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General scaling laws of space charge effects in field emission

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The characteristics of field electron and ion emission change when the space charge formed by the emitted charge is sufficient to suppress the extracting electric field. This phenomenon is well described for planar emitting diodes by the one dimensional (1D) theory. Here we generalize for any 3D geometry by deriving the scaling laws describing the field suppression in the weak space
charge regime. We propose a novel corrected equivalent planar diode model, which describes the space charge effects for any geometry in terms of the 1D theory, utilizing a correction factor that adjusts the diode's scaling characteristics. We then develop a computational method, based on the Particle-In-Cell technique, which solves numerically the space charge problem. We validate our theory by comparing it to both our numerical calculations and existing experimental data, either of which can be used to obtain the geometrical correction factor of the corrected equivalent planar diode model.

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