HAKONE XIII

International Symposium on High Pressure Low Temperature Plasma Chemistry

25th Anniversary

Book of Contributed Papers

PAN
POLSKA AKADEMIA NAUK

Kazimierz Dolny, Poland
September 9-14, 2012

OBSERVATION OF DYNAMIC BEHAVIOR OF GLIDING ARC DISCHARGE

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In this work, we report on time-resolved dynamic behavior of gliding arc discharge plasma using comparison of obtained results between high-speed camera photographs and the corresponding electric properties. For a gliding arc discharge in Ar 20 L/min, the plasma path became complex with gliding due to turbulence gas and reconnections for plasma path were observed. The applied voltage was decreased and small pulsed current flowed at the moment of the reconnection.

1. Introduction

There has been much interest in gliding arc discharge plasma[1] due to its potential for pollution control[2-5], material processing, surface treatment and biological application[6-8]. The gliding arc discharge can realize high electron temperature, electron density and low gas temperature which no thermal or non-thermal plasma can satisfy. The gliding arc discharge starts from breakdown of atmospheric gas at the shortest gap between two divergent electrodes under DC or AC power source and it glides along the same direction as the gas flow. The fundamental studies such as electrical properties, temperature distribution[9,10], power supply[11,12], electrode geometry[13], optical emission spectroscopy[14-16] and acoustic emission[17] have been done. The dynamic behavior of the gliding arc discharge[18] becomes rather complex especially in turbulent gas flow, however, time-resolved analysis for the behavior of the plasma with the simultaneous measurement of the time-corresponding electric properties has not been investigated. Therefore, in this work, we report on time-resolved dynamic behavior of the gliding arc discharge plasma in turbulence gas using comparison of obtained results between high-speed camera photographs and the corresponding electric properties.

2. Experimental Setup

Fig.1 shows the schematic diagram of a dynamic measurement system for gliding arc discharge. Two knife edge-shaped electrodes are made of iron and their shortest gap was adjustable (3-6 mm). The electrodes were set inside an acrylic chamber. Outlet of a gas supply was placed at the bottom of the acrylic chamber. The gas flow rate was controlled by a digital flow instrument. High voltage (sine around 5.7, 8.0 and 10.3 ms as can be seen in Fig.3. It was also revealed that small voltage drop and pulsed current were caused at the same time as the reconnections. The arc disappeared at 11.1 ms at upper region where the arc impedance increased with the arc length. Immediately after the disappearance of the arc, vibration of the applied voltage was observed.

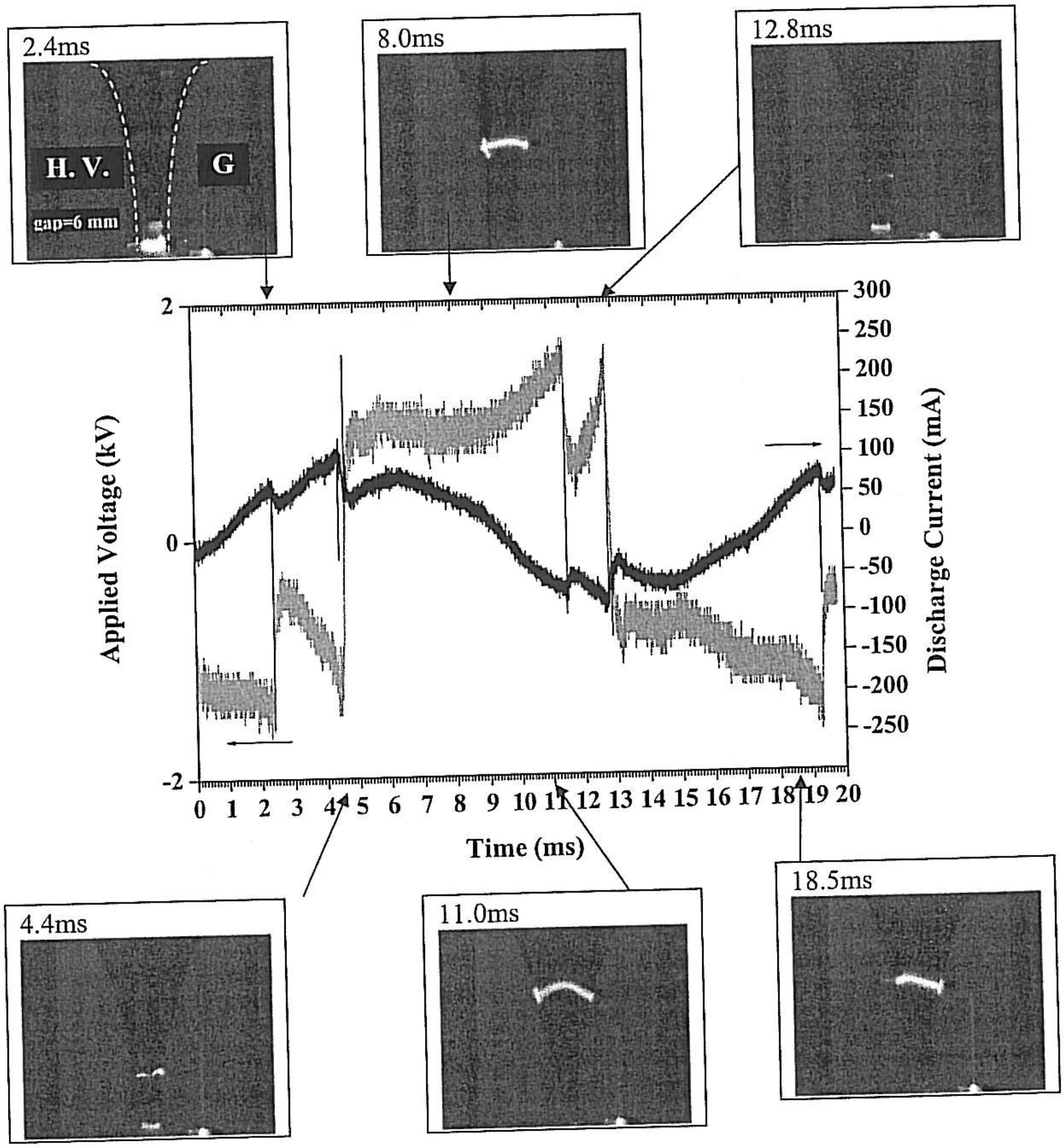

Fig. 2 Waveforms of applied voltage and current for a gliding arc discharge in He (10 L/min) with the corresponding high speed camera photographs.

4. Summary

Time-resolved dynamic behavior of gliding arc discharge plasma was investigated using comparison of obtained results between high-speed camera photographs and the corresponding electric properties. For a gliding arc discharge in He gas flow, relationship between electric properties and plasma behavior was well mapped. In addition, polarity effect was confirmed around the edge of a electrode. For a gliding arc discharge in Ar 20 L/min, the plasma path became complex with gliding due to turbulence gas and reconnections for plasma path were observed. The applied voltage was decreased and small pulsed current flowed at the moment of the reconnection.

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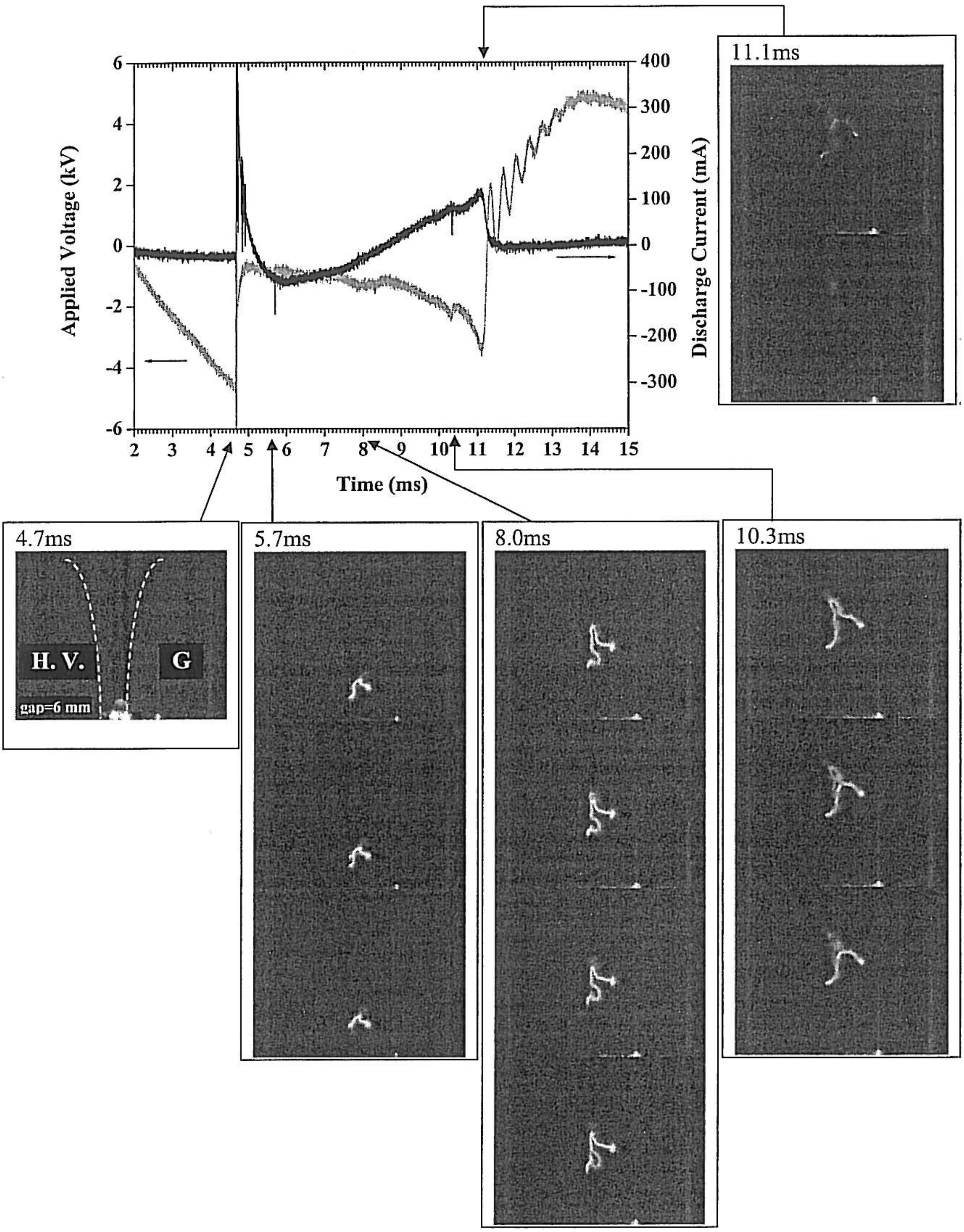

Fig. 3 Waveforms of applied voltage and current for a gliding arc discharge in Ar (20 L/min) with the corresponding high speed camera photographs.

wave, 60 Hz) was applied between the two electrodes with a high-voltage transformer (VIC international, 120:1). The amplitude was adjusted with a voltage slide autotransformer (TAMABISHI, S-130-39). Applied voltage waveform during discharge was observed with a high-voltage probe (IWATSU, HV-P60). Discharge current waveform was measured by clamping a current sensor (Tektronix). The both waveforms were captured with a digital oscilloscope. Time-resolved digital photographs for a gliding plasma were recorded by a high speed digital camera (Photron, FASTCAM SA1.1) with the frame rate of 54,000 frames per second and 320 x 256 pixels. The observation time for the digital oscilloscope and the high speed camera were synchronized by an external trigger signal.

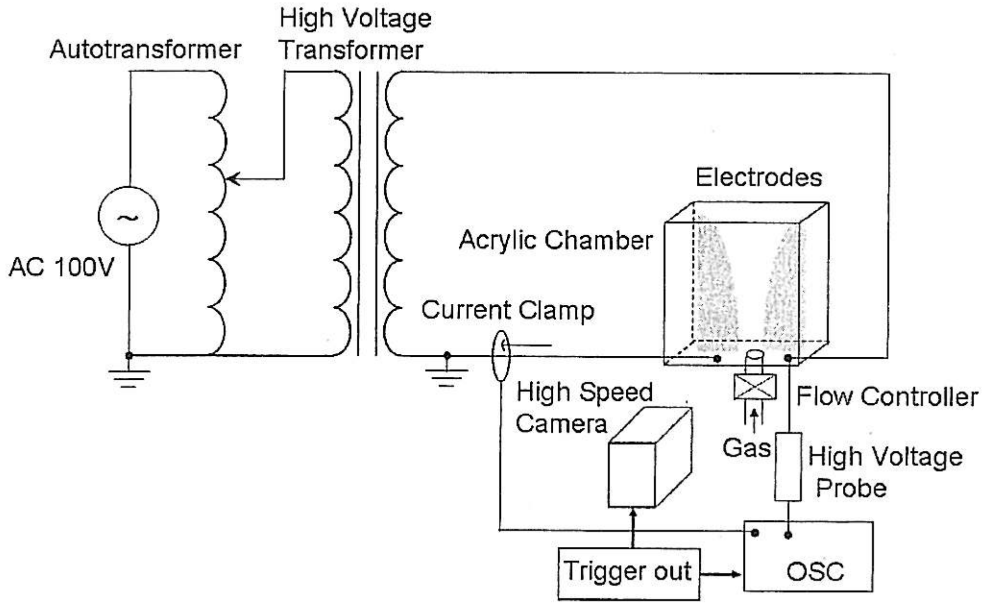

Fig. 1 Experimental setup for measurement of dynamic behavior of gliding arc discharge.

3. Results and Discussion

Gliding arc plasmas in different gases of He, N_2 and Ar with various flow rate (10-50 L/min) were observed. Here, we show typical results. Fig.2 shows waveforms of applied voltage and discharge current during period of approximately one cycle for a gliding arc discharge in He (10 L/min) with the corresponding high speed camera photographs. Exposure time of the each photographs was about 19 us (about 900 photographs per one cycle of applied voltage). As can be seen from Fig.2, the phase of the displacement component of the current waveform was advanced by about 90 degrees from the applied voltage because the influence of the reactance of the capacitance component between the electrodes was remarkable. A breakdown of He occurred at 1.5 kV and the shortest gap (6 mm) with a large discharge current and rapid voltage drop at 2.4 ms. The applied voltage increased with gliding of the arc plasma and next breakdown appeared at the shortest gap (4.4 ms). The arc plasma glided to upper side with recovery of the applied voltage due to the increase of the impedance of the plasma ,which was caused by the increased plasma path, until 11.0 ms. Almost same tendency as the above mentioned behavior was observed in case of the opposite polarity of the applied voltage. However, polarity dependence was confirmed from the evidence that strong optical emission appeared at a positive electrode along the edge. Rather different dynamic behavior was observed for gliding arc discharges in Ar with the increased flow rate (20 L/min). The results were shown in Fig.3. A breakdown of Ar occurred at 4.7 ms (4.5 kV) and gliding of the arc began after that. The gliding of the arc continued until around 11 ms with the almost the same gliding speed as the gas flow. Complex dynamic behavior of the gliding arc plasma path was induced because of the turbulent gas flow. During the complex gliding of the arc, reconnections of the arc path were able to be found out at

Book of Contributed Papers of 13th International Symposium on High Pressure Low Temperature Plasma Chemistry.

Symposium organized by

Institute of Electrical Engineering and Electrotechnologies
Lublin University of Technology

Commission of Low-Temperature Plasma Chemistry
Polish Academy Of Sciences
Branch in Lublin

Editors: Local Organizing Committee

ISBN: 978-83-62596-99-7

Publisher: Lublin University of Technology
Realization: Lublin University of Technology Library
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www.biblioteka.pollub.pl
Print: TOP Agencja Reklamowa Agnieszka Łuczak
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