PROPAGATED VELOCITY OF SURFACE DISCHARGE IN NE/XE MIXTURES

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ABSTRACT

Surface discharge behavior and light emission properties for the configuration with two plane electrodes on the dielectric plate with a flat cable backside electrode have been investigated. In the case of negative polarity, surface discharge developed from the HV electrode to the grounded electrode. The negative surface discharge extension behavior is basically similar to that for the positive one. However, the extension of the negative surface streamer is significantly faster than that of positive one in 2%-Xe mixture.

1. INTRODUCTION

Intensive investigations on the surface discharge phenomena have been performed for the last several decades, because the suppression of the surface discharge is very important to prevent the accidents on the power apparatuses. On the contrary, the surface discharge is very useful for the practical applications in reactors, light sources and displays [1, 2]. So the control technology of surface discharge has been very interested and it should be one of the important technologies. From the above-mentioned standpoint, discharge characteristics for the configuration with two plane electrodes on the dielectric plane with a flat cable backside electrode have been investigated [3, 4]. We demonstrated that discharge modes, which are gaseous discharge, surface discharge and their multiplication, can be controlled by configurations and conditions such as backside electrode width and gas pressure. In this work, we have studied detailed discharge behavior and light emission properties in Ne/Xe mixtures for the electrode configuration have been investigated.

2. EXPERIMENTAL DETAILS

Figure 1 shows the schematic diagram of the electrode configuration in this work. A borosilicate glass plate with an area of 76 x 52 mm^2 and a thickness of t = 0.3 mm was used as a dielectric plate. Two copper plate electrodes with 21 mm in width as a HV electrode and a grounded electrode were distance between them was set at 10 mm. The back side electrode was attached on another side of the glass plate. A frat cable was used as a backside electrode. Rectangular Cu conductor with 0.7 mm in width and with 50 μm in thickness was laminated by polyester thin film above configuration was set in a brass chamber. Figure 2 shows schematic diagram of experimental setup in this work. After the evacuation up to 0.1 Pa, and then the chamber was filled with Ne gas or Ne/Xe gas mixtures under the pressure of p = 10~100 kPa. After that, pulse voltage with some interval (stop time) which was represented by number of interval cycle was applied to the HV electrode. Upon the application of pulse voltage, the waveform of the voltage and discharge current were monitored by using digital oscilloscope (Yokogawa, DL-1740E, 200 MS/s). Typical waveform of applied pulse voltage is indicated in Figure 3.

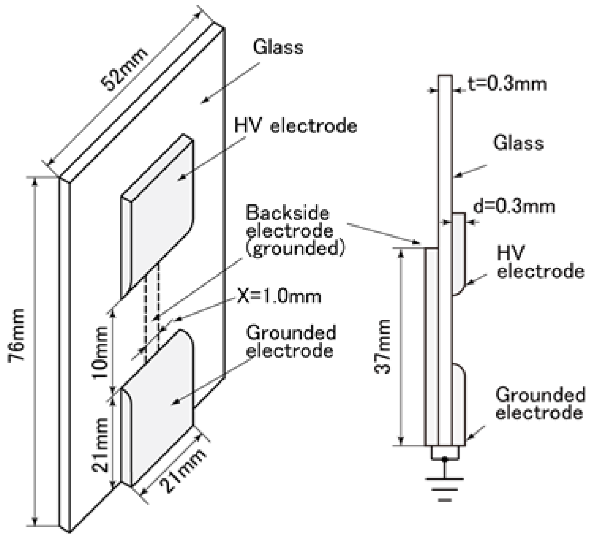


Fig.1 Schematic diagram of the electrode configuration

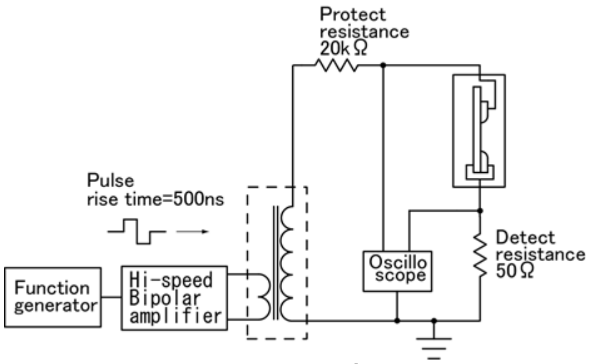


Fig. 2 Experimental setup

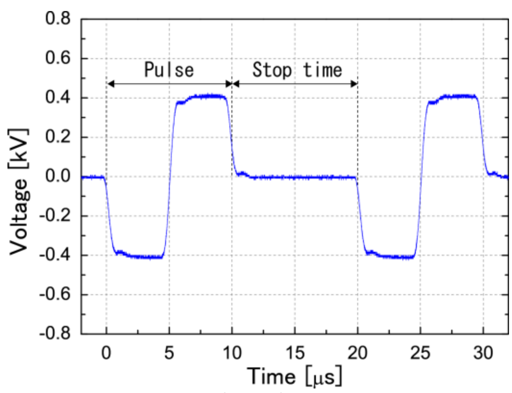
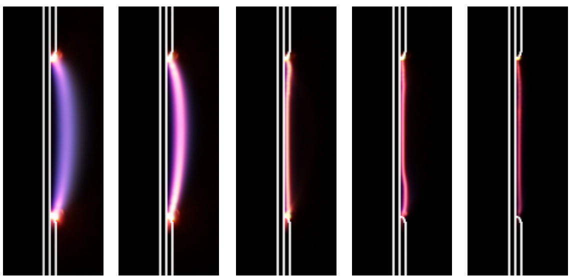


Fig. 3 Typical waveform of applied pulse voltage



(a) 0µs (b) 10µs (c) 40µs (d) 90µs (e) 190µs

Fig.4 Discharge images of the side view and influence of stop time of pulse voltage application in Ne

3. EXPERIMENTAL RESULTS

Figure 4 shows the discharge behavior for the present electrode configuration in pure Ne gas for the several intervals. Side views are indicated in the figure. As is evident from the side viewed images, discharge was not along the solid dielectric surface and extended to the gaseous space upon continuous pulse voltage application. However, the discharge developed along the dielectric surface by increasing the interval. In the case of the stop time of 90 and 190 µs, the discharge almost tightly developed on the dielectric surface, so called surface discharge was clearly appeared. In the case of Ne/Xe mixtures, discharge developed tightly along the dielectric surface regardless of interval.From these results about the inception voltage and discharge behavior and the influence of interval of pulse voltage application, in the case of short interval, number of residual charges such as electrons will exist on the dielectric surface and gaseous space. These residual charges results in lower discharge inception voltage and discharge extension toward the gaseous space. By increasing interval, the influence of residual charge should by reduce.

Figure5 and figure6 shows typical waveforms of positive and negative applied voltage and discharge current in 2%-Xe mixture. It should be noted that the relative small current observed at the wave-front of pulse voltage is not discharge current but charging current of dielectric material. The first small discharge current was observed after disappearance of charging current at the crest of voltage, and then the current was markedly enhanced and the voltage-drop was induced due to bridging between electrodes. In the case of the negative polarity, the behavior was almost same as in the positive polarity, but the discharge current before bridging was significantly larger than that the positive one.

Figure 5 and figure 6 shows positive and negative surface discharge extension behavior in 2%-Xe in Ne captured by using fast-gated image-intensified camera with exposure time of 20 ns. In the case of positive polarity, positive streamer with intense emission at its tip developed gradually to the grounded electrode from the HV electrode on the dielectric plate surface. After reaching at the grounded electrode, discharge with relative strong emission

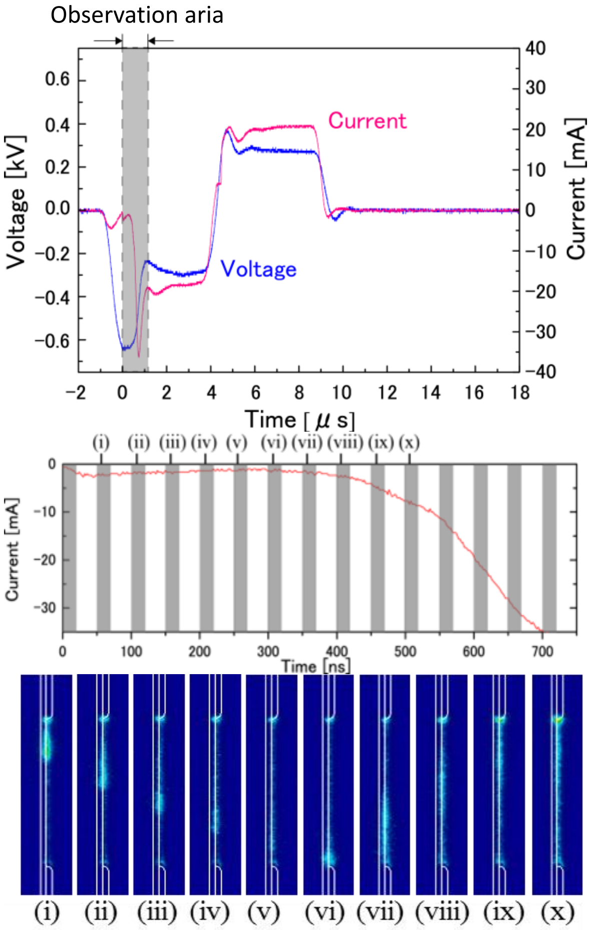


Fig.5 Extension behavior of negative discharge

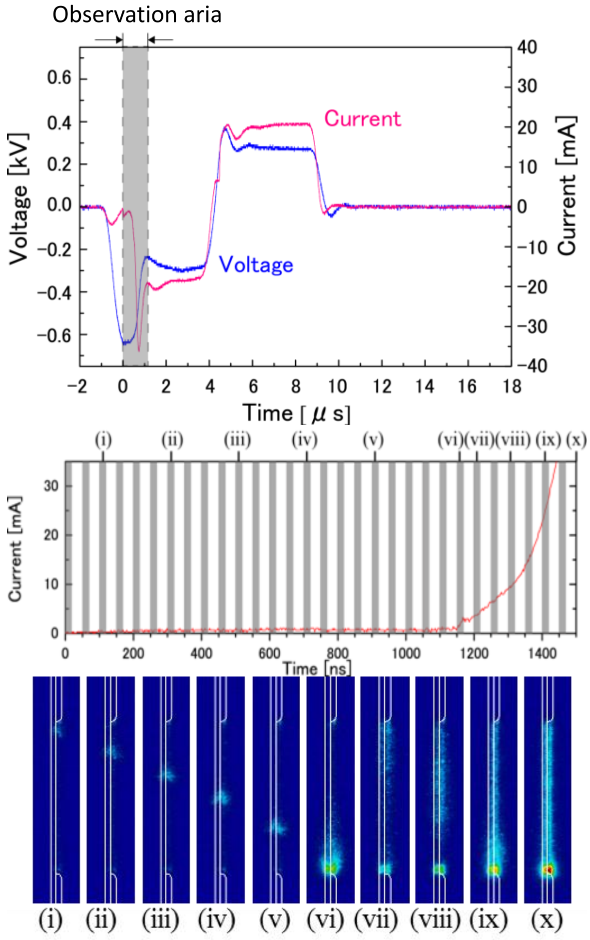


Fig.6 Extension behavior of positive discharge

developed again on the dielectric surface with backing electrode from the HV electrode and toward the grounded electrode. And then, emission between these electrodes decreased. Namely, surface discharge changed from streamer discharge to grow-like discharge.

In the case of negative polarity, surface discharge developed from the HV electrode to the grounded electrode. And, the negative surface discharge extension behavior is basically similar to that for the positive one. In the case of the positive polarity, the positive streamer developed from the HV electrode to the grounded electrode for 1.1 μs. On the contrary, the negative streamer reached at the grounded electrode only for 0.3 μs. Namely, the extension of the negative surface streamer is significantly faster than that of positive surface streamer.

It is well-known that the positive streamer extension is higher than that negative one in gaseous discharge due to the photo-ionization in front of the streamer head by UV emission from the discharge. Photoelectrons will be supplied by UV radiation from the streamer. In addition, in the case of the negative polarity, electrons near the head of streamer were accelerated to the direction of dielectric surface due to the presence of backing electrode of the investigated electrode configuration. It results in collision between electrons and dielectrics surface, leading to secondary emission. This effect is possible only for the negative polarity.

Figure 7 shows discharge inception voltage in Ne/Xe mixture gas. A minimum value of discharge inception voltage has been observed for 2 % Xe gas admixture into Ne gas.

Figure 8 shows propagated velocity in Ne/Xe mixture gas. In the case of 2 % Xe gas admixture into Ne gas, the propagated velocity of the surface streamer is significantly faster than that of positive surface streamer. In the case of 10 % Xe gas admixture into Ne gas, propagated velocity of the positive surface streamer is faster than that of negative surface streamer.

4. CONCLUSION

Surface discharge behavior and light emission properties for the configuration with two plane electrodes on the dielectric plate with a flat cable backside electrode have been investigated.

In the case of negative polarity, surface discharge developed from the HV electrode to the grounded electrode. The extension of the negative surface streamer is significantly faster than that of positive surface streamer. These results suggest that electrons with high energy are included in the negative surface streamer head and the photoemission and the secondary emission play important role in the negative streamer extension.

5. ACKNOWLGEMENTS

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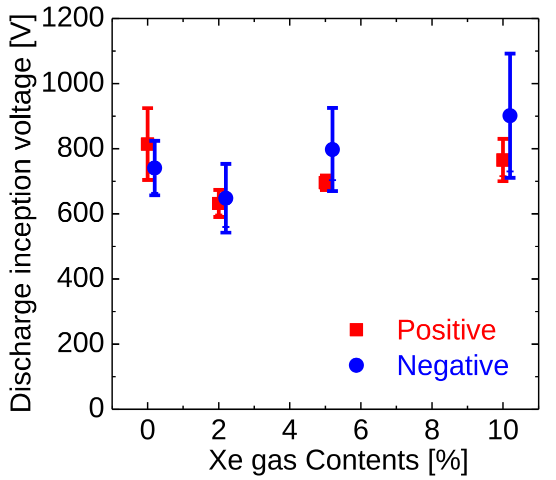

Fig. 7 Ne/Xe gas content dependence of discharge inception voltage.

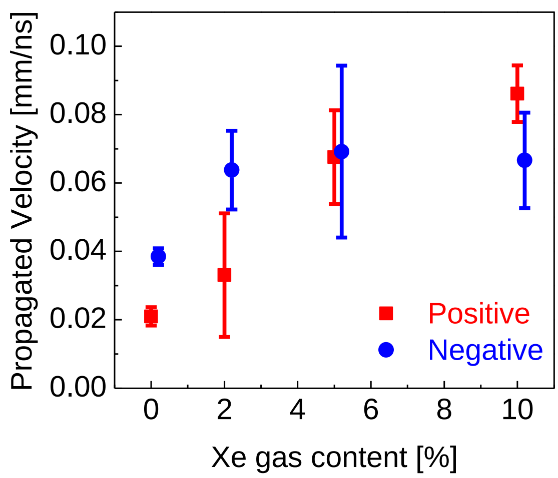

Fig. 8 Ne/Xe gas content dependence of propagated velocity.