Title: Mass-transport degradation of interconnects for 3-D IC, toward a predictive modeling

Abstract

3D integration involves vertically stacking of several integrated circuits and establishing electrical connections between them. Although 3D interconnect technologies have obvious advantages and their manufacturing process has almost reached the status of mass production, there are several reliability issues, as is often the case in emerging technologies. Electromigration is one of those concerns. A failure related to electromigration is generally related to a high current density that flows in a metal interconnection. This phenomenon induces the nucleation of cavities in the metal line and their growth essentially leads ultimately to open circuits. The most viable solution for fine understanding of the electromigration degradation is to use numerical simulations based on physical models. This tool provides designers/reliability engineers with complementary information to experimental tests to better understand the causes and kinetics of the electromigration degradation to improve the design and manufacture of more reliable interconnects. The model (nucleation and void growth) will be implemented in the COMSOL software. The implementation of the phase field approach will be required for the void growth phase. The results obtained will be compared with those obtained experimentally to verify the robustness of the numerical model and the defined hypotheses. This model will be improved by taking into account the microstructure and/or, in the particular in the case of alloys, the evolution of intermetallic compounds (IMC) as a function of temperature, electric current and time.

Work description

- 1st phase
    1. Completion of the numerical model developed for the nucleation phase of a void: effect of the vacancies displacement on the mechanical stress
    2. Upgrade of the numerical model by taking into account the void growth kinetics: implementation of the "phase field" approach, correlation with experiments (TSV and hybrid bonding technologies)
- 2nd phase
    1. Upgrade of the numerical model (nucleation phase only) by taking into account the microstructure (Voronoï method for example) in order to set up a statistical distribution of times-to-failure
    2. Electromigration issue in solder-based interconnects (e. g.: solder bump, copper pillar): evolution of intermetallic compounds (IMC) thanks to the temperature and the electron flow

Profile

PhD degree in Computer Science, Engineering, Mathematics, or Physics; basics of microelectronic technologies with emphasis on 3D interconnect schemes will be a plus.

Good knowledge and interest in multiphysics (material science, mechanics, heat science), modeling (FEM [COMSOL especially], phase field method) is an asset.

Mentors/supervisors

This internship will take place in the characterization and reliability lab. in conjunction with the simulation and modelling one in a technological and scientific research environment.

For further information or for application, please contact Stéphane MOREAU (stephane-nico.moreau@cea.fr) and Olga CUETO (olga.cueto@cea.fr).

References

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