In an investigation of various cermets it was established [1] that, compared with specimens having a homogeneous structure, those with a pronounced structural heterogeneity are characterized by much higher coefficients of ion-electron emission. In view of this, it is of interest to study the effect of artificially created heterogeneities on ion-electron emission and determine the optimum size of heterogeneity cells.

The increase in ion-electron emission exhibited by heterogeneous cathodes may be qualitatively explained as follows. The coefficient of ion-electron emission of large grains of a dielectric is higher than that of fine semiconducting and metallic grains of a relatively homogeneous cermet. Furthermore, on the surface of a heterogeneous cathode there are zones of increased electric field strength, which also intensify ion-electron emission. For example, it is reported [2] that, when electric field strength is increased to $2 \cdot 10^5$ V/cm, the Schottky effect doubles or even trebles the coefficient of ion-electron emission. In semiconductors and dielectrics, the character of this phenomenon is more complex, because in this case it is necessary to take into account the depth of penetration of the electric field into the material. Under these conditions, certain phenomena may be observed analogous to those taking place during field-intensified secondary-electron emission [3].

Thus, the coefficient of ion-electron emission of cermets placed in a strong electric field may be increased by a lowering of the potential barrier on the solid surface, fuller evacuation of excited electrons from the main volume of material, and multiplication of excited electrons during their travel toward the surface.

Establishment of high electric field strengths at the surface of a homogeneous plane cathode in gas discharges is a matter of considerable difficulty and can only be accomplished at extremely low gas pressures. Use of heterogeneous cathodes facilitates this task and enhances the energetic effectiveness of cold cathodes and their emissive power, but their structural heterogeneity results in nonuniform density of the emission current. The permissible degree of emission nonuniformity, $h$, is determined by the conditions of application of cathodes and their design. To an approximation, it may be evaluated as follows: When the surface of a plane cathode consists of separate emission centers (Fig. 1) located at a mean distance $h$ (linear size of the heterogeneity cell) from one another, during the passage of current in a plane-parallel system of electrodes the electron currents will merge at a certain distance from the cathode. This distance is given by the expression

$$h = 2\delta = 2 \cdot \Delta t = 2 \frac{V}{2\eta\nu d} = 2d \sqrt{\frac{U_t}{U_a}},$$

where $\delta$ is the electron displacement due to the transverse component of thermal velocity, $\nu_X$ the mean thermal velocity of emitted electrons, $\Delta t$ the flight time of an electron from the cathode to the point where the separate electron currents merge (anode), $\eta$ the charge-to-mass ratio of an electron, $d$ the distance from the cathode to the point where the separate electron currents merge, $U_t$ the mean thermal velocity
of emitted electrons, expressed in terms of equivalent voltage, and $U_A$ the electron-accelerating voltage. Under high-voltage glow-discharge conditions, we obtain $h \approx 0.1 \, d$.

This method of evaluating the size of emission heterogeneity cells is a very approximate one and merely indicates the mean permissible distance between the maximum emission points when such points are sufficiently numerous.

The size of the heterogeneity cell affects the magnitude of the maximum electric field strength at the cathode surface. When, for example, the distance between the metallic grains or fibers in a cermet is very small, this reduces the field strength at the surface of individual edges as a result of mutual screening. On the other hand, an excessive distance between the grains raises the degree of structural heterogeneity of the material without appreciably increasing the field strength at the surface. Thus, there is an optimum size of heterogeneity cells giving maximum electric field strength at the individual edges with a relatively homogeneous structure of the material.

Theoretical calculations of the field at the surface of a heterogeneous cathode are precluded by the complexity of the real geometry. Investigations performed with the aid of model devices for an idealized system of edges \[4\] have shown that the optimum size of a heterogeneity cell is approximately three times the linear size of the inclusion causing the heterogeneity.

Thus, in the development of heterogeneous cold cathodes, it is necessary to start with the permissible degree of emission heterogeneity and the condition that maximum electric field strength is to be attained at the cathode surface. However, the coefficient of ion-electron emission depends also on many other factors that do not readily lend themselves to evaluation. In view of this, experiments were carried out on zirconia-base cermet specimens in which structural heterogeneity was artificially created by introducing not metal powders but unoriented tungsten and molybdenum fibers of 0.06-mm diameter and 1.5-2.5-mm length.

Test cermet specimens were prepared in this work by the hot pressing technique. The starting material employed was a stabilized zirconium dioxide powder (matrix material), to which molybdenum and tungsten fibers were added. The zirconium dioxide was ground in a mortar and then mixed with metal fibers in a closed can on a roller conveyor for 1.5-2 h. After mixing, the material was charged into a graphite die, with a boron nitride top layer acting as a partition, and lightly densified.