REFRACTORY CARBIDES AS THE FIELD POINT EMITTERS OF THE ELECTRONS AND IONS

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The charged particles emitters which use the phenomena of field electron emission and field evaporation may be great interest as electron and ion sources in various high-resolution electron-beam instruments as well as in nanotechnology. Presently alongside the metal emitters, of most interest are emitters of carbon and carbon-containing emitters in particular emitters from refractory metal carbides. The major advantages of these emitters are their chemical inertness to residual gases, a small variation of the work function in the process of adsorption, and the ion bombardment stability. All this allows one to obtain a highly stable and steady emission of charged particles even in not the most favorable external conditions.

In this work the emission properties of the tungsten carbide field emitters was studied. These emitters can readily be prepared when a tungsten emitter interacts either directly with carbon or with any hydrocarbon (benzene, paraffin, stearin, etc.) vapor. In this case, in the tungsten carbonization process, either the classical carbide, WC, or W_2C with a close-packed hexagonal structure can be formed, as well as a carbide with the body-centered cubic structure as a tungsten but with faces differing in their development from tungsten. In this study we used field electron microscopy, field mass-spectrometry and the methods of a determination of the emission properties of the field emitter surfaces.

The efficient application of these emitters in the high-resolution instruments and nanotechnology requires that their emission localization be sharply increased and the charged particles field sources, which emit into extremely small solid angle up to hundredth and even thousandth of STERRAD. In a rather effective method to increase the emission localization, sharp nanoprotrusions are grown on the field emitter surfaces, which has as a rule a curvature radius near 1 micron and emission angle from 1 to 2 STERRAD. These nanoprotrusions increase the value of local field strength and the value of emission current by several orders.

The formation of such protrusions may be obtained by simultaneously action on the field emitters in situ the strong electric field strengths F and high temperatures T. As a rule the values of T ~ 1500 – 1800 K and F ~ 5 – 10 V/nm for the tungsten carbide emitters. In the process of this thermo-field action or thermo-field treatment the same stages of a form change field emitter such as on the emitters from pure tungsten are observed, a stage of change of a faced a single crystal emitter and the stage of field crystal growth both the small nanoprotrusions and the large crystal outgrowths. It is possible to obtain in this case enough large number of the nanoprotrusions – up to some tens on a emitter surface and to produce the electron sources like to “watering-pot”. It is possible also to control of the number of the emitting nanoprotrusions, to change its number and to obtain a single-crystal emitting nanoprotrusion, which formed point source of the charged particles with very high emission localization. The emission parameters of this single nanoprotrusion are close to those for a single carbon nanotube but the advantages of these carbide emitters with nanoprotrusions on the surface over nanotubes are complete reproducibility of their emission parameters and the possibility of use such emitters as the emitters not only the electrons but also as the emitters of the various atomic, molecular and cluster ions.

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