

CHAPTER ONE: INTRODUCTION.....	1
STUDY GOALS AND OBJECTIVES.....	1
REASONS FOR DOING THIS STUDY	1
INTENDED AUDIENCE.....	2
SCOPE OF REPORT	3
METHODOLOGY AND INFORMATION SOURCES.....	4
RELATED BCC RESEARCH STUDIES	5
ANALYST CREDENTIALS.....	6
BCC ONLINE SERVICES.....	6
DISCLAIMER	7
 CHAPTER TWO: SUMMARY.....	 8
SUMMARY.....	8
<i>SUMMARY TABLE GLOBAL MARKET FOR PAPER-THIN DISPLAYS, THROUGH 2015 (\$ MILLIONS)</i>	9
<i>SUMMARY FIGURE GLOBAL MARKET FOR PAPER-THIN DISPLAYS, 2008-2015 (\$ MILLIONS)</i>	9
 CHAPTER THREE: OVERVIEW	 10
INTRODUCTION	10
THE DISPLAY INDUSTRY.....	10
<i>TABLE 1 ADVANCED DISPLAY TECHNOLOGIES</i>	10
<i>FIGURE 1 THE ADVANCED DISPLAY INDUSTRY: GLOBAL MARKET SHARE BY TECHNOLOGY, 2010 (%)</i>	11
HISTORY OF PAPER-THIN DISPLAYS AND RECENT EVENTS	12
<i>TABLE 2 ADVANCED DISPLAYS—TECHNOLOGICAL MILESTONES</i>	12
<i>TABLE 2 (CONTINUED)</i>	13
<i>TABLE 2 (CONTINUED)</i>	14
<i>TABLE 2 (CONTINUED)</i>	15
<i>FIGURE 2 PAPER-THIN DISPLAYS—WORLDWIDE PATENT APPLICATIONS AND PATENTS ISSUED, 1995–2010</i>	16
PAPER-THIN DISPLAYS: TYPES, MATERIALS, AND FABRICATION METHODS.....	16
RIGID AND FLEXIBLE DISPLAYS	16
Rigid Displays.....	16
Flexible Displays	17
MANUFACTURING TECHNOLOGIES.....	17
LIQUID CRYSTAL DISPLAYS	18
Transmissive, Reflective, and Transflective LCDs	18
Basic LCD Configuration	19
Passive Matrix LCDs.....	20
Twisted and Super-Twisted Nematic.....	20
Active Matrix LCDs.....	20
In-Plane Switching	20

Advanced Fringe-Field Switching	21
Vertical Alignment.....	21
Ferroelectric Liquid Crystals	21
Cholesteric LCDs	21
Blue Phase Mode.....	22
Bistable LCDs	22
LCD Technologies for Paper-Thin Displays	22
POLYMER-DISPERSED LIQUID CRYSTAL DISPLAYS.....	23
Encapsulation	23
Phase Separation.....	23
Holography.....	24
Prefabricated Templates	24
SUSPENDED PARTICLE DISPLAYS.....	24
ELECTROCHROMIC DISPLAYS	25
Electrochromic Materials	25
Tungsten Oxide-based Electrochromic Devices.....	26
Features of Electrochromic Devices.....	26
THERMOCHROMIC DISPLAYS	27
ELECTROPHORETIC DISPLAYS.....	27
Basic Design.....	27
Microcapsule Design.....	28
Main Characteristics of Electrophoretic Displays.....	29
TWISTING BALL DISPLAYS	29
ORGANIC LIGHT-EMITTING DIODE DISPLAYS.....	29
Basic Design.....	29
Characteristics of OLED Displays	30
Electronics on Plastic by Laser Release	30
MEMS DISPLAYS.....	31
ELECTROWETTING DISPLAYS	31
Basic Design.....	32
Characteristics of Electrowetting Displays	32
ELECTROMAGNETIC DISPLAYS.....	32
PHOTONIC CRYSTAL DISPLAY	33
CURRENT AND EMERGING APPLICATIONS FOR PAPER-THIN DISPLAYS	33
<i>TABLE 3 CURRENT AND EMERGING APPLICATIONS OF PAPER- THIN DISPLAYS.....</i>	<i>34</i>
SIGNS AND DISPLAYS FOR ADVERTISING	34
PRICE TAGS AND SMART LABELS	34
TV MONITORS	35
ELECTRONIC PORTABLE DEVICES.....	35
<i>TABLE 4 ELECTRONIC PORTABLE DEVICES USING PAPER-THIN DISPLAYS.....</i>	<i>35</i>
SECURITY AND SAFETY DEVICES.....	36

AUTOMOTIVE DISPLAYS	36
HEALTHCARE DEVICES.....	36
OTHER PRODUCTS.....	36
CHAPTER FOUR: GLOBAL MARKET.....	37
ANALYSIS OUTLINE	37
GLOBAL MARKET SUMMARY	38
TABLE 5 GLOBAL MARKET FOR PAPER-THIN DISPLAYS, THROUGH 2015 (\$ MILLIONS).....	39
FIGURE 3 GLOBAL MARKET FOR PAPER-THIN DISPLAYS, 2008- 2015 (\$ MILLIONS).....	39
THE MARKET FOR PAPER-THIN DISPLAYS	40
INTRODUCTION.....	40
CURRENT TECHNICAL ISSUES	40
Lightweight and Small Size	40
Reliability and Legibility.....	40
Flexibility	40
Image Retention	41
Cost.....	41
LATEST TECHNOLOGICAL DEVELOPMENTS, 2008 TO PRESENT.....	41
Electrophoretic Display for Roll-to-Roll Manufacturing.....	41
Carbon Nanotube Display	42
Quantum Dot Display.....	43
Flexible Display Utilizing a Gaseous Phase.....	44
In-Plane Switching Electrophoretic Color Display	45
Smectic LCDs.....	46
Smectic LCDs (Continued)	47
Electrofluidic Display	48
Electrofluidic Display (Continued).....	49
CURRENT MARKET STATUS	50
Current Market Summary	50
TABLE 6 GLOBAL MARKET FOR PAPER-THIN DISPLAYS, THROUGH 2010 (\$ MILLIONS).....	51
Revenues by Display Type	51
TABLE 7 PAPER-THIN DISPLAYS: GLOBAL REVENUES BY TYPE, 2010 (\$ MILLIONS/%).....	52
FIGURE 4 PAPER-THIN DISPLAYS: MARKET SHARE BY TYPE, 2010 (%).....	52
Revenues by Application	53
TABLE 8 PAPER-THIN DISPLAYS: GLOBAL REVENUES BY APPLICATION, 2010 (\$ MILLIONS/%).....	53
FIGURE 5 PAPER-THIN DISPLAYS: MARKET SHARE BY APPLICATION, 2010 (%)	54
Revenues by Region.....	54

<i>TABLE 9 PAPER-THIN DISPLAY: REVENUES BY REGION, THROUGH 2010 (\$ MILLIONS)</i>	55
<i>FIGURE 6 PAPER-THIN DISPLAYS: MARKET SHARE BY REGION, 2010 (%)</i>	56
MARKET GROWTH TRENDS.....	56
INDUSTRY GROWTH AND TECHNOLOGICAL TRENDS.....	57
Electronic Portable Devices.....	57
E-book Readers	57
Color E-book Readers	57
Flexible E-Readers	58
Tablet PCs	58
Cell Phones and Smartphones	59
Price Tags and Smart Labels	59
Signs and Displays for Advertising	59
TV Monitors	60
Automotive Displays.....	60
Safety and Security Devices.....	61
Healthcare Devices.....	61
<i>TABLE 10 FORECAST—DIAGNOSTIC KITS, MONITORING DEVICES, AND PORTABLE MEDICAL EQUIPMENT: GLOBAL REVENUES, 2010-2015 (\$ BILLIONS)</i>	61
Other Industry Segments.....	62
OTHER TECHNOLOGICAL TRENDS.....	62
REGIONAL TRENDS	62
PROJECTED PAPER-THIN DISPLAY MARKET.....	63
KEY OBSERVATIONS	63
<i>TABLE 11 FACTORS AFFECTING SALES OF PAPER-THIN DISPLAYS, THROUGH 2015</i>	63
<i>TABLE 11 (CONTINUED)</i>	64
MARKET FORECAST	64
Revenues by Application	64
<i>TABLE 12 FORECAST — PAPER-THIN DISPLAYS: GLOBAL REVENUES BY APPLICATION, THROUGH 2015 (\$ MILLIONS)</i>	65
<i>FIGURE 7 FORECAST — PAPER-THIN DISPLAYS: MARKET SHARE BY APPLICATION, 2015 (%)</i>	66
Revenues by Display Type	67
<i>TABLE 13 FORECAST—PAPER-THIN DISPLAYS: GLOBAL REVENUES BY TYPE, THROUGH 2015 (\$ MILLIONS)</i>	68
<i>FIGURE 8 FORECAST — PAPER-THIN DISPLAYS: GLOBAL MARKET SHARE BY TYPE, 2015 (%)</i>	68
Revenues by Region.....	69
<i>TABLE 14 FORECAST PAPER-THIN DISPLAYS: REVENUES BY REGION, 2010 THROUGH 2015 (\$ MILLIONS)</i>	69

<i>FIGURE 9 FORECAST—PAPER-THIN DISPLAYS: MARKET SHARE BY REGION, 2015 (%)</i>	70
CHAPTER FIVE: GLOBAL INDUSTRY STRUCTURE.....	71
GLOBAL INDUSTRY STRUCTURE.....	71
MANUFACTURERS AND DEVELOPERS OF PAPER-THIN DISPLAYS	72
<i>TABLE 15 MANUFACTURERS AND DEVELOPERS OF PAPER-THIN DISPLAYS</i>	72
<i>TABLE 15 (CONTINUED)</i>	73
<i>TABLE 15 (CONTINUED)</i>	74
<i>TABLE 16 GEOGRAPHICAL DISTRIBUTION OF KEY PLAYERS, 2010 (NUMBER OF COMPANIES)</i>	75
<i>FIGURE 10 MANUFACTURERS AND DEVELOPERS OF PAPER-THIN DISPLAYS: DISTRIBUTION BY SIZE (NUMBER OF COMPANIES)</i>	76
<i>FIGURE 11 HISTORICAL GROWTH OF PTD MANUFACTURERS AND DEVELOPERS (NUMBER OF COMPANIES)</i>	77
OTHER PLAYERS IN THE PAPER-THIN DISPLAY INDUSTRY	77
<i>TABLE 17 OTHER RELEVANT PLAYERS IN THE PAPER-THIN DISPLAY INDUSTRY</i>	78
PTD PRODUCTION BY REGION	78
<i>TABLE 18 PAPER-THIN DISPLAYS: MANUFACTURING BY REGION, 2008–2015 (PERCENT OF SALES)</i>	79
PTD CONSUMPTION BY REGION	79
<i>TABLE 19 PAPER-THIN DISPLAYS: CONSUMPTION BY REGION, 2008–2015 (PERCENT OF SALES)</i>	80
COMPANY PROFILES	80
ACREO/PAPERDISPLAY.....	80
AU OPTRONICS	81
AVESO	82
BRIDGESTONE	83
Bridgestone (Continued)	84
CHIMEI INNOLUX	85
CITALA.....	86
DAI NIPPON PRINTING	87
E INK HOLDINGS.....	88
E Ink Corporation.....	88
Acquisition of E Ink	89
FUJITSU	90
GPEG INTERNATIONAL	91
KENT DISPLAYS	92
LG DISPLAY	93
LG Display (Continued).....	94
NANOX.....	95
RIT DISPLAY	95

SAMSUNG MOBILE DISPLAY	96
SIPIX IMAGING	97
TDK.....	98
TOHOKU PIONEER.....	98
TRED DISPLAYS.....	99
VARITRONIX.....	99
VISIONOX.....	100
CHAPTER SIX: INDUSTRY COMPETITIVENESS.....	101
PTD DEVELOPMENT ACTIVITIES.....	101
<i>TABLE 20 ORGANIZATIONS INVOLVED IN PTD RESEARCH,</i>	
<i>WORLDWIDE</i>	101
<i>TABLE 20 (CONTINUED)</i>	102
<i>TABLE 20 (CONTINUED)</i>	103
<i>TABLE 20 (CONTINUED)</i>	104
<i>TABLE 20 (CONTINUED)</i>	105
UNITED STATES	106
Arizona State University.....	106
<i>TABLE 21 ASU RESEARCH</i>	107
FlexTech Alliance	107
<i>TABLE 22 FLEXTech ALLIANCE RESEARCH</i>	108
Massachusetts Institute of Technology	108
<i>TABLE 23 MIT RESEARCH</i>	109
Stanford University.....	109
<i>TABLE 24 STANFORD UNIVERSITY RESEARCH</i>	110
University of California at Los Angeles.....	111
<i>TABLE 25 UCLA RESEARCH</i>	111
University of Florida	111
<i>TABLE 26 UNIVERSITY OF FLORIDA RESEARCH</i>	112
<i>TABLE 26 (CONTINUED)</i>	113
EUROPE.....	113
Centre National de la Recherche Scientifique	113
<i>TABLE 27 CNRS RESEARCH</i>	114
Fraunhofer-Gesellschaft Institutes	114
<i>TABLE 28 FRAUNHOFER RESEARCH</i>	115
ASIA-PACIFIC	115
Industrial Technology Research Institute.....	115
<i>TABLE 29 ITRI RESEARCH</i>	116
Korea Advanced Institute of Science and Technology	116
<i>TABLE 30 KAIST RESEARCH</i>	117
Nanyang Technological University.....	118
<i>TABLE 31 NTU RESEARCH</i>	118
University of Tokyo	119
<i>TABLE 32 UNIVERSITY OF TOKYO RESEARCH</i>	119

SUMMARY OF GLOBAL R&D ACTIVITIES IN PTD TECHNOLOGY.....	119
FIGURE 12 CURRENT GLOBAL PTD RESEARCH AND DEVELOPMENT BY TYPE (%).....	120
FIGURE 12 (CONTINUED)	121
FIGURE 13 CURRENT GLOBAL PTD RESEARCH AND DEVELOPMENT BY SUBJECT (%).....	122
INDUSTRY INITIATIVES	122
OTHER CONSIDERATIONS.....	123
COST FACTOR	123
QUALITY FACTOR	123
TECHNOLOGY FACTOR.....	123
MANUFACTURING CAPABILITY	124
KEY GROWTH MARKETS	124
TABLE 33 GLOBAL GROWTH FORECAST FOR CURRENT AND POTENTIAL PTD APPLICATIONS, THROUGH 2015	125
Electronics.....	125
Automotive.....	125
Safety and Security	125
Healthcare.....	126
DRIVING FORCES AND THEIR IMPACT ON MARKET GROWTH	126
TABLE 34 PERCENTAGE IMPACT OF MAJOR COMPETITIVE FACTORS ON THE GROWTH OF THE PTD MARKET, 2010–2015.....	127
CHAPTER SEVEN: U.S. PATENT ANALYSIS.....	128
INTRODUCTION	128
SUMMARY OF PATENTS AWARDED DURING THE PERIOD 2007 THROUGH 2010.....	128
TABLE 35 PAPER-THIN DISPLAYS—U.S. PATENTS, 2010.....	129
TABLE 35 (CONTINUED).....	130
TABLE 35 (CONTINUED).....	131
TABLE 35 (CONTINUED).....	132
TABLE 35 (CONTINUED).....	133
TABLE 35 (CONTINUED).....	134
TABLE 36 PAPER-THIN DISPLAYS—U.S. PATENTS, 2009.....	134
TABLE 36 (CONTINUED).....	135
TABLE 36 (CONTINUED).....	136
TABLE 36 (CONTINUED).....	137
TABLE 36 (CONTINUED).....	138
TABLE 37 PAPER-THIN DISPLAYS—U.S. PATENTS, 2008.....	139
TABLE 37 (CONTINUED).....	140
TABLE 37 (CONTINUED).....	141
TABLE 38 PAPER-THIN DISPLAYS — U.S. PATENTS, 2007.....	141
TABLE 38 (CONTINUED).....	142

<i>TABLE 38 (CONTINUED)</i>	143
GENERAL TRENDS.....	143
<i>TABLE 39 PAPER-THIN DISPLAYS: U.S. PATENT TRENDS, 2007–</i>	
<i>2010</i>	144
<i>FIGURE 14 PAPER-THIN DISPLAYS: U.S. PATENT TRENDS, 2007–</i>	
<i>2010</i>	144
TRENDS BY COUNTRY AND REGION.....	145
<i>FIGURE 15 SHARES OF U.S. PATENTS RELATED TO PAPER-THIN</i>	
<i>DISPLAYS BY REGION, 2007–2010 (%)</i>	146
<i>FIGURE 16 PAPER-THIN DISPLAYS: PATENTS BY COUNTRY, 2007–</i>	
<i>2010 (%)</i>	147
TRENDS BY ASSIGNEE	148
<i>TABLE 40 ASSIGNEES OF U.S. PATENTS RELATED TO PAPER-THIN</i>	
<i>DISPLAYS, 2007–2010</i>	149
<i>TABLE 40 (CONTINUED)</i>	150
<i>FIGURE 17 PAPER-THIN DISPLAYS: SHARES OF U.S. PATENTS BY</i>	
<i>ORGANIZATION TYPE, 2007–2010 (%)</i>	151
TRENDS BY PATENT CATEGORY	152
<i>FIGURE 18 PAPER-THIN DISPLAYS: SHARES OF U.S. PATENTS BY</i>	
<i>CATEGORY, 2007–2010 (%)</i>	153
TRENDS BY APPLICATION	153
TRENDS BY APPLICATION (CONTINUED).....	154
<i>FIGURE 19 PAPER-THIN DISPLAYS: SHARES OF U.S. PATENTS BY</i>	
<i>APPLICATION, 2007–2010 (%)</i>	155
TRENDS BY DISPLAY TYPE.....	155
<i>FIGURE 20 PAPER-THIN DISPLAYS: SHARES OF U.S. PATENTS BY</i>	
<i>DISPLAY TYPE, 2007–2010 (%)</i>	156
<i>FIGURE 20 (CONTINUED)</i>	157