Controlled integrated vacuum elements on niobium field cathodes for microdisplays

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1. Introduction

The paper presents the methods of creation and research results of matrices of electronic elements on field cold cathodes with given geometric and electrophysical parameters. The developed controlled matrices are small-sized, highly efficient sources of electron beams with low energy consumption for microelectronic devices, such as microdisplays. Field emission elements with nanostructured cathodes in the triode and diode configurations are implemented based on original structural and technological methods for the electrochemical formation of vertically oriented arrays of metal oxide niobium nanostructures, compatible with the latest nanotechnologies used in the manufacture of promising optoelectronic and nanoelectronic products.

2. Results

Arrays of vertically oriented metal oxide nanostructures were formed by electrochemical anodization of the two-layer Al/Nb system [1]. The array of nanostructures had the following parameters: column diameter - 50–150 nm; location period - from 500 nm to 70 nm; scatter in height - not more than 5%; array height - 0.5–1 μm. Figure1 shows micrographs of the surface and the cross section of the resulting array of niobium nanostructures.

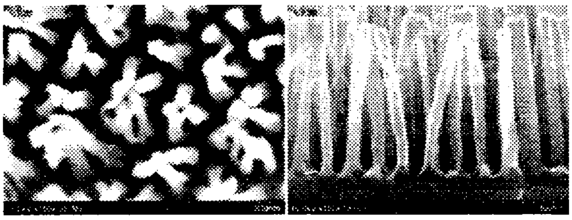

Figure 1: SEM of the surface and the cross section of niobium nanostructures array

Geometric models of matrices of vacuum elements have been developed and investigated. The distribution of electric field lines was simulated when a voltage of 10 to 150 V was applied between the anode and cathode. The design and manufacturing technology of a crystal with a matrix of field emission elements consisting of 100 field elements interconnected by a common control bus is developed. The cathode control bus is located directly on the plate, the vacuum part of the elements is placed in cavities formed using specially developed processes of local plasma-chemical and liquid etching of dielectric and conductive layers, providing insulation functions and acting as a control grid and anode. In each cavity, there is one field emission nanostructured cathode from an array of niobium metal oxide columns. A schematic representation of the matrice of field cathodes is presented in Figure 2.

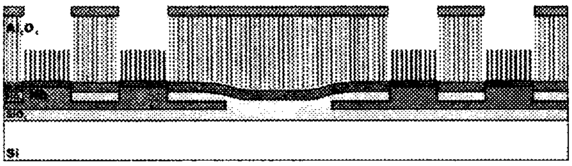

Figure 2: Schematic representation of the matrice of field cathodes

The matrices of elements based on field cathodes were fabricated. Figure 3 shows electron microscopic images of the formed matrices at different stages of their manufacture.

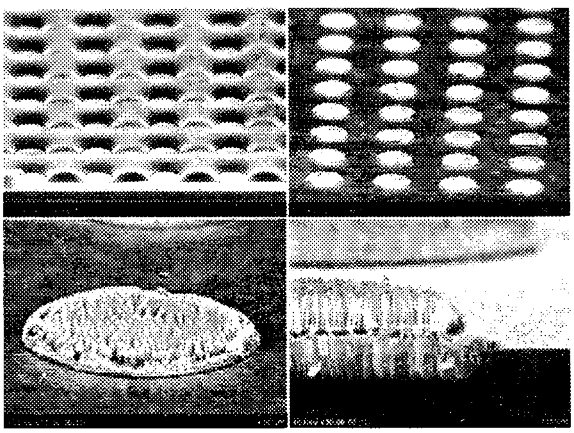

Figure 3: SEM images matrices of cold cathodes and individual cathodes based on **niobium nanostructures**

The fabricated matrices of emission elements had the following characteristics: control voltages 20–32 V/μm; threshold voltage 2 - 4.5 V/μm; emission current of at least 30 mA/cm^2 at a voltage of 16 V.

3. Acknowledgements

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4. References

[1] A. Pligovka, A. Lazavenka, G. Gorokh, "Anodic Niobia Column-like 3-D Nanostructures for Semiconductor Devices" IEEE Transactions on Nanotechnology, Vol. **18**. pp. 790-797, 2019.