CORONA DISCHARGE AS A METHOD OF VISUALIZATION OF THE FIELD-EMISSION CENTERS

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Introduction

Corona discharge arises at rather high pressure of gas (the order atmospheric) in strongly nonuniform electric field. Such field can be obtained between two electrodes if the surface of one of which has the great curvature (a thin wire, an edge). The presence of the second electrode is not obligatory, its role the surrounding earthed electrodes can play. When the electric field near to an electrode with greater curvature reaches approximately $3\times10^4\,V/m$, a luminescence appears around of this electrode. Such a luminescence is looking like an environment or a corona, whence there was a name of the discharge.

Results and discussion

For the first time voltage-current characteristic of the corona discharge has been received by Townsend in 1914 [1] for a corona between a wire and the coaxial cylinder. Assuming a smallness and spatial homogeneity of a volume discharge in an interelectrode gap, Townsend has received the equation describing the voltage-current characteristic for the corona discharge

$$J = \mu_i \frac{2U(U-U_0)}{R^2 \ln R/r} = kU\left(U-U_0\right), \qquad (1)$$

J – current of the crown (from a length unit of electrode), U_0 – crown discharge firing potential, U – applied voltage, R and r – radii of the external and internal electrodes, μ_i – ion mobility.

In spite of the fact that initially equation (1) has been received for cylindrical geometry and small currents of a corona, the subsequent experimental and design-theoretical researches has shown, that at an accurate choice of size and dimension of factor *k* it can successfully be used for description voltage-current characteristics of a unipolar corona in any other geometry and at greater currents.

In the literature on the corona discharge the most commonly used convention employs the so-called reduced voltage-current characteristic [2] which represents the relationship $J/U = f\left(U\right)$. From (1) it appears, that

$$J/U = k\left(U-U_0\right).$$

The reduced voltage-current characteristic for the corona discharge from an edge on air is shown in Fig. 1.

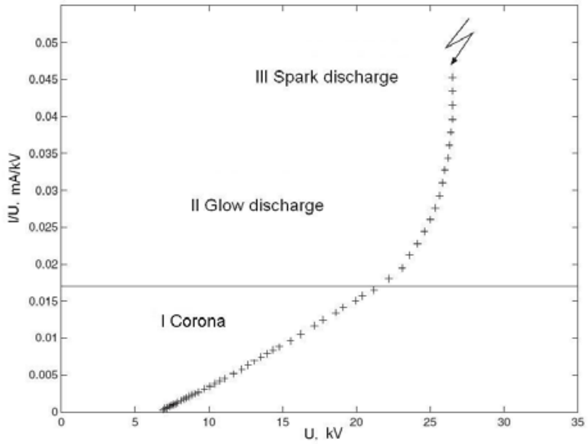

Fig. 1. Reduced voltage-current characteristic for the corona discharge from an edge on air (14 mm interelectrode gap).

In experiment with corona discharge the cathodes of carbon foil were tested in diode regime on air. Carbon foil can be obtained at fast heating (better thermal shock) of carbon inclusion complexes at which occurs 300 - 400 multiple volume increase of substance [3].

Treatment of a cathode material consists in an exposure of an emitting surface to linearly polarized pulse radiation of the $YAG:Nd^{3+}$ laser ($\lambda = 1064\,nm$). Influence of laser radiation on the analyzed samples consists in ultra-fast heating due to absorption of light and the subsequent evaporation of the emitter material. After the laser impulse influence essential expansion of a part of foil strip subjected to an exposure, was observed also. Therefore the emitting surface of a foil got the rounded off form.

Experiments were spent at atmospheric pressure. To control the field-emission current inan anode circuit an ammeter has been included. The distance between the anode and the cathode was *l* = 5 – 10 mm, cathode voltage was maintained at

$U = 8$ kV. Meanwhile, the field-emission current $I = 70 – 80$ μA has been received.

(a)

(b)

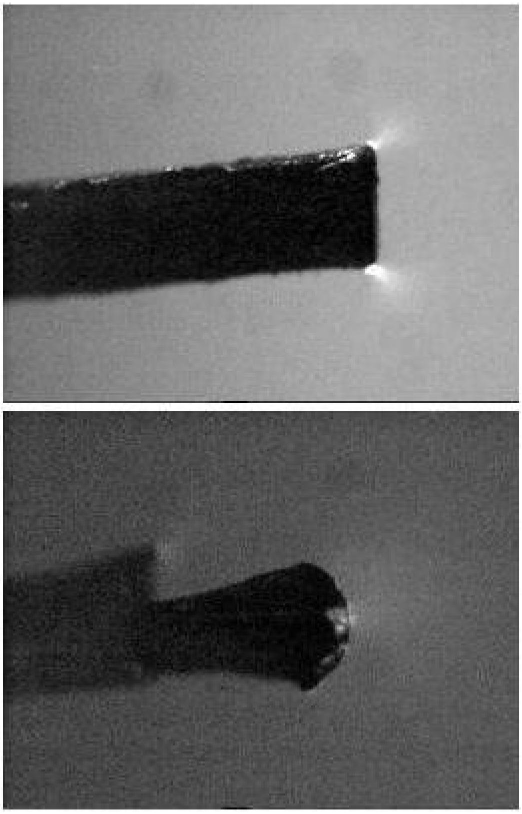

Fig. 2. Corona discharge tests confirming higher uniformity of electrical field distribution near laser treated cathode (b) than non-treated one (a).

If apply to the cathode a high negative potential (the anode is earthed) on the cathode there is an observable corona. When a mechanically treated cathode was tested corona formed at peripheral parts of the emitting edge (Fig. 2a). In case of laser treated cathode the corona formation region increased considerably and the whole emitting part of the cathode was involved in the process (Fig. 2b).

Conclusions

This experiment provides that more uniform distribution of intensity of an electric field can be obtained at a surface of the sample treated by laser radiation, as the process of formation of a crown is directly connected with the intensity.

The field distribution uniformity increase leads to the increase of the emitting surface area decreasing the current loads on each emitting site. As the result we get a cathode more stable to the current load with the ultimate current orders higher. The fact was confirmed during long term tests. Laser treated cathodes showed more stable characteristics with lower fluctuations than non-treated ones.

References

1.Townsend J.S. The potentials required to maintain current between coaxial cylinders. – Phil. Mag., 1914; 28: 83-87.

2.Jones J.E., Davies M., Goldman A., Goldman M. A simple analytic alternative to Warburg's law. – J. Phys. D: Appl. Phys., 1990; 23: 542-552.

3.Fialkov A.S. Carbon, interlaminar bondings and composites on its basis. - M.: Aspect Press, 1997. – 718 p.