Wire Bonding Simulation: Harmonic Perturbation For Improving Accuracy

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Abstract

Semiconductor companies are one of the major users of Finite Element Method simulations, trying to study manufacturing processes. A well-defined model can in fact guarantee significant savings of costs and time for the release to production of new technologies. The equilibrium between model ability to cover different cases and the reproduction of physics phenomena is fundamental to obtain reliable estimations.
In this paper, a step of the ongoing optimization of one of these processes, is presented. A study on thermo-sonic wire bonding model, is performed to increase its accuracy and efficiency.
Qualitative models of thermo-sonic wire bonding have been successfully used in the past to develop pad schemes in different technologies. Recently the challenge has been pursuing a more quantitative correlation with the experimental process, which includes several phenomena (heat, friction, acoustic softening). The inclusion of acoustic softening has been investigated in the past [1].
One of the next challenges in the development of the model is to include a larger number of vibration cycles (that experimentally are tens of thousands). This work focuses on the introduction of harmonic perturbation to account for ultrasonic vibration, reducing computational cost with respect to straightforward displacement implementations (which proved unfeasible). Given the vibration amplitude is small with respect to ball overall deformation, a linear superposition can be assumed. Lateral movement occurs in the frequency domain on top of the highly nonlinear static model, decreasing numerical complexity. To evaluate this methodology ball deformation with rigid pad is performed. Comparison with the straightforward approach is presented accompanied with an extension to an increased number of cycles that will eventually lead to increased accuracy.
The introduction of a larger amount of cycles requires an optimization of computational costs.
The geometrical complexity of metals structures is mainly due to the great variety of design together with the high aspect ratios: strips length can be tens of micrometers while thickness is around hundreds of nanometers or tens of nanometers in the case of barriers or capping layers. To be able to carry simulations out efficiently it's important to have disconnected meshes; if not the number of elements can be very high with a very low quality to guarantee reasonable computational times. A different simulation approach is presented in order to build the mesh of each layer independently (no constraint arising from the adjacent layouts) by using assembly (with identity pairs) instead of union, in the finalization of the geometry. To evaluate this method a two thin metal levels geometry is selected and a comparison of simulation computational time and accuracy of different cases is reported.

Reference

[1] “Acoustic softening characterization to improve copper wire bonding FEM simulation”, L. Guarino, C. Caglio, B. Carasi, M. Alesi, R. Villa, L. Cecchetto, Eurosime 2024

Figures used in the abstract

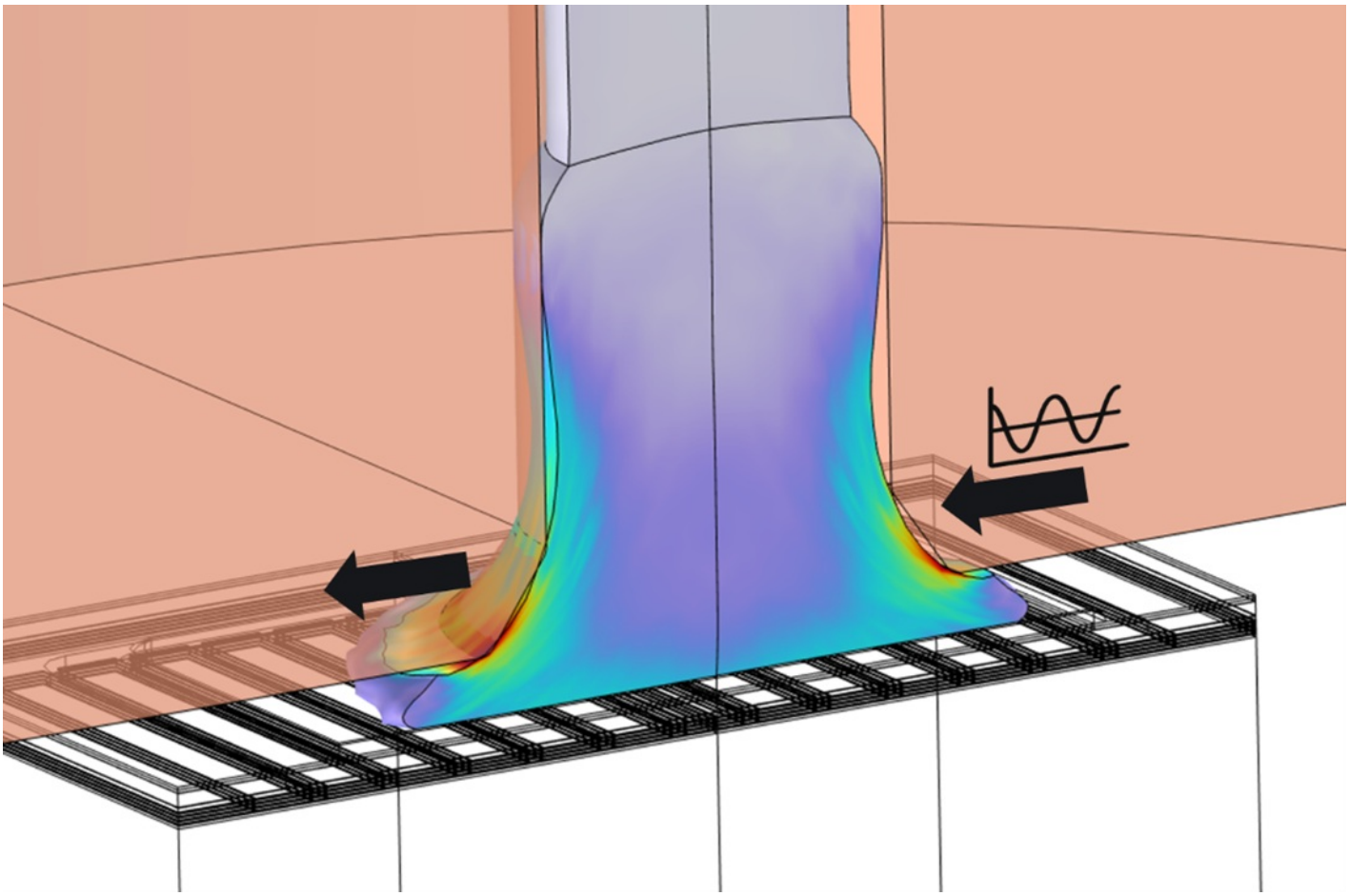

Figure 1 : Figure 1 Harmonic perturbation of wire bonding

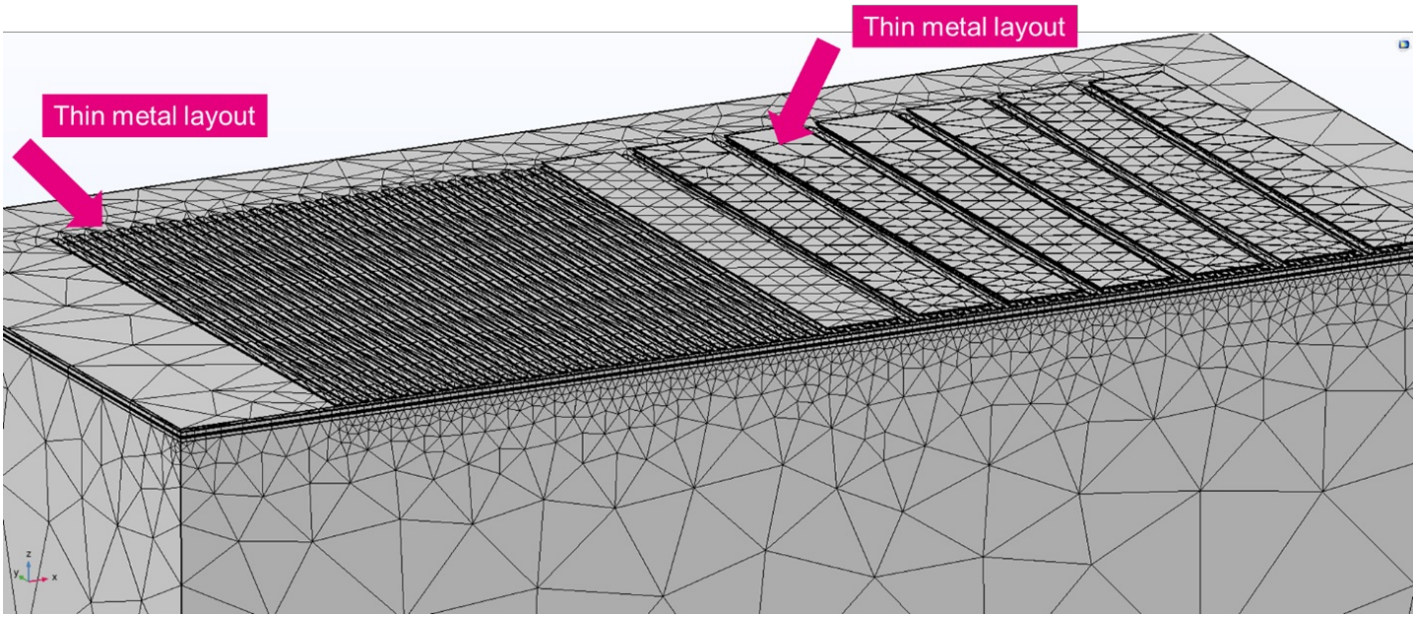

Figure 2 : Figure 2 Mesh with two thin metal layouts