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THE STUDY OF THE MAGNETICALLY TAILORED ATMOSPHERIC PRESSURE DC ARC PLASMA WITH AEROSOL SUPPLY FOR ANALYTICAL APPLICATION

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Abstract

Preliminary studies have shown that external oscillatory magnetic fields of a few mT imposed to the atmospheric pressure DC argon arc plasma with aerosol supply, can produce significant favourable changes of its spatial and spectral characteristic. These changes are promising for improvement the analytical performance of such treated plasma. In this work, the applied magnetic fields strengths were in the range of 29-23 mT and frequencies of 300-900 Hz. Spatial emission intensities of several element lines have been investigated in such magnetic field-plasma configuration with various plasma operating conditions and arc device construction modifications. Applied magnetic field induces lines emission intensity enhancements of the most elements observed. Enhancements (up to 20 times) depend on arc current, magnetic field strength and frequency applied, composition of sprayed solution, spatial plasma zone observed and construction details.

Introduction

Direct current arc plasma with aerosol supply still attracts considerable attention as excitation source for atomic spectroscopy in routine analytical work. Beside such application, a large number of arc constructions are improved and used in wide areas of technology (material processing-welding, cutting, plasma spraying; development of new materials-semiconductors, nano-material synthesis, etc).

In analytical application, one of the limiting factors for improvement of arc analytical capabilities is demixing effect existence caused by presence of radial electric field inside the plasma volume [1, 2]. In steady state this effect hinders sample vapor penetration the hottest plasma zones and consequently limits the analyte spectral emission. The introduction of potassium as an easily ionizable element (EIE) in the arc plasma reduces demixing effect and produces enhancement of the analyte emission [2].

If the DC arc plasma is imposed to a fast oscillating transverse magnetic field of sufficiently strength, the ionized plasma core will be oscillatory driven and penetrates the immovable surrounding gas mantle abundant with analyte vapour. If such penetrating is fast enough (comparable to the velocity of analyte species diffusion) emission intensity enhancement should be expected.

This is our idea in the most extensive experiments how to reduce existing demixing effect in DC arc plasma and improve its analytical capabilities. Preliminary results are presented in this work.

Experiment and Discussion

The device for stabilized DC arc plasma generation is described elsewhere [3]. A single magnet coil was positioned 18 mm away from the arc axis and collinearly to the optical axis of monochromator. Sinusoidal wave current powered magnet coil. Such plasma - magnetic coil configuration induces plasma core oscillations perpendicular to the optical axis, according to $\vec{E}x\vec{B}$ coupling. Solutions that contain elements of interest are introduced into the plasma as aerosol, generated by pneumatic nebulizer.

When the whole plasma volume was focused onto the collimator, the applied magnetic fields of 23 mT and 800 Hz produces strong emission enhancement for the several elements measured, while the background stays nearly unchanged. It is also noticed that enhancement increase with ascending the arc current, but this increase is smaller if nebulized solutions contains EIE.

For more detail picture about the changes induced by imposed magnetic fields, lateral plasma scans were performed at YII 566.292 nm line for different fields strengths and frequencies, Fig. 1. Signal-to-background ratio (SBR) was used as a measure of effect. The plasma zone, 1 mm high, above the central segment was observed. Obviously, the strongest field (lower frequency) produces the biggest SBR net grow, but under such conditions plasma is less usable because it is wide stretched surrounded by flame-like tufts and spatially unstable because of swinging. When the frequency of applied field is much higher (780 Hz), there is no appreciable movement of the plasma core, Fig. 2., but there is still strong SBR peak, about six times higher in comparison when no magnetic field applied, Fig 1.

Conclusion

The data presented suggest that DC arc plasma can be effectively modeled by external magnetic field to improve its analytical characteristics. Basic assumption is qualitatively indicated, but further analysis of spatial and temporal behavior of the effect will provide details about its mechanism.

Acknowledgments

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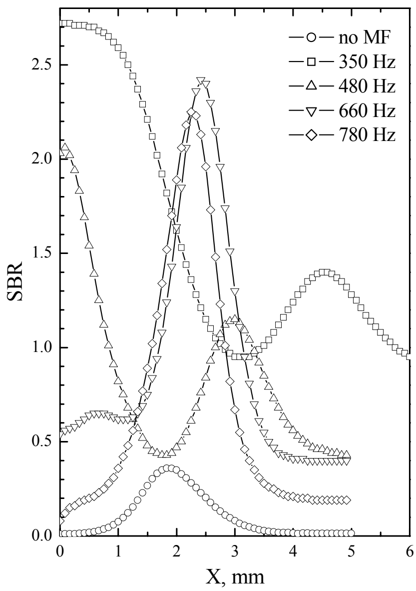

Figure 1. Lateral distribution of signal-to-background ratio (SBR) for line YII 566.292 nm for different magnetic field strengths and frequencies. Arc current 8A.

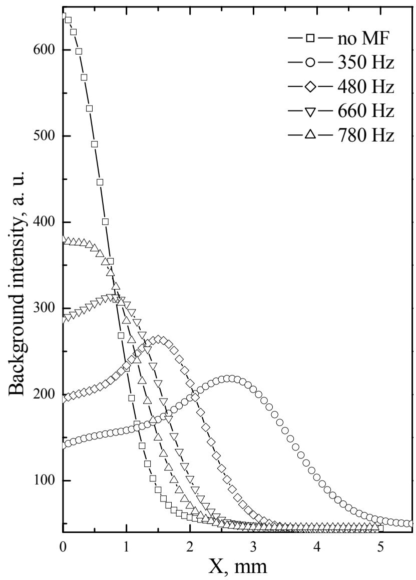

Figure 2. Lateral background intensity for different magnetic field strengths and frequencies. Arc current 8A.