



Electronics Materials Information

WAFER LEVEL METAL PLATING CHEMICALS

FOR FRONT END SEMICONDUCTOR
MANUFACTURING AND ADVANCED
PACKAGING APPLICATIONS 2021

Prepared By:

Terry A Francis

With contributions from

Dan Tracy, and Lita Shon-Roy

TECHCET CA LLC

11622 El Camino Real #100

San Diego, CA 92130

www.TECHCET.com

info@TECHCET.com

RESEARCH METHODOLOGY

TEHCET employs subject matter experts having first-hand experience within the industries which they analyze. Most of TEHCET's analysts have over 25 years of direct and relevant experience in their field. Our analysts survey the commercial and technical staff of IC manufacturers and their suppliers, and conduct extensive research of literature and commerce statistics to ascertain the current and future market environment and global supply risks. Combining this data with TEHCET's proprietary, quantitative wafer forecast results in a viable long-term market forecast for a variety of process materials.

READER'S NOTE

This report represents the interpretation and analysis of information generally available to the public or released by responsible agencies or individuals. Data was obtained from sources considered reliable. However, accuracy or completeness is not guaranteed.





TERRY FRANCIS

Director of Technology & Sr. Analyst of TECHCET— covers metal chemicals and specialty wet cleans. His work experience includes CTO, Sr. Director, Technical application expert, process manager and engineering management from companies such as Matheson, Air Products, Applied Materials, Burroughs, NCR, AMI, and National Semiconductor. He has over 40 years of experience in the semiconductor industry and has managed businesses from \$2M to over \$100M in revenues. In addition, he is experienced in material, chemical, and electrical engineering as well as the R&D and development programs in the Chemical/OEM/IDM sectors in the microelectronic industry. He holds a M.B.A. from National University, and a B.A. in chemistry from Oregon State University.

TABLE OF CONTENTS

1.1 EXECUTIVE SUMMARY

1.2 ADVANCED PACKAGING PER WAFER STARTS	11
1.3 DEVICE DEMAND DRIVERS - LOGIC	12
1.4 PLATING FORECAST FOR DAMASCENE (FE) AND ADVANCED PACKAGING	13
1.5 MARKET SHARES	14
1.6 SUPPLIER ACTIVITIES – VARIOUS ANNOUNCEMENTS	15
1.7 ANNOUNCEMENTS	16
1.8 RISK FACTORS	17
1.9 ANALYST ASSESSMENT	18

2 SCOPE, PURPOSE AND METHODOLOGY

2.1 SCOPE	20
2.2 PURPOSE	21
2.3 METHODOLOGY	22
2.4 OVERVIEW OF OTHER TECHCET CMR™ REPORTS	23

3 SEMICONDUCTOR INDUSTRY MARKET OUTLOOK

3.0 SEMICONDUCTOR INDUSTRY STATUS & OUTLOOK	24
3.1 SEMICONDUCTOR INDUSTRY TIED TO WORLDWIDE ECONOMY	25

3.1.1 SEMICONDUCTOR INDUSTRIES TIES TO THE GLOBAL ECONOMY	29
3.1.2 SEMICONDUCTOR SALES GROWTH	30
3.1.3 TAIWAN MONTHLY SALES TRENDS	31
3.1.4 SEMICONDUCTOR UNITS AND WAFER SHIPMENT GROWTH FORECAST	32
3.2 ELECTRONIC GOODS MARKET	33
3.2.1 SMARTPHONES	34
3.2.2 PC UNIT SHIPMENTS	35
3.2.3 AUTOMOTIVE SALES	36
3.2.3.1 AUTOMOTIVE SALES AND IMPACT ON SEMICONDUCTOR SALES	37
3.2.3.2 ELECTRIC VEHICLE (EV) MARKET TRENDS	38
3.2.3.3 INCREASE IN SEMICONDUCTOR CONTENT FOR AUTOS	39
3.2.3.4 SEMICONDUCTOR CONTENT BY AUTOMOTIVE ELECTRONIC SYSTEM	40
3.2.4 SERVERS / IT	41
3.2.4.1 SERVERS / IT, CONTINUED – FORECASTS	42
3.3 SEMICONDUCTOR FABRICATION GROWTH & EXPANSION	43
3.3.1 EQUIPMENT SPENDING TRENDS	44
3.3.2 RECENT INVESTMENT AND FAB/PLANT EXPANSION ACTIVITY	46
3.4 POLICY & TRADE TRENDS AND IMPACT	48
3.4.1 POLICY AND TRADE ISSUES	49
3.4.2 U.S. CHIPS ACT	51

TABLE OF CONTENTS

3.4.3 OTHER SEMICONDUCTOR FUNDING ACTIVITY	52	4.3.5.1 WW NI PLATING MARKET FORECAST	71
3.4.4 OVERALL CHINA MARKET TRENDS	53	4.4 DAMASCENE GROWTH TRENDS	72
3.5 SEMICONDUCTOR MATERIALS OUTLOOK	55	4.4.1 DAMASCENE GROWTH DRIVERS	73
3.5.1 TECHCET WAFER START FORECAST	56	4.4.2 DAMASCENE CU PLATING REVENUES	74
3.5.2 SEMICONDUCTOR – LEADING EDGE NODE GROWTH	57	4.4.3 DAMASCENE ADDITIVE VOLUMES	75
3.5.3 WAFER STARTS OTHER DEVICES	58		
3.5.4 SEMICONDUCTOR MATERIALS MARKET FORECAST	59	5 TECHNICAL TRENDS	76
4 METAL CHEMICALS MARKET BY SEGMENT	60	5.0 TECHNOLOGY CHALLENGE	77
4.1 DEFINITIONS	61	5.0.1 METAL CLEANINGS CHALLENGE	78
4.2 METAL CHEMS MARKET OVERVIEW	62	5.1 PACKAGING TECH TRENDS	79
4.2.1 OVERVIEW - ADVANCED PACKAGING AND DAMASCENE METALLIZATION	63	5.1.1 KEY TRENDS IN ADVANCED PACKAGING	80
4.2.2 OVERVIEW - PLATING MARKET TRANSITIONAL TRENDS	64	5.1.2 MARKET DYNAMICS	81
4.3 ADVANCED PACKAGING METALLIZATION – MARKET DRIVERS	65	5.1.3 IDM—WAFER LEVEL PLATING	82
4.3.1 ADVANCED PACKAGING - ADDITIVES FOR CU PLATING REVENUE	66	5.1.4 MARKET DRIVERS OF ADVANCED PACKAGING APPLICATIONS	83
4.3.2 ADVANCED PACKAGING – COPPER CHEMICALS REVENUE	67	5.1.5 TECH TRENDS – RDL	84
4.3.3 ADVANCED PACKAGING ADDITIVE VOLUMES	68	5.1.5.1 DAMASCENE-TYPE RDL	85
4.3.4 OTHER PLATING MATERIALS FOR ADVANCED PACKAGING	69	5.1.6 INTERPOSERS (NOT WLP)S	86
4.3.5 SN / SNAG PLATING	70		

TABLE OF CONTENTS

5.1.6.1 APPLE EXAMPLE INTERPOSERS (EPWORK CONFIDENTIAL)	87	6 COMPETITIVE LANDSCAPE	104
5.1.7 TSV FILLING 2.5-3D	88	6.1 TOTAL ADVANCED PACKAGING AND DAMASCENE MARKET SHARES	105
5.1.8 PACKAGING ELECTROPLATING REQUIREMENTS	89	6.2 MARKET SHARE BY APPLICATION	106
5.1.8.1 PACKAGING ELECTROPLATING REQUIREMENTS - LISTING	90	6.3 MARKET SHARE BY APPLICATION	107
5.2 DAMASCENE TECH TRENDS	91	6.4 REGIONAL PLAYERS AND OTHERS	108
5.2.1 MARKET DRIVES TECHNOLOGY TRENDS	92	6.5 M&A ACTIVITY	109
5.2.1.2 TRENDS - MOL AND BEOL PERFORMANCE CHALLENGES	93	7 ANALYST ASSESSMENT	110
5.2.2 CU DAMASCENE QUALIFICATION REQUIREMENTS	94	7.1 ANALYST ASSESSMENT	111
5.2.3 LOGIC METALLIZATION ROADMAP	95	8 SUPPLIER PROFILES	112
5.2.3.1 INTERCONNECT FOR ADVANCED LOGIC	96	MACDERMID ENTHONE INDUSTRIAL SOLUTIONS	JX NIPPON MINING AND METALS
5.2.4.1 GENERAL PROCESS FLOW ADVANCED DRAM	98	UYEMURA	INCHEON CHEMICAL COMPANY
5.2.5 PRECURSOR TECHNOLOGY ROADMAP: 3D NAND USING MO OR RU	99	ATOTECH	MITSUYA
5.2.5.1 3D-NAND GENERATIONS 2020 -2025	100	ISHIHARA CHEMICAL/UNICON	SHANGHAI SINYANG
5.2.6 EXAMPLE OF LOGIC PROCESS FLOW 20 NM TO 32 NM LOGIC PVD	101	DUPONT	BASF
5.2.7 TECHNICAL REQUIREMENTS SUMMARY ½	102	MOSES LAKE INDUSTRIES	SOULBRAIN
5.2.7.1 TECHNICAL REQUIREMENTS SUMMARY 2/2	103	APPENDICES	169
		APPENDIX A	170
		APPENDIX B	172
		APPENDIX C	181

TABLE OF CONTENTS

TABLE OF FIGURES

FIGURE 1: PLATING MATERIALS FOR ADVANCED PACKAGING AND INTERCONNECT REVENUES (\$M'S)	11	FIGURE 14: MONTHLY AUTOMOTIVE SALES TRENDS	37
FIGURE 2: ADVANCED PACKAGING (AP)	12	FIGURE 15: GLOBAL EV TRENDS	38
FIGURE 3: ADVANCED LOGIC DEVICES GROWTH FORECAST	13	FIGURE 16: SEMICONDUCTOR SPEND PER VEHICLE TYPE.	39
FIGURE 4: COPPER PLATING CHEMICALS REVENUES (\$M'S) FOR ADVANCED PACKAGING & FE/DAMASCENE	14	FIGURE 17: SEMICONDUCTOR CONTENT BY AUTOMOTIVE APPLICATION.	40
FIGURE 5: TOTAL PLATING MARKET SHARES FOR ADVANCED PACKAGING AND SEMICONDUCTOR DEVICE MFG 2021	15	FIGURE 18: AMAZON SERVER FARM	41
FIGURE 6: GLOBAL ECONOMY AND THE ELECTRONICS SUPPLY CHAIN (2020)	28	FIGURE 19: SEMICONDUCTOR REVENUE GROWTH FORECASTS (AS OF MARCH 2020)	43
FIGURE 7: WORLDWIDE SEMICONDUCTOR SALES	30	FIGURE 20: CAPITAL SPENDING TRENDS BY TECHNOLOGY NODE.	44
FIGURE 8: WORLDWIDE SEMICONDUCTOR SALES (TSMC, UMC, VIS, ASE, CHIPMOS, KYEC)	31	FIGURE 21: OVERVIEW OF LOGIC ROADMAP TRENDS	45
FIGURE 9: SEMICONDUCTOR WAFER AREA SHIPMENTS	32	FIGURE 22: CHINA IC MARKET AND PRODUCTION TRENDS	53
FIGURE 10: SEMICONDUCTOR CHIP APPLICATIONS	33	FIGURE 23: 300MM WAFER STARTS	57
FIGURE 11: MOBILE PHONE SHIPMENTS WW ESTIMATES	34	FIGURE 24: > 32NM NODE LOGIC DEVICES GROWTH FORECAST (200MM EQUIV.)	58
FIGURE 12: PC NOTEBOOK SHIPMENTS	35	FIGURE 25: GLOBAL SEMICONDUCTOR MATERIALS HISTORY & FORECAST	59
FIGURE 13 : U.S. AUTOMOTIVE SALES	36	FIGURE 26: PACKAGING METALLIZATION APPLICATIONS	61
		FIGURE 27: PLATING MATERIALS FOR ADVANCED PACKAGING AND FE INTERCONNECT REVENUES (\$M'S).	62
		FIGURE 28: CU PLATING CHEMICALS 5-YEAR FORECAST	63

TABLE OF CONTENTS

FIGURE 29: ADVANCED PACKAGING APPLICATIONS IN MILLIONS OF WAFERS	65	FIGURE 44: OSATS PACKAGING BUSINESS CANNIBALIZATION TREND	81
FIGURE 30: CU PLATING ADVANCED PACKAGING REVENUE FORECAST ESTIMATES	66	FIGURE 45: WAFER LEVEL PLATING	82
FIGURE 31: CU PILLAR/BUMP & CU RDL SEGMENTED FORECAST	67	FIGURE 46: ADVANCED PACKAGING MARKET DRIVERS AND APPLICATIONS	83
FIGURE 32: ADV. PACKAGING CU/VMS VOLUME DEMAND FORECAST	68	FIGURE 47: COMPARISON WITH DAMASCENE- TYPE RDL	85
FIGURE 33: ADV. PACKAGING CU PLATING ADDITIVES VOLUME DEMAND FORECAST	68	FIGURE 48: APPLE EXAMPLE INTERPOSERS	87
FIGURE 34: OTHER PLATING MATERIALS FOR ADVANCED PACKAGING	69	FIGURE 49: TSV PROCESS FLOW EXAMPLE	88
FIGURE 35: SN AND SNAG PLATING REVENUE	70	FIGURE 50: METAL LEVELS PER LOGIC NODE	92
FIGURE 36: NICKEL PLATING REVENUE	71	FIGURE 51: METAL LEVELS PER LOGIC NODE	93
FIGURE 37: ADVANCED LOGIC DEVICES GROWTH FORECAST	72	FIGURE 52: CU DAMASCENE QUALIFICATION	94
FIGURE 38: METAL PLATING WAFER PASSES	73	FIGURE 53: DRAM Structure	97
FIGURE 39: WW DAMASCENE REVENUE FORECAST ESTIMATES	74	FIGURE 54: 3DNAND Structure	99
FIGURE 40: DAMASCENE CU VMS VOLUME DEMAND FORECAST ESTIMATES	75	FIGURE 55: TOTAL PLATING FOR ADV. PACKAGING AND SEMICONDUCTOR DEVICE MANUFACTURING 2021	101
FIGURE 41: DAMASCENE CU PLATING ADDITIVES CHEMICAL VOLUME DEMAND FORECAST	75	FIGURE 56: PLATING EQUIPMENT OEM MARKET SHARES 2020	106
FIGURE 42: CLEANING COMPLEXITY	77	FIGURE 57: PLATING CHEMICAL SUPPLIER FOR DAMASCENE AND ADVANCED PACKAGING APPLICATIONS	107
FIGURE 43: KEY TRENDS IN ADVANCED PACKAGING	80		

TABLE OF CONTENTS

LIST OF TABLES

TABLE 1: GLOBAL GDP AND SEMICONDUCTOR REVENUES*	27	TABLE 14: TECHNICAL REQUIREMENTS SUMMARY	102
TABLE 2: WORLD BANK ECONOMIC OUTLOOK*	28	TABLE 15: TECHNICAL REQUIREMENTS SUMMARY	103
TABLE 3: DATA CENTER SYSTEMS AND COMMUNICATION SERVICES FORECAST 2021.	42	TABLE 16: REGIONAL PLAYERS – MARKET LEADER AND “OTHERS”	108
TABLE 4: DEVICE MAKER INVESTMENT ACTIVITY	46		
TABLE 5: DEVICE MAKER INVESTMENT ACTIVITY, CONTINUED	47		
TABLE 6: US CHIPS ACT PROVISIONS	51		
TABLE 7: CU PACKAGING APPLICATIONS AND REQUIREMENTS	90		
TABLE 8: LOGIC DEVICE ROADMAP FOR METALS	95		
TABLE 9: METALS REQUIRED FOR DEVICE FEATURES	96		
TABLE 10: DRAM USE OF MO OR RU PRESENT & FUTURE	97		
TABLE 11: GENERAL PROCESS FLOW ADVANCED DRAM	98		
TABLE 11: 3DNAND MATERIAL CHANGES PRESENT & FUTURE	99		
TABLE 12: NUMBER OF STRINGS PER GENERATION OF 3DNAND	100		
TABLE 13: EXAMPLE OF LOGIC PROCESS FLOW 20 NM TO 32 NM LOGIC PVD 101			

2 SCOPE, PURPOSE AND METHODOLOGY

2.1

SCOPE

- This report covers the Metal Chemicals market trends and supply-chain as it applied to **Advanced Packaging** (wafer level) and **Semiconductor Device Manufacturing** (damascene process).
- Included are forecasts for copper plating and additives, market shares, technical trends, and supplier profiles. Also included in the appendix is a supplier product comparison table of publicly available information on plating products used for advanced packaging.
- The report contains data and analysis from TECHCET's data base and Sr. Analyst experience, as well as that developed from primary and secondary market research. For more information on TECHCET Critical materials Reports™ please go to <https://TEHCET.com>

2.2

PURPOSE

- This Critical Materials Report™ (CMR) provides focused information for supply-chain managers, process integration and R&D directors, as well as business development managers, and financial analysts. The report covers information about key suppliers, issues/trends in the material supply chain, estimates on supplier market share, and forecast for the material segments.
- Providing current information and actionable content is the intent of the information contained within this report and the quarterly updates.
- As important as the supply side of the equations is the demand requirements of the market in terms of the economic variables, leading edge technology requirements and the wafer start forecast.

2.3

METHODOLOGY

TEHCET employs subject matter experts having first-hand experience within the industries which they analyze. Most of TEHCET's analysts have over 25 years of direct and relevant experience in their field. Our analysts survey the commercial and technical staff of IC manufacturers and their suppliers and conduct extensive research of literature and commerce statistics to ascertain the current and future market environment and global supply risks. Combining this data with TEHCET's proprietary, quantitative wafer forecast results in a viable long-term market forecast for a variety of process materials.

2.4

OVERVIEW OF OTHER TECHCET CMR™ REPORTS

TEHCET produces electronic material supply chain reports each year as one of its functions for the Critical Materials Council. Reports to be published in 2019 can be found at www.techcet.com and are listed in the table below:

2021	CMR Report Schedule
1	CMP Pads and Slurry
2	Equipment Components – Quartz
3	Gases + Xeon / Neon
4	Photoresist
5	Precursors - Dielectric Precursors
6	Precursors - Hi K / ALD CVD Metal Precursors
7	Silicon Wafers
8	Specialty Cleaning Chems / Wet Chems
9	Equipment Components – Ceramics/SiC
10	Metal Chemicals
11	Targets
12	Equipment Components- Silicon 2020 version with 2021 forecast