

TCAD Approach for the Assessment of Interconnect Reliability

Hajdin Ceric¹, Roberto Lacerda de Orio², and Marco Rovitto¹

¹*Christian Doppler Laboratory for Reliability Issues in Microelectronics at the Institute for Microelectronics*

Institute for Microelectronics, TU Wien, Gußhausstraße 27-29, 1040 Wien, Austria

²*School of Electrical and Computer Engineering, UNICAMP*

Av. Albert Einstein 400, 13083-852 Campinas - SP, Brazil

Abstract: The complexity of layouts and diversity of applied materials and processes pose a substantial challenge for the reliability assessment of modern interconnects. Since the 1960s reliability estimates and prognoses based on the Black's equation have won a wide popularity. Despite the fact that Black carried out his original studies for a straight aluminum lines his equation was utilized to describe almost any electromigration related reliability issue. Even if Black's equation can successfully be fitted to a number of experimental measurements it has hardly brought any new physical insights.

Since the late 1990s several authors have developed and gradually improved a full and general 3D electromigration model which handles electromigration failure as a multiphysics phenomenon including, besides electromigration force itself, also effects of mechanical stress and dynamics of point defects. This full physical model opened a way to rigorously consider effects of interconnect metal microstructure and characteristics of interconnects interfaces to surrounding layers.

Full physical modeling provides a tool to cope with reliability challenges not only of the well-established dual-damascene technologies but also of the new structures applied for 3D integration like through-silicon-vias and solder bumps. Moreover, in moving toward nano-interconnects, full physical model approach opens ways to understand the interplay between electron scattering effects which, on the fundamental level give rise to the electrical resistivity and the electromigration.

Today it is possible to carry out comprehensive TCAD reliability studies of interconnects by implementing the full physical model in some commercial or university based simulation tools. TCAD studies enable a high degree of understanding of degradation and failure mechanisms in modern interconnects and in such way provide solid foundation for designing the new and more reliable interconnect structures.

In the first part of my talk I will present an overview over the full electromigration physical model. In the second, I will show examples of reliability studies for the cases of dual-damascene vias, through-silicon-vias, and Sn based solder bumps. In the last part I am going to present some modeling concepts to meet reliability challenges rising with nano-interconnect technologies.