EFFECTS OF EMISSION MODELS ON ICEPIC SIMULATIONS OF LONG-PULSE MAGNETRONS

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It has been shown that both the transient and steady state behavior of a cross-field diode is sensitive to the emission algorithms used to inject electrons . In this work, we investigate the effects of emission models on simulations using the Air Force Research Laboratory (AFRL) Improved Concurrent Electromagnetic Particle-In-Cell (ICEPIC) code. We simulated an experimental tested, 923-MHz strapped magnetron with a helical, thermionic cathode and axial power extraction2. This effort works toward resolving the physical and numerical issues that arise with emission in magnetrons. Even with high-performance computing, it is challenging to model this magnetron at sufficient resolution for a long enough time to reproduce the start up transient that is seen in the experiment, about 2ms. Starting at the coarsest, which places approximately 3.5 cells across each vane gap, we carried out a parameter scan in voltage and emitted current, centered around the experimental voltage of 27.6 kV from 24kV through 39 kV, with various cathode emission models: thermionic (Richardson-Dushman), field enhanced thermionic emission (a.k.a. Schottky effect), and space charge limited flow. These studies attempted to address the uncertainty in the physical properties of the cathode such as temperature, Richardson constant material correction factor, and the workfuction. Finally, we consider the fact that the heater current of the cathode (~212A) also affects the electron flow through the magnetic field it produces. We then performed a limited number of simulations, roughly 10 times higher resolution, to confirm the results of the lower resolution simulations.

In general, we observed that highest current cases (space-charge-limited, 27.3A) started up faster than the cases with the thermionic emission. The thermionic emission was varied to have a resulting tube current from 5 A to 19.7 A. The tube efficiency varied from 70% to 80% over this parameter range with the output power varying by a factor of 4. The experimental efficiency is 86.3% at 27.6 kV and 7.8 A. The frequency of oscillation also increased slightly as the current was increased; this trend was also seen in the experiment.

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2. Twisleton, J.R.G., "Twenty-kilowatt 890 MHz Continuous-Wave Magnetron." Proc. IEEE, vol. 111, No. 1, January 1964.