Facilitating effect of non-stationary electric field on electron emission from nanocarbon films

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Previous experiments have demonstrated that non-stationary electric field can have temporary enhancing effect on field-induced electron emission from a few types of nanostructured carbons comprised by low-aspect-ratio particles [1,2]. This effect finds no direct explanation in Fowler-Nordheim theory, but fits well in the model of emission via acceptor-type transient states localized in the surface layer of the nanostructure, where electron states' energies are influenced by the external field. Recently performed computer simulations showed good agreement with experimental characteristics, provided that the model system includes two sets of surface transient states with different parameters and different (but close) localization. The deeper states are filled with electrons as soon as electric field is turned on, but the potential barrier separating them from vacuum is too high to allow efficient emission. The shallower states, having good connection with vacuum, remain empty in static or slowly changing field, as their energy doesn't reduce below the Fermi level. Introduction of a short field kick pulse results in charge exchanged between the sets of transient states, and the shallower states are populated with electrons, which boosts emission current. This scenario looks generally realistic, because in the presence of non-stationary field the whole system becomes non-conservative, and some part of electrons can acquire additional energy facilitating their emission. Further simulations demonstrated that under the effect of rf field component of sufficient magnitude, the activation of emission properties remains permanent. The necessary rf field magnitude can be reduced for a system with larger number of interacting states, serving for consecutive elevation of electron energy in a series of inter-state transitions.

Even in the case of static external electric field, electron energy distributions can be distorted by non-conservative field effects – the ones associated with auto-oscillations of emission current, experimentally observed in our previous work [3]. In the digital model, such oscillations developed in systems with one or two transient states. The oscillatory mechanism required a start-up excitation, but then its magnitude was self-maintained and supported huge increase of emission current.

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[3] A.V. Arkhipov, M.V. Mishin, G.G. Sominski, et al. *Tech. Digest IVNC/IFES* (Guilin, China), 221 (2006).