ELECTRODE AND DIELETRIC BARRIER MODIFICATION IN A DIELECTRIC BARRIER DISCHARGE

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Dielectric barrier discharge is widely used in the surface processing, plasma chemistry and aerodynamic applications. The surface discharge, initiated from the electrode mounted directly on the dielectric surface, is one of the popular configurations in aerodynamic studies. In air at atmospheric pressures discharge is formed as a set of separate microdischarges with a localized electrode spot. During the "forward stroke" (when the voltage on the corona electrode decreases) the cathode layer is formed, with the extremely high temperatures and energy input density. Using the analogy with the negative corona discharge, one can assume that the intensive energy release in a cathode spot can lead to the sputtering of the electrode material and redeposition of the oxidized particles on the electrode surface and adjacent regions of barrier. Meanwhile the electrode edge modification should have a dramatic effect on the discharge electrical parameters and the characteristics of the discharge-based devices. Despite the obvious importance of the problem for practical applications, no facts could be found in literature describing the effect of the barrier discharge on the exposed metallic electrode.

Most used materials in practice for electrodes manufacturing is aluminum and copper. The electrodes are usually used in foils 10-100 μm, glued on the surface of the barrier. This work is devoted to the phenomenological study of the modification of the edges of aluminum and copper electrodes and the adjacent barrier surface during the discharge exposure, and its effect on the power consumption of the discharge. All discharges were exposed in the discharge during 96 hours, in 2-8 hour periods. The discharge was powered by the sinusoidal voltage with frequency 25 and 110kHz and amplitude 3.3, 4.2kV; weak convection of air was organized through the discharge region. During the exposure, discharge and electrode images were taken trough the 100x microscope, and the discharge power was measured using the current-voltage curves integration. Detailed study of the electrode and barrier was performed using the laser confocal microscope Olympus Lext OLS4000 with spatial resolution better than 500nm.

Irrespective of the material used, the exposed electrode edge suffers from significant morphological changes already after several hours of the discharge operation. The structure of the electrode edge is found to be directly connected to the microdischarges dynamics. The latter appears to be dependent on the electrode material: on copper electrode, the MD position is constant across a number of high voltage periods, an aluminum- the MD is wandering along the electrode edge. One can assume that this effect is due to the charging of the oxide film covering the electrode.

On a copper electrodes, at the position of the electrode spot a melted crater is formed with 1-2 μm diameter. On the edges of the crater there forms the dendrite- and sponge-type structures are formed. For the copper electrode, discharge power does not significantly alters for small exposures. At large exposures (more than 20 h at 110 kHz) discharge power is increased due to the folding of the electrode edge.

In the case of alumina electrode, the electrode spots are stationary only during the first minutes of the discharge operation. Immediately after the discharge onset, the dark region (probably γ-Al2O3) is formed around the MD position. After the dark region formation, the electrode spots moves away from the electrode edge, covering the oxidized surface. The dark regions grow rather intensively, forming finally a single band, with a width up to 200 μm from the electrode edge. On the edge of the band, the oxide step is formed with a dendrite structure. Formation of the oxidize band leads to the significant (up to 5 times) decrease of the discharge power during first 2 h of the discharge exposure and to the decrease of the plasma layer length. At high exposures, increasing mechanical stresses in the electrode leads to the tearing the band away from the electrode body, upon which a new cycle of electrode oxidizing starts. Uncovering of the fresh edge leads to the stepwise increase of the discharge power.

The dielectric barrier is not significantly eroded by the discharge. In the case of copper electrode, the oxide formations are built on the dielectric surface, slightly increasing the surface roughness. The latter process intensifies with the voltage amplitude increase.