

INTRODUCTION	XXIII
STUDY GOAL AND OBJECTIVES	XXIV
REASONS FOR DOING THE STUDY	XXIV
CONTRIBUTION OF THE STUDY AND FOR WHOM	XXIV
SCOPE AND FORMAT	XXIV
METHODOLOGY	XXV
ABOUT THE AUTHOR	XXVI
RELATED REPORTS	XXVII
BCC ON-LINE SERVICES	XXVIII
SUMMARY	XXIX
<i>SUMMARY TABLE REVENUES IN WORLD THERMAL MANAGEMENT MARKET,</i>	
<i>THROUGH 2008 (\$ MILLIONS)</i>	XXIX
<i>SUMMARY FIGURE REVENUES IN WORLD THERMAL MANAGEMENT MARKET,</i>	
<i>THROUGH 2008 (\$ MILLIONS)</i>	XXIX
THERMAL MANAGEMENT INDUSTRY OVERVIEW	1
INDUSTRY OVERVIEW AND DESCRIPTION	1
INDUSTRY DRIVERS	2
TECHNOLOGICAL REASONS	3
LOGISTICAL REASONS	3
PHYSICAL REASONS	4
Physical Reasons (Continued)	5
<i>FIGURE 1 MAJOR CAUSES OF ELECTRONIC FAILURE (% OF OCCURRENCES)</i>	6
<i>TABLE 1 WORLD THERMAL MANAGEMENT REVENUE, THROUGH 2008 (\$</i>	
<i>MILLIONS)</i>	7
INDUSTRY DRIVERS AND STRUCTURE	7
POWER DISSIPATION AS A DRIVER	7
Power Dissipation as a Driver (Continued)	8
Power Dissipation as a Driver (Continued)	9
<i>FIGURE 2 TECHNOLOGY NEEDS AS A DRIVER FOR THERMAL MANAGEMENT</i>	10
INDUSTRY STRUCTURE	10
Industry Structure (Continued)	11
Industry Structure (Continued)	12
GLOBAL AND REGIONAL TRENDS FOR THERMAL	
MANAGEMENT	13
<i>TABLE 2 WORLD THERMAL MANAGEMENT REVENUE BY REGION, THROUGH</i>	
<i>2008 (\$ MILLIONS)</i>	13
<i>FIGURE 3 WORLD THERMAL MANAGEMENT REVENUE BY REGION, 2002, 2003</i>	
<i>AND 2008 (\$ MILLIONS)</i>	14
AMERICAS	14
EUROPE	15
ASIA-PACIFIC	15
JAPAN	15
THERMAL MANAGEMENT END-USE APPLICATION TRENDS	16

<i>TABLE 3 WORLD THERMAL MANAGEMENT REVENUE BY APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	17
<i>FIGURE 4 WORLD THERMAL MANAGEMENT REVENUE BY APPLICATION, 2002, 2003 AND 2008 (\$ MILLIONS)</i>	17
COMPUTER	18
<i>TABLE 4 WORLD THERMAL MANAGEMENT REVENUE – COMPUTER APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	18
TELECOM	19
<i>TABLE 5 WORLD THERMAL MANAGEMENT REVENUE – TELECOM APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	19
Telecom and Network Industry Challenges	19
Telecom and Network Industry Challenges (Continued)	20
Telecom and Network Industry Challenges (Continued)	21
Telecom and Network Industry Challenges (Continued)	22
Telecom and Network Industry Challenges (Continued)	23
AUTOMOTIVE.....	24
<i>TABLE 6 WORLD THERMAL MANAGEMENT REVENUE – AUTOMOTIVE APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	24
Automotive (Continued)	25
CONSUMER.....	26
<i>TABLE 7 WORLD THERMAL MANAGEMENT REVENUE – CONSUMER APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	26
MEDICAL/OFFICE EQUIPMENT	26
<i>TABLE 8 WORLD THERMAL MANAGEMENT REVENUE – MEDICAL/OFFICE APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	26
INDUSTRIAL/MILITARY	27
<i>TABLE 9 WORLD THERMAL MANAGEMENT REVENUE – INDUSTRIAL/MILITARY APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	27
ENVIRONMENTAL AND REGULATORY FACTORS IN THERMAL MANAGEMENT	28
THERMAL MANAGEMENT – TECHNOLOGY DISCUSSION	29
EFFECTIVE THERMAL DESIGN FOR ELECTRONIC SYSTEMS.....	29
Concept Development.....	30
Concept Development Phase Thermal Tools	30
Detailed Design	31
Detailed Design Phase Thermal Tools.....	31
Hardware Test	31
Hardware Test Phase Thermal Tools	31
THERMAL MANAGEMENT TECHNICAL PROPERTIES	32
THERMAL CONDUCTIVITY.....	32
<i>TABLE 10 THERMAL PROPERTIES OF MATERIALS</i>	33
Composites	33

<i>TABLE 11 METAL MATRIX COMPOSITES</i>	34
Ceramics	34
Alumina (Al ₂ O ₃)	35
Aluminum Nitride (AlN).....	35
Silicon Carbide (SiC).....	36
Aluminum Silicon Carbide (AlSiC)	36
Beryllium (BeO)	36
Other Thermal Management Materials.....	37
Conductors	37
LOW TEMPERATURE ELECTRONIC COOLING.....	38
Low Temperature Electronic Cooling (Continued)	39
PACKAGING: DESIGNING FOR THERMAL PERFORMANCE	40
Packaging: Designing for Thermal Performance (Continued)	41
IMPORTANCE OF THERMAL TEST DIES	42
HIGH PERFORMANCE THERMAL MANAGEMENT MATERIALS	43
High Performance Thermal Management Materials (Continued)	44
High Performance Thermal Management Materials (Continued)	45
THERMAL MANAGEMENT OF OUTDOOR ENCLOSURES.....	46
Thermal Management of Outdoor Enclosures (Continued).....	47
FUTURE TRENDS IN THERMAL MANAGEMENT.....	48
INNOVATION – A THERMAL MANAGEMENT ESSENTIAL	49
Thermally Conductive Polymers.....	50
Customization	51
THERMALLY INSULATED AUTOMOBILES.....	52
Thermally Insulated Automobiles (Continued).....	53
SYSTEM LEVEL COOLING SOLUTION FOR CELLULAR PHONES	54
THERMOELECTRIC COOLERS IN MODULE COOLING ENHANCEMENT	54
SIGNIFICANCE IN CONTEMPORARY DATA CENTERS	55
THERMAL-ACOUSTIC TRADEOFF IN MODERN SYSTEMS.....	56
Thermal-Acoustic Tradeoff in Modern Systems (Continued)	57
CASE STUDY: COOLING A FLAT TV MONITOR.....	58
System Risk Assessment.....	58
Module Risk Assessment.....	59
Sub-Module and Components Assessment.....	59
Testing.....	60
VALVELESS FLUID PUMP FOR COOLING	60
THERMAL SOLUTIONS FOR PORTABLE COMPUTERS.....	60
Thermal Solutions for Portable Computers (Continued).....	61

LATEST UPDATES	62
Thermal Cooling as a Crucial Design Factor	62
Thermal Cooling as a Crucial Design Factor (Continued)	63
Thermal Cooling as a Crucial Design Factor (Continued)	64
THERMAL MANAGEMENT PRODUCT CATEGORIES	65
PRODUCT SUMMARY MARKET OVERVIEW.....	65
PRODUCT SUMMARY FORECASTS	66
TABLE 12 GLOBAL THERMAL MANAGEMENT REVENUE BY PRODUCT CATEGORIES, THROUGH 2008 (\$ MILLIONS).....	66
FIGURE 5 GLOBAL THERMAL MANAGEMENT REVENUE BY PRODUCT CATEGORIES, 2002, 2003 AND 2008 (\$ MILLIONS).....	67
THERMAL MANAGEMENT HARDWARE	68
WORLDWIDE MARKET FORECAST	68
TABLE 13 GLOBAL THERMAL MANAGEMENT HARDWARE REVENUES, THROUGH 2008 (\$ MILLIONS).....	69
GLOBAL AND REGIONAL TRENDS FOR THERMAL MANAGEMENT HARDWARE	69
TABLE 14 THERMAL MANAGEMENT HARDWARE REVENUE BY REGION, THROUGH 2008 (\$ MILLIONS).....	70
THERMAL MANAGEMENT HARDWARE END-USE APPLICATION TRENDS	70
TABLE 15 GLOBAL THERMAL MANAGEMENT HARDWARE REVENUE BY APPLICATION, THROUGH 2008 (\$ MILLIONS).....	71
THERMAL MANAGEMENT HARDWARE SUB-PRODUCT CATEGORIES	71
TABLE 16 GLOBAL THERMAL MANAGEMENT HARDWARE REVENUE BY SUB- PRODUCTS, THROUGH 2008 (\$ MILLIONS).....	71
FIGURE 6 GLOBAL THERMAL MANAGEMENT HARDWARE REVENUE BY SUB- PRODUCTS, 2002, 2003 AND 2008 (\$ MILLIONS).....	72
Fans and Blowers: Overview.....	72
Fans and Blowers: Overview (Continued)	73
Fans and Blowers: Overview (Continued)	74
TABLE 17 GLOBAL THERMAL MANAGEMENT FANS AND BLOWERS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)	75
Heat Sinks: Overview	75
TABLE 18 GLOBAL THERMAL MANAGEMENT HEAT SINKS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)	76
Fan Sinks: Overview	76
Fan Sinks: Overview (Continued)	77
TABLE 19 GLOBAL THERMAL MANAGEMENT FAN SINKS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)	78
Heat Pipes: Overview	78
Heat Pipes: Overview (Continued).....	79
TABLE 20 GLOBAL THERMAL MANAGEMENT HEAT PIPES END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)	80

Cold Plates: Overview	80
Cold Plates: Overview (Continued)	81
<i>TABLE 21 GLOBAL THERMAL MANAGEMENT COLD PLATES END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	82
Thermoelectric Coolers: Overview	82
Thermoelectric Coolers: Overview (Continued).....	83
<i>TABLE 22 GLOBAL THERMAL MANAGEMENT THERMO-ELECTRIC COOLERS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	84
TECHNOLOGY TRENDS IN THERMAL MANAGEMENT	
HARDWARE	84
Thermoelectric Coolers – The Technical Angle	85
Fan Selection Issues	86
Steps to Fan Selection	87
Estimate the Required Airflow	87
Estimate the Actual Airflow	88
Consider Multiple Fans	88
Tube-Axial Fan Designs – Primary Overview.....	88
Comparison Techniques	89
Fan Pricing	89
Fan Design.....	89
Reliability.....	90
Mechanical Attachment.....	90
Adhesive Attachment.....	91
Repair	91
Heat Pipes – The Technical Angle	92
Heat Pipes – The Technical Angle (Continued).....	93
Pulsating Heat Pipes	94
Pulsating Heat Pipes (Continued).....	95
Increasing Area.....	96
Dissipation and Materials.....	97
FUTURE TRENDS IN THERMAL MANAGEMENT	
HARDWARE	97
Controlling Fan Speeds	97
Fan-Monitoring Options	98
Methods of Speed Control.....	99
Methods of Speed Control (Continued)	100
Synchronizing Fans	101
Expanded Arsenal of Heat Sink Options.....	101
Expanded Arsenal of Heat Sink Options (Continued)	102
Expanded Arsenal of Heat Sink Options (Continued)	103
Expanded Arsenal of Heat Sink Options (Continued)	104

Expanded Arsenal of Heat Sink Options (Continued)	105
Expanded Arsenal of Heat Sink Options (Continued)	106
Latest Updates.....	107
Blowers Raise the Cooling Bar for Pressure.....	107
Fan Is Cool Solution Under Pressure	107
Blower for Office Automation Kit.....	107
Cooling Specialist Targets Automotive Sector	108
Fan for High-Density Applications	108
Diagonal Venturi Fans Provide Compact Cooling.....	108
Easy Installation for CPU Cooler.....	109
Backward Curved Impellers Boost Blower Flow	109
Paddle Impeller Boosts Airflow and Lowers Noise	109
Chip Cooler Keeps Low Profile Onboard	110
Brushless Motors Help Blowers Run Smoothly.....	110
Impeller Design Boosts Blower Airflow	111
Fans for Automotive Duties	111
Airflow Detector Keeps Fans Functioning Freely	111
Master-Slave System for Uniform Cooling	112
Miniature Blower Reduces Height and Weight.....	112
Panther Provides Silent Solution.....	112
Sealed Fans Operate Reliably in Harsh Environments	113
Low-Profile Fan Provides High Pressure And Flow.....	113
NetworkAIR Rm Air Distribution Unit: CPU Cooler Takes On Intel Xeon Processors	114
Blower Performs Under Pressure	114
THERMAL MANAGEMENT SOFTWARE	114
WORLDWIDE MARKET FORECAST	115
<i>TABLE 23 GLOBAL THERMAL MANAGEMENT SOFTWARE REVENUES, THROUGH 2008 (\$ MILLIONS).....</i>	<i>116</i>
GLOBAL AND REGIONAL TRENDS FOR THERMAL MANAGEMENT SOFTWARE	117
<i>TABLE 24 THERMAL MANAGEMENT SOFTWARE REVENUE BY REGION, THROUGH 2008 (\$ MILLIONS).....</i>	<i>117</i>
THERMAL MANAGEMENT SOFTWARE END-USE APPLICATION TRENDS	117
<i>TABLE 25 GLOBAL THERMAL MANAGEMENT SOFTWARE REVENUE BY APPLICATION, THROUGH 2008 (\$ MILLIONS).....</i>	<i>118</i>
<i>FIGURE 7 GLOBAL THERMAL MANAGEMENT SOFTWARE REVENUE BY APPLICATION, 2002, 2003 AND 2008 (\$ MILLIONS).....</i>	<i>118</i>
<i>TABLE 26 ANALYSIS OF COMPUTER APPLICATIONS TRENDS, 2003 AND 2008 (%)</i>	<i>119</i>
Thermal Management Software End-use Application Trends (Continued)	120
How to Use Parametric Features in Thermal Software	121

THERMAL MANAGEMENT SOFTWARE SUB-PRODUCT CATEGORIES	122
TABLE 27 GLOBAL THERMAL MANAGEMENT SOFTWARE REVENUE BY SUB-PRODUCTS, THROUGH 2008 (\$ MILLIONS).....	122
CFD: Overview.....	122
TABLE 28 GLOBAL THERMAL MANAGEMENT CFD END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	123
CHT: Overview	123
TABLE 29 GLOBAL THERMAL MANAGEMENT CHT END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	124
Circuit Design: Overview	124
TABLE 30 GLOBAL THERMAL MANAGEMENT CIRCUIT DESIGN END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	125
Power Management: Overview	125
TABLE 31 GLOBAL THERMAL MANAGEMENT POWER MANAGEMENT END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	126
Other Software Overview	126
TABLE 32 GLOBAL THERMAL MANAGEMENT OTHER SOFTWARE END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	127
TECHNOLOGY TRENDS IN THERMAL MANAGEMENT SOFTWARE	127
Virtual Prototyping Becoming More Popular than Ever	127
Geometry Creation.....	128
Meshing.....	128
Solving.....	128
Post-Processing	129
The Essential Modeling Process.....	129
Examine Overall Airflow.....	129
Model at the Component Level	129
Simulate Thermal Performance	129
Move Towards Standardized Thermal Models.....	130
Move Towards Standardized Thermal Models (Continued)	131
Graphical Simulation	132
Design Turnaround	132
Electronics Industry Influence.....	133
FUTURE TRENDS IN THERMAL MANAGEMENT SOFTWARE	133
Power Consumption As a Driver.....	134
Power Consumption As a Driver (Continued)	135
Power Consumption As a Driver (Continued)	136
Improving Productivity in Electronic Packaging with Flow Network Modeling.....	137
Improving Productivity ... Flow Network Modeling (Continued)	138

Improving Productivity ... Flow Network Modeling (Continued)	139
Improving Productivity ... Flow Network Modeling (Continued)	140
Computing Platform Developments.....	141
Downloadable Libraries	141
On-Line Characterization	142
Greater Computational Accuracy	142
Object Orientation	143
Simplest Models Form Best Designs	143
Tips to Use Cooling Software	144
Tips to Use Cooling Software (Continued).....	145
Latest Updates.....	146
Software Sorts Out Enclosure Cooling.....	146
Eldon Signs Up for Cool Solutions	146
Software Takes Control of Equipment Cooling	147
New Facility Dedicated to Thermal Management	147
THERMAL MANAGEMENT INTERFACE	147
WORLDWIDE MARKET FORECAST	148
TABLE 33 GLOBAL THERMAL MANAGEMENT INTERFACE REVENUES, THROUGH 2008 (\$ MILLIONS).....	148
GLOBAL AND REGIONAL TRENDS FOR THERMAL MANAGEMENT INTERFACE	148
TABLE 34 THERMAL MANAGEMENT INTERFACE REVENUE BY REGION, THROUGH 2008 (\$ MILLIONS).....	149
THERMAL MANAGEMENT INTERFACE END-USE APPLICATION TRENDS	149
TABLE 35 GLOBAL THERMAL MANAGEMENT INTERFACE REVENUE BY APPLICATION, THROUGH 2008 (\$ MILLIONS).....	150
FIGURE 8 GLOBAL THERMAL MANAGEMENT INTERFACE REVENUE BY APPLICATION, 2002, 2003 AND 2008 (\$ MILLIONS).....	151
THERMAL MANAGEMENT INTERFACE SUB-PRODUCT CATEGORIES	152
TABLE 36 GLOBAL THERMAL MANAGEMENT INTERFACE REVENUE BY SUB- PRODUCTS, THROUGH 2008 (\$ MILLIONS).....	153
Thermal Grease: Overview	153
TABLE 37 GLOBAL THERMAL GREASE END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	154
Thermal Compound: Overview	154
TABLE 38 GLOBAL THERMAL COMPOUND END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	155
Thermal Pads: Overview	155
TABLE 39 GLOBAL THERMAL PADS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS).....	156
Adhesive Film and Tape: Overview	156
TABLE 40 GLOBAL THERMAL MANAGEMENT ADHESIVE FILM AND TAPE END- USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)	157

Epoxy: Overview	157
<i>TABLE 41 GLOBAL THERMAL MANAGEMENT EPOXY END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	158
TECHNOLOGY TRENDS IN THERMAL MANAGEMENT	
INTERFACE	158
Interface Materials – The Technical Angle	159
Interface Materials – The Technical Angle (Continued)	160
Increased Contact	161
Phase Change Materials	162
Automated Assembly	162
Gap Filling	163
<i>TABLE 42 EXAMPLES OF THERMAL INTERFACE PROPERTIES</i>	164
FUTURE TRENDS IN THERMAL MANAGEMENT	
INTERFACE	165
Growing Importance of Interface Technologies.....	165
Optimal Attachment Methods	166
Optimal Attachment Methods (Continued)	167
Optimal Attachment Methods (Continued)	168
Disk Drive Reliability and Thermal Management.....	169
Latest Updates.....	170
Conductive Thermal Interface Tape Aids Cooling	170
Interface Materials Bridge the Thermal Gap	170
Gap Fillers Provide Thermal Relief	171
Air Distribution Unit Keeps Racks Cooler	172
Thermal Tape Sticks Sinks to Plastic BGAs	172
THERMAL MANAGEMENT SUBSTRATE	173
WORLDWIDE MARKET FORECAST	173
<i>TABLE 43 GLOBAL THERMAL MANAGEMENT SUBSTRATE REVENUES, THROUGH 2008 (\$ MILLIONS)</i>	173
GLOBAL AND REGIONAL TRENDS FOR THERMAL	
MANAGEMENT SUBSTRATE.....	173
<i>TABLE 44 THERMAL MANAGEMENT SUBSTRATE REVENUE BY REGION, THROUGH 2008 (\$ MILLIONS)</i>	174
THERMAL MANAGEMENT SUBSTRATE END-USE	
APPLICATION TRENDS	174
<i>TABLE 45 GLOBAL THERMAL MANAGEMENT SUBSTRATE REVENUE BY APPLICATION, THROUGH 2008 (\$ MILLIONS)</i>	175
<i>FIGURE 9 GLOBAL THERMAL MANAGEMENT SUBSTRATE REVENUE BY APPLICATION, 2002, 2003 AND 2008 (\$ MILLIONS)</i>	175
Thermal Management Substrate ... Trends (Continued)	176
THERMAL MANAGEMENT SUBSTRATE SUB-PRODUCT	
CATEGORIES	177
<i>TABLE 46 GLOBAL THERMAL MANAGEMENT SUBSTRATE REVENUE BY SUB-PRODUCTS, THROUGH 2008 (\$ MILLIONS)</i>	178
Thermally-Enhanced Packages: Overview	178

Thermally-Enhanced Packages: Overview (Continued)	179
<i>TABLE 47 GLOBAL THERMALLY-ENHANCED PACKAGES END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	180
Heat Spreader: Overview	180
<i>TABLE 48 GLOBAL THERMAL MANAGEMENT HEAT SPREADERS END-USE APPLICATIONS, THROUGH 2008 (\$ MILLIONS)</i>	181
TECHNOLOGY TRENDS IN THERMAL MANAGEMENT	
SUBSTRATE	181
Technology Trends in Thermal Management Substrate (Continued)	182
FUTURE TRENDS IN THERMAL MANAGEMENT	
SUBSTRATE	183
Advanced IC Technologies	183
Alternative to Bulk Heat Sinks	184
Latest Updates	185
Thermally - Enhanced Version of PBGA Package from STATS	185
International Rectifier's Solution Reduces Space and Cost	185
Two-Phase Flow Cooling in High-Power Electronics	185
Graftech Develops Natural Graphite Heat Spreader....	186
 THERMAL MANAGEMENT MARKET SHARES AND COMPANY	
PROFILES	187
TOTAL THERMAL MANAGEMENT INDUSTRY MARKET SHARES	187
<i>TABLE 49 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT MARKET, 2001 AND 2002 (\$ MILLIONS)</i>	188
<i>FIGURE 10 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT MARKET, 2002 (%)</i>	188
THERMAL MANAGEMENT HARDWARE	189
MARKET SHARES	189
<i>TABLE 50 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT HARDWARE MARKET, 2001 AND 2002 (\$ MILLIONS)</i>	189
<i>FIGURE 11 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT HARDWARE MARKET, 2002 (%)</i>	190
COMPANY PROFILES	191
Aavid Thermal Technologies	191
New Developments	192
Air Filtration Products	192
Alcoa	192
New Developments	193
Alpha Technologies Group	193
New Developments	194
AMETEK, Inc	194
New Developments	194
Calmark Corp	195

Ceramics Process Systems (CPS).....	195
New Developments	196
CMC Electronics Cincinnati (Cincinnati Electronics)	196
Comair Rotron	197
New Developments	197
Control Resources.....	198
New Developments	198
Cool Innovations	199
CTS Electronics	199
New Developments	199
Dow Corning	200
New Developments	200
DuPont De Nemours and Company.....	201
New Developments	201
Dynatron	202
Eastern Air Devices (EAD).....	202
New Developments	202
EBM	203
New Developments	203
EME Fan & Motor (Sunon)	203
New Developments	204
ERM	204
New Developments	204
ETRI	205
New Developments	205
Hoffman Engineering	205
New Developments	206
Indek	206
New Developments	207
ITW Vortec.....	207
New Developments	207
Keats Manufacturing	207
Knürr.....	208
New Developments	208
Kooltronic.....	209
New Developments	209
Kyocera.....	209
New Developments	210
Liebert.....	210
New Developments	210
Lockhart.....	211
Lytron.....	211
New Developments	212
MELCOR-Materials Electronic Products	212

New Developments	212
Micronel	213
NMB	213
New Developments	213
Noren Products	214
Operating Technical Electronics	214
New Developments	214
PC Power & Cooling	214
Pfannenberg	215
New Developments	215
IGC-Polycold Systems	215
New Developments	216
Precision Extrusions	216
New Developments	216
PressCut Industries	217
Qualtek Electronics	217
Quest Engineering	217
New Developments	218
Raytheon	218
New Developments	218
Rittal Corporation	218
Sumitomo	219
Tellurex	219
TelTec	219
New Developments	220
TennMax	220
Thermacore	220
New Developments	221
Thermagon	221
New Developments	221
U.S. Toyo Fan Corp	221
Unitrack Industries	222
THERMAL MANAGEMENT SOFTWARE	222
MARKET SHARES	222
<i>TABLE 51 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT SOFTWARE</i>	
<i>MARKET, 2001 AND 2002 (\$ MILLIONS).....</i>	<i>223</i>
<i>FIGURE 12 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT SOFTWARE</i>	
<i>MARKET, 2002 (%).....</i>	<i>223</i>
COMPANY PROFILES	224
Aavid Thermal Technologies	224
New Developments	225
ACUSIM Software	225
New Developments	226
Advanced Thermal Solutions	226
Ansoft	227

New Developments	227
ANSYS	228
New Developments	228
APW	229
New Developments	230
Daat Research.....	230
New Developments	231
Degree Controls	231
New Developments	231
Dynamic Soft Analysis	231
New Developments	232
Enertron.....	232
New Developments	232
Flomerics.....	233
New Developments	233
Fluent.....	234
New Developments	235
Harvard Thermal.....	235
New Developments	236
Netzsch Thermal Analysis	236
New Developments	236
ICEM CFD	237
New Developments	237
Intricast.....	237
New Developments	238
Isothermal Systems Research (ISR)	238
Lytron.....	238
New Developments	239
Mentor Graphics	239
New Developments	239
MSC Software	239
New Developments	240
Parametric Technology.....	240
New Developments	240
PEI Technologies - Thermal Management Research Center	241
Synopsys.....	241
New Developments	241
Transoft.....	242
Wyle Laboratories.....	242
New Developments	243
THERMAL MANAGEMENT INTERFACE	243
MARKET SHARES	243
<i>TABLE 52 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT INTERFACE MARKET, 2001 AND 2002 (\$ MILLIONS).....</i>	<i>243</i>

FIGURE 13 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT

INTERFACE MARKET, 2002 (\$ MILLIONS).....	244
COMPANY PROFILES.....	245
AI Technology	245
New Developments	245
Alpha Metals.....	246
New Developments	246
Bergquist.....	247
New Developments	247
Carborundum.....	248
New Developments	248
Ceramx Ceramaseal	248
New Developments	249
Chomerics (Division Of Parker Hannifin)	249
New Developments	250
CMW	250
Dow Corning	251
New Developments	251
DuPont De Nemours and Company.....	252
New Developments	252
Electro-Science Laboratories.....	252
Epoxy Technology	253
Evox Rifa	253
New Developments	253
GE Specialty Materials	254
New Developments	254
Heraeus.....	254
New Developments	255
II-VI Inc.....	255
JARO Components	255
New Developments	256
Johnson Matthey	256
New Developments	257
Lord Chemical Products	257
New Developments	257
Luxtron.....	257
New Developments	258
Master Bond.....	258
New Developments	258
Mathis Instruments.....	259
Metal Matrix Cast Composites	259
NTK Technical Ceramics	259
ORCUS.....	260
Panasonic Industrial	260
New Developments	260

Polese Company.....	261
Power Devices	261
New Developments	261
Raytheon	262
New Developments	262
R-Theta	262
New Developments	263
Saxonburg Ceramics (SCI).....	263
SEMIX Microelectronic Packaging Group	264
New Developments	264
Tech Spray	264
New Developments	265
W.L. Gore & Associates	265
Wakefield Engineering.....	265
WESGO Inc.....	266
New Developments	266
THERMAL MANAGEMENT SUBSTRATE	266
MARKET SHARES	266
<i>TABLE 53 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT SUBSTRATE</i> <i>MARKET, 2001 AND 2002 (\$ MILLIONS).....</i>	<i>267</i>
<i>FIGURE 14 TOP FIVE VENDORS – GLOBAL THERMAL MANAGEMENT</i> <i>SUBSTRATE MARKET, 2002 (%)</i>	<i>267</i>
COMPANY PROFILES.....	268
Aavid Thermal Technologies.....	268
New Developments	269
Amkor Electronics	269
New Developments	270
ASAT	270
New Developments	271
Brush Engineered Materials.....	271
New Developments	271
ChipPAC	272
New Developments	272
Cooler Master.....	273
New Developments	273
Diamonex	273
Fujikura	274
Hybricon.....	274
New Developments	274
Ibis Technology	275
New Developments	275
Isonics	276
New Developments	276
Lord Chemical Products	276
New Developments	276

Marlow	277
New Developments	277
OSE	277
Transene	278
Vishay	278
New Developments	278
New Developments (Continued)	279
 PATENTS.....	 280
OVERVIEW.....	280
TABLE 54 NUMBER OF U.S. THERMAL MANAGEMENT PATENTS, 2000-2003*	280
TABLE 55 TOP U.S. THERMAL MANAGEMENT PATENT ASSIGNEES, 2000-2003.....	281
THERMAL MANAGEMENT PATENTS 2000-2003	281
Patents: Thermal Management Hardware	281
Patents: Thermal Management Hardware (Continued)	282
Patents: Thermal Management Hardware (Continued)	283
Patents: Thermal Management Hardware (Continued)	284
Patents: Thermal Management Hardware (Continued)	285
Patents: Thermal Management Hardware (Continued)	286
Patents: Thermal Management Hardware (Continued)	287
Patents: Thermal Management Hardware (Continued)	288
Patents: Thermal Management Hardware (Continued)	289
Patents: Thermal Management Hardware (Continued)	290
Patents: Thermal Management Hardware (Continued)	291
Patents: Thermal Management Hardware (Continued)	292
Patents: Thermal Management Hardware (Continued)	293
Patents: Thermal Management Hardware (Continued)	294
Patents: Thermal Management Hardware (Continued)	295
Patents: Thermal Management Hardware (Continued)	296
Patents: Thermal Management Software	297

Patents: Thermal Management Software (Continued)	298
Patents: Thermal Management Software (Continued)	299
Patents: Thermal Management Software (Continued)	300
Patents: Thermal Management Software (Continued)	301
Patents: Thermal Management Interface	302
Patents: Thermal Management Interface (Continued)	303
Patents: Thermal Management Interface (Continued)	304
Patents: Thermal Management Interface (Continued)	305
Patents: Thermal Management Interface (Continued)	306
Patents: Thermal Management Interface (Continued)	307
Patents: Thermal Management Interface (Continued)	308
Patents: Thermal Management Interface (Continued)	309
Patents: Thermal Management Interface (Continued)	310
Patents: Thermal Management Interface (Continued)	311
Patents: Thermal Management Substrate	312
Patents: Thermal Management Substrate (Continued)	313
Patents: Thermal Management Substrate (Continued)	314
Patents: Thermal Management Substrate (Continued)	315