SPECTRAL INVESTIGATION OF FIREBALLS IN ARGON PLASMA

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Fireballs are well-known [1,2] self-organized luminous structures that appear in plasma in front of the anode of a glow discharge, or in front of a positively biased electrode immersed in plasma, up to a threshold value of the applied voltage. These structures consist of a positive nucleus (ion-enriched plasma) confined by an electrical double layer.

Here we report on experimental results concerning the spectral investigation of such a fireball in the spectral domain 400-1000 nm. The experiments were made in a diffusive hot filament discharge plasma under the following conditions: argon pressure $p = 5\times10^{-3}$ mbar, plasma density $n_{pl} \cong 10^7$-10^8 cm^{-3}. The fireball was obtained in front of a positively biased supplementary disk electrode 1 cm in diameter, the voltage between the electrode and the plasma being $V_E = 120$ V. The diameter of the fireball was about 28 mm. The spectral resolution was 0.8 mm approximately. The spectra were recorded every 2 mm in axial direction (perpendicular to the electrode surface), starting from electrode surface until a position outside the fireball. Figure 1 shows two spectra recorded inside and outside the fireball, respectively. The excited states of argon, observed inside the fireball (Figure 1) are due to the electron-neutral impact excitations [3], the electrons being accelerated in the voltage drop across the double layer at the border of the structure.

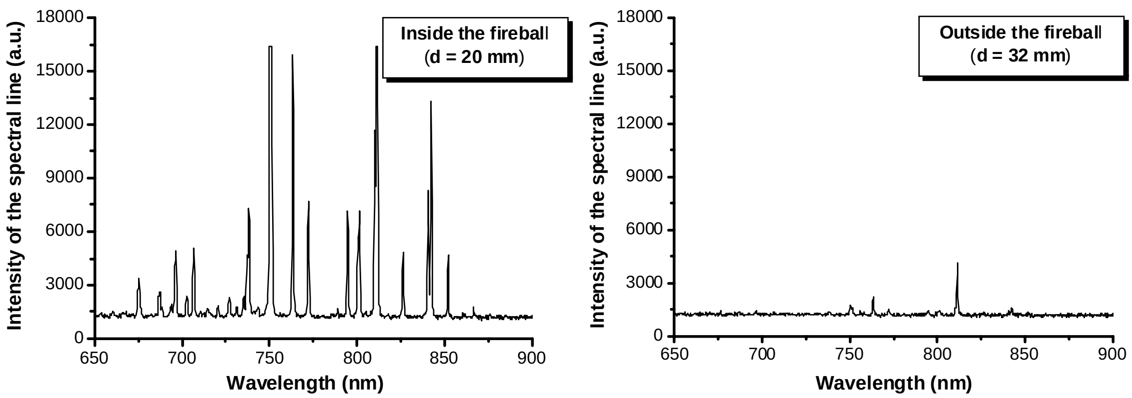

Fig. 1 Optical spectra at two different distances from electrode, inside and outside of the fireball, respectively.

Figure 2 shows the axial profile of two spectral lines, λ_1 = 763.51 nm and λ_2 = 842.46 nm, respectively. The intensities of the spectral lines have maximum values at a distance from the electrode of about 14 mm. The axial profile of the ratio of the two spectral lines intensities is shown in figure 3. For the positions 14 mm < d < 20 mm, this ratio is almost constant and the spectral line intensities have maximum values, so we can consider that the conditions for local thermal equilib-

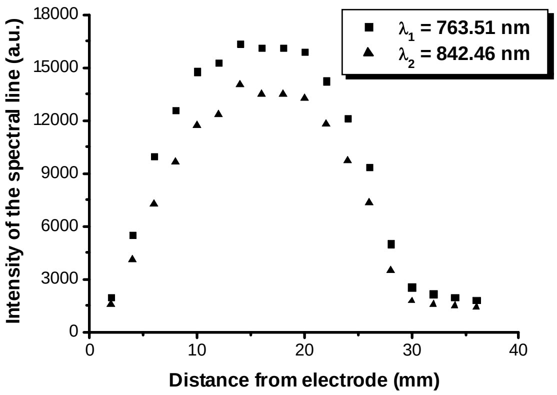

Fig. 2 Axial profiles of two spectral lines (λ_1 = 763.51 nm and λ_2 = 842.46 nm).

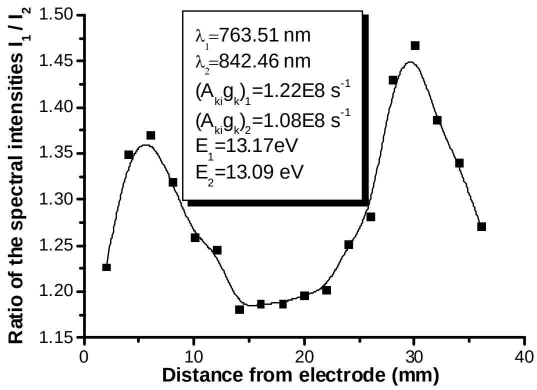

Fig. 3 Axial profile of the intensities ratio of the two spectral lines from Fig. 2.

rium are fulfilled. So, in this region we can estimate the electron temperature, using the ratio of the two spectral line intensities [4]:

$$\frac{I_1}{I_2} = \frac{A_1 g_1}{A_2 g_2} \frac{\lambda_2}{\lambda_1} e^{\frac{E_2 - E_1}{kT}} \tag{1}$$

where $I_{1,2}$ are the spectral line intensities, $A_{1,2}$ are the Einstein coefficients, $E_{1,2}$ are the energy levels, k is the Boltzmann constant and T is the local electron temperature, respectively. By using the values of the parameters from the NIST database [5], we obtained an average local temperature of the electrons of about $T \cong 1.87$ eV.

The two maxima of figure 3 suggest that the energy distribution function of the electrons at the border of the structure is different from that of the electrons inside the structure, which is in good agreement with the existing phenomenological model [1,6].

The obtained results are important in order to understand the mechanism of the fireball appearance. The important role of the electron-neutral impact excitations and ionizations is well-known [6], but it is important to know which excited levels of the gas atoms are involved in this mechanism, and to establish the role of the metastable levels.

Acknowledgments

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Reference

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