Tungsten-graphite cathodes as electron sources for 3D-printed field emission microscopes

Mohammad M. Allaham[1], Daniel Burda[1], Alexandr Knápek[1], Michał Krysztof[2], Kamil Baranowski[2], Mathias Hausladen[3], and Rupert Schreiner[3]
[1] Institute of Scientific Instruments of CAS, Kr´alovopolsk´a 147, 612 00 Brno, Czech Republic.
[2] Wroclaw University of Science and Technology, 11/17 Janiszewskiego Str, 50-372 Wroclaw, Poland.
[3] Ostbayerische Technische Hochschule Regensburg, Regensburg 93053, Germany.
E-mail of corresponding author: allaham@isibrno.cz

ABSTRACT

MEMS technology is used to build miniature electron microscopes, which is known as MEMS electron microscopes. In this technology, field-emission electron guns are used and designed to produce a stable and high field emission performance electron beam, which is crucial for obtaining high-quality images at the microscopic level [1, 2].
In recent studies, it was shown that traditional uncoated tungsten field emission cathodes have several limitations when operated outside of ultra-high vacuum conditions, such as high threshold voltages, short life and operation time, and widespread electron beam. However, it was also shown that coating the nano apex of such cathodes with graphene nano layers helped to improve their performance in scanning tunneling microscopy, along with excellent field emission performance and characteristics [3].
In this study, tungsten nano tips were prepared and cleaned following the electrochemical etching process described in [4]. The uncoated tungsten samples were attached to a 3D-printed field emission microscope that consists of a cylindrical sample holder, cylindrical extractor of 2 mm in aperture diameter, and cylindrical Einzel lens system of 4 mm in aperture diameter. Moreover, electrical conductivity was established by coating the electrodes with 60 nm of chromium followed by another 30 nm of gold. Then, the electrodes of the printed structure and the prepared tungsten nanotip were then coated by exfoliated colloidal graphite to ensure better electrical conductivity at the gold/tungsten-graphite interface, Figure 1 presents a schematic diagram for the tungsten-graphite cathodes.

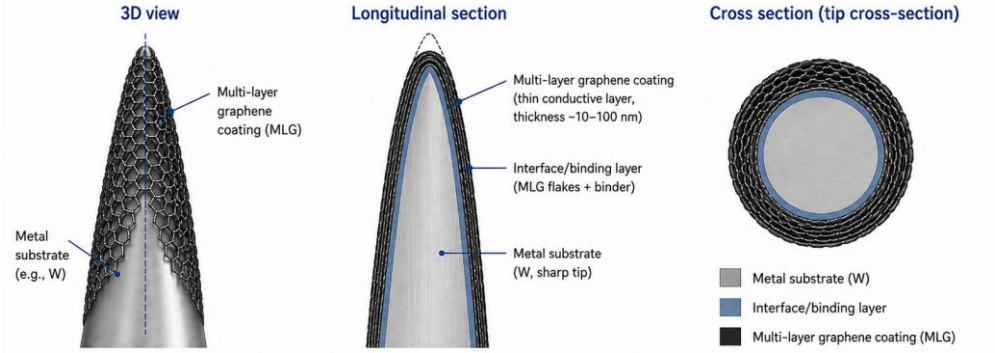

Figure 1: Schematic diagram for a tungsten-graphite electrode apex.

Acknowledgemnt

This research was funded in part by the Grant Agency of the Czech Republic under grant No. 25-19981L, "INFASCOPE – Integrated Field Emission Electron Source Analysis." Additionally, we acknowledge the Czech Academy of Sciences (RVO:68081731) under project number (L100652601).

References

[1] M. Krysztof. Microsystems & Nanoengineering, 7(43) (2021).
[2] M. Białas, T. Grzebyk, M. Krysztof, and A. Górecka-Drzazga. Ultramicroscopy, 244 (2023).
[3] M. M. Allaham, S. I. Daradkeh, H. A. Al-Braikat, R. Dallaev, D. Burda, Z. Košelová, M H. Al-Akhras, A. M.D. Jaber, M. S. Mousa, D. Sobola, V. Kolařík, A. Knápek. Surfaces and Interfaces, 35(2) (2024).
[4] Z. Košelová, L. Horáková, D. Burda, M. M. Allaham, A. Knápek, Z. Fohlerová. Journal of electrical engineering, 75 (2024).