Optimization Design of Atmospheric Pressure Plasma Generator for Sterilization of Endoscope

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***Abstract*— Endoscopy is an important tool that can be used to identify and treat diseases and is essential to avoid cross infection when used on different people. Cold atmospheric-pressure plasmas (CAPs) offer the prospect of a future basic technology for decontaminating and sterilizing of endoscope. In this paper, we intend to design an endoscope sterilization device based on CAPs. The various lengths of gap between electrodes and electrodes themselves are considered, and the plasma distribution and its evolution are investigated.**

***Index Terms*— Cold plasma, multielectrode, sterilization.**

COLD atmospheric-pressure plasmas (CAPs) are of great interest for myriad of applications, such as plasma biomedicine [1]. In particular, they generate amount of electrons, reactive species, sufficient to drive many reaction chemistry for modifying proteins and cell membranes, whereas their gas temperature is close to room temperature, thus allowing the decontamination and sterilization of heat-sensitive devices like endoscope.

Endoscopy is an important tool of minimally invasive surgery that can be used to identifying and treating disease [2]. Although a strict infection control is used to endoscopy to prevent lapses in reprocessing and the possibility of transmission of infection, there are still many reported cases of nosocomial infection associated with a contaminated endoscope [3]. Besides the traditional methods, CAPs offer the prospect of a future basic technology for endoscope sterilization [4].

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In our experiments, the device consists of a long tygon tube with 2-mm inner and 4-mm outer diameters. A series of metallic electrodes is wrapped around the tygon tube (“U” shape to allow the image taken) with active and grounded electrodes in turn. In each case, the electrode width is either 6 or 12 mm, while the interval gap width is in contrary, i.e., 12 or 6 mm. An MKS mass flow controller was employed to provide a constant argon flow of three SLM through the tube. A power source, providing a 12 kV, 50-kHz sinusoid high voltage, was connected to the active electrodes. A Tektronix P6015A 75-MHz high voltage probe and a Pearson 2877 1 V/1 A 200-MHz current monitor were employed. The voltage and current signals were recorded by a Tektronix DPO3000 digital oscilloscope. The images were taken by an ICCD camera (Andor, DH334T).

It can be seen in Fig. 1(a) and (b) that the plasma in electrode gap is much narrower than in hollow electrode. As the increase of electrode width and decrease of electrode gap, the plasma in hollow electrode expands from the center part to the edge region. The plasma in electrode gap tends to spread to edge as well. These benefit the sterilization of endoscope because: 1) the contaminants are attaching on the inner wall of endoscope and 2) only the plasma region several-to-several hundred micrometers near to the wall is effective for the supply of decontamination agents [5]. In addition, the plasma shown in Fig. 1(b) is more uniform thus better for sterilization of the whole long endoscopy channel.

Fig. 1(f) and (g) shows the two adjacent discharges both under positive and negative half cycles (P1–P5 and N1–N5 show the first discharge process, P6–P10 and N6–N10 show the second discharge process), respectively, and the second discharge is much weaker than the first one. In positive half cycle, the plasmas originate in both edges of grounded electrode, and propagate into the grounded electrode firstly, then toward to the active electrode, at last expand in the hollow electrodes. The plasma intensity inside grounded electrode is the strongest. While in negative half cycle, the evolution of plasma is similar in morphology, only in contrary, the plasma in active or grounded electrode is exchanged. In morphology, the plasma is easy to occur along the tube axis, and it expands to electrodes due to the local electric field.

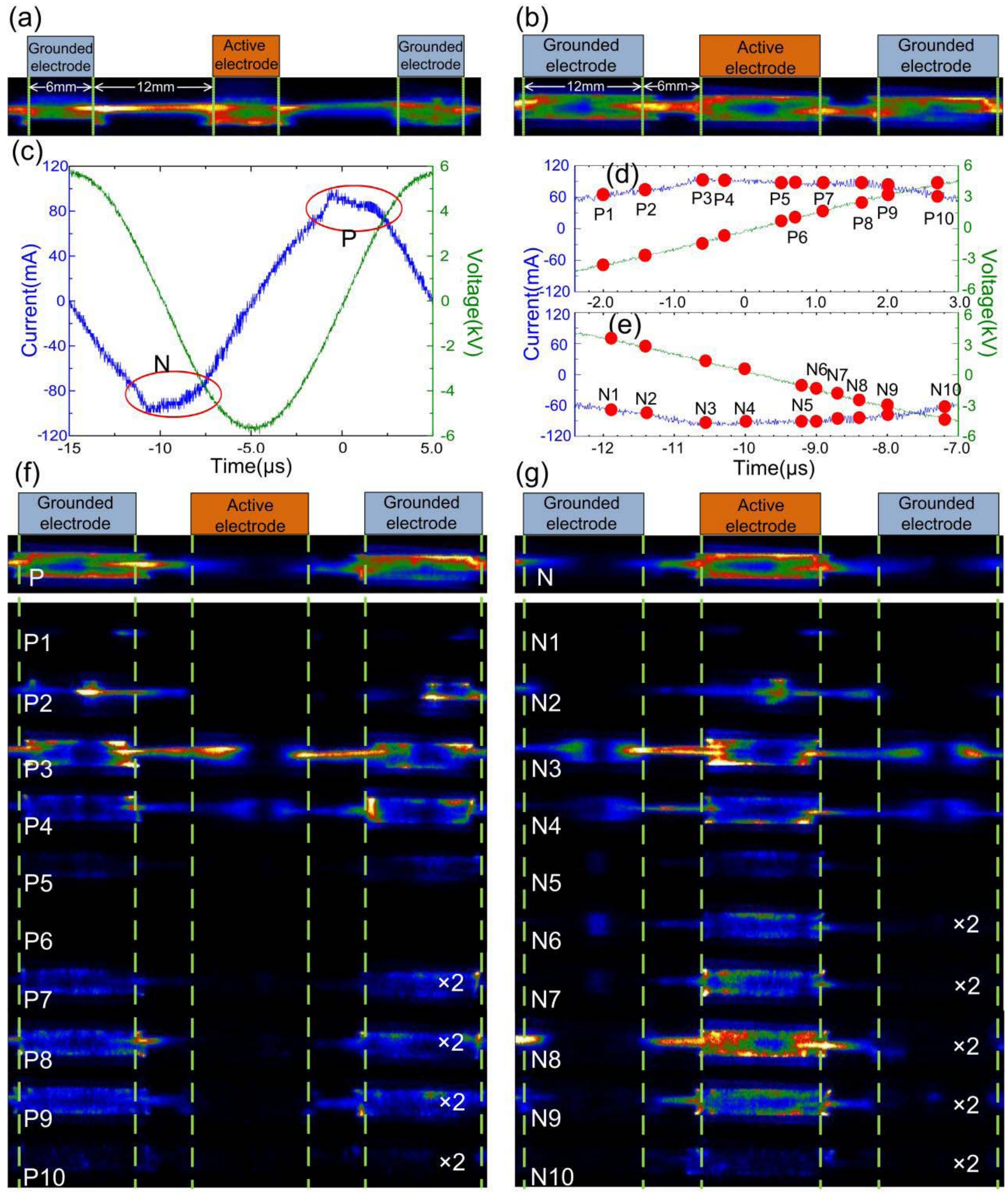

Fig. 1. Plasma distribution comparisons of different electrodes width and gaps width under argon gas condition. (a) and (b) Plasma distribution for one cycle with 6-mm electrode width and 12-mm gap, and 12-mm electrode width and 6-mm gap, respectively, and (b)–(g) have the same electrode/gap configuration. (c) Discharge voltage and current in one cycle. (d) and (e) Breakdown phases in negative and positive half cycles, which are marked in (c) with N and P, respectively. (f) and (g) Plasma distribution at the moments of P1–P10 and N1–N10 (exposure time is 50 ns), indicate the moments, which are given in detail in (d) and (e). P and N denote the positive and negative half cycle discharges accumulation, respectively, and ×2 denotes the light density of those images were doubled.

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