USING MURPHY-GOOD PLOTS TO ANALYZE MEASURED FIELD EMISSION CURRENT-VOLTAGE DATA

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ABSTRACT

This Poster reports a small part of a multistage project to improve the interpretation of measured field electron emission (FE) current-voltage [$I_m(V_m)$] data. The first project stage involves five or so proposals that aim to improve data interpretation within the framework of the almost universally used (but not physically realistic) *smooth planar metal emitter (SPME) theoretical methodology*. This models a real emitter, which is usually needle-shaped or post-shaped, as if the emission were coming from a finite area on a smooth, planar structureless metal surface, using Sommerfeld-type free-electron theory and semi-classical quantum mechanics to do so. In the past, this has been thought an "adequate" approximation, for all emitter materials, if the emitter apex radius of curvature is sufficiently large. It seems procedurally important to first establish best practice in the context of SPME methodology, to bring everybody to a common starting point for future development, whilst also working in parallel on better methodology for interpreting data from post-shaped and needle-shaped emitters.

This Poster reports one of these five or so proposals. Measured FE $I_m(V_m)$ data are traditionally analysed via Fowler-Nordheim (FN) plots, as $\ln\{I_m/V_m^2\}$ vs $1/V_m$. These have been used since 1929, because in 1928 FN predicted they would be linear. In the 1950s, a mistake in FN's thinking was found. Corrected theory by Murphy and Good (MG) made theoretical FN plots slightly curved. This causes difficulties when attempting to extract *precise* values of emission characterization parameters from straight lines fitted to slightly curved experimental FN plots. Improved mathematical understanding, from 2006 onwards, has now enabled a new FE data-plot form, the "Murphy-Good plot" [1]. This plot has the form $\ln\{I_m/V_m^{(2-\eta)}\}$ vs $1/V_m$, where η depends only on the assumed local work function. Modern ("21st century") MG theory predicts that a theoretical MG plot should be "almost exactly" straight. This makes precise extraction of well-defined characterization parameters from ideal $I_m(V_m)$ data much easier. This Poster gives the theory needed to extract values of characterization parameters and of scaled field from MG plots, and discusses why this extraction procedure is better and easier than the FN-plot procedure. It is also shown how an orthodoxy test can be applied to a Murphy-Good plot [2]. It is argued that, certainly in precise science-oriented experimental work, MG plots should now supersede FN plots.

References

[1] R.G. Forbes, R. Soc. Open Sci. **6**, 190912 (2019).
[2] M.M. Allaham, R.G. Forbes, A. Knápek, M.S. Mousa, J. Electr. Eng. Slovak **71**, 37 (2020).