THE STRUCTURE AND DYNAMICS OF THE FREE DC GLIDING AND POINT ARCS BETWEEN THE METAL ELECTRODE AND THE SOLUTION SURFACE STUDIED BY THE VIDEO TECHNIQUE

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Our earlier investigations [1] show that the plasma-solution system may be applied to initiate the soft oxidation processes in solutions. However, the plasma action efficiency is dependent on the variation of the external parameters. This fact may be explained by the variations of the plasma properties. In this paper the free DC gliding and point to plane discharge between the metal electrode and the solution surface is investigated by the video technique.

1. Experiment

The DC discharge was maintained in the point to plane geometry at the current of 50 - 200 mA and excited in a gap of 1-10 mm width. The construction of the DC power supply allows to ignite the arc by selfbreaking for the length up to 3 mm. In the working regime the voltage was in the range from 300 to 3000 V. The current fluctuated with frequency of 100 Hz in the range of 1-5 % of the average current for dc point to plane arc. The solutions of NaOH, NaCl, N_2SO_3 and Cu_2SO_4 with concentrations 0.025, 0.0125 or 0.005 mol/l, respectively, were used as cathode or anode. The schematic drawing of the experiment is shown in Fig. 1. The video record was made with the Panasonic NV-M5EG camera (3) in SVHS PAL standard directly as well as trough interference filters (2) with the maximum of the transparency at 335, 351, 500, 589, 652 and 659 nm. The record was transferred to the IBM Pentium (4) computer by the VIDEO HIGHWAY video card.

Fig. 1.

The dc point to plane discharge excited over the solution with concentration 0.025 and 0.005 mol/l NaCl and NaOH was chosen for the more detailed investigation.

The different zones of plasma were observed and recorded for different types of dc point to plane discharge with liquid electrolyte solution as the cathode and as the anode. The dependencies of the plasma visible volume and electrode spots area were determined for different discharge currents and discharge lengths. In our calculation the axial symmetry of the discharge and the angle between the camera direction and the horizontal level were taken into consideration. The dynamic behaviour of the discharge was studied by video records and by the observed fluctuation of the discharge current.

2. Results and discussion

If steel or copper electrodes are used and the heating of the electrodes is not sufficient to evaporate the electrode material into discharge plasma the interference filters allow to pick out the emission of the N_2 molecular bands (filter 351 nm), H_α and H_β lines (filters 500 and 652

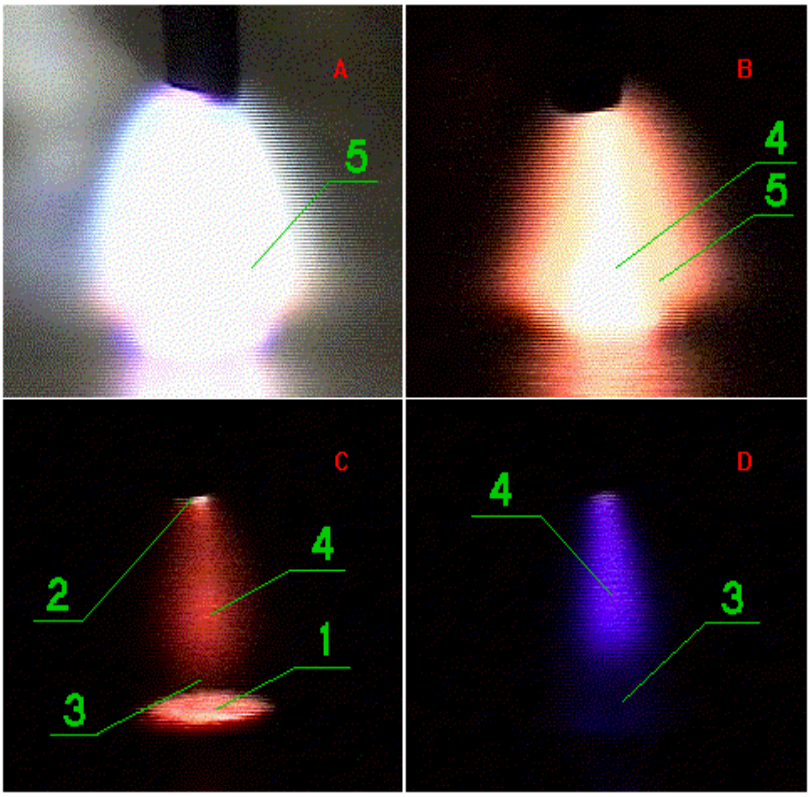

Fig. 3. *Electrolyte solution*

1 - cathode spot,
2 - anode spot,
3 - dark spase,
4 - plasma

5 - surrounding, glow

Fig. 2. *The images of DC discharge with 0.025 mol/l NaOH solution as cathode. Current - 150 mA, length - 7 mm*

nm, respectively) and Na doublet (filter 589 nm) as can be seen in Fig. 2.

In the presented case the following zones of plasma appear : 1 - cathode spot, 2 - anode spot, 3 - “dark” space, 4 - discharge channel and 5 - surrounding glow. It is interesting to remark that if the electrolyte solution are used as anode, the dark space is close to the liquid surface again and the discharge channel disappeared (Fig. 3). The measured size of the electrode spot area and the plasma volume depend on the properties of the applied interference filter and recording parameters. In the studied range of the discharge current and the length the cathode spot area is independent on the discharge length and increase with the increasing in the current so that the cathode current density remain approximately constant (Fig. 4). It is necessary to note that measurement of the cathode spot area without filters is correct for low electrolyte concentrations only. For the high electrolyte concentration the intensive emission

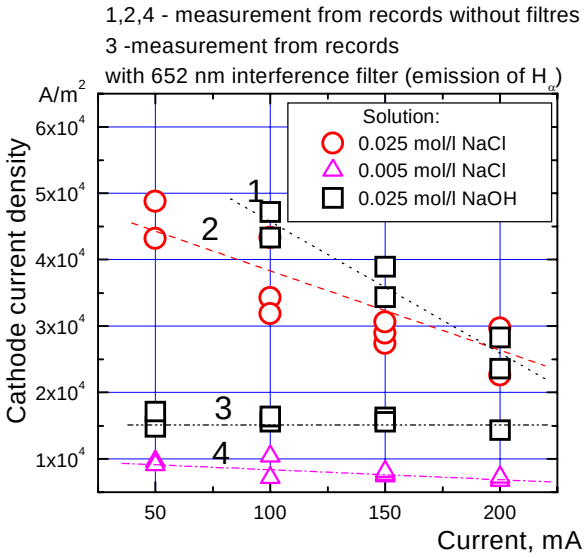

Fig. 4.

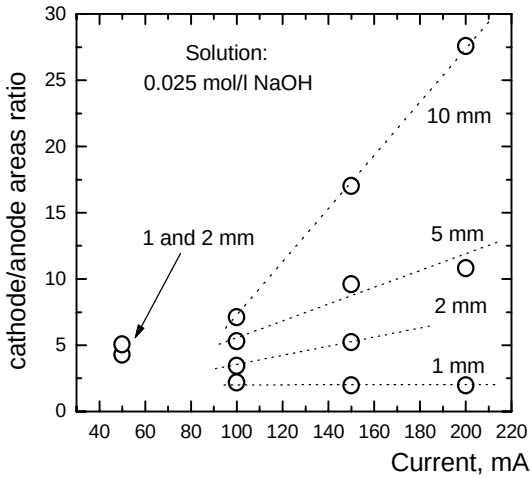

Fig. 5.

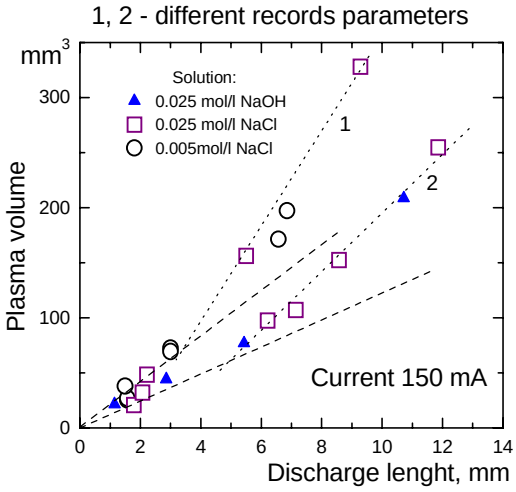

Fig. 6.

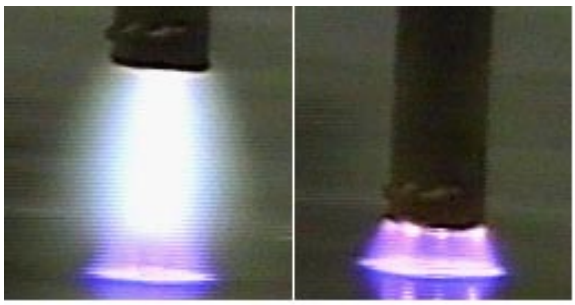

Fig. 7.

on Na in the plasma channel (Fig. 2) leads to the decrease in the visible cathode spot area and to the increase in the calculated cathode current density. In the considered concentration range the increase in the electrolyte concentration (connected with solution conductivity) evokes the increase in the cathode current density. For a long discharge gap the anode spot area is small and almost independent on the current. If the short discharge gap is used the area of the anode spot is proportional to the area of the electrode spot on the cathode (see Fig. 5). The plasma volume as function of the discharge length is non-linear (see Fig. 6). In our experiments it may be explained by the conversion of the short discharges to the multichannel regime (see Fig. 7). The appearance of the multichannel regime correlate with the increase in the current fluctuation amplitude. Beside that the transfer of the metal electrode material into plasma zone for the multichannel regime of the discharge is not observed regime (see Fig. 7). The low frequency evolution of the discharge is evoked by the displacement of the electrode spot and the fluctuation of the species flow from the liquid electrolyte surface. It is interesting to remark that the transfer of Na from liquid to the plasma zones occurs during the impulses non-correlated with the observed current fluctuations.

The evolution of the gliding discharge electrode phenomena with electrolyte solution as cathode is too fast and the evolution of the discharge structure cannot be recorded by means of the video camera used. Because the gliding discharge is excited in the flowing media (gas, vapour) the influence of the liquid electrolyte electrode on the plasma is probably less pronounced with respect to the point to plane discharges.

Acknowledgements

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References

[1] J. Janča, S. Kuzmin, A.I. Maximov, and A. Tálský: “The investigation of the chemical action of the gliding and point arc between the metallic electrode and water solution.” *18th Symp. On Plasma Physics and Technol.,* Prague, 1997, p. 277.