Role of nano-sized objects in field-induced electron emission facilitation

Arkhipov A.V.*, Bondarenko V.B., Gabdullin P.G.

St. Petersburg State Polytechnic University, 195251, St. Petersburg, Russia
**e-mail: arkhipov@rphf.spbstu.ru*

Phenomenon of facilitated field-induced electron emission from nano-structured materials with relatively smooth surface morphology is often described in terms of two-stage emission model. This model allows to explain principle possibility to obtain substantial emission current from a surface characterized by a high value of work-function (as it is for various forms of carbon) in the absence of strong local field enhancements at elements with high-aspect-ratio geometry. In this model, electrons are first transferred onto some high-energy intermediary states localized near the emitter surface and then emitted to vacuum, separated from these states by a barrier that is transparent for electrons. Yet description of details of this model – such as the nature of the intermediary states – often meets substantial problems. We think that at least some problems may be solved if we assume that the intermediary states are associated with conductive nano-sized objects at the emitter surface. For many carbon-based emitter of the discussed type, such objects (surface crystallites, onion-like particles, nano-sized islands of coating film, etc.) were directly observed –- see, for instance, in [1]. External electric field can be enhanced at the junction between the nano-particle and emitter bulk (or other nano-particles comprising the emitter material), allowing electrons to gain substantial energy and occupy high-energy levels of the nano-sized object. According to recently published research results [2], the lifetime of “hot” electrons in nano-particles may be very large (up to nanoseconds) if the energy spacing between electron levels exceeds the highest photon energy of the lattice, thus excluding the most efficient mechanism of electron energy losses. This feature allows “hot” electrons to travel through the particle to its vacuum boundary where they can easily leave the emitter. The presented work includes numerical estimates and simulations performed to demonstrate applicability of the proposed model to a few types of carbonic nano-structures investigated in previous experiments.

[1] A.V. Arkhipov, P.G. Gabdullin, S.V. Gordeev, S.B. Korchagina, M.V. Mishin, Abstract P6.04 (In this book).

[2] W.A. Tisdale, K.J. Williams, B.A. Timp, D.J. Norris, E.S. Aydil, X.-Y. Zhu, *Science* **328**, 1543 (2010).