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Consistent Asymptotic Expansion of Mott's Solution for Oxide Growth[1] MATTHEW SEARS, WAYNE SASLOW, Texas A&M University —
Many relatively thick metal oxide films grow according to what is called the parabolic law $L = \sqrt{2At} + \ldots$. Mott explained this by assuming that ions and electrons are the bulk charge carriers, and that their number fluxes vary as $t^{-1/2}$ at sufficiently long t. In this model no charge is present in the bulk, and surface charges were not discussed. It can be thought of as a discharging capacitor, with the oxide surfaces as the plates. However, the theory then is inconsistent because the field decreases, corresponding to discharge, but there is no net current to cause discharge. The present work systematically extends the theory and obtains the discharge current. Because the Planck-Nernst equations are nonlinear (although Gauss's Law and the continuity equations are linear) this leads to a systematic order-by-order expansion in powers of $t^{-1/2}$ for the number currents, concentrations, and electric field during oxide growth. At higher order the bulk develops a non-zero charge density, with a corresponding non-uniform net current, and there are corrections to the electric field and the ion currents. The second order correction to ion current implies a logarithmic term in the thickness of the oxide layer: $L = \sqrt{2At} + B \ln t + \ldots$.

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