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# Designing TSVs for 3D Integrated Circuits

 Springer

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*To my wife and my daughter.*

NHK

*To my parents, who gave me life, and my  
children, who give it light.*

SH



# Preface

Stacking multiple dies to form 3-D integrated circuits (ICs) has emerged as a promising technology to reduce interconnect delay and power, to increase device density, and to achieve heterogeneous integration. Through-silicon vias (TSVs), metallic interconnect between dies, are a key enabling technology for 3-D ICs. TSVs can be used for routing signals, for power delivery, and for heat extraction. TSV manufacturing advances are well under way. However, there is little experience in designing optimally with TSVs.

This book explores challenges and best strategies to design with TSVs and offers several key contributions. Signal TSVs induce noise in the substrate and affect neighboring devices. This book proposes a novel technique, the GND Plug, to mitigate TSV-induced noise. The results show the superiority of this technique in grounding noise compared to other techniques adapted from 2-D planar technologies such as a backside ground plane and traditional substrate contacts. The book also investigates, in the form of a comparative study, the impact of TSV size and granularity, spacing of C4 connectors, off-chip power delivery network, shared and dedicated TSVs, and coaxial TSVs on the quality of power delivery in 3-D ICs. The book provides detailed best design practices for designing 3-D power delivery networks. TSVs occupy silicon real estate and impact device density. This book provides four iterative algorithms to minimize the number of TSVs in a power delivery network. Unlike prior work, these algorithms can be applied in early design stages when only functional block-level behaviors and a floorplan are available. Finally, the book explores using carbon nanotubes to design the TSVs and power grid, and the results show that the use of carbon nanotubes for grid design offers substantial advantages in terms of reducing IR drops. Overall, the book advances 3-D IC design.

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