ACCELERATOR SEMINAR

Evaluation of TiN-Coated Aluminum Electrodes for DC High Voltage Electron Guns

Md Abdullah Maman,
Old Dominion University and Jefferson Lab

DC high voltage thermionic and photoemission electron guns require cathode electrodes that do not exhibit field emission. Field emission is the unregulated release of electrons from the cathode electrode surface when the cathode is biased at high voltage. Field emission is problematic for a number of reasons: it degrades the vacuum level via electron stimulated desorption and leads to shortened operating lifetime of the gun, it creates unwanted x-rays that are harmful to nearby personnel, and high levels of field emission can damage electron gun components.

Cathode electrodes for electron guns are typically manufactured from hard metals like stainless steel, titanium-alloy, or molybdenum. Once fabricated at the machine shop, the relatively rough surface of the electrode must be mechanically polished by hand using silicon carbide paper and diamond grit, to obtain a smooth surface free of microscopic protrusions which cause field emission. However, the polishing process for electrodes manufactured from hard metals is time consuming and labor intensive.

In this research, the field emission characteristic of electrodes manufactured from soft aluminum metal were studied using a high voltage field emission test stand, before and after coating the surface of the electrodes with titanium-nitride (TiN). Electrodes manufactured from aluminum are relatively easy to polish, requiring only hours to obtain a mirror-like finish, rather than days. The electrodes coated with TiN performed markedly better than the uncoated electrodes and the best electrode exhibited no measurable field emission (<10 pA) at a field strength of > 22.5 MV/m. In sharp contrast, the uncoated electrodes exhibited significant field emission at field strength of just ~ 5 MV/m. The electrodes were evaluated using scanning electron microscopy with x-ray microanalysis (SEM/EDS) to investigate morphological and structural variations associated with the polishing and coating processes, and due to the high voltage processing which included gas conditioning with helium and krypton. Small test coupons were studied using an atomic force microscope and nanoindenter, to evaluate surface morphology, hardness and modulus of the TiN thin films.

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CEBAF Center, Auditorium

Jefferson Lab

For further info, please contact Alex Bogacz at x5784 or Anne-Marie Valente at x6073