11th CONFERENCE ON BEAM INJECTION ASSESSMENT OF MICROSTRUCTURES IN SEMICONDUCTORS (BIAMS11)
25-28 June 2012 - Annaba, Algeria

Interelectrode gap of Ni field emission microcathodes obtained by electron probe microanalysis

S.V. Baryshev[1, 2, *] and G.M. Gusinskii[2]

[1]Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439, USA

[2]Ioffe Institute, 26 Polytekhnicheskaya, St. Petersburg 194021, Russia

[*]sbaryshev@anl.gov

The ion-track technology enables low cost and large scale fabrication of multiple Ni tip field emission microscopic electron sources (field emission microcathodes, μFECs) inside a polymer matrix. Such a source operates at voltages as low as ~100 V and provides technologically significant emission currents ~10^6 A/cm^2 at the current load of a single microemitter of ~10 μA [1]. This is due to creation of extra-high electric field gradients E≥10^7 V/cm. In this μFEC design, emitted electrons do not induce surface charges and hence the gradients depend on an emitting tip diameter, an anode aperture diameter and an interelectrode gap (emitter-anode distance) [1]. The diameters are measured directly by scanning electron microscopy (SEM) in the secondary electron mode [1], while the gap evaluation is not a trivial problem and should be carried out in a somewhat different way.

In this work, we propose to measure the interelectrode gap of a μFEC inside a SEM by x-ray microanalysis in the energy dispersive (EDS) mode, so that it is done along with the diameters evaluation in the same experimental set, and thus provides flexible and rapid determination of the all three key μFEC parameters. Measurements were performed by *JSM7001F JEOL* SEM equipped with EDS *INCA Energy* system by *Oxford Instruments*. The setup of the experiment was as follows. The sample was a 10 μm Mylar film, bottom surface of which was plated with Ni serving as a support (and an electrical contact when operating as emitter) for Ni cones inside latent tracks produced by ions of MeV energy range [1]. Emitting nanotips were not revealed on the opposite anode front surface being buried in Mylar film. Recording an intensity of the Ni lines as the electron probe energy gradually increased, we plotted Ni signal versus the probe energy. Differentiation of this *erf*-like curve gives one a characteristic energy corresponding to the depth of the nanotips below the host matrix surface. Taking the Ni *K*-line ionization threshold energy, a calculation of the actual depth was performed in the terms of Kanaya-Okayama model [2]. Calculation results suggest that the sought value was of 1.98 μm, which correlated with a number roughly estimated from a chemical etching rate of Mylar, and corresponded well to 2 μm, the value anticipated for the best performance of the μFEC system. To self-check the used approach, the sample was covered with a calibrated 1 μm Mylar film. The same experimental procedure gave a shift of the characteristic energy towards a higher value, and hence an increase in the burying depth of the nanotips from 1.98 to 3 μm.

Acknowledgement: This work was supported in part by UChicago Argonne, LLC, contract DE-AC02-06CH11357.

Keywords: field emission, ion-track technology, nickel, multiple metallic cathode, SEM, x-ray microanalysis

References

[1] L.A. Baranova, S.V. Baryshev, G.M. Gusinskii *et al*, Nucl. Instr. Methods Phys. Res. B, 268 (2010) 1686

[2] K. Kanaya and S. Okayama, J. Phys. D: Appl. Phys., 5 (1972) 43