# Surface Discharge in Various Electrode Geometries

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**Abstract**

The breakdown characteristics of surface discharge investigated experimentally agree well with the analytic results of previous reports [1-3] in various electrode geometries. Additionally, we find that the electrode geometry effects on the firing voltage can be understood with the ionization probability relating to the number of priming particles. We have also observed the shape of surface discharge and the surface striations in the gap geometry with the pressure, the applied voltage, and the driving frequency.

## 1. Introduction

For the high efficiency of the present AC-PDPs we have many aspects to study such as the electrode structure, the gas properties, the materials of phosphor and dielectrics, and the circuit and the driving technology, etc. Basically it is the first step to analyze the electrode structure and it is important to verify the fundamental relations between the electrode structure and the coplanar discharge. The relations between the discharge and various electrode parameters have been reported in some papers [1-4] theoretically. In this report we investigate the surface discharge characteristics in various electrode geometries and the electrode parameters experimentally. The shapes of surface discharge and the surface striation [4] are also analyzed.

## 2. Experiments

### 2-1. Parallel, Wedge, and Coplanar Discharge

Paschen curves for the parallel, the wedge, and the coplanar diodes are shown in Fig. 1. In the experiment, the electrode length in both sides is 8 cm, the gap distance is 1 mm, and the electrode is covered with a dielectrics whose layer depth are 160, 320, 480 (μm).

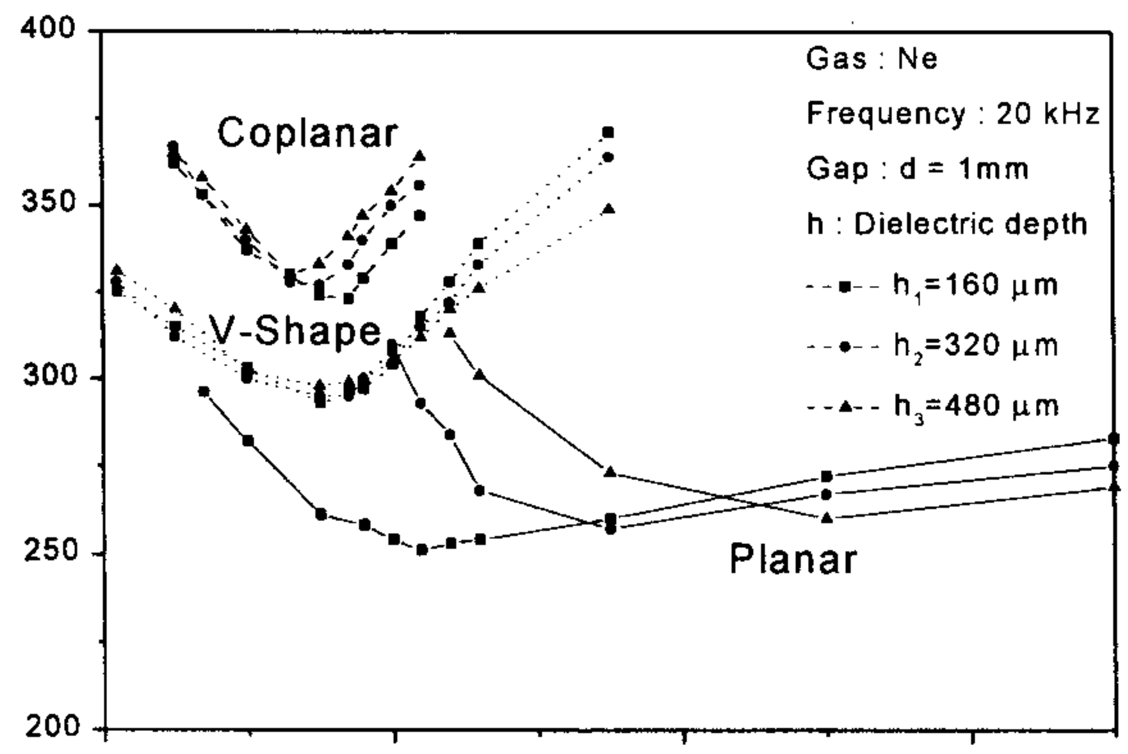


Figure 1. Paschen curves for three geometries, a parallel plate diode, a V-shaped plate diode, and a coplanar electrode.

The results including the dielectric effects agree well with the theoretical results reported previously [3]. In the case of parallel plate diode as well as wedge type diode the firing voltage is smaller as the dielectric layer depth increases in a range of high pressure However, we cannot find these trends in the coplanar discharge. Especially, as the wedge angel becomes large from the parallel to be a coplanar shape, the firing voltage increases and there exist a narrow range of pressure. In a parallel diode the uniform field in the whole discharge space provides the wide area for the breakdown with the same ionization probability, while the non-uniformity of the field strength in a coplanar discharge gives some restrictions for a definite area involving the breakdown..

### 2-2. Coplanar Discharge with Basic Electrode Parameters

In the coplanar electrode structure of AC-PDP, the basic electrode parameters are the gap distance, the electrode length, and the electrode width along the gap edge. The effects of these parameters except the lateral width have been analyzed in two dimensional space [1-2]. Here, the experimental results are shown in Figs. 2-4 for each electrode parameters, respectively.

Figs. 2 represent Paschen curves with the gap. The curves of the actual AC-PDPs having the gap distance of a few tens and hundreds of μm are shown in Fig. 2-(a) for He or Ar gas. Fig. 2-(b) is the results with the coplanar electrode, the electrode length 5cm and the lateral width 0.5cm in both sides. These figures show that there exists the appropriate pressure range corresponding to the gap distance. Basically the variations of firing voltage agree well with the analytic results [1-2]. The effects of the electrode lateral width on Paschen curves are shown in Fig. 3 where the firing voltage become lower as the edge width increases. From this results we consider the ionization probability proportional to the edge width involving the priming particles for breakdown and the large area of uniform field. Fig. 4 with different electrode length shows that the firing voltage is lower as the electrode length increases in the range of a low pressure. For the case of long electrode there exist a long discharge path and a low pressure keeping the constant value of *pl* with the minimum firing voltage. Since there exists a short path (*l*) for a high pressure in three different electrode length shown in Fig. 4, we expect the effects of the capacitance due to the electrode area on the firing. However, in the region of high pressure we cannot find the consistent trends even while the firing voltage is higher for the longer electrode length.

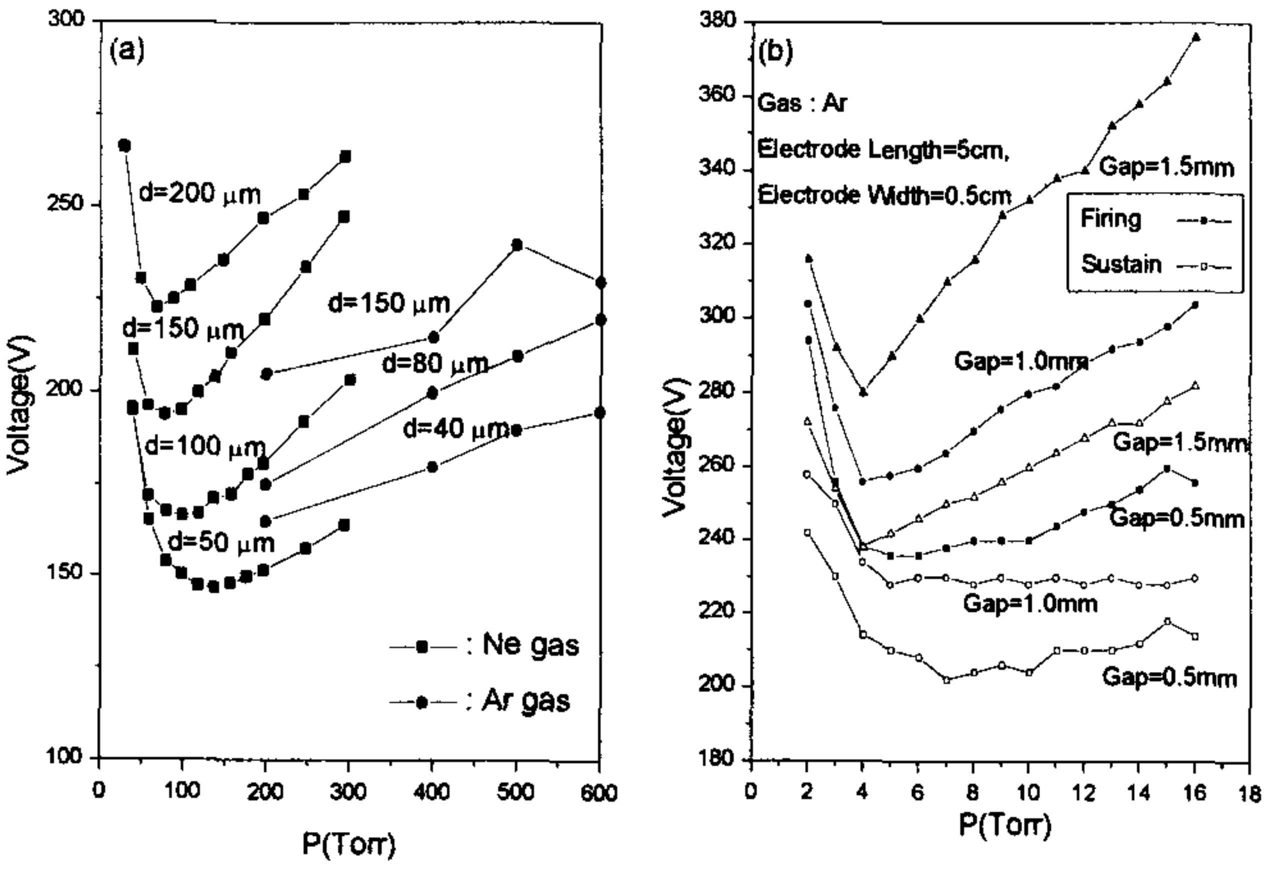


Figure 2. Paschen curves for the different gap distances in the actual AC-PDPs(a) and in the coplanar discharge(b).

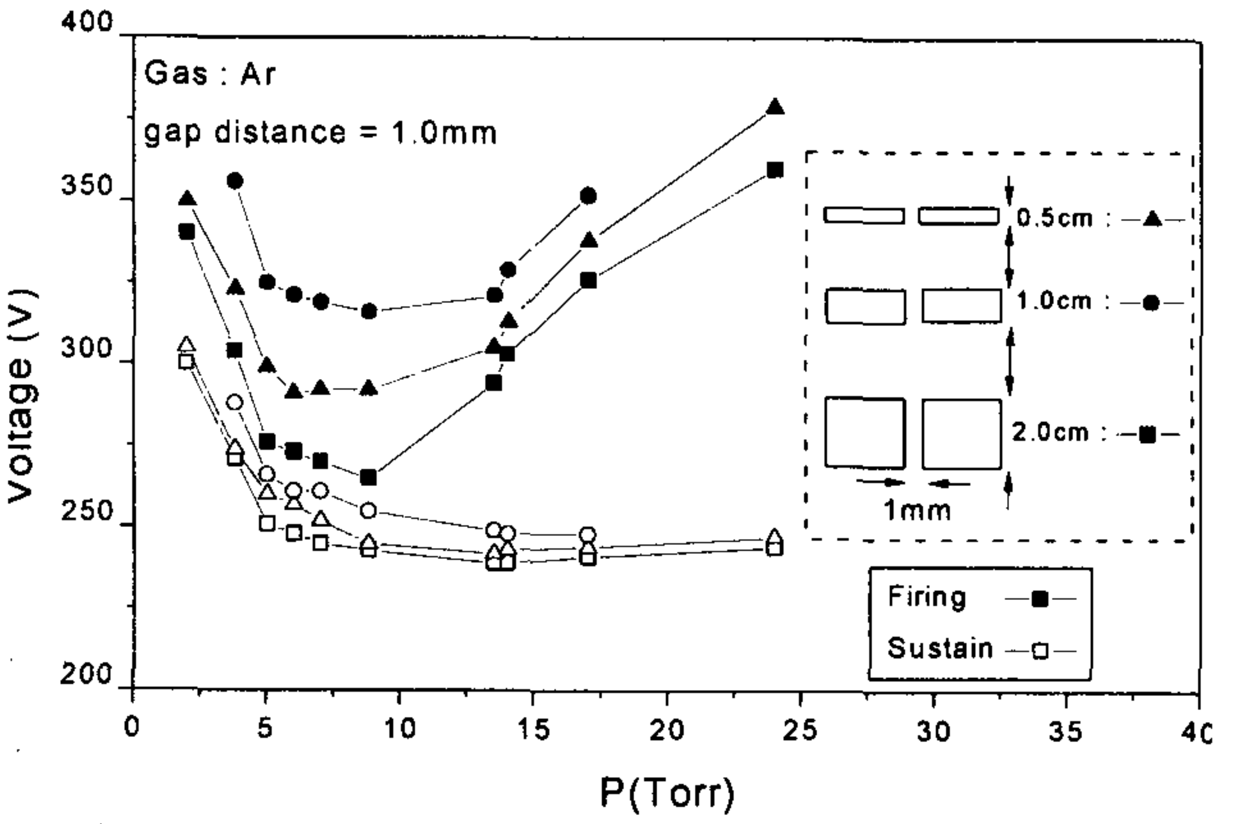


Figure 3. Paschen curves for three different electrode edge widths as 2.0, 1.0. 0.5 (cm) with gap distance d=1.0 mm and Ar gas.

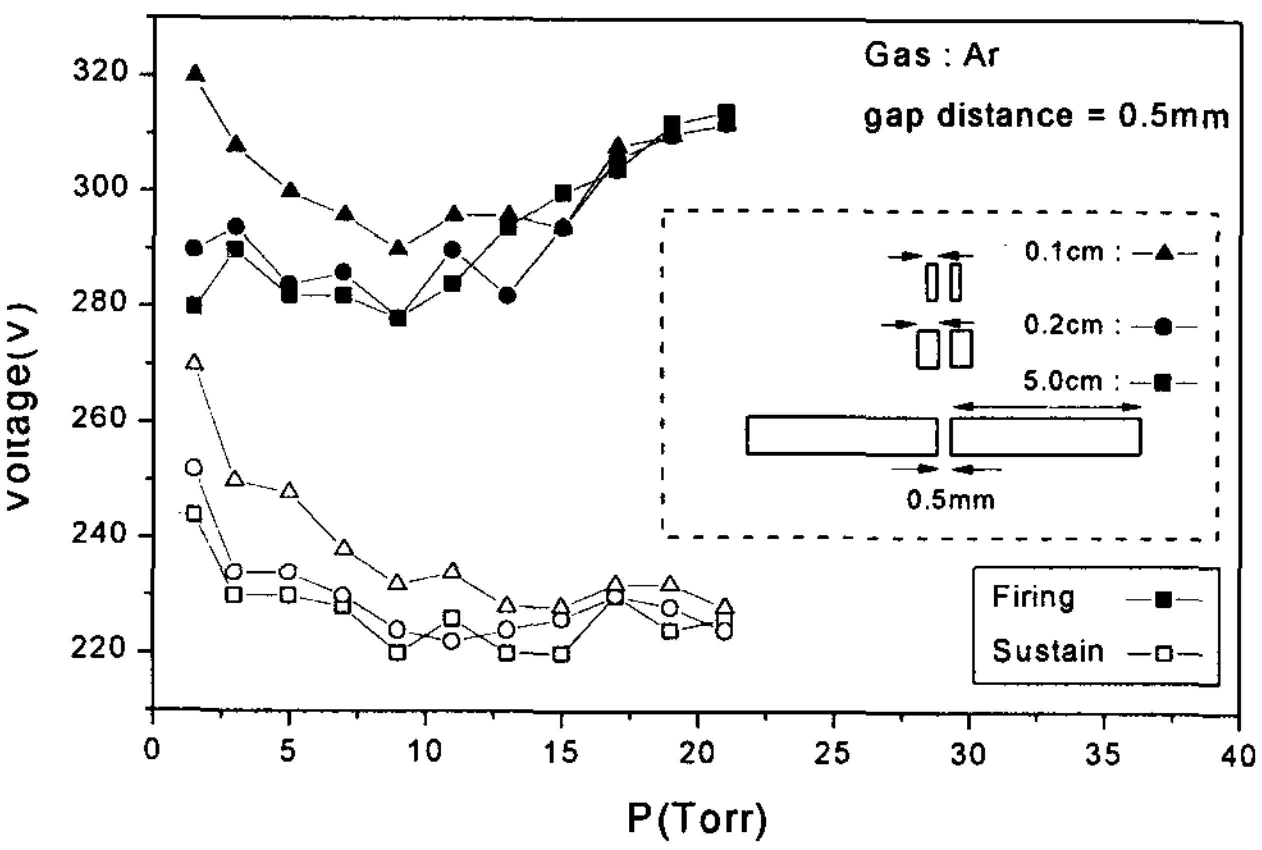


Figure 4. Paschen curves for three different electrode lengths as 5.0, 0.2. 0.1 (cm) with gap distance d=0.5 mm and Ar gas.

## 2-3. Discharge in Various Gap Geometry

The gap edge geometry is also important in a coplanar discharge. In this section we will discuss the gap geometry relating the firing voltage and the shapes of the surface glow as shown in Fig. 5 and 6. In Fig. 5 with the same gap distance between both sides of the nearest gap edge, the firing voltage is lower as the longer the nearest gap edge. The firing voltage for the edge of the straight line is lower than that of rounded or triangular gap. In the straight edge line the ionization probability is proportional to the length of line edge where the uniform field is formulated both sides of the electrode, while the strong field localized at a narrow area provides a small ionization probability for the case of triangular edge. The shape of surface glow and the striations in the surface discharge are some dependence on the applied voltage, the pressure, and the driving frequency. Two pictures of the experimental results are represented in Fig. 6. More details will be described in forth coming papers.

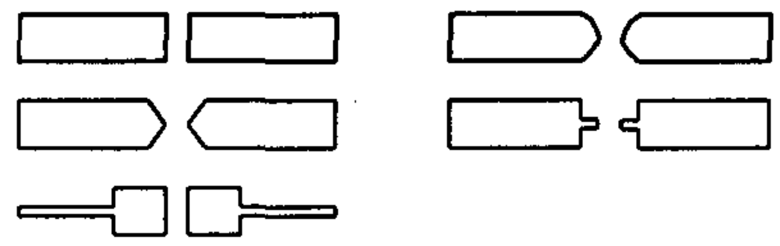

Figure 5. Various gap-edge geometries with the same gap distance between nearest gap sides.

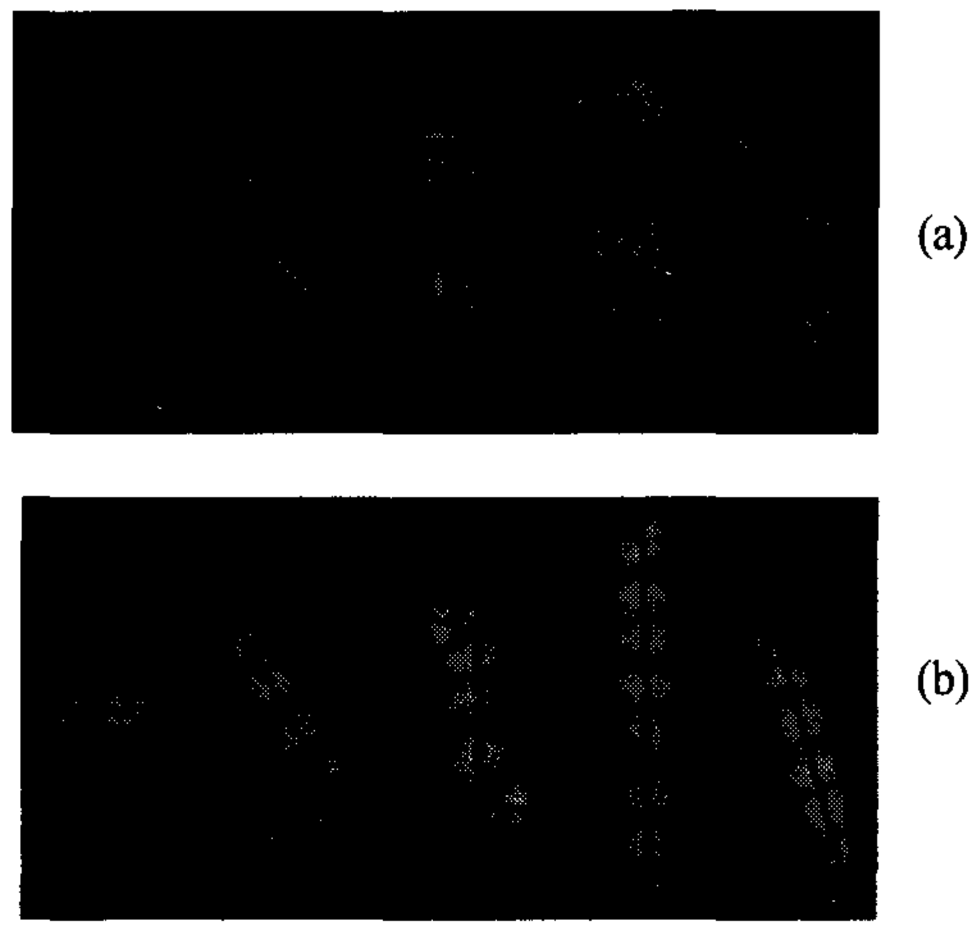


Figure 6. Pictures of discharge in various gap edges. (a) is to low pressure(mTorr) and (b) to the high sustain frequency(100 Hz) in Ar gas, respectively.

## 3. Summary

The fundamental characteristics of surface discharge are investigated in various electrode geometries experimentally. Paschen curves for electrode geometry and the basic electrode parameters agree well with the theoretical results. Especially, the gap edge geometry has been shown to be important on the discharge with the applied voltage, the pressure, and the driving frequency.

## Reference

[1] G. S. Cho, Y. G. Kim, Y. S. Kim, D. G. Joh and E. H. Choi, Jpn. J. Appl. Phys. 37(10A) (1998) L1178.

[2] Y. G. Kim, Y. S. Kim, D. G. Joh, J. J. Ko, E. H. Choi, G. S. Cho, IDW '98, Kobe, Japan pp. 563.

[3] Y. G. Kim, Y. S. Kim, D. G. Joh, J. J. Ko, D. I. Kim, E. H. Choi, Y. H. Seo, G. S. Cho, Jpn. J. Appl. Phys. 37(12B) (1998) L1549.

[4] G. S. Cho, E. H. Choi, J. G. Kim, Y. G. Kim, J. J. Ko, D. I. Kim, C. W. Lee, Y. H. Seo, H. S. Uhm, Jpn. J. Appl. Phys. 38(7B) (1999) L830.