# MULTISCALE SIMULATION OF FIELD EMISSION TRIODE NANOSTRUCTURES

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## ABSTRACT

Problems of field emitters arrays development are well known [1]: ensuring the required level of emission current for the efficient operation of electronic devices, ensuring reliable and long-term operation of emitters, ensuring the formation of the electron beam with optimum geometry and parameters, creating of technology for micro- and nanoscale emitters manufacturing and assembling.
Along with various difficulties of technological, technical, physical and electrical aspects, which impose restrictions on the choice of one or another triode nanostructure when creating a device, characteristics in an external electrical circuit play an important role in this choice. The field emission triode structures of vacuum micro- and nanoelectronics possesses differential parameters in static mode which significantly (by orders of magnitude) differ from the analogous characteristics of conventional electron tubes [2], which together with miniaturization significantly expands the possibilities of their use. Multiscale mathematical modelling and computer simulation are performed for analysis of triode nanostructures characteristics in static mode. This paper presents comparison and analysis of triode parameters both from experimentally measured current-voltage characteristics and from simulation results. Micro- and nanoscale modelling is based on a current function that is analogous to one used in hydrodynamics [3]. Finite-element method over a non-uniform mesh is used for electric field calculations and algorithms in Matlab PDE Toolbox and Comsol Multiphysics are implemented [4, 5]. Mathematical model of nanostructured field emission surface is proposed. Scientific research were performed at the Research park of St. Petersburg State University Computing Center.
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## References

[1] N. EGOROV, E. SHESHIN, Field Emission Electronics, Springer Series in Advanced Microelectronics 60 (Springer International Publishing, 2017) 568 p.
[2] K.A. NIKIFOROV, Z.R. GALLYAMOV, Journal of Physics: Conference Series 643(1) (2015) 012123.
[3] K.A. NIKIFOROV, AIP Conference Proceedings 1648 (2015) 450014.
[4] A.N. ZARTDINOV, K.A. NIKIFOROV, Journal of Physics: Conference Series 741(1) (2016) 012006.
[5] K.A. NIKIFOROV, N.V. EGOROV, M.F. SAIFULLIN, Technical Physics 60(11) (2015) 1626.