Investigation and Modeling of Electromigration stresses of Advanced Node Conductors through Pulsed Power Behavior.

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Abstract:

Electromigration induced failure is one of the main reliability issues for the microelectronics industry. The continuous scaling of the interconnect dimensions leads to higher operating current densities and temperatures, which accentuates the electromigration failure. As a consequence, electromigration still poses challenges for the development of the new technological nodes. In industry semi-empirical models with parameters of fitting calculated by distribution of experimental data obtained by accelerated tests are conventionally used to estimate the lifetime of interconnections.

Using this experimental data, we explore the effect of pulsed direct current on Electromigration failure. Interconnects are stressed via a pulsed current during standard use, rather than the constant direct current used during conventional accelerated reliability testing. The pulsed direct current affects both the mass transport driving forces and the degradation of the interconnect. There exists a current-induced stress gradient that induces an opposing driving force to the electromigration driving force. During direct current testing, electromigration is the dominant failure mechanism. In intermittent current testing, during periods of no current stress, the stress gradient is the dominant driving force acting on the conductor. This driving force alters the degradation of the interconnect.

There is a need for deeper understanding of the physical phenomena behind pulsed power EM damage, since it can provide a deeper knowledge basis to anticipate the EM effect. In this context, experimental characterization coupled with mathematical modeling becomes a convenient way to understand the EM-induced failure. The modeling can act as a fundamental tool for explaining experimental observations under pulsed power and ultimately, can deliver a stronger basis for design and production of reliable metallizations. The aim of this work is to merge the two different domains: on one hand side the experimental characterization of interconnect structures conventionally done in industry and on other hand side the development of mathematical models, suitable for implementation in a Finite Element Analysis software acting as a tool for numerical simulations.

In this talk, I will be covering the experimental observations made during pulsed power EM testing. Modeling is still in infancy and may be a topic of discussion on a later date.