Convection Prevailing Regimes in Thin-Layer Electrodeposition

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When dendrites grow through an electrochemical thin-layer cell they encounter complex 3D ion transport phenomena. Ion transport is governed by diffusion, migration and convection. Convection is driven mainly by Coulombic forces due to local charges and by buoyant forces due to concentration gradients that lead to density gradients. Here we study ion transport with a generalized 3D macroscopic model that allows full transport mode interaction in the presence of dendrites, in particular when convection prevails. In this case, electroconvection and gravitoconvection are governed by the electric and gravity Grashof numbers, respectively. When gravity Grashof is dominant, the model predicts the existence of: i)concentration shells and convection rolls near each electrode expanding toward one another; and ii) the interaction mode between convection and ramified deposits: the shell and roll bend and surround filaments forming a sort of three dimensional envelope tube squeezed by the filament tip and slaved to the deposit front. When electroconvection is dominant, the model predicts the existence of vortex rings and a spherical symmetry for the electric field, centered around the tip, due to the accumulation of space charges near the growing filament tip. In those cases for which experimental results are available they corroborate model predictions.