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A Materials Genome Approach for Heterogeneous Integration

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Abstract

As heterogeneous integration and orthogonal scaling gradually dominate the semiconductor industry ecosystem, a holistic approach of co-designing materials, process, chip and system interactions is required. In particular, materials used in the heterogeneous integration are approaching their physical limits. As such current and new materials are key to the development of new devices and disruptive technologies. The myriad of materials spanning multiple scales and the inherent multiscale microstructures of materials ultimately control the properties of components and thence the performance of devices. In the orthogonal scaling era, material and microstructural parameters at scales ranging from an electronic and atomistic/molecular scale up to a meso-scale become significant and drives the continuation of the orthogonal scaling. A co-design platform for heterogeneous integration requires a transition from computer-aided new material design to novel simulation and virtual integration during product development. In such a scenario, key material parameters with respect to interfaces, dispersion of nano-material constituents, porosity, and hierarchical microstructural information need to be quantified in the first instance, followed by establishing linkages among materials, process and device performance using deep learning algorithms. Such hierarchical microstructural informatics, or the so called “materials genome”, is currently lacking but needs to be accessible and fully incorporated into the co-design platform for new future devices. This paper outlines the necessity of the materials genome approach for heterogeneous integration and reviews the building blocks and recent progress towards this direction in light of the accomplishments of the US Materials Genome Initiative (MGI) in the first five years.