On possible structure of field-induced electron emission centers of nano-porous carbon

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Nano-porous carbon (NPC) gives a good example of carbonic material with "smooth" surface morphology demonstrating promising field-emitter properties [1]. Electron current extracted from NPC exceed predictions of classic Fowler-Nordheim theory by a few orders of magnitude. For many other micro- and nano-structured carbons, this feature is explained by interaction between domains with sp^2 and sp^3 hybridization of C atoms. In this model, graphite-type areas secure electron transport to the sample surface, where electrons tunnel onto conduction-band states of a diamond-like film, grain or inclusion separated from vacuum by only a thin and low barrier. This process is possible due to low conductivity of sp^3 carbon, which allows electric field to penetrate into its volume to reduce energy of the conduction band bottom below volumetric Fermi level. We propose modification of the model to make it relevant to the case of fully graphitic NPC.

According to [2], NPC is a porous conglomerate of small (1-2 nm) graphene sheets mixed with larger onion-like particles (up to 50 nm in size). Electrophysical properties of the material are those of a p-type semiconductor, which means non-zero bandgap and Fermi level position below the top of the valence band. The excessive holes appear due to trapping of electrons at interface boundary states, thus all crystalline volumes are charged positively relative to their boundaries. Due to strong band bending effect, grains are separated by tunnel junctions. In this situation, a grain of optimal size and conductivity situated at the surface can efficiently emit electrons. Its polarization in external field leads to field enhancement at the junction separating it from the rest of the sample. If this junction switches to tunnel-diode regime, electrons from the Fermi level are injected to the conduction band of the surface grain, which facilitates their further transfer to vacuum. Viability of this scenario for NPC is confirmed with quantitative estimates and simulation.

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[1] V.B. Bondarenko, P.G. Gabdullin, N.M. Gnuchev, et al. *Tech. Phys.* **49,** 1360 (2004).
[2] A.I. Veinger, B.D. Shanina, A.M. Danishevskii, et al. *Phys. Solid State* **45**, 1197 (2003).