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3D ICs: The Near Future of Integrated Circuits

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Abstract: *Three-dimensional integrated circuits (3D ICs) have emerged as a promising solution to the scaling challenges faced by the semiconductor industry as Moore's Law approaches its physical limits. As traditional planar scaling confronts increasing difficulties at advanced nodes, including short-channel effects, electron tunneling, and thermal management issues, 3D integration offers an alternative path forward by stacking silicon layers vertically rather than shrinking transistors horizontally. This vertical integration provides numerous advantages, including increased functional density, improved performance through shorter interconnects, heterogeneous integration of different technologies, reduced form factors, and potential cost benefits. Various implementation approaches have been developed, from die stacking and wafer-on-wafer bonding to monolithic integration and chiplet architectures. Despite these benefits, significant challenges must be addressed before widespread adoption, including thermal management in densely packed structures, development of 3D-aware design tools, complex testing requirements, manufacturing reliability concerns, and the need for industry standardization. Advancements in electronic design automation, cooling technologies, manufacturing processes, and design methodologies are creating a path forward that will enable the semiconductor industry to continue delivering performance improvements beyond the limitations of traditional scaling*

Keywords: 3D Integration, Through-Silicon Vias, Heterogeneous Integration, Thermal Management, Chiplet Architecture

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