

CHAPTER ONE: INTRODUCTION.....	1
STUDY GOAL AND OBJECTIVES	2
REASONS FOR DOING THE STUDY	2
INTENDED AUDIENCE.....	2
SCOPE OF REPORT	2
METHODOLOGY	3
ABOUT THE AUTHORS.....	3
RELATED BCC REPORTS	4
BCC ONLINE SERVICES.....	5
DISCLAIMER	5
 CHAPTER TWO: SUMMARY.....	 6
<i>SUMMARY TABLE WORLD THERMAL MANAGEMENT MARKET,</i> <i>THROUGH 2015 (\$ MILLIONS)</i>	 6
<i>SUMMARY FIGURE WORLD THERMAL MANAGEMENT MARKET</i> <i>TRENDS, 2009-2015 (\$ MILLIONS)</i>	 7
 CHAPTER THREE: THERMAL MANAGEMENT OVERVIEW	 8
INDUSTRY OVERVIEW AND DESCRIPTION.....	8
INDUSTRY OVERVIEW AND ... (CONTINUED).....	9
INCREASING IMPORTANCE OF THERMAL MANAGEMENT.....	10
TECHNOLOGICAL REASONS.....	10
LOGISTICAL REASONS.....	10
PHYSICAL REASONS.....	11
Physical Reasons (Continued).....	12
<i>FIGURE 1 MAJOR CAUSES OF ELECTRONIC FAILURE (% OF</i> <i>OCCURRENCES)</i>	 13
INDUSTRY DRIVERS AND STRUCTURE	14
POWER DISSIPATION AS A DRIVER	14
Power Dissipation as a Driver (Continued).....	15
NOISE LEVELS	16
INDUSTRY STRUCTURE.....	16
Industry Structure (Continued).....	17
TECHNOLOGY	18
ENVIRONMENTAL AND REGULATORY FACTORS IN THERMAL MANAGEMENT.....	19
GLOBAL AND REGIONAL MARKET TRENDS FOR THERMAL MANAGEMENT.....	19
<i>TABLE 1 WORLD THERMAL MANAGEMENT MARKET, THROUGH</i> <i>2015 (\$ MILLIONS)</i>	 19
<i>TABLE 2 WORLD THERMAL MANAGEMENT MARKET BY REGION,</i> <i>THROUGH 2015 (\$ MILLIONS)</i>	 20
<i>FIGURE 2 WORLD THERMAL MANAGEMENT MARKET SHARES BY</i> <i>REGION, 2009 AND 2015 (%)</i>	 21
AMERICAS.....	22

EUROPE.....	22
ASIA-PACIFIC	22
JAPAN	23
THERMAL MANAGEMENT END-USE APPLICATION TRENDS	23
<i>TABLE 3 WORLD THERMAL MANAGEMENT MARKET BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS).....</i>	<i>24</i>
<i>FIGURE 3 WORLD THERMAL MANAGEMENT MARKET SHARES BY END-USE APPLICATION, 2009 AND 2015 (%).....</i>	<i>24</i>
<i>FIGURE 3 (CONTINUED)</i>	<i>25</i>
COMPUTERS.....	25
TELECOMS.....	26
Telecoms (Continued)	27
Telecoms (Continued)	28
Telecoms (Continued)	29
AUTOMOTIVE.....	30
CONSUMER PRODUCTS	30
MEDICAL/OFFICE ELECTRONICS.....	31
INDUSTRIAL/MILITARY ELECTRONICS	31

CHAPTER FOUR: THERMAL MANAGEMENT TECHNOLOGY

OVERVIEW	32
INTRODUCTION	32
MATERIALS	32
<i>TABLE 4 THERMAL PROPERTIES OF MATERIALS.....</i>	<i>33</i>
COMPOSITES.....	33
<i>TABLE 5 METAL MATRIX COMPOSITES.....</i>	<i>34</i>
CERAMICS.....	34
Alumina (Al ₂ O ₃)	35
Aluminum Nitride (AlN)	35
Silicon Carbide (SiC)	35
Aluminum Silicon Carbide (AlSiC).....	36
Beryllium (BeO).....	36
Other Thermal Management Materials	36
CONDUCTORS	37
DISSIPATION AND MATERIALS.....	38
EFFECTIVE THERMAL DESIGN FOR ELECTRONIC SYSTEMS	38
CONCEPT DEVELOPMENT	39
Concept Development Phase Thermal Tools.....	40
DETAILED DESIGN	40
Detailed Design Phase Thermal Tools.....	41
HARDWARE TEST	41
Hardware Test Phase Thermal Tools	41
TECHNOLOGY TRENDS.....	42
PACKAGING DESIGNED FOR THERMAL PERFORMANCE.....	42
Packaging Designed ... (Continued)	43

THERMAL TEST DIES	44
NEW THERMAL SENSING TECHNOLOGIES	45
THERMALLY CONDUCTIVE POLYMERS.....	45
Thermally Conductive Polymers (Continued)	46
COMPOSITES.....	47
Composites (Continued)	48
NEW MANUFACTURING PROCESSES	49
RAPID PROTOTYPING AND FAST DELIVERY OF FINAL PRODUCT	50
THERMAL MANAGEMENT OF OUTDOOR ENCLOSURES	50
Thermal Management of Outdoor ... (Continued)	51
Thermal Management of Outdoor ... (Continued)	52
PORTABLE DEVICES.....	53
DATA CENTERS	54
HIGH-PERFORMANCE COMPUTING	55
High-Performance Computing (Continued)	56
 CHAPTER FIVE: THERMAL MANAGEMENT PRODUCT CATEGORIES	 57
PRODUCT SUMMARY MARKET OVERVIEW.....	57
PRODUCT SUMMARY FORECASTS	58
<i>TABLE 6 GLOBAL THERMAL MANAGEMENT MARKET BY PRODUCT TYPE, THROUGH 2015 (\$ MILLIONS)</i>	 58
<i>FIGURE 4 GLOBAL THERMAL MANAGEMENT REVENUE BY PRODUCT SEGMENT, 2009 AND 2015 (%)</i>	 58
<i>FIGURE 4 (CONTINUED)</i>	59
PRODUCT SUMMARY ... (CONTINUED)	60
 CHAPTER SIX: THERMAL MANAGEMENT HARDWARE.....	 61
MAIN TYPES OF THERMAL MANAGEMENT HARDWARE.....	61
FANS AND BLOWERS.....	61
Fans and Blowers (Continued).....	62
Controlling Fan Speeds	63
Fan-Monitoring Options	63
Methods of Speed Control.....	64
Methods of ... (Continued).....	65
Synchronizing Fans	66
Fan Selection Issues	67
Steps to Fan Selection	68
• Estimate the Required Airflow	68
• Estimate the Actual Airflow	68
• Consider Multiple Fans	68
HEAT SINKS	69
Expanded Arsenal of Heat Sink Options.....	69
Expanded Arsenal ... (Continued).....	70
Expanded Arsenal ... (Continued).....	71

Expanded Arsenal ... (Continued).....	72
Expanded Arsenal ... (Continued).....	73
Expanded Arsenal ... (Continued).....	74
Increasing Area.....	75
Attachment and Thermal Interface Options.....	76
Mechanical Attachment.....	76
Adhesive Attachment.....	77
Repair.....	77
FAN SINKS.....	78
HEAT PIPES.....	78
Heat Pipes (Continued).....	79
Heat Pipes (Continued).....	80
Pulsating Heat Pipes.....	81
COLD PLATES.....	82
OTHER TYPES OF COOLING HARDWARE.....	83
Low-Temperature (Vapor Phase) Electronic Cooling.....	83
Low-Temperature ... (Continued).....	84
Low-Temperature ... (Continued).....	85
Thermoelectric Coolers.....	86
Pumped Liquid Cooling Systems.....	87
Water-Chilled Doors.....	88
SprayCool.....	88
Non-Water Liquid Cooling Systems.....	88
Ionic Wind Engines.....	89
Microchannel-Microjet Cooling.....	89
Nanofluid Coolants.....	90
Metal Foam Heat Exchangers.....	90
Zigzag Heat Sink Fins.....	90
WORLDWIDE MARKET FORECAST.....	91
<i>TABLE 7 GLOBAL THERMAL MANAGEMENT HARDWARE MARKET, THROUGH 2015 (\$ MILLIONS).....</i>	<i>91</i>
GLOBAL AND REGIONAL TRENDS FOR THERMAL MANAGEMENT HARDWARE.....	91
<i>TABLE 8 THERMAL MANAGEMENT HARDWARE REVENUE BY REGION, THROUGH 2015 (\$ MILLIONS).....</i>	<i>92</i>
<i>FIGURE 5 WORLD THERMAL MANAGEMENT HARDWARE MARKET SHARES BY REGION, 2009 VS. 2015 (%).....</i>	<i>93</i>
THERMAL MANAGEMENT HARDWARE END-USE APPLICATION TRENDS.....	94
<i>TABLE 9 GLOBAL THERMAL MANAGEMENT HARDWARE MARKET BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS).....</i>	<i>94</i>
<i>FIGURE 6 WORLD THERMAL MANAGEMENT HARDWARE MARKET SHARES BY END-USE SEGMENT, 2009 VS. 2015 (%).....</i>	<i>95</i>

THERMAL MANAGEMENT HARDWARE SUBPRODUCT CATEGORIES	96
TABLE 10 GLOBAL THERMAL MANAGEMENT HARDWARE SHIPMENTS BY PRODUCT SUBSEGMENTS, THROUGH 2015 (\$ MILLIONS).....	96
FIGURE 7 GLOBAL THERMAL MANAGEMENT HARDWARE REVENUE BY PRODUCT SEGMENT, 2009 VS. 2015 (%).....	97
Fans and Blowers	98
TABLE 11 GLOBAL SHIPMENTS OF THERMAL MANAGEMENT FANS AND BLOWERS BY END-USE APPLICATIONS, THROUGH 2015 (\$ MILLIONS).....	98
Heat Sinks	99
TABLE 12 GLOBAL SHIPMENTS OF THERMAL MANAGEMENT HEAT SINKS BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS).....	100
Fan Sinks	100
TABLE 13 GLOBAL SHIPMENTS OF THERMAL MANAGEMENT FAN SINKS BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)....	100
Heat Pipes.....	101
TABLE 14 GLOBAL MARKET FOR THERMAL MANAGEMENT HEAT PIPES BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)....	101
Cold Plates	102
TABLE 15 GLOBAL MARKET FOR THERMAL MANAGEMENT COLD PLATES BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS).....	102
Other Types of Hardware.....	103
TABLE 16 GLOBAL MARKET FOR OTHER TYPES OF THERMAL MANAGEMENT HARDWARE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS).....	103
CHAPTER SEVEN: THERMAL MANAGEMENT SOFTWARE	104
MAIN TYPES OF THERMAL MANAGEMENT SOFTWARE	104
COMPUTATIONAL FLUID DESIGN.....	104
How to Use Parametric Features in Thermal Software	105
CHT: Overview	106
Circuit Design: Overview	106
Power Management: Overview	106
Other Software Overview	106
TRENDS IN THERMAL MANAGEMENT SOFTWARE.....	107
Virtual Prototyping	107
Geometry Creation.....	108
Meshing	108
Solving.....	108
Post-Processing	109
The Essential Modeling Process.....	109

• Examine Overall Airflow	109
• Model at the Component Level	109
• Simulate Thermal Performance.....	109
Standardized Thermal Models.....	109
Standardized Thermal ... (Continued).....	110
Standardized Thermal ... (Continued).....	111
Graphical Simulation	112
Design Turnaround	112
Electronics Industry Influence.....	113
Power Consumption as a Driver	113
Power ... (Continued).....	114
Power ... (Continued).....	115
Power ... (Continued).....	116
Flow Network Modeling	117
Flow Network ... (Continued).....	118
Flow Network ... (Continued).....	119
Flow Network ... (Continued).....	120
Computing Platform Developments.....	121
Downloadable Libraries	121
Online Characterization.....	121
Greater Computational Accuracy	122
Object Orientation	122
Simplified Models	122
Simplified Models (Continued).....	123
Enclosure Cooling Software	124
Fan Control Software	124
WORLDWIDE MARKET FORECAST.....	124
<i>TABLE 17 GLOBAL THERMAL MANAGEMENT SOFTWARE</i>	
<i>REVENUES, THROUGH 2015 (\$ MILLIONS)</i>	125
GLOBAL AND REGIONAL TRENDS FOR THERMAL	
MANAGEMENT SOFTWARE	125
<i>TABLE 18 MARKET FOR THERMAL MANAGEMENT SOFTWARE BY</i>	
<i>REGION, THROUGH 2015 (\$ MILLIONS)</i>	126
<i>FIGURE 8 WORLD THERMAL MANAGEMENT SOFTWARE MARKET</i>	
<i>SHARES BY REGION, 2009 AND 2015 (%)</i>	126
<i>FIGURE 8 (CONTINUED)</i>	127
THERMAL MANAGEMENT SOFTWARE END-USE	
APPLICATION TRENDS.....	127
<i>TABLE 19 GLOBAL THERMAL MANAGEMENT SOFTWARE</i>	
<i>REVENUES BY END-USE APPLICATION, THROUGH 2015 (\$</i>	
<i>MILLIONS)</i>	127
<i>FIGURE 9 WORLD THERMAL MANAGEMENT SOFTWARE MARKET</i>	
<i>SHARES BY END-USE APPLICATION, 2009 AND 2015 (%)</i>	128

<i>TABLE 20 ANALYSIS OF COMPUTER APPLICATIONS TRENDS, 2009 AND 2015 (%)</i>	129
THERMAL MANAGEMENT SOFTWARE SUB-PRODUCT CATEGORIES.....	130
<i>TABLE 21 GLOBAL MARKET FOR THERMAL MANAGEMENT SOFTWARE BY PRODUCT TYPE, THROUGH 2015 (\$ MILLIONS)</i>	130
<i>FIGURE 10 WORLD THERMAL MANAGEMENT SOFTWARE MARKET SHARES BY PRODUCT TYPE, 2009 AND 2015 (%)</i>	131
COMPUTATIONAL FLUID DYNAMICS SOFTWARE.....	132
<i>TABLE 22 GLOBAL MARKET FOR CFD SOFTWARE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	132
COMPUTATIONAL HEAT TRANSFER SOFTWARE	132
<i>TABLE 23 GLOBAL MARKET FOR CHT SOFTWARE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	133
CIRCUIT DESIGN SOFTWARE	133
<i>TABLE 24 GLOBAL MARKET FOR THERMAL MANAGEMENT CIRCUIT DESIGN SOFTWARE BY END-USE APPLICATIONS, THROUGH 2015 (\$ MILLIONS)</i>	133
POWER MANAGEMENT SOFTWARE.....	134
<i>TABLE 25 GLOBAL MARKET FOR POWER MANAGEMENT SOFTWARE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	134
OTHER SOFTWARE	134
<i>TABLE 26 GLOBAL MARKET FOR OTHER TYPES OF THERMAL MANAGEMENT SOFTWARE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	135
THERMAL MANAGEMENT INTERFACE.....	135
MAIN TYPES OF THERMAL INTERFACE PRODUCTS	136
THERMAL GREASES	136
THERMAL COMPOUNDS	137
THERMAL PADS.....	137
ADHESIVE FILMS AND TAPES.....	138
EPOXIES	139
TECHNOLOGY TRENDS IN THERMAL MANAGEMENT INTERFACE	140
Filler Materials.....	140
Phase Change Materials	140
Silk-Screenable Interface Materials	141
Compressible/Conformable Gap Fillers.....	141
Viscoelastic Gap Fillers.....	142
Carbon Nanotube Interface Materials.....	142
“Chip Cap”.....	143
WORLDWIDE MARKET FORECAST	143

<i>TABLE 27 GLOBAL MARKET FOR THERMAL MANAGEMENT INTERFACE MATERIALS, THROUGH 2015 (\$ MILLIONS)</i>	143
GLOBAL AND REGIONAL TRENDS FOR THERMAL MANAGEMENT INTERFACE	144
<i>TABLE 28 THERMAL MANAGEMENT INTERFACE MARKET SHARES BY REGION, THROUGH 2015 (\$ MILLIONS)</i>	144
<i>FIGURE 11 WORLD THERMAL MANAGEMENT INTERFACE MARKET SHARES BY REGION, 2009 AND 2015 (%)</i>	144
<i>FIGURE 11 (CONTINUED)</i>	145
THERMAL MANAGEMENT INTERFACE END-USE APPLICATION TRENDS	145
<i>TABLE 29 GLOBAL THERMAL MANAGEMENT INTERFACE MARKET REVENUE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	146
<i>FIGURE 12 WORLD THERMAL MANAGEMENT INTERFACE MARKET SHARES BY END-USE APPLICATION, 2009 AND 2015 (%)</i>	147
THERMAL MANAGEMENT INTERFACE SUBPRODUCT CATEGORIES	148
<i>TABLE 30 GLOBAL MARKET FOR THERMAL MANAGEMENT INTERFACE PRODUCTS BY TYPE OF PRODUCT, THROUGH 2015 (\$ MILLIONS)</i>	148
<i>FIGURE 13 WORLD THERMAL MANAGEMENT INTERFACE MARKET SHARES BY TYPE OF PRODUCT, 2009 AND 2015 (%)</i>	149
Thermal Grease	150
<i>TABLE 31 GLOBAL MARKET FOR THERMAL GREASE BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	150
Thermal Compounds	150
<i>TABLE 32 GLOBAL MARKET FOR THERMAL COMPOUNDS BY END- USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	150
Thermal Pads	151
<i>TABLE 33 GLOBAL MARKET FOR THERMAL PADS BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	151
Adhesive Films and Tapes	151
<i>TABLE 34 GLOBAL MARKET FOR THERMAL MANAGEMENT ADHESIVE FILMS AND TAPES BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	152
Epoxies	152
<i>TABLE 35 GLOBAL MARKET FOR THERMAL MANAGEMENT EPOXIES BY END-USE APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	153
CHAPTER EIGHT: THERMAL MANAGEMENT SUBSTRATES	154
MAIN TYPES OF THERMAL SUBSTRATES	154
THERMALLY ENHANCED PACKAGES	154
Thermally Enhanced ... (Continued)	155

HEAT SPREADERS.....	156
Two-Phase Heat Spreaders	157
Natural Graphite Heat Spreaders	158
Diamond Heat Spreaders	158
WORLDWIDE MARKET FORECAST.....	159
<i>TABLE 36 GLOBAL MARKET FOR THERMAL MANAGEMENT</i>	
<i>SUBSTRATES, THROUGH 2015 (\$ MILLIONS)</i>	<i>159</i>
GLOBAL AND REGIONAL TRENDS FOR THERMAL	
MANAGEMENT SUBSTRATE.....	159
<i>TABLE 37 THERMAL MANAGEMENT SUBSTRATE MARKET BY</i>	
<i>REGION, THROUGH 2015 (\$ MILLIONS)</i>	<i>160</i>
<i>FIGURE 14 THERMAL MANAGEMENT SUBSTRATE MARKET</i>	
<i>SHARES BY REGION, 2009 AND 2015 (%)</i>	<i>160</i>
<i>FIGURE 14 (CONTINUED)</i>	<i>161</i>
THERMAL MANAGEMENT SUBSTRATE END-USE	
APPLICATION TRENDS.....	161
<i>TABLE 38 GLOBAL THERMAL MANAGEMENT SUBSTRATE</i>	
<i>MARKET BY END-USE APPLICATION, THROUGH 2015 (\$</i>	
<i>MILLIONS).....</i>	<i>161</i>
<i>FIGURE 15 WORLD THERMAL MANAGEMENT SUBSTRATE</i>	
<i>MARKET SHARES BY END-USE APPLICATION, 2009 AND 2015 (%)....</i>	<i>162</i>
THERMAL MANAGEMENT SUBSTRATE SUBPRODUCT	
CATEGORIES.....	163
<i>TABLE 39 GLOBAL MARKET FOR THERMAL MANAGEMENT</i>	
<i>SUBSTRATES BY TYPE OF PRODUCTS, THROUGH 2015 (\$</i>	
<i>MILLIONS).....</i>	<i>163</i>
Thermally Enhanced Packages.....	163
<i>TABLE 40 GLOBAL MARKET FOR THERMALLY ENHANCED</i>	
<i>PACKAGES BY END-USE APPLICATION, THROUGH 2015 (\$</i>	
<i>MILLIONS).....</i>	<i>164</i>
Heat Spreaders	164
<i>TABLE 41 GLOBAL MARKET FOR HEAT SPREADERS BY END-USE</i>	
<i>APPLICATION, THROUGH 2015 (\$ MILLIONS).....</i>	<i>164</i>
CHAPTER NINE: THERMAL MANAGEMENT MARKET SHARES AND	
COMPANY PROFILES.....	165
TOTAL THERMAL MANAGEMENT INDUSTRY MARKET SHARES.....	165
<i>TABLE 42 LEADING GLOBAL THERMAL MANAGEMENT VENDORS,</i>	
<i>2008 (\$ MILLIONS/%).....</i>	<i>166</i>
<i>FIGURE 16 GLOBAL THERMAL MANAGEMENT MARKET SHARES,</i>	
<i>2008 (%).....</i>	<i>166</i>
THERMAL MANAGEMENT HARDWARE	167
MARKET SHARES	167
<i>TABLE 43 GLOBAL THERMAL MANAGEMENT HARDWARE</i>	
<i>MARKET LEADERS, 2008 (\$ MILLIONS/%).....</i>	<i>168</i>

COMPANY PROFILES.....	168
Aavid Thermalloy LLC	168
Alcoa	169
Calmark Corp	169
CPS Technologies Corp.	170
Comair Rotron	170
Control Resources.....	170
Cool Innovations	171
Dynatron	171
EBM-Papst.....	172
ETRI	172
The Filter Factory Inc.	172
Vortec	173
JARO Components	173
Knürr AG	173
Kooltronic.....	174
Laird Technologies.....	174
Liebert Corp.....	174
Lytron.....	175
Marlow Industries, Inc.	175
Micronel	175
NMB Technologies Corp.....	176
Noren Products	176
PC Power & Cooling	176
Pfannenberg Inc.....	177
Polycold Systems	177
Qualtek Electronics Corp.	177
Rittal Corporation.....	178
Sunon Inc.	178
Tellurex	178
TennMax	179
Thermacore	179
U.S. Toyo Fan Corp	180
Unitrack Industries	180
United Thermal Engineering Corp.	180
Vette Corp.	181
Wakefield Thermal Solutions.....	181
THERMAL MANAGEMENT SOFTWARE	181
MARKET SHARES	181
<i>TABLE 44 GLOBAL THERMAL MANAGEMENT SOFTWARE MARKET</i>	
<i>LEADERS, 2008 (\$ MILLIONS/%)</i>	182
<i>FIGURE 17 GLOBAL THERMAL MANAGEMENT SOFTWARE</i>	
<i>MARKET SHARES, 2008 (%)</i>	183
COMPANY PROFILES.....	184

ACUSIM Software	184
Ansoft/ANSYS.....	184
ANSYS	185
Daat Research Corp.....	185
Degree Controls, Inc.	186
Enertron.....	186
Flomerics Group PLC	186
Intricast/Radian Heatsinks.....	187
SprayCool, Inc.....	187
Lytron.....	187
MSC Software	188
Netzsch Instruments, Inc.....	188
THERMAL MANAGEMENT INTERFACE	188
MARKET SHARES	188
<i>TABLE 45 GLOBAL THERMAL MANAGEMENT INTERFACE</i>	
<i>MARKET LEADERS, 2008 (\$ MILLIONS/%)</i>	189
<i>FIGURE 18 GLOBAL THERMAL MANAGEMENT INTERFACE</i>	
<i>MARKET SHARES, 2008 (%)</i>	189
Market Shares (Continued).....	190
COMPANY PROFILES.....	191
AI Technology	191
Bergquist Co.	191
Chomerics (Division of Parker Hannifin)	191
Cookson Electronics Assembly Materials.....	192
Henkel Corp.	192
Lord Corp.	192
Master Bond.....	193
Metal Matrix Cast Composites	193
Semiconductor Packaging Materials, Inc.	193
THERMAL MANAGEMENT SUBSTRATE	194
MARKET SHARES	194
<i>TABLE 46 GLOBAL THERMAL MANAGEMENT SUBSTRATE</i>	
<i>MARKET LEADERS, 2008 (\$ MILLIONS/%)</i>	194
<i>FIGURE 19 TOP-FIVE VENDORS — GLOBAL THERMAL</i>	
<i>MANAGEMENT SUBSTRATE MARKET, 2008 (%)</i>	195
COMPANY PROFILES.....	196
Amkor Technology	196
ASAT Inc.	196
Brush Engineered Materials.....	197
STATS ChipPAC Ltd.....	197
Cooler Master.....	197
Diamonex	198
Hybricon.....	198
Isonics	198

OSE	199
CHAPTER TEN: PATENTS.....	200
OVERVIEW.....	200
<i>FIGURE 20 U.S. PATENTS RELATED TO ELECTRONIC THERMAL MANAGEMENT ISSUED SINCE MARCH 2008* (%).....</i>	<i>200</i>
<i>FIGURE 20 (CONTINUED)</i>	<i>201</i>
<i>TABLE 47 TOP U.S. THERMAL MANAGEMENT PATENT ASSIGNEES, 2008–2010.....</i>	<i>201</i>