, which is small in size, portable, cost-effective, and provides electrical and temperature safety to the device. The power supply can generate high-voltage quasi-sinusoid pulse waveforms with variable amplitude (ranging from 0.9 kV to 28 kV) and variable pulse repetition frequency (ranging from 18.5 kHz to 30 kHz). The pulse width can also be varied from 11 μs to 18 μs. The invention also involves a dielectric barrier discharge (DBD) source setup. The DBD source consists of a cylindrical-shaped brass rod with a hemispherical tip at one end. The other end of the brass rod has a flat surface and is connected to the high-voltage power supply. The high-voltage electrode is covered by quartz glass (thickness of 1 mm) working as a dielectric medium. The second electrode is a stainless-steel foil/mesh, which is grounded. A Teflon holder is used to hold the high-voltage electrode and is dissembled and reassembled easily for cleaning and connecting the high-voltage, which also protects the surroundings from high voltage. The high-voltage high-frequency power supply with the DBD source generates cold atmospheric plasma and can be advantageous for biomedical applications, and material treatment.

High voltage high frequency pulse power supply:

Fig. 1 is a block diagram showing a pulse power supply generator **115,** which can generate high-voltage quasi-sinusoid pulse waveforms with variable amplitude (can be varied from 0.9 kV to 28 kV) and variable pulse repetition frequency (can be varied 18.5 kHz to 30 kHz). Pulse width can also be varied from 11 μs to 18 μs. The power supply **115** is supplied with a single-phase AC voltage (220V, 50 Hz). Two switched mode power supply (SMPS) **102** and **103** are working as DC power supply for the required DC voltage supply. The SMPS **103** of 12V/4.2A (model: Mean Well LRS-50-12) is used to supply power for the frequency control circuit **109** and cooling fans **114**. The SMPS **102** is 24V/14.6A (model: Mean Well LRS-350-24) and works as the primary source for the HV power generation. The output of DC power supply **102** is connected to a DC-DC converter circuit **104** through a temperature controller **105**. The output of the DC-DC converter **104** is controlled by using an external potentiometer **117** which further controlled the amplitude of the output voltage pulse **116**.

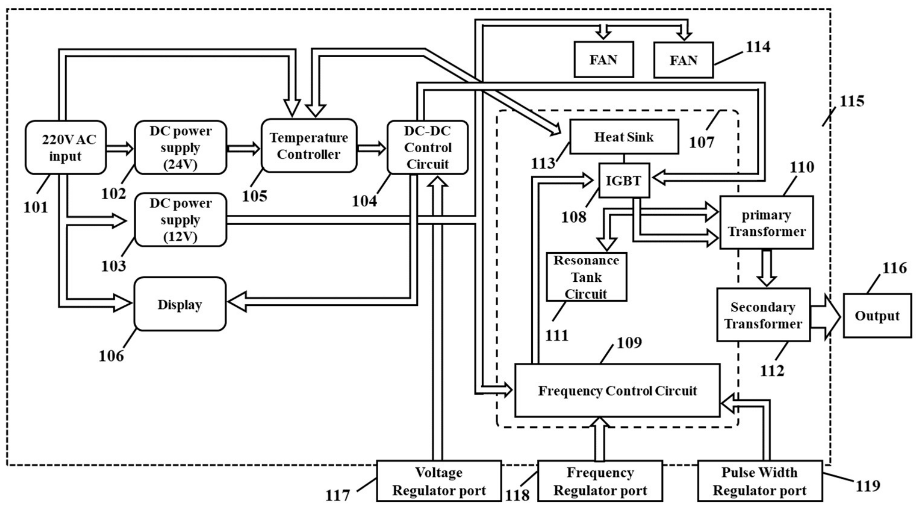

Fig. 2: Block diagram of high-voltage, high-frequency pulse power supply.

The output of the DC-DC control circuit **104** is connected to a display **106** and the emitter terminal of an IGBT (model: K75T60) **108**. The IGBT transistor **108** is used as a high-frequency switching device, which is used to create high-frequency oscillation to the primary coil of a high-voltage transformer **110**. A control pulse generator card, also known as a PWM circuit **107**, controls IGBT **108** gate pulses from frequency 18 kHz to 30 kHz and pulse width (FWHM of negative pulse) from 11 μs to 18 μs. An integrated circuit (IC) U3525L creates controlled signals in the PWM circuit **107**. The frequency and the pulse width of the signal are controlled through two external potentiometers **118** and **119** connected to the IC. A capacitor bank is used to create resonance frequency in the frequency-matching network **111**. The resonance frequency matching network **111** contains a series combination of two induction cooker capacitors of 0.3μF (Model: 0.3 μF J 630V AC 1200V DC Induction Cooker Capacitor 50 kHz). For high-voltage generation, a ferrite core step-up transformer is used. The ratio of primary to secondary is 1:800 in the system.

The IGBT **108** is connected to a heat sink **113,** and the temperature is measured through a temperature probe connected to the temperature controller **105** (model: Subzero 7510t). The temperature controller displays the temperature inside the power supply as well as protects the IGBT **108** from overheating. It will automatically cut off the input power supply of DC-DC converter **104** if the temperature rises above 40 ^{0}C and start again when it falls below 35 ^{0}C. Two 12 V cooling fan is connected to the DC power supply **103** to maintain the temperature inside the power supply unit. All the components are kept in a metal housing box **115** of dimensions 44 cm, 31 cm, and 13 cm corresponding to length, breadth and height.

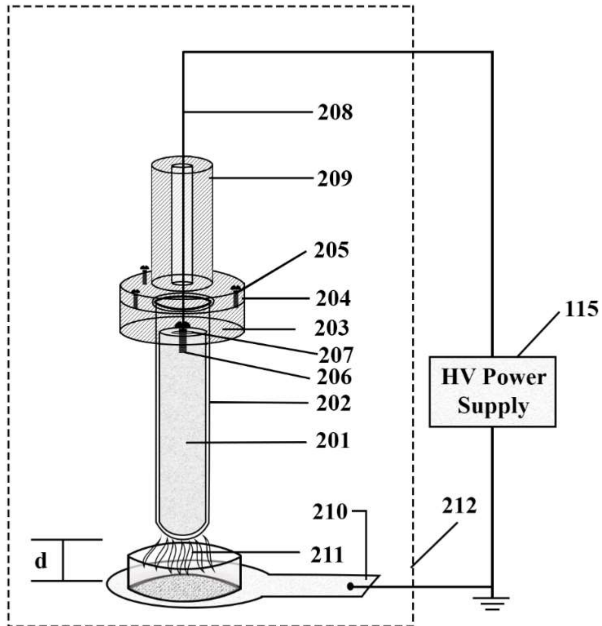

Fig. 3: Schematic of DBD setup.

Dielectric barrier discharge (DBD) setup:

Fig. 3 shows a DBD-CAP setup **212** with a high-voltage, high-frequency pulse power supply. The electrode setup has two electrodes: a high-voltage electrode and a ground electrode. The high voltage electrode contains a cylindrical brass rod **201** of diameter 10 mm and length 30 mm having a hemispherical tip. The brass rod **201** is covered with a quartz tube having a length of 41 mm, an inner diameter of 11 mm, and a thickness of 1 mm. The quartz glass tube **202** is chosen in such a way that the brass electrode **201** can fit properly inside it. The top of the electrode has a small screw **206** and a flat circular steel washer **207**. The steel washer **207** and the screw **206** are used for electrical connection of the high voltage electrode using a high-voltage connecting wire **208.**

A Teflon cylinder **203** with a thickness of 9 mm and a diameter of 33.5 mm is used as a bottom housing for holding the quartz glass **202** with brass electrode **201**. The Teflon cylinder **203** has a hole having a diameter of 12.5 mm in the centre. The quartz tube **202** has a collar at the open end, and the diameter of the through hole of the Teflon cylinder **203** is such that it can adequately hold the quartz tube. The bottom teflon holder **203** has three threaded holes, which is tightened to the screws **205** with the top teflon holder **204** to hold the two pieces together. The top teflon holder **204** has a through-hole diameter of 6 mm at the centre. The high-voltage connecting wire **208** is passed through the holes of the upper Teflon holder **204** and connected to the brass electrode **201**. The arrangement facilitates to disassemble and reassemble the set for cleaning of the various components like brass electrode **201,** quartz tube **202** etc after a long period of operation.

The high-voltage electrode **201** is connected to the output of the power supply through a high-voltage connecting wire **208**. The ground plate **210** is a flat stainless-steel plate or stainless-steel mesh connected to the ground port of the high-voltage, high-frequency pulse power supply. The high voltage electrode setup **212** has the advantage of cleaning easily before performing any experiments. The ground plate can be customized as the requirement of the sample to be treated. The distance ‘d’ is the distance of the gas gap between the high voltage electrode **201** and the ground **210**, which can be varied adequately.

5. What problem was solved or applicability of the technology

The power suppliers that are available till now to generate cold atmospheric plasma are bulky in size and involve complex electric circuit designs to generate the required output. Additionally, in those power suppliers, the pulse width of the output voltage waveform cannot be varied. However, compared to the available power suppliers the power supply which is proposed by the invention is small in size and can be used portably for any application. Additionally, the power supply does not involve any complex circuitry and requires fewer electrical components. Along with the variable output voltage and frequency, the pulse width of the output voltage waveform can also be varied from 11 μs to 18 μs. The power supply has protection against electrical shock and high temperature which are not very common in high voltage power supplies.

6. Patent status

An Indian Paten has been applied in September 2023 Application No. 202311062859, and currently under Application Awaiting Examination.

7. Contact details of the concerned scientist for further information

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