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Striations in an ethyl alcohol glow discharge

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Abstract. This research shows the behavior of striations in glow discharge generated with high purity ethyl alcohol at a pressure of 0.6 Torr. This paper present the number of striations as a function of the of current and voltage discharge.

Introduction

The formation of alternating dark and bright regions (striations) in the positive column of a glow discharge is a universal property of discharges in tubes [1]. This phenomenon is observed in atomic and molecular gases. The striations can be either stationary or can move. The interest of 3-D stratification in a glow discharge has about ten years [2–6]. It was shown that the spatial luminosity regions for geometry may represent the number of lighting thin closed surfaces nested into each other. The main physical peculiarity of the discharge in this geometry is that recombination processes occur in a volume, contrary to the discharge in a tube, where recombination takes place on the walls. The visual stratifications not observed in simple gases (Ar, N_2, He). The admixture of high molecular gases (acetone, alcohol, benzol, and some others) results in well-pronounced discharge stratification. The parameters of striations (number, geometry spectrum, and intensity) depend on gas pressure, gas composition, current, and geometry of the discharge gap, change of these parameters allows the verification of intensity, color, shape, and topology of a luminosity region. For example, increasing the current leads to the enlargement of striation dimension so that the current density remains the same. The present work studied the striations produced in a glow discharge of ethyl alcohol.

Experimental details

Experimental setup is shown in Fig. 1. The experiments were carried out in an aluminum cylindrical vacuum chamber of 24 cm in length and 21 cm in diameter. The discharge cell consists of two movable parallel electrodes enclosed in the vacuum chamber. The two electrodes were made of planar-copper with5.0 cm in diameter. The electrodes are positioned at the center of the reaction chamber with 10 mm gap spacing. The plasma chamber has a volume of 8.31×10^3 cm^3 and it was pumped down by a vacuum system Varian D302 to a base pressure of 10^{-3}Torr. The ethyl alcohol vapor inlet is controlled by a micro regulator valve with a continuous flow, the alcohol purity has HPLC grade. A DC glow discharge of ethyl alcohol vapor was produced between the two electrodes, keeping a total

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pressure of 0.6 Torr. The current discharge was between 6.3 and 70.0 mA (measured by a digital Fluke multimeter model 8846A), while the power supply voltage (Spellman SA4) in the range of 470 to830 V. The voltage and current discharges were found as function of the number of striations produced in the glow discharge. In the lateral flange, a quartz window was used to monitor the active species generated in the glow discharge by plasma emission spectroscopy; the spectrum (200–1000 nm) of the emission cell was measured using a spectrometer Ocean Optics HR4000CG-UV-NIR. The spectrometer has a resolution of 0.15 nm.

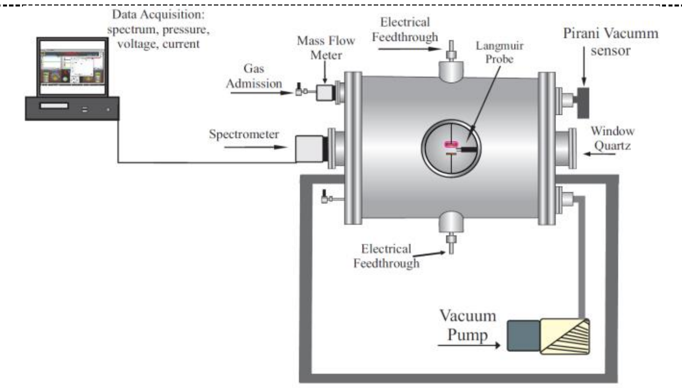

Figure 1. Experimental setup

Results

Optical emission spectroscopy (OES) measurement of anethyl alcohol (CH_3CH_2OH) glow discharge at pressure of 0.6 Torr is display in figure 2.Keeping the pressure and the flow of ethyl alcohol into the reaction chamber and varying the current and voltage of the discharge, it can be observed the formation of striations in the positive column. As the electrical power is incremented the number of striation increase. The electrical power of 2.96 (6.3 mA at 0.47 kV), 8.26 (15.6 mA at 0.53 kV), 20.79 (33.0 mA at 0.63 kV) and 58.1 Watts (70.0 mA at 083 kV) correspond to 1, 2, 3 and 4 striations respectively. This means that the plasma needs more electrical power in the mixture to generate more striations.

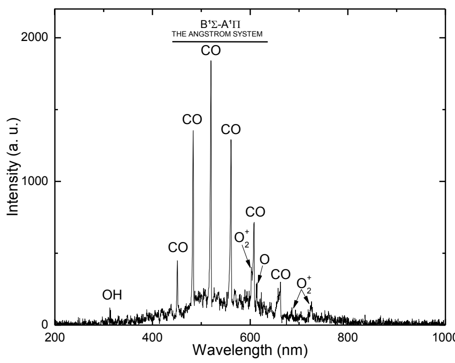

Figure 2. Optical emission spectrum corresponding to an Ethyl alcohol glow discharge, in which it can see the principal species generated.

Figure 2 shows the measurement of OES for the case of the formation of 4 striations.In the case of 1, 2 and 3 striations, the corresponding spectrums have the same bands with only variations in the intensity less than 10%.

The main elements identified in the ethyl alcohol glow discharge are:OHat 312.64 nm ($X^2\Pi$-$A^2\Sigma^+$); CO at 450.55 nm ($d^3\Pi$ -$a^3\Delta$, the Triplet bands); CO at 483.53, 519.82, 561.02, 607.99 and 661.90 nm ($B^1\Sigma$-$A^1\Sigma$, the Angstrom System); O_2^+at 602.27, 685.63 and 723.50 nm ($b^4\Sigma_g^+$-$a^4\Pi_u$,the First Negative System) and O at 613.70 nm (3p5P - 4d³D°).From the OES measurements, it can observe that the most intense bands emitted in the ethyl alcohol glow dischargewere O_2^+ and CO [7].The main CO bands are more common found in the range of length wavelength of 412-662 nm [8-9], which correspond to the Fourth positive systemand third positive Angstrom system. In the present experiment, the principal CO band observed by OES measurement was the positive Angstrom system.

Figure 3 displays the power needed to generate the discharge as a function of the number of striations.Fora glow discharge of alcohol at0.6 Torr and power of 58.1 Watt, it is possible to see four striations figure 4d, withwell-defined geometry and intensity. Subsequently, the power was decreased to yield 3, 2 and 1 striations, with powers of 20.79, 8.26, 2.96 Watt, respectively.It can be seen that the electrical power to produce onestriation is approximately 19 times lower than that for producing 4 striations, in this case the voltage and current is kept constant when formed striations. The luminescence is produced in the cathode.

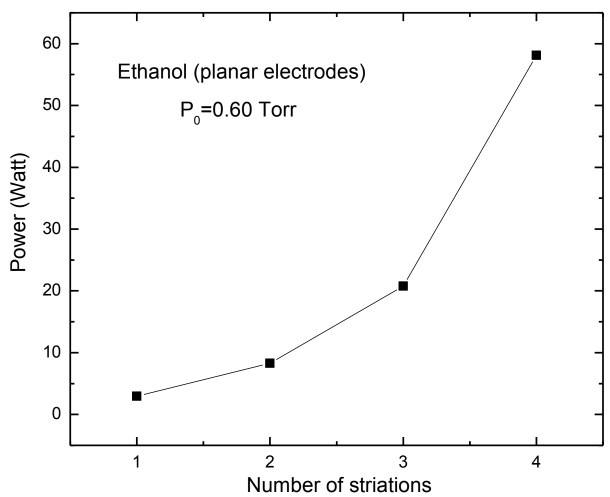

Figure 3. Number of striationsas a function ofelectrical power applied to the discharge.

The striations were stable once they are formed, as it can see in Figure 4.The formation, geometry and color intensity of the images 4cand 4dshow more clearly that the images 4a and 4b. The experiment was a self-sustained glow discharge in all cases shown in figure 4,and it was observed that the parameters measured depend on the composition of the ionized gas and the material of the electrodes, besides the pressure within the reaction chamber. By analysingthe ratio ofthe radius of the striations, it is observed that these are concentric and keep a constant rate depending on the number of striations formed.It found that the relation (r_{n-1}/r_n) where r is the striations radius and n number of striationsis 0.74.

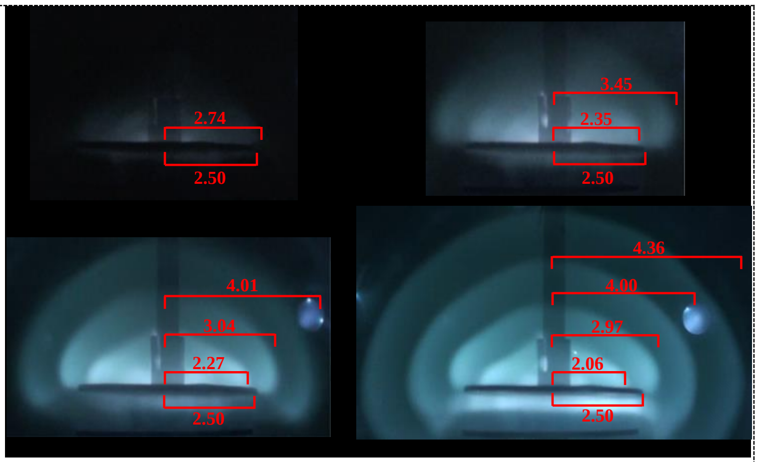

Figure 4. Pictures of striations as afunction of power discharge.

Conclusions

In the present experiment, the number maximum of the striations formed was four. The number of striation grows as the power of the glow discharge increase.The striations only were observed at low pressure. The most intense band observed by OES measurements was CO transitions that correspond to the Angstrom system.It found that the ratio (r_{n-1}/r_n) is 0.74.

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