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STUDY OF PRESSURE INFLUENCE ON LAST PHASES OF PLASMA FOCUS

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Abstract

PF can be worked at various conditions. But change any operating parameter caused change of discharge. In this report we show, what a gas pressure influenced on a discharge lifetime and a lifetime of some phases of the discharge. Electrical parameters of the discharge were recorded using digital oscilloscope Tektronix TDS 3052. Pictures of discharges were take using fast camera IMACON 645.

Introduction

Plasma-Focus (PF) device is one of the family of the dynamic, non-cylindrical Z-pinches. PF is based on pulsed high-current discharge between two coaxial electrodes, which were separated by a insulator. PF is known as a well source of hot and fast plasma stream, different types of ionizing radiation – fast electrons [1], fast ions [2], neutrons [3] and soft/hard X-rays [4,5]. Efficiency of the source is quite high and is very well fitted to a number of applications in medicine or material engineering. But, physical processes ruling a generation of radiation still does not understand completely. It's a well-known fact that their are connected with the final phases of the discharge, a radial compression, a pinch and a post-pinch phase. Changes of a course of these phases caused the change in radiation. So, the understanding of the influence of the individual process parameter on final phases of the discharge is very important.

The radial compression started when current sheath (CS) leaves a zone between an anode and a cathode. At the moment the CS moved over a surface of an anode end from its edge to its centre. When the CS reach the anode end centre the pinch is formed. A pinch lifetime is estimated on several nanoseconds. Next the pinch is disintegrated. The well recognizing and understanding of these processes is important for technological application of PF to thin film depositing because at these phases of the discharge material from the anode end is emitted. In this report we show the influence of a filling gas pressure on the discharge, the radial compression and pinch lifetimes.

Experimental set-up

Schema of PF device is show in fig. 1. The device consists of two coaxial electrodes and an alumina insulator. They are closed in a vacuum chamber. An anode was made from copper and its diameter was 25 mm. A cathode was constructed from twelve stainless steel bars. The wide of zone between the anode and the cathode bar was 7 mm. The PF and power supply system was detailed described in our earlier paper [6].

The chamber was filling by argon at 0.6, 0.8 or 1 Tr of pressure. A capacitor bank was charged to 15 kV. The current (I) and derivate of current (dI/dt) were reordered using digital oscilloscope Tektronix TDS 3052. The pinch was indicated by a sharp peak in signal of dI/dt.

A fast camera IMACON 645 was used to take pictures of final phases of the discharge. A diaphragm in the camera was adjusted at the anode and two bars of the cathode (fig. 2). In this way, the radial compression can be observed.

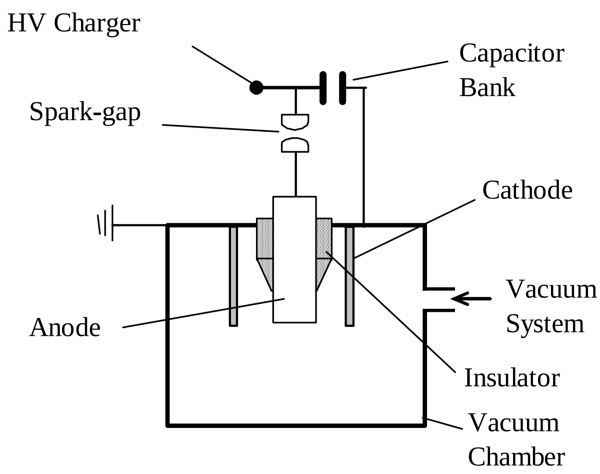

Fig. 1. Schema of experimental set-up

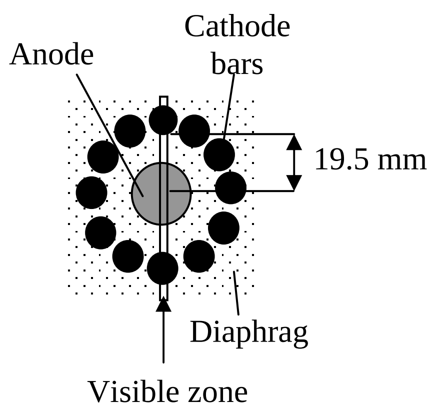

Fig. 2. Schema of electrodes and position of the camera diaphragm

Results and discussion

As an example the picture of final phases of discharge, which was generated at 0.8 Tr of the argon pressure is showed in fig. 3. A current (I) and derivate of current (dI/dt) traces of this discharge are showed in fig. 4. In the fig. 3 can be see the radial compression of CS, the pinch and an electrode erosion. The pinch lifetime was very short and its have poor eyesight, but the pinch lifetime is possible to estimate. The pinch lifetime were 15, 20 and 25 ns at 0.6, 0.8 and 1 Tr of the argon pressure respectively. The radial compression of CS and the electrode erosion were well visible, because its lifetime is longer than the pinch lifetime. The radial compression lifetime also depended on gas pressure. At pressure of 0.6 Tr, the lifetime of the radial compression was 20 ns, and its mean that an average velocity of CS from the edge of the anode end to the centre of the anode end was $6*10^5$ m/s. At pressure of 0.8 Tr, the lifetime of the radial compression was 30 ns and the average velocity of CS was $4*10^5$ m/s. At pressure of 1 Tr, the duration of the radial compression was 130 ns, and the average velocity of CS was only $1*10^5$ m/s. As can be seen the velocity of CS decreased with pressure increasing. These results was expected because at 0,6 Tr of pressure the number of particles was lower than at 0.8 or 1 Tr of pressure. The compression of small number of particles is easier than the compression of bigger number of particles. If a compression difficulty increases then an amount of energy, which is necessary to compression of the gas increases too and the time, which is necessary to transferred from magnetic field to gas increase. This results is in accordance with researches on other PF device [7].

The lifetime of discharge depended from the gas pressure also. The pinch was appear at 2.3 μs from the discharge beginning at 0.6 Tr of argon pressure. At 0.8 Tr of pressure, the pinch was delayed at 0.5 μs. Whereas the pinch was appear at 3.6 μs at 1 Tr of argon pressure. Differences between lifetimes of the radial compression and the pinch for various pressure, which were used in this research, were lower than 0.1 μs, whereas differences between discharge lifetimes was bigger than 0.5 μs. It proved that the earlier phases of the discharge, like an ignition and a run-down of CS also increased with pressure increasing.

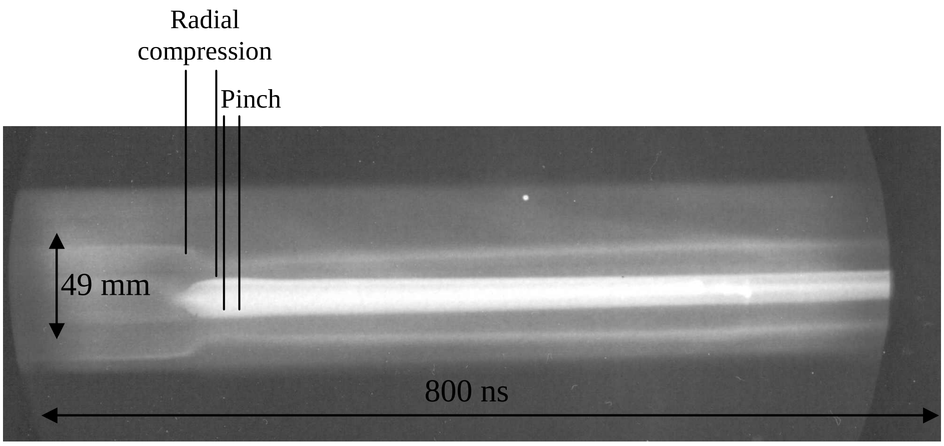

Fig. 3. Picture of the final phases of the discharge, which was generated at 0.8 Tr of argon pressure

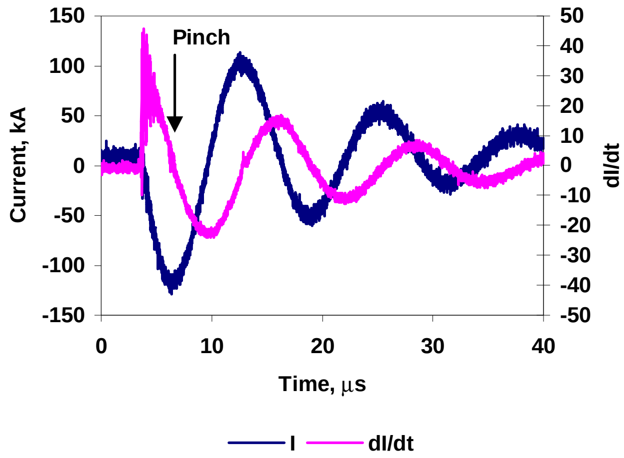

Fig. 4. Traces of the current (I) and the derivate of current (dI/dt) of discharge which was generated at 0.8 Tr of argon pressure.

Conclusions

The fast camera is a useful tool to investigation of final phases of the discharge.

The lifetime of the radial compression of CS increased from 30 to 120 ns when the argon pressure increased from 0.6 to 1 Tr.

The lifetime of the pinch also increased when the pressure increased.

The discharge lifetime depended on the gas pressure and increased from 2.3 to 3.6 µs when the argon pressure increased from 0.6 to 1 Tr.

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