# Development of a Pulse Vacuum Arc Discharge in the Gap Containing an Insulator Sputtered with Electrode Material

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The paper addresses a breakdown of a vacuum gap containing an insulator sputtered with electrode material. A mechanism for development of repeated discharges in the given electrode configuration is described.

**Keywords:** electrodes, arc discharge, cathode spot

## 1 INTRODUCTION

Although works concerning the burning of a vacuum discharge are sufficiently numerous [1-3], at the moment there is no fairly complete description of the burning of an arc in the vacuum gap containing a conducting layer sputtered on an insulator.

## 2 EXPERIMENT

Research of an arc vacuum discharge was carried out using a high-speed camera that allows taking snapshots of the arc burning with exposure from 5 ns to several microseconds.

To detect light emission of an arc vacuum discharge, an experimental setup was developed. It comprised of a high-speed camera, an oscilloscope, a camera control unit, a delay generator, a trigger-pulse generator, an electrode system power supply unit and a personal computer. Fig. 1 presents a flow chart of the setup.

The setup operates as follows. A pulse for initiation of a process from a trigger-pulse generator comes to the input of a delay generator. The generator produces pulses for ignition of the electrodes system, pulses to open an electronic shutter of the camera and to trigger the oscilloscope. The delay generator permits independent shifting in time of front edges of output pulses relative to the edge of an input pulse with an increment of 5 ps. Thus, the delay generator permits to change the moments of opening and closing of the camera's electronic shutter relative to the moment of the beginning of an ion source pulse.

## 3 RESULTS

Figs 2 - 10 show processed snapshots of a discharge with exposure 1 μs and a pause between snapshots 1 μs. Figs 2 - 5 show initial phases of a discharge. Fig 3 shows, that during the initial period two arcs are burning at the ends of the sputtered layer. In the first – third microseconds the cathode spots on the sputtered layer increase their brightness in the vicinity of the anode. In some cases the spots shift downwards.

In the fourth – seventh microseconds the cathode spots die away with a typical spattering of hot drops. Glowing in the ceramic – cathode gap is not significant, which means that the cathode spot on the cathode is burning on its inner side.

In the Fig. 6 appears a clearly visible glowing from the ceramic – cathode gap. This means that the cathode spot is close to the upper edge of the cathode.

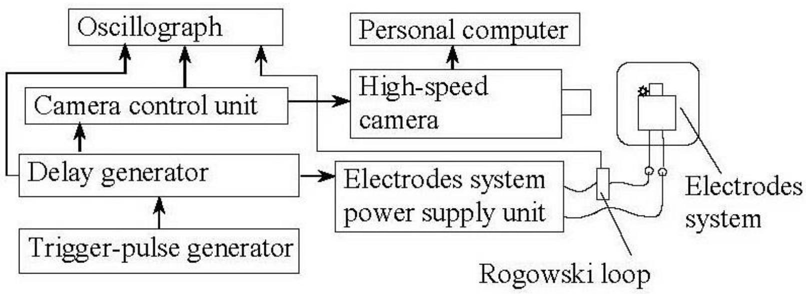


*Fig. 1: Flow chart of a setup for high-speed photography of discharge burning process*

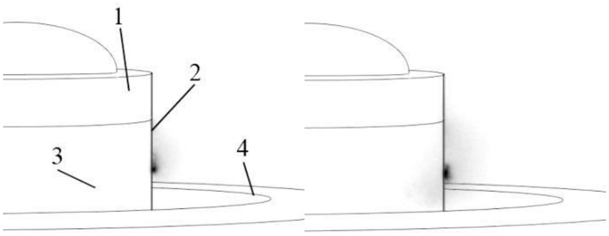


*Fig. 2: Arc discharge; on the left – the first microsecond; on the right – the third microsecond. 1- anode, 2- sputtered layer, 3- ceramic insulator, 4- cathode*

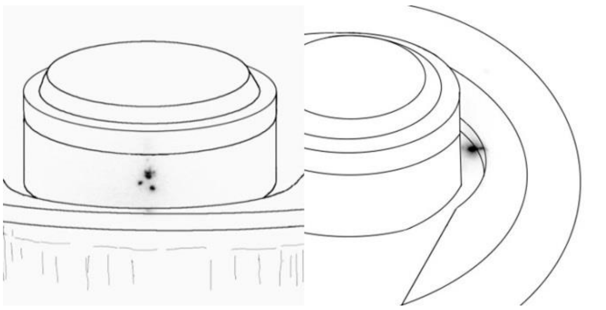

*Fig. 3: Arc discharge; the first microsecond; a snapshot from different angles*

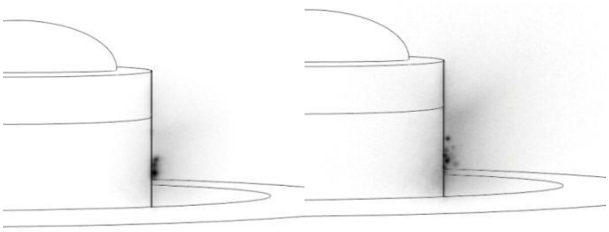

*Fig. 4: Arc discharge; on the left – the third microsecond; on the right – the fifth microsecond*

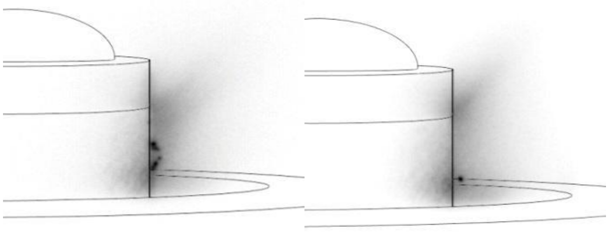

*Fig. 5: Arc discharge; on the left – the fifth microsecond; on the right – the seventh microsecond*

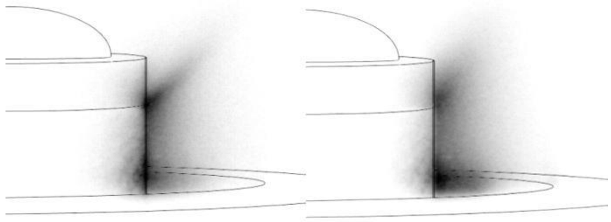

*Fig. 6: Arc discharge; on the left– the seventh microsecond; on the right – the ninth microsecond.*

Figs 7 - 10 show the final phase of the discharge. Beginning with the fourteenth microsecond cathode spots start dying, which is accompanied by spattering of drops of the cathode material. Beginning with the sixth – seventh microseconds cathode spots shift onto the inner edge of the cathode and tend to yield on its upper plane. Up to the seventh microsecond the discharge burns in the gap between the ceramic and cathode ejecting the plasma from the gap upwards. Beginning with the seventh microsecond the discharge appears on the edge and the upper surface of the cathode ejecting plasma, among others, in the lateral direction.

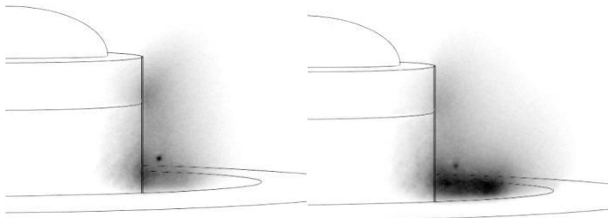

*Fig. 7: Arc discharge; on the left – the ninth microsecond; on the right – the eleventh microsecond.*

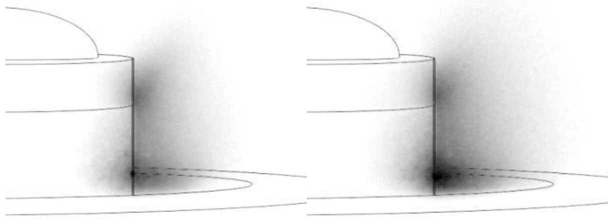

*Fig. 8: Arc discharge; on the left – the eleventh microsecond; on the right – the thirteenth microsecond.*

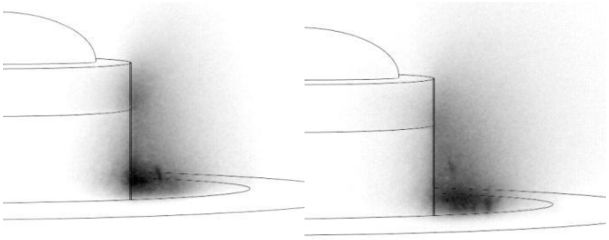

*Fig. 9: Arc discharge; on the left – the thirteenth microsecond; on the right – the fifteenth microsecond*

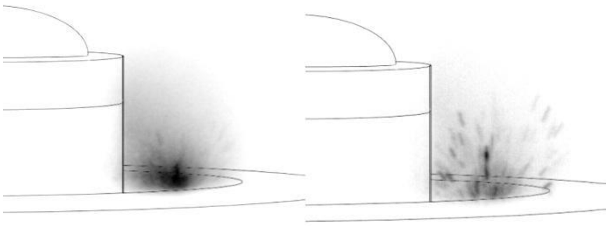

*Fig. 10: Arc discharge; on the left – the fifteenth microsecond; on the right – the seventeenth microsecond*

Fig. 11 presents the burning voltage of an arc discharge of the studied electrode system.

## 4 CONCLUSION

Based on the conducted experiment a mechanism of arc burning in the vacuum gap with an insulator sputtered with electrode material was developed. It was established that at the moment of ignition two discharges are burning between the electrodes and the areas of the sputtered layer adjacent to the electrodes, which can explain why the voltage value of arc burning in the experiment exceeds the voltage of arc burning on the electrodes of similar materials [4].

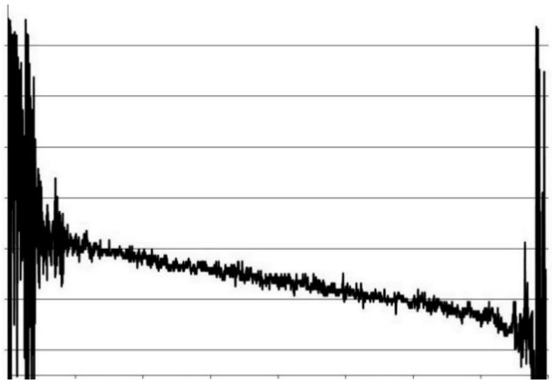

*Fig. 11: Burning voltage of an arc discharge*

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