HIGH-DENSITY PACKAGING (MCM, MCP, SIP, 3D-TSV): MARKET ANALYSIS AND TECHNOLOGY TRENDS

Table Of Contents

Chapter 1	**Introduction**	**1-1**
Chapter 2	**Executive Summary**	**2-1**
2.1	Summary of Technology Issues	2-1
2.2	Summary of Market Forecasts	2-7
Chapter 3	**Technology Issues and Trends**	**3-1**
3.1	Overview of HDP Technology	3-1
3.1.1	Need for Multiple IC Integration	3-1
3.1.2	Challenges of Multiple IC Integration	3-9
3.1.3	Technical Constraints of Integration	3-10
3.1.4	Economic Benefits of HDP	3-12
3.1.5	Technology Issues	3-16
3.2	2D Packages	3-18
3.2.1	MCMs	3-18
3.2.1.1	Substrates	3-22
3.2.1.2	Thermal Management	3-30
3.2.1.3	Design	3-32
3.2.1.4	Known Good Die	3-36
3.2.2	System In Package (SiP)	3-37
3.2.2.1	SiP Challenges	3-40
3.2.2.2	Cost	3-43
3.2.2.3	SiP Design	3-46
3.2.2.4	SoC Versus SiP	3-47
3.2.3	Multichip Package (MCP)	3-49
3.2.4	Package-On-Package (PoP)	3-51
3.3	2.5D and 3D Packages	3-56

3.3.1	Conventional Wafer Fan-Out Technologies	3-58
3.3.2	Silicon Interposers	3-66
3.3.3	3D-IC Stacks	3-67
Chapter 4	**Applications**	**4-1**
4.1	Semiconductor Industry by End Market	4-1
4.2	Memory	4-9
4.2.1	DRAM	4-9
4.2.2	NAND	4-16
4.2.3	China Memory	4-23
4.2.4	HDD vs SSD	4-25
4.3	Foundry Sector	4-31
Chapter 5	**Competitive Environment**	**5-1**
5.1	HDP Manufacturers	5-1
Chapter 6	**3-D-TSV Technology**	**6-1**
6.1	Driving Forces In 3D-TSV	6-1
6.2	3-D Package Varieties	6-11
6.3	TSV Processes	6-17
6.4	Critical Processing Technologies	6-19
6.4.1	Plasma Etch Technology	6-23
6.4.2	Cu Plating	6-27
6.4.3	Thin Wafer Bonding	6-28
6.4.4	Wafer Thinning/CMP	6-32
6.4.5	Lithography	6-33
6.5	Applications	6-38
6.6	Limitations Of 3-D Packaging Technology	6-44
6.6.1	Thermal Management	6-44
6.6.2	Cost	6-46
6.6.3	Design Complexity	6-47

6.6.4	Time To Delivery	6-52
6.7	Company Profiles	6-53
Chapter 7	**Market Forecast**	**7-1**
7.1	Overview of Advanced Packages	7-1
7.2	Driving Forces	7-2
7.3	System-in-Package (SiP)	7-3
7.4	Flip Chip/Wafer Level Packaging	7-10
7.5	Worldwide IC Market Forecast	7-19
7.6	Worldwide Packaging Market Forecast	7-22
7.7	Worldwide Advanced Package Forecast	7-24
7.7.1	Worldwide 3-D Through Silicon Via (TSV) Market	7-34
7.7.1.1	TSMC CoWoS	7-42
7.7.1.2	Intel Foveros	7-48
7.7.1.3	HBM (High Bandwidth Memory) Packages	7-51
7.7.1.4	Chiplets	7-57

List of Tables

3.1	Multichip Modules Vs. Circuit Board Assemblies	3-13
3.2	MCM Cost Comparison	3-15
3.3	Materials Challenge For Packaging	3-17
3.4	Substrate Technology Features	3-25
3.5	Comparison of SoC and SiP Architectures	3-48
3.6	Comparison of CSP and PoP Architectures	3-52
4.1	Global Semiconductor Forecast By End Market	4-5
4.2	Global Semiconductor Revenue Forecast By Device Type	4-7
4.3	Global Semiconductor Unit Forecast By Device Type	4-8
4.4	DRAM Supply	4-10
4.5	DRAM Demand	4-11
4.6	DRAM Revenues	4-13
4.7	NAND Supply	4-17
4.8	NAND Supply-Demand	4-19

4.9	NAND Unit Demand By Application	4-20
4.10	NAND Revenues	4-21
4-11	Comparison Of HDD and SSD For Storage	4-26
4-12	Foundry Market Forecast	4-32
4-13	Comparison Of Foundry Capacities	4-35
5.1	MCM Manufacturers	5-10
6.1	3-D Mass Memory Volume Comparison Between Other Technologies and TI's 3D Technology In Cm^3/Gbit	6-7
6.2	3-D Mass Memory Weight Comparison Between Other Technologies and TI's 3D Technology In $Grams^3$/Gbit	6-8
7.1	Semiconductor Forecast by Revenues	7-20
7.2	Worldwide IC Package Market Forecast	7-23
7.3	Worldwide Advanced Package Market	7-29
7.4	TSMC'S CoWoS Revenue Analysis	7-49
7.5	HBM TAM Demand 2023-2026	7-56

List of Figures

1.1	Schematic Cross-Section View Of An MCM-D	1-3
1.2	Cross-Section Of The RF And Microwave MCM-D Structure	1-5
1.3	Thin Film Layers On The Planarized Core Layer Of MCM-SL/D Technology	1-8
1.4	Flip Chip MCP	1-11
1.5	SIP Cross Section	1-14
3.1	IC Packaging Trends	3-6
3.2	Technology Tree For HDP Types	3-7
3.3	Form Factor Decrease By Package Type	3-8
3.4	Wafer Level Packaging Processing Line	3-60
3.5	TSMC's InFO	3-63
3.6	SLIM and SWIFT Package Definition	3-65
4.1	Global Semiconductor Forecast By End Market	4-6
4.2	DRAM Roadmap By Die Shrink	4-15
4.3	3D NAND Roadmap By Die Layers	4-22
4.4	HDD and SSD Shipments Forecast	4-28

4.5	HDD and SSD ASP	4-29
4.6	HDD and SSD Zetabytes	4-30
4.7	Pure-Play Foundry Market Shares	4-34
6.1	3-D Technology On DRAM Density	6-2
6.2	3-D Through-Silicon Via (TSV)	6-5
6.3	Graphical Illustration Of The Silicon Efficiency Between MCMs And 3D Technology	6-9
6.4	Silicon Efficiency Comparison Between 3D Packaging Technology And Other Conventional Packaging Technologies	6-10
6.5	3D Packages	6-12
6.6	Via First, Middle, And Last Process Flows	6-18
6.7	Via First TSV Process Flow	6-21
6.8	New Applications Driving TSV Growth	6-39
6.9	Projection Of TSV Applications And Process Requirements	6-41
6-10	3-D Technology For DRAM	6-43
6.11	Moore's Law For Active Element Density	6-48
7.1	Various System-In-Package (SiP) Applications	7-4
7.2	SiP Structures	7-7
7.3	Wire Bond Versus Flip Chip	7-15
7.4	Flip Chip And Wire Bond Equipment Forecast	7-16
7.5	Growth In Copper Wire Bonding	7-18
7.6	UNIT SHIPMENTS OF SEMICONDUCTORS	7-21
7.7	WLP Demand By Devices	7-31
7.8	Device Shipment Forecast FIWLP vs FOWLP	7-32
7.9	WLP Demand By Wafers	7-33
7.10	Projection of 3-D TSV Applications And Process Requirement	7-36
7.11	Market Forecast of 3-D TSV Units	7-37
7.12	Market Forecast of 3-D TSV Wafers	7-38
7.13	TSMC’s CoWoS Advanced Package	7-44
7.14	TSMC’s CoWoS Advanced Package Revenues	7-47
7.15	SK hynix HBM3 Package	7-53