Analysis of Miram Curves with Two-Dimensional Work Function Distributions*

Abhijit Jassem and Y. Y. Lau

Department of Nuclear Engineering & Radiological Sciences, University of Michigan, Ann Arbor, MI 48109-2104 (yylau@umich.edu)

The performance of thermionic cathodes is commonly characterized by its Miram curve, a plot of anode current vs cathode temperature that shows the transition from temperature limited electron emission to a space charge limited regime. This transition is known as the knee in the curve, and the physical reasons for its shape have not been definitively identified. An ideal 1D cathode has a Miram curve with a highly sharp knee, while experimental curves exhibit a much smoother and more rounded knee. This matter is important, since thermionic cathodes are almost always operated in the vicinity in the knee for considerations of thermal stability and cathode life. We extend a model [1] of a 1D planar diode with a thermionic cathode in which the Poisson and Vlasov equations are solved in 3D assuming an infinite magnetic field. Our approach allows us to study how various 2-dimensional cathode work function distributions, both realistic and idealized, can impact the shape of the Miram curve. For example, Fig. 1c shows a comparison of a striped (Fig 1a) and a checkered (Fig. 1b) pattern of two work functions (2.0 & 2.2 eV) where the stripe width s has been set to either 53 or 265 μm and demonstrates how emission in the knee region is modified through the action of 2D space charge forces. In this work, we show (i) that discrete work function distributions may lead to smooth Miram curves, (ii) that even with a large fraction of the cathode being non-emitting, the anode current is still governed by the 1D Child-Langmuir Law as if the entire cathode were emitting, and (iii) that decreasing the length scale of work function variations leads to a sharper Miram knee.

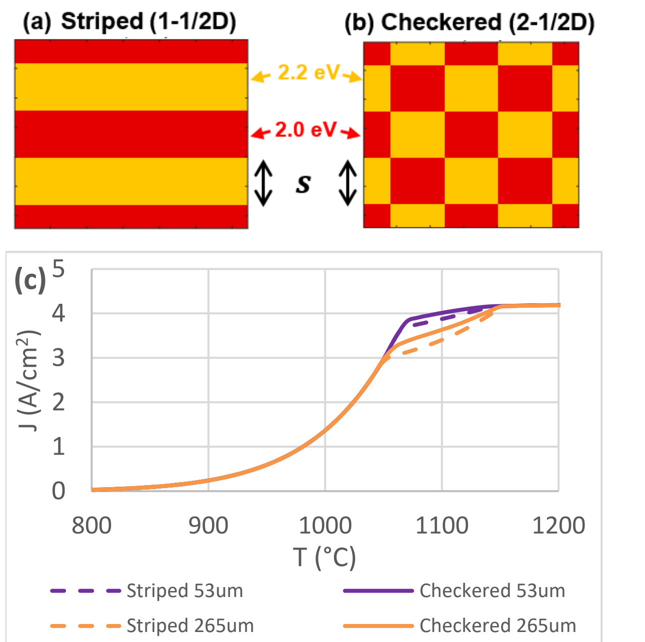

Figure 1 - (a) Striped pattern (1-1/2D) (b) Checkered pattern (2-1/2D) (c) Comparison of striped vs checkered arrangements of $\phi_1 = 2.0$ eV and $\phi_2 = 2.2$ eV for two square/stripe widths s =53 μm, 265 μm.

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References

[1] D. Chernin *et al.*, "Effect of Nonuniform Emission on Miram Curves," *IEEE Trans. Plasma Sci.*, vol. 48, no. 1, pp. 146–155, Jan. 2020, doi: 10.1109/TPS.2019.2959755.