Stress Evolution During the Nanoindentation in Open TSVs

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Three-dimensional technology is considered necessary to maintain integrated circuit performance on the path described by Moore’s law. Several layers of different materials compose an open Through Silicon Via (TSV) structure. For the sake of the TSVs mechanical stability, it is important to understand and to predict the behaviour of each material subjected to an external force. Although a significant progress has been made in the mechanical characterization of TSV structures, the physics of the stress development, cracking, and crack propagation in each layer remains unclear.

Nanoindentation enables to study the stress development in each layer of a TSV and to assess the risk of cracking and delamination. This technique is one of the most common experimental tools to test the mechanical properties of materials. Nanoindentation is based on an interaction between the tip and the material. The tips can have different shapes and can be made of different materials.

In this work we have investigated nanoindentation in TSV structures by means of simulation. For our calculations, we have considered diamond tips with different shapes. During the nanoindentation, the tip penetrates into the TSV and applies a force onto the material, causing the deformation of the material. The comparison between the loading force and penetration depth allows obtaining information about the mechanical properties of the device.

The equations of the mechanical model are solved using the finite element method. The obtained results enabled to understand the stress development in the different layers composing the TSV. The stress fields are found to be particularly sensitive to the thickness of the layers. Thereby we improved the understanding how an external force influences the device structure and the location where the conditions for cracking and delamination are met.