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THE EFFECT OF NON-METALLIC INCLUSIONS AND FILMS ON THE CATHODE ON SOME PROCESSES DURING VACUUM DISCHARGES

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Introduction. Paper [1] described the regularities of the formation of emission centers (e.c.) under the plasma of the cathode spot during the spark and the arc stages of the vacuum discharge. The comparison of experimental results with the conditions in the pre-cathode layer enabled to set the limits of realization of two possible mechanisms of new e.c. formation. The mechanism connected with the microprotrusion explosion as affected by the thermionic-field-emissive current may be realized at a distance of $r \sim 10^{-4}$ cm from the initial emission center. The mechanism connected with the breakdown of non-metallic inclusions and films enables to explain the new e.c. formation at a distance of $r \lesssim 10^{-2}$ cm. In the case of a spark discharge ($\frac{di}{dt} > 10^8$ A/s) new e.c. can emerge according to the second mechanism at distances of $r = 0.2-1$ cm at moments of spike on the current traces when the periphery plasma sections turn out to be charged up to a high ($\sim 10^2$ V) potential relative to the cathode. The results obtained in [1] may be used to explain the effects observed during vacuum discharges.

1. The motion of the vacuum arc cathode spot

The experiments with a high temporal and spatial resolution [2] detected the spots of two types: fast moving spots (the 1st type) and slow moving ones (the 2nd type). In our opinion the moving of spots of the 1st type stipulated by the decay of some fragments and by the appearance of others is explained by charging and followed by the breakdown of non-metallic inclusions and films. As it is shown in paper [3] the 1st type spots emerge only on the non-conditioned cathode surface. After the cathode being conditioned by the arc discharges the spots turned out to be not mobile inspite of the presence of a great number of micropoints of various dimensions on the cathode. The craters left after the spots of the 2nd type had a relatively large dimensions and a characteristic substructure. The appearance of the substructure points out that new e.c. emerged in the area of initially appeared center [4] i.e. only in this case the field-emission mechanism of e.c. formation is possible. Thus, one can suppose the spots of the 2nd type to be, in fact, the spots of the 1st type grouping in a very small area (a characteristic distance between the fragments is $\sim 10^{-4}$ cm), the consequence of this is the manifestation of additional thermal effects increasing the cathode erosion.

2. A spontaneous emergence of new cathode spots

A spontaneous emergence of new cathode spots ahead of the old ones is known to be observed at the current growth rate higher than $10^8$ A/s. A radial extension of the spot front occurs only during the current growth stage, the maximum extension rate being $2 \cdot 10^6$ cm/s. The current growth in the high-voltage ignitron as was stated [5] to be accompanied by appearance of the current spikes and by formation of luminous striations between the electrodes. The formation of striations seem to be identified with the moving of more dense plasma layers from the trigger site on the cathode formed in the consequence of non-uniform cathode material arrival at plasma. The result of this is the formation of breakages in plasma with a

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considerable potential drop. Comparing the data of papers \([5,6]\) with the results of paper \([1]\) we may assume the spontaneous emergence of the cathode spots during the spark discharge to occur according to the mechanism associated with the breakdown of non-metallic inclusions and films, and to be stipulated by the charging of the plasma periphery layers \((r>0.2 \text{ cm})\) up to a high potential. Naturally, the maximum spot front extension velocity must be determined by the cathode plasma extension velocity, i.e. it is to be equal \(2 \times 10^6 \text{cm/s}\).

3. The cathode erosion during nanosecond vacuum discharges

The investigations of the cathode erosion at explosive emission showed that the more the e.c. on the cathode the less the material removal per one pulse. This fact is proved in \([3]\) by the way of comparison of the surface of Mo wire cathode maintained in ultra-high and oil vacuum during nanosecond discharges. In pure vacuum conditions a small number of e.c. seem to function on the cathode in consequence of which the craters of large sizes emerged. During the cathode operation in oil vacuum the crater sizes were less that resulted in more smooth cathode surface. We also conclude from \([3]\) that the cathode erosion in the oil vacuum is lower than that in the UHV one. We suppose this difference to be caused by the presence of the oil film on the cathode that results in appearance of a great number of e.c.

4. The appearance of double electric layers in "straight discharge" type assembly

It was stated \([8]\), that there is appeared a double charged layer moving from the cathode at voltage applicability to the discharge gap preliminarily filled with plasma \((n \sim 10^{12} \text{cm}^{-3})\). The reason of the appearance and of the moving of the layer is that the plasma density increases at the cathode up to the value exceeding the plasma density in the gap. However, the pre-cathode plasma formation mechanism wasn't investigated. It is shown in \([9]\) that the pre-cathode plasma is formed when a crucial charge density \(Q = (1-5) \times 10^{-6} \text{c/cm}^2\) on the surface of the dielectric films available on the cathode is created. The authors believe the plasma to be formed due to desorption and of gas ionization on the surface of these films by the electrons tunnelling through the film.

In our opinion the pre-cathode plasma formation in the system of occurs due to the breakdown of non-metallic films and inclusions and of the emergence of an effective plasma source - cathode spot. As it is shown in \([1]\), the critical surface charge density resulting in the film breakdown is \((1+5) \times 10^{-6} \text{c/cm}^2\) as well.

REFERENCES