The Driftless Electromigration Theory*,**

(Diffusion-Generation-Recombination-Trapping)

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Abstract

Electromigration (EM) is the transport of atoms and ions in metals at high electrical current-density (>100kA/cm^2) leaving behind voids. It was delineated in 1961 by Huntington [1] in gold wire, and empirically modeled by the 1969-Black formula [2] to fit the Time-To-Failure (TTF) experimental data of metal interconnect lines in integrated circuits with power-law dependences of electron-current density and sample temperature, and a thermal activation energy, TTF = $AJ^{-\beta}T^{\gamma}\exp(-E_{\alpha}/k_BT)$. Tan and Roy recently reviewed the 40-year applications [3]. Since the first Landauer theoretical analysis in 1957 [4], theorists have attempted for 50 years to derive the Black formula by trying to justify the force of the electrons to move an atom, known as electron-wind. Landauer concluded in 1989 [5] that electron wind is untenable even at the most fundamental and complete many-body quantum transport theory. Sah showed in his 1996 homework solution manual for undergraduate device core-course [6] that the Black formula can be derived for a generic void model using the simple classical macroscopic transport theory, including diffusion and the often if not always neglected generation-recombination-trapping (DGRT) of the ions, without the empirical electron-wind force. We review this driftless model in this presentation.

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** This theory was first described as the solution of a home work problem in 1996 by Sah [6].

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