Title	Surface Discharge and Light Emission Properties on Solid Dielectric Plate with Strip Backing Electrode in Ne/Xe Mixtures
Author(s)	Ueno, Hideki; Okuda, Tomohiro; Hayashi, Karin
Citation	電気材料技術雑誌. 2011, 20(2), p. 117-120
Version Type	VoR
URL	https://hdl.handle.net/11094/76889
rights	
Note	

電気材料技術雑誌　第20巻第２号
J. Soc. Elect. Mat. Eng.　Vol.20,　No.2　２０１１

Surface Discharge and Light Emission Properties on Solid Dielectric Plate with Strip Backing Electrode in Ne/Xe Mixtures

Hideki Ueno, Tomohiro Okuda, Karin Hayashi

Department of Electrical Engineering and Computer Sciences, University of Hyogo,
2167 Shosha, Himeji 671-2280, Japan,
Tel: +81-79-267-4863, Fax: +81-79-267-4855
E-Mail: ueno@eng.u-hyogo.ac.jp

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 (cathode) to the grounded electrode (anode). 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 surface streamer.

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 plate with a flat cable backside electrode have been investigated [3-5]. 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 DETAIL

Figure 1 shows the schematic illustration of the electrode configuration and experimental set-up in the present work. A borosilicate glass plate (permittivity ε_r=7.0, volume resistivity ρ_v=1.1 x 10^{12} Ω·m, surface resistivity ρ_s=1.4 x 10^{11} Ω) with an area of 76 x 52mm^2 and a thickness of t=1.0mm was used as a dielectric plate. Two copper plate electrodes with 21mm in width as a HV electrode and a grounded electrode were placed on the glass dielectric plate and the distance between them was

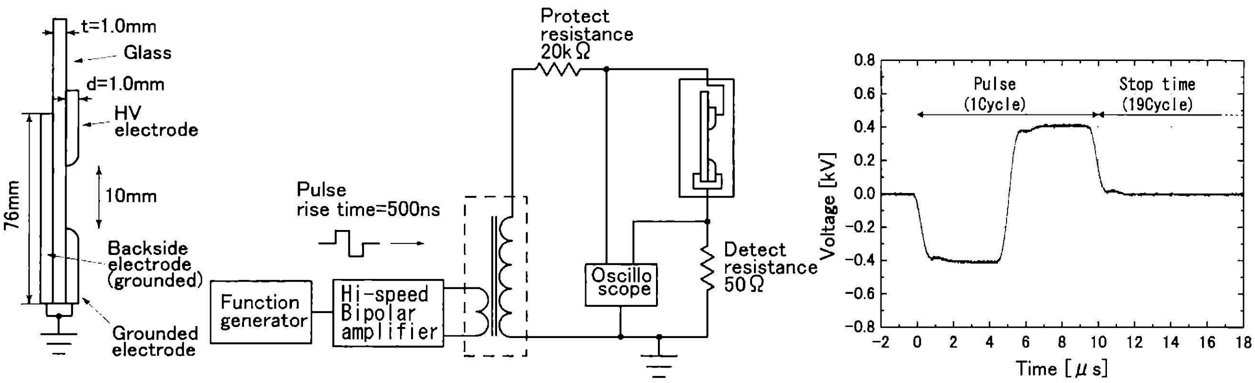

Fig.1 Electrode configuration, experimental set-up and typical waveform of applied pulse voltage

set at 10mm. The backside electrode was attached on another side of the glass plate. A flat cable was used as a backside electrode. Rectangular Cu conductor with 0.7mm in width and with 50μm in thickness was laminated by polyester thin film on the used flat cable.

Above configuration was set in a brass chamber. After the evacuation up to 0.1Pa, and then the chamber was filled with Ne gas or Ne/Xe gas mixtures under the pressure of p=10~100kPa. 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 waveforms of the voltage and discharge current were monitored by using a digital oscilloscope (Yokogawa, DL-1740, 200 MS/s). Typical waveform of applied pulse voltage is also indicated in Fig.1.

3. RESULTS AND DISCUSSION

Electric field analysis for the present configuration by FEM has been performed. Figure 2 shows the electric field along the HV electrode edge as indicated in Fig. 1 and the position is represented the distance from the center of the HV electrode edge. Here, the configuration without the backside electrode is defined by X=0mm. In the case of the glass plate thickness of t=1.0mm, Electric field is intensified by the backside electrode. However, the electric field increased gradually at the backside electrode edge (Cu conductor edge) as seen in the case of X=1mm. In the case of t=0.1mm, the electric field is more intensified by the backside electrode compared with that for t=1.0mm due to the reduction of the distance between the HV electrode and the backside electrode. Furthermore, the change of electric field corresponding to alignment of the Cu conductors in the backside electrode is clearly recognized for X=9.5mm.

Figure 3 shows discharge inception voltage in negative polarity upon pulse voltage application in pure Ne gas. It should be noted that the interval (stop time) of 0 cycle means continuously pulse voltage application. The negative discharge inception voltage increased with increasing interval of pulse, especially at relative short interval. In

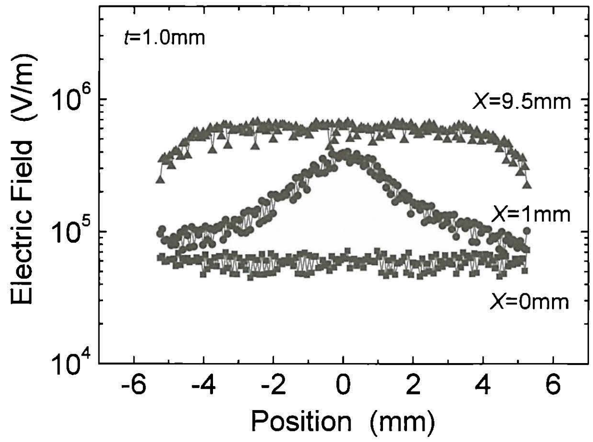

Fig. 2 Electric field analysis of the configuration

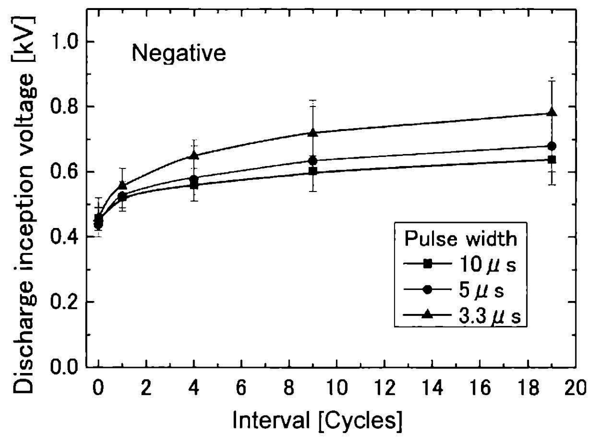

Fig. 3 Dependency of interval (stop time) on discharge inception voltage in Ne gas

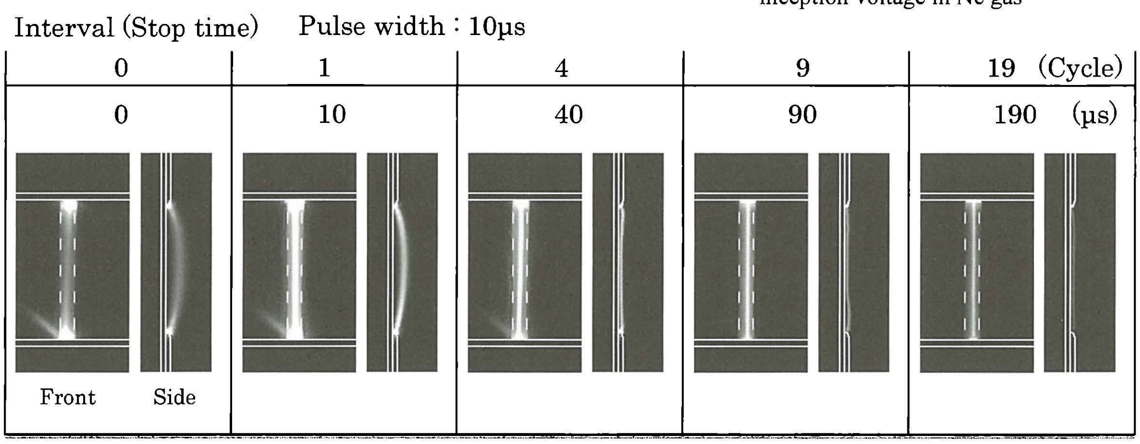

Fig.4 Discharge images of the present configuration in Ne and influence of interval of pulse voltage application

addition, by decreasing pulse width, the dependency became clearly because of the shorter duration with high electric field. Though the positive discharge inception voltage is little higher than the negative ones, the dependency of interval on the inception voltage in positive polarity is almost same as in the negative polarity.

The discharge behavior for the present electrode configuration in pure Ne gas for the several intervals is shown in Fig.4. Front and 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 (interval : 0). However, the discharge developed along the dielectric surface by increasing the interval. In the case of the intervals of 9 and 19, 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.

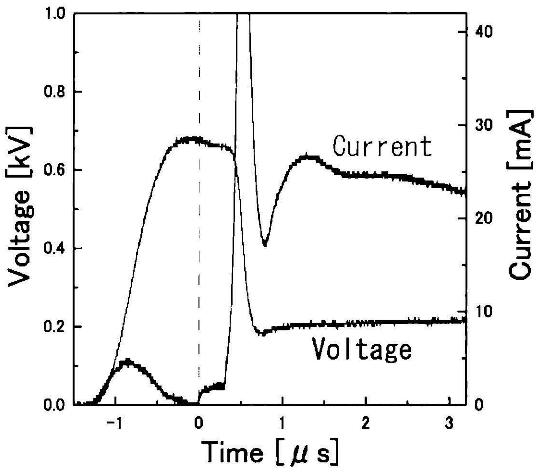

Fig.5 Typical waveforms of voltage and discharge current in Ne/Xe mixture for positive polarity

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 be reduced.

Figure 5 shows typical waveforms of voltage and discharge current in 2%-Xe mixture for the polarity. 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 indicated in Fig. 5.

Figure 6 shows positive and negative surface discharge extension behavior in 2%-Xe in Ne

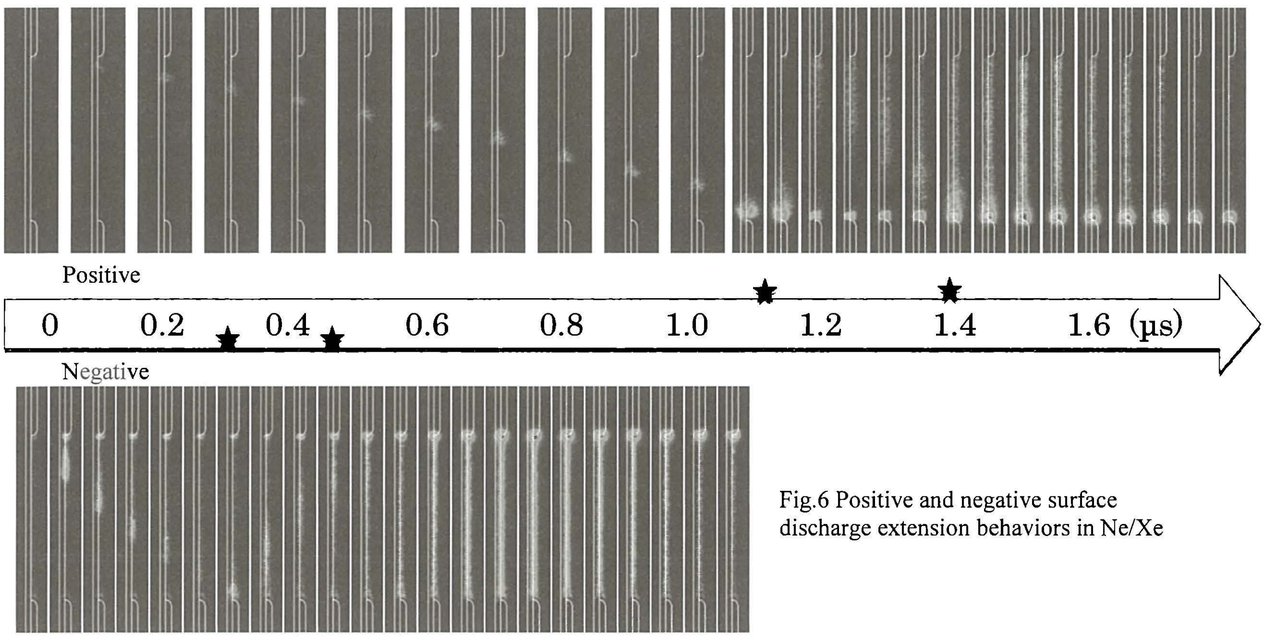

Fig.6 Positive and negative surface discharge extension behaviors in Ne/Xe

captured by using fast-gated image intensified camera with exposure time of 20ns. In the case of positive polarity, positive streamer with intense emission at its tip developed gradually to the grounded electrode from the HV electrode (cathode) on the dielectric plate surface. After reaching at the grounded electrode, discharge with relative strong emission 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 (cathode) to the grounded electrode (anode). 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 1.1μs. On the contrary, the negative streamer reached at the grounded electrode only for 0.3μs. 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 passible only for the negative polarity. In the present investigation about surface discharge in Ne/Xe mixture, number of electrons will be supplied from the dielectric surface. Therefore, it is considered that the negative surface streamer extension is faster than the positive one.

4. CONCLUDING REMARKS

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 (cathode) to the grounded electrode (anode). 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.

ACKNOWLGEMENTS

A part of this work was supported by JSPS Grant-in-Aid for Scientific Research (C) (No.23560336). The authors would like to thank to Sumitomo Electric Industries, Ltd. for kindly providing the flat cables.

REFERENCES

[1] R. Hackam and H. Akiyama: "Air pollution control by electrical discharges" IEEE Trans. on DEI, Vol.7, pp.654-683, 2000.
[2] H. Ueno, K. Hata and H. Nakayama: "Barrier Discharge Characteristics for the Multiple Needles-to-Plane Configuration", Proc. 15th Internat'l Conf. on Gas Discharge and Their Applications, Toulouse, Vol.1, pp.227-230, 2004.
[3] M. Suzuki: "Assessment of inert-gas mixtures in a full-color Townsend discharge panel for TV display", Proceedings of SID, Vol.32, p.237, 1991.
[4] H. Ueno, T. Tohara, and H. Nakayama: "Creeping discharge and light emission characteristics between two plane electrodes on the solid dielectric with Stripe backside electrode", Proc. 15th Internat'l Symp. of High Voltage Engineering, Ljubljana, p.129, 2007.
[5] H. Ueno, J. Takegawa, T. Tohara and H. Nakayama: "Surface discharge and light emission on a dielectric plate with a backing-strip electrode in Ne and Ne/Xe", Proc. 17th Internat'l Conf. on Gas Discharge and Their Applications, Cardiff, pp.253-256, 2008.