



Electronics Materials Information

2019-20

# Wet Chemicals and Specialty Cleaning Chemistries

For Semiconductor Device Process Applications

*a TECHCET Critical Materials Report*

**Prepared by**

Terry A Francis

TECHCET CA LLC  
11622 El Camino Real, Suite #100  
San Diego, CA 92130

[www.TECHCET.com](http://www.TECHCET.com)

[info@TECHCET.com](mailto:info@TECHCET.com)

+1-480-382-8336

## RESEARCH METHODOLOGY

TECHCET employs subject matter experts having first-hand experience within the industries which they analyze. Most of TECHCET'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 TECHCET's proprietary, quantitative wafer forecast results in a viable long-term market forecast for a variety of process materials.

Readers 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.

## Table of Contents

	Page #
<b>1. Executive Summary .....</b>	<b>7</b>
<b>2. Scope and Purpose .....</b>	<b>12</b>
<b>2.1 Scope .....</b>	<b>12</b>
<b>2.2 Purpose .....</b>	<b>12</b>
<b>2.3 Methodology .....</b>	<b>12</b>
<b>2.4 Brief overview of other TECHCET Reports .....</b>	<b>13</b>
<b>3. Market Outlook .....</b>	<b>14</b>
<b>3.1 Worldwide Economy .....</b>	<b>14</b>
<b>3.2 End Market Drivers .....</b>	<b>20</b>
<b>3.3 Semiconductor Device Outlook .....</b>	<b>25</b>
<b>3.4 Summary of Equipment Spending/Capital Investments/Fab Investments .....</b>	<b>28</b>
<b>3.5 Overall China Market News &amp; Trends .....</b>	<b>32</b>
<b>3.6 TECHCET 5-Year Wafer Start Forecast .....</b>	<b>35</b>
<b>3.7 Semiconductor Market Overview Summary .....</b>	<b>35</b>
<b>4. Basic Chemicals .....</b>	<b>37</b>
<b>4.1.1 Market Revenues .....</b>	<b>38</b>
<b>4.1.2 Worldwide Electronic Wet Chemical Market Ranking .....</b>	<b>39</b>
<b>4.2 Sulfuric Acid .....</b>	<b>41</b>
<b>4.3 Hydrogen Peroxide .....</b>	<b>45</b>
<b>4.4 Phosphoric Acid .....</b>	<b>47</b>
<b>4.5 HF/BOE products .....</b>	<b>53</b>
<b>4.6 Nitric Acid .....</b>	<b>57</b>
<b>4.7 Isopropyl Alcohol .....</b>	<b>58</b>
<b>4.8 Hydrochloric Acid (HCl) .....</b>	<b>60</b>
<b>4.9 PGMEA .....</b>	<b>63</b>
<b>5. Market Overview – Formulated Chemicals .....</b>	<b>65</b>
<b>5.1 PERR .....</b>	<b>68</b>
<b>5.1.1 Aluminum Cleans .....</b>	<b>78</b>
<b>5.1.2 Copper Cleans .....</b>	<b>79</b>
<b>5.2 CMP Cleans .....</b>	<b>79</b>
<b>5.2.1 PCMP .....</b>	<b>81</b>
<b>5.2.2 Post-CMP Cleaning Market Overview/Dynamics .....</b>	<b>92</b>
<b>6. Materials Opportunities .....</b>	<b>94</b>
<b>7. Green Chemistries .....</b>	<b>97</b>
<b>7.1 Blending systems .....</b>	<b>101</b>
<b>8. Metrology Challenges .....</b>	<b>102</b>
<b>9. Company Profiles .....</b>	<b>104</b>
<b>9.1 Avantor .....</b>	<b>105</b>
<b>9.2 BASF .....</b>	<b>108</b>
<b>9.3 KMG .....</b>	<b>113</b>

9.4	Dow-DuPont.....	117
9.5	Eastman .....	122
9.6	Entegris.....	126
9.7	FUJIFILM Corporation.....	130
9.8	GrandiT .....	135
9.9	Honeywell .....	139
9.10	Hubei Sinophorous (Xingfa Parent Company).....	143
9.11	Jiangyin Runma Electronic Material Co .....	145
9.12	Jiangyin Jianghua Microelectronics Materials Co .....	148
9.13	JSR Corporation.....	151
9.14	Kanto Chemical Co., Inc.....	154
9.15	LCY.....	158
9.16	Mitsubishi Gas Chemical Company, Inc. (MGC) .....	161
9.17	Merck KGaA / EMD .....	165
9.18	Rudong Zhenfeng Yiyang Chemical Co., Ltd .....	169
9.19	SACHEM .....	172
9.20	Solvay.....	174
9.21	Soulbrain .....	178
9.22	Sumitomo Chemical Company, Ltd.....	182
9.23	Suzhou Crystal Clear .....	186
9.24	XINGFA.....	190
<b>10.</b>	<b>Appendix .....</b>	<b>196</b>
10.1	PERR Background.....	196
10.2	PERR Overview.....	196
10.3	Ge Wet clean .....	199
10.4	TiN Wet Etching .....	201
10.5	Effect of Additives in HF cleans .....	202
10.6	Front End of Line Specialty Cleans in Brief .....	203
10.7	Low Temperature EPI.....	203
10.8	Hi K Gate Preclean .....	204
10.9	Post CMP Cleans Background .....	204
<b>11.</b>	<b>Appendix A: China's 5 Year Plan .....</b>	<b>211</b>
<b>12.</b>	<b>Appendix B: Supply Chain Connections-Makers &amp; Suppliers .....</b>	<b>214</b>
<b>13.</b>	<b>Appendix C: Wet Chemical Purity Requirements and Trends .....</b>	<b>216</b>
<b>14.</b>	<b>Appendix E: Environmental, Health and Safety .....</b>	<b>219</b>

## List of Figures

Figure 1 2018 Global Economy and the Electronics Supply Chain.....	15
Figure 2 Worldwide Semiconductor Sales.....	16
Figure 3 Global Purchasing Managers Index.....	17
Figure 4 Global Electronics Production Annual Growth.....	20
Figure 5 Global Electronics Production Annual Growth.....	21
Figure 6 Automotive Electronic Content Growth .....	24
Figure 7 Automotive Semiconductor Market Growth.....	25
Figure 8 2019 Semiconductor Revenue Growth Forecasts .....	26
Figure 9 2019 Semiconductor Market Size by Device Segment.....	27
Figure 10 Semiconductor Device Unit Growth .....	28
Figure 11 200 mm Fab Capacity Outlook to 2022 .....	32
Figure 12 China IC Production Share and Consumption Trends.....	33
Figure 13 TECHCET Wafer Starts by Technology Node and Device Type .....	36
Figure 14 WW Electronic Wet Chemicals & Specialty Cleaning Chemicals.....	39
Figure 15 WW Sulfuric Acid Revenue Estimate (US\$M).....	44
Figure 16 Sulfuric Acid Price Index .....	45
Figure 17 WW Hydrogen Peroxide Revenues Estimate (US\$M's).....	46
Figure 18 Phosphoric Acid Supply Chain .....	48
Figure 19 Phosphor Rock Production by Region.....	49
Figure 20 Phosphoric Acid Pricing Index .....	50
Figure 21 Phosphor Rock Price Trends in China.....	50
Figure 22 WW High Purity Phosphoric Acid Revenues Estimate (US\$M) .....	52
Figure 23 Fluorspar Pricing in China .....	54
Figure 24 WW HF/BOE Revenues Estimate (US\$M) .....	56
Figure 25 WW Nitric Acid Revenues Estimate (US\$M) .....	58
Figure 26 IPA Usage Trends and Issues .....	59
Figure 27 IPA/Solvents Market Forecast .....	60
Figure 28 The World Consumption of Hydrochloric Acid.....	62
Figure 29 Interconnect Milestones (Edelstein) .....	67
Figure 30 Wafers Requiring PERR [Wafer Passes] Estimates .....	69
Figure 31 Aluminum PERR Relative Volume Forecast Estimates .....	70
Figure 32 Copper PERR Relative Volume Forecast Estimates .....	72
Figure 33 Double Patterning ArFi .....	73
Figure 34 Immersion Multi Patterning Process Steps .....	74
Figure 35 Copper Cleans Volume Trend below 22 nm .....	75
Figure 36 PERR Aluminum and Copper Revenue Forecast Estimates .....	76
Figure 37 PERR Supplier Market Shares Estimates (% total revenues).....	77
Figure 38 CMP Challenges in 10 nm/7 nm.....	80
Figure 39 pCMP Cleans per Node.....	84
Figure 40 pCMP Ceria Relative Volumes Forecast .....	85
Figure 41 pCMP HkMG Electrode Relative Volumes Forecast .....	86

Figure 42 pCMP HkMG Oxide + Oxide : Relative Volumes Forecast .....	87
Figure 43 pCMP Tungsten Relative Volumes Forecast .....	88
Figure 44 pCMP Cu Relative Volume Forecast .....	89
Figure 45 Revenue pCMP Cleans .....	90
Figure 46 pCMP Supplier Market Share Range Estimates (% of total revenues) .....	92
Figure 47 Ge Wet Clean NH <sub>4</sub> OH versus .....	199
Figure 48 Surface Cleaning Metal Removal Efficiency on Si and Ge .....	200
Figure 49 Wet Cleaning of WF Metals in FinFET .....	201
Figure 50 CMP Process Steps per Node .....	205
Figure 51 Advance copper Cleaning Mechanism .....	207
Figure 52 Design of EKC Gen IV Cleaner .....	208
Figure 53 III-V Cleaning and Etching.....	210

## List of Tables

Table 1 Supply Chain Issues .....	10
Table 2 2019 TECHCET Critical Material Reports .....	13
Table 3 Global GDP and Semiconductor Revenues .....	14
Table 4 IMF World Economic Outlook .....	18
Table 5 World Bank GDP Forecast .....	19
Table 6 Worldwide IT Spending Forecast (Billions of U.S. Dollars) .....	21
Table 7 Smartphone Vendor Shipments (Millions of Units) .....	22
Table 8 VLSI Research Semiconductor Revenue by Segment .....	27
Table 9 2019 Semiconductor Equipment Outlook.....	29
Table 10 Top IDM and Foundry Capex Spenders .....	29
Table 11 Investment Plans for Selected Device Companies .....	30
Table 12 Worldwide (WW) Wet Chemicals Market Ranking .....	40
Table 13 Semiconductor Wet Chemical Regional Market Leaders & Market Shares .....	40
Table 14 Smelter Maintenance Plans .....	42
Table 15 Mask per Device Type.....	68
Table 16 Chelating Agents for Different Metals .....	202
Table 17 Wet Chemical Suppliers for Selected Chemicals.....	215
Table 18 Phosphoric Acid Specification - SEMI Standards - 2013.....	217