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*of the 7th International Conference*
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# STUDY OF A LONG TERM PROCESSES IN D.C. ARGON ARC PLASMA BY SQUARE POWER MODULATION WITH VARIABLE LOW CURRENT PERIOD

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## Abstract

U-shaped d.c. argon stabilized arc with aerosol supply was investigated by current modulation between 9 and 3 A level and low current period lasting from 0.05 to 40 ms. The variable low current period has great influence on delayed line intensity response that provides information about a recombination and transport processes in plasma. The obtained results indicate that plasma slowly reaches stationary state and that processes related to changes in atom concentration play important role. Character of temporal responses strongly depends on first ionization energy of analyte.

## Introduction

The method of power modulation is a useful tool for studying processes in plasma [1]. At a moment of a sudden current drop various processes starts. Termalization processes, in which plasma particles reach new stationary temperature, has time constant with order of magnitude of few microseconds. On the other hand, ionization-recombination balance takes place on a time scale ranging from few hundred microseconds to several milliseconds or even more depending on ionization energy of analyte and radial distance of the observed part of plasma. Analyte atom concentration increases due to recombination and diffusion from plasma periphery. This type of diffusion is caused by decreasing of the demixing effect as a consequence of radial field declining [2]. The diffusion process is usually slower than recombination process.

In the moment of sharp current jump the reverse processes take place. The time evolution of these processes strongly depends on the plasma state reached during the low current period. In other words temporally response of line intensities accompanying the current jump depend on the extent transport processes have reached in evolution to stationary state. If the low current period lasted long enough and plasma reached stationary state further increase of the low period has no effect. Interruption of intensity evolution at different temporally points give insight into processes that govern reestablishment of a stationary state.

## Experimental

This study is performed with U-shaped d.c. argon arc operating at atmospheric pressure, construction details described elsewhere [3]. The analyte water solutions were introduced into plasma as aerosol obtained with glass concentric nebulizer and double-pass cloud chamber.

The arc current was square modulated (sharply changed between 9 and 3 A) by electronic switch circuit based on fast MOS-FET transistors connected in parallel with the arc gap. The arc current circuit was optimized in such a way as to minimize the current transition rise time (less than 2 μs). In order to monitor the power evolution the oscilloscope current probe was used. Repetition period was 100 and 200 ms, with low period lasting from 0.05 to 40 ms.

The photomultiplier current was amplified by a factor of 50 with a fast pre-amplifier, and fed into a digital storage oscilloscope. The oscilloscope is PC controlled via GPIB interface. The oscilloscope traces are averaged 32 times, and subsequently transferred to the PC. The whole measurement process was governed by PC program specially developed for this purpose.

## Results and Discussion

Figure 1. illustrates typical responses of line intensity for high ionization energy elements in a submilisecond time domain. The intensity responses are normalized to stationary state and vertically shifted for the clearness of presentation.

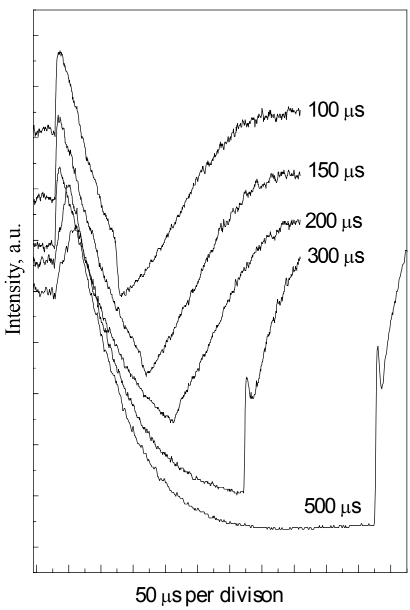


**Figure 1.** Intensity responses of Ar I 696.54 nm line for short low current period.

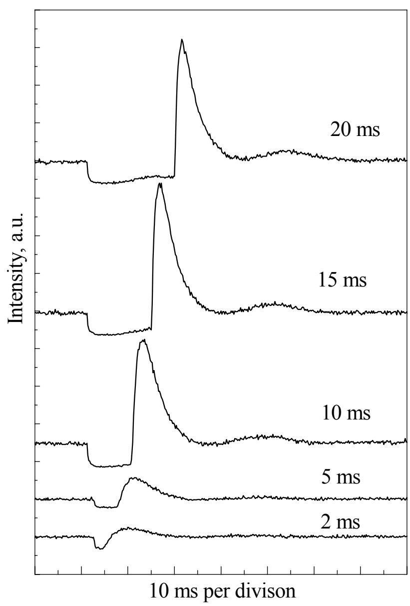


**Figure 2.** Intensity responses of Be II 313.04 nm line for low current period longer than 1ms.

It is evident that the behavior of responses drastically changes with prolonged low current period. Such behavior is related to decreasing electron number density i.e. with change in excitation mechanisms [3]. Elements with lower ionization energy shows even more pronounced intensity peak that is connected with a current jump (order of magnitude of the time constant several microseconds). This intensity peak first shows increase with increasing low period time and than starts to decrease thus indicating connection with recombination processes. The appearance of this intensity peak is probably related to fast changes in excitation balances. Spatially resolved intensity measurements demonstrate that appearance of this peak is connected with the arc core because at larger radial distances peak disappears.

Influence of the millisecond low period duration on intensity responses is illustrated in Figure 2. As a representative example results for Be II are shown. As it can be seen, at the moment of a current jump, a large peak appears. The shape and intensity of this peak are strongly determined by a low period duration, ionization energy of analyte and radial position of the observed part of plasma. Influence of a low period duration on peak intensity and its relaxation time indicates that this process is connected with diffusion of analyte atoms. Among previously mentioned factors, the time length of disturbances has major influence on the time needed for plasma to reach stationary state. A care was taken that the influences of two subsequent perturbations do not overlap.

## Conclusion

The obtained results have shown that time evolution of intensity responses on a sub millisecond scale are preferably induced by processes connected with electrons (excitation, ionization-recombination and transport) while for responses on a millisecond scale the dominant role has diffusion of analyte.

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