

OPTICAL SENSING: TECHNOLOGIES AND GLOBAL MARKETS



PHO021A
November 2015

Sinha G.
Project Analyst

ISBN: 1-62296-182-X



BCC Research
49 Walnut Park, Building 2
Wellesley, MA 02481 USA
866-285-7215 (toll-free within the USA),
or (+1) 781-489-7301
www.bccresearch.com
information@bccresearch.com

TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
STUDY GOALS AND OBJECTIVES	2
REASONS FOR DOING THE STUDY	2
SCOPE OF REPORT	2
INTENDED AUDIENCE	3
INFORMATION SOURCES	3
ANALYST'S CREDENTIALS	4
RELATED BCC RESEARCH REPORTS	4
BCC RESEARCH WEBSITE	4
DISCLAIMER	4
CHAPTER 2 SUMMARY	6
<i>SUMMARY TABLE GLOBAL MARKET FOR OPTICAL SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	7
<i>SUMMARY FIGURE GLOBAL MARKET FOR OPTICAL SENSORS BY INDUSTRY END USER, 2014-2020 (\$ MILLIONS)</i>	7
CHAPTER 3 OVERVIEW	9
MARKET DEFINITION AND EVOLUTION OF OPTICAL SENSORS	9
FUTURE OUTLOOK AND EXPECTATIONS	9
VALUE CHAIN	10
<i>FIGURE 1 VALUE CHAIN OF OPTICAL SENSORS</i>	10
IMPORTANT OPTICAL SENSORS PATENTS	12
OPTICAL SENSOR	12
MULTIFUNCTIONAL OPTICAL SENSOR UNIT	13
OPTICAL SENSOR	13
SENSOR	14
LIGHT SENSORS HAVING DIELECTRIC OPTICAL COATING FILTERS	15
NAVIGATION SYSTEM INCLUDING OPTICAL AND NON-OPTICAL SENSORS	15
IMAGE SENSOR BASED OPTICAL READER	16
OPTICAL LIQUID LEVEL SENSOR HAVING A PLURALITY OF OPTICAL FIBERS	17
SENSOR	17
OPTICAL GAS SENSOR	18
SUBSURFACE MOTORS WITH FIBER OPTIC SENSORS	19
PRINTER CONTROL USING OPTICAL AND ELECTROSTATIC SENSORS	19
PARALLEL MULTISENSOR OPTICAL PARTICLE SENSORS FOR FLOWING FLUID SYSTEMS	20
REFLECTIVE OPTICAL SENSOR AND IMAGE FORMING APPARATUS	21
SENSOR DEVICE	21
OPTICAL SENSORS FOR DETECTING RELATIVE MOTION AND/OR POSITION AND METHODS AND SYSTEMS FOR USING SUCH OPTICAL SENSORS	22
OPTICAL SENSOR AND IMAGE FORMING APPARATUS	22
REFLECTIVE ELEMENT FOR FIBER OPTIC SENSOR	23
ELECTROSURGICAL DEVICE INCLUDING AN OPTICAL SENSOR	24
OPTICAL SENSOR AND IMAGE FORMING APPARATUS	24
METHOD OF FABRICATING AN OPTICAL-FIBER-COMPATIBLE SENSOR	25

TOPIC	PAGE NO.
DIGITALLY SCANNED MULTI-CELL ELECTRO-OPTIC SENSOR	26
PROXIMITY SENSORS WITH OPTICAL AND ELECTRICAL SENSING CAPABILITIES	26
OPTICAL SENSOR HAVING A NON-NEGLIGIBLE SOURCE COHERENCE LENGTH	27
OPTICAL SENSOR INCLUDING DISPOSABLE AND REUSABLE ELEMENTS	28
ATTACHMENT FOR PLACEMENT ONTO AN OPTICAL SENSOR AND METHOD OF OPERATING AN OPTICAL SENSOR	28
TEMPERATURE SENSOR USING AN OPTICAL FIBER	29
OPTICAL-WAVEGUIDE SENSOR CHIP, METHOD OF MANUFACTURING THE SAME, METHOD OF MEASURING SUBSTANCE, SUBSTANCE-MEASURING KIT AND OPTICAL-WAVEGUIDE SENSOR	30
CMOS IMAGE SENSOR HAVING OPTICAL BLOCK AREA	30
OPTICAL SENSORS FOR DETECTING RELATIVE MOTION AND/OR POSITION AND METHODS AND SYSTEMS FOR USING SUCH OPTICAL SENSORS	31
OPTICAL SENSOR CONFIGURATION FOR RATIOMETRIC CORRECTION OF GLUCOSE MEASUREMENT	32
REFLECTION TYPE OPTICAL SENSOR AND IMAGE GENERATION APPARATUS	32
CHAPTER 4 OPTICAL SENSOR MARKET BY TYPE	35
INTRODUCTION	35
<i>FIGURE 2 OPTICAL SENSOR MARKET BY TYPE</i>	35
MARKET DYNAMICS	35
DRIVERS	35
Rising Penetration of Smartphones in Global Market	35
<i>FIGURE 3 GLOBAL SHIPMENTS OF SMARTPHONES, 2014-2019 (BILLIONS)</i>	36
Increase in Demand for High Bandwidth	36
RESTRAINTS	37
High Cost and Low Level of Automation of Fiber Optics	37
OPPORTUNITY	38
Technological Advancements	38
Growth of Optical Systems in Asia-Pacific Region	38
EXTRINSIC SENSORS	39
<i>TABLE 1 GLOBAL MARKET FOR EXTRINSIC SENSORS BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	39
<i>TABLE 2 GLOBAL MARKET FOR EXTRINSIC SENSORS BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	41
<i>FIGURE 4 GLOBAL MARKET FOR EXTRINSIC SENSORS BY APPLICATION, 2014-2020 (\$ MILLIONS)</i>	41
<i>TABLE 3 GLOBAL MARKET FOR EXTRINSIC SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	42
<i>FIGURE 5 GLOBAL MARKET FOR EXTRINSIC SENSORS BY INDUSTRY END USER, 2014-20200 (\$ MILLIONS)</i>	42
<i>TABLE 4 GLOBAL MARKET FOR EXTRINSIC SENSORS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	43
<i>FIGURE 6 GLOBAL MARKET FOR EXTRINSIC SENSORS BY REGION, 2014-2020 (\$ MILLIONS)</i>	43
INTRINSIC SENSORS	44
<i>TABLE 5 GLOBAL MARKET FOR INTRINSIC SENSORS BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	44

TOPIC	PAGE NO.
<i>TABLE 6 GLOBAL MARKET FOR INTRINSIC SENSORS BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	45
<i>FIGURE 7 GLOBAL MARKET FOR INTRINSIC SENSORS BY APPLICATION, 2014-2020 (\$ MILLIONS)</i>	45
<i>TABLE 7 GLOBAL MARKET FOR INTRINSIC SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	46
<i>FIGURE 8 GLOBAL MARKET FOR INTRINSIC SENSORS BY INDUSTRY END USER, 2014-2020 (\$ MILLIONS)</i>	46
<i>TABLE 8 GLOBAL MARKET FOR INTRINSIC SENSORS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	47
<i>FIGURE 9 GLOBAL MARKET FOR INTRINSIC SENSORS BY REGION, 2014-2020 (\$ MILLIONS)</i>	47
CHAPTER 5 OPTICAL SENSOR MARKET BY APPLICATION	50
INTRODUCTION	50
<i>FIGURE 10 OPTICAL SENSOR MARKET :APPLICATION</i>	50
MARKET DYNAMICS	50
DRIVERS	50
Increasing Adoption of MEMS Technology	50
Increasing Application of Fiber Optic Connectors in the Medical Sector	51
RESTRAINTS	51
Remarkable Growth of Wireless Networking Systems	51
OPPORTUNITIES	52
Increase in Demand for Optical Interconnects in Data Center Networks	52
MILITARY AND LAW ENFORCEMENT	52
<i>TABLE 9 GLOBAL MARKET FOR OPTICAL SENSORS IN MILITARY AND LAW ENFORCEMENT BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	53
<i>FIGURE 11 GLOBAL MARKET FOR OPTICAL SENSORS IN MILITARY AND LAW ENFORCEMENT BY REGION, 2014-2020 (\$ MILLIONS)</i>	53
NIGHT VISION CAMERAS	54
<i>TABLE 10 GLOBAL MARKET FOR OPTICAL SENSORS IN NIGHT VISION CAMERAS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	54
<i>FIGURE 12 GLOBAL MARKET FOR OPTICAL SENSORS IN NIGHT VISION CAMERAS BY REGION, 2014-2020 (\$ MILLIONS)</i>	54
BIOMETRICS	55
<i>TABLE 11 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOMETRICS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	55
<i>FIGURE 13 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOMETRICS BY REGION, 2014-2020 (\$ MILLIONS)</i>	55
PARTIAL DISCHARGE DETECTION	56
<i>TABLE 12 GLOBAL MARKET FOR OPTICAL SENSORS IN PARTIAL DISCHARGE DETECTION BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	57
<i>FIGURE 14 GLOBAL MARKET FOR OPTICAL SENSORS IN PARTIAL DISCHARGE DETECTION BY REGION, 2014-2020 (\$ MILLIONS)</i>	57
BIOLOGICAL IMAGING	58
<i>TABLE 13 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOLOGICAL IMAGING BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	58
<i>FIGURE 15 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOLOGICAL IMAGING BY REGION, 2014-2020 (\$ MILLIONS)</i>	58
CHEMICAL SENSING	59

TOPIC	PAGE NO.
<i>TABLE 14 GLOBAL MARKET FOR OPTICAL SENSORS IN CHEMICAL SENSING BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	59
<i>FIGURE 16 GLOBAL MARKET FOR OPTICAL SENSORS IN CHEMICAL SENSING BY REGION, 2014-2020 (\$ MILLIONS)</i>	59
OTHERS	60
<i>TABLE 15 GLOBAL MARKET FOR OPTICAL SENSORS IN OTHER APPLICATIONS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	61
<i>FIGURE 17 GLOBAL MARKET FOR OPTICAL SENSORS IN OTHER APPLICATIONS BY REGION, 2014-2020 (\$ MILLIONS)</i>	61
CHAPTER 6 OPTICAL SENSOR MARKET BY INDUSTRY END USER	63
INTRODUCTION	63
<i>FIGURE 18 GLOBAL OPTICAL SENSOR MARKET: INDUSTRY END USER</i>	63
MARKET DYNAMICS	64
DRIVERS	64
Government Regulations	64
Growth in Demand for Process Automation in Different Industry Verticals	64
RESTRAINTS	64
High Replacement and Installation Costs	64
Maturity of End-User Segment	65
OPPORTUNITY	65
Upcoming Technological Advancements Helping the Growth of New Applications	65
Development of Smart Cities	65
AEROSPACE AND DEFENSE	66
<i>TABLE 16 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	66
<i>FIGURE 19 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY TYPE, 2014-2020 (\$ MILLIONS)</i>	66
<i>TABLE 17 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	67
<i>FIGURE 20 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY REGION, 2014-2020 (\$ MILLIONS)</i>	67
UTILITIES	68
<i>TABLE 18 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	68
<i>FIGURE 21 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY TYPE, 2014-2020 (\$ MILLIONS)</i>	68
<i>TABLE 19 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	69
<i>FIGURE 22 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY REGION, 2014-2020 (\$ MILLIONS)</i>	70
CONSTRUCTION	70
<i>TABLE 20 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	71
<i>FIGURE 23 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY TYPE, 2014-2020 (\$ MILLIONS)</i>	71
<i>TABLE 21 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	71

TOPIC	PAGE NO.
<i>FIGURE 24 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY REGION, 2014-2020 (\$ MILLIONS)</i>	72
CHEMICAL INDUSTRY	73
<i>TABLE 22 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	73
<i>FIGURE 25 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY TYPE, 2014-2020 (\$ MILLIONS)</i>	73
<i>TABLE 23 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	74
<i>FIGURE 26 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY REGION, 2014-2020 (\$ MILLIONS)</i>	74
OIL AND GAS	75
<i>TABLE 24 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	75
<i>FIGURE 27 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY TYPE, 2014-2020 (\$ MILLIONS)</i>	75
<i>TABLE 25 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	76
<i>FIGURE 28 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY REGION, 2014-2020 (\$ MILLIONS)</i>	77
OTHERS	77
<i>TABLE 26 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	78
<i>FIGURE 29 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY TYPE, 2014-2020 (\$ MILLIONS)</i>	78
<i>TABLE 27 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	79
<i>FIGURE 30 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY REGION, 2014-2020 (\$ MILLIONS)</i>	79
CHAPTER 7 OPTICAL SENSOR MARKET BY REGION	81
INTRODUCTION	81
<i>FIGURE 31 OPTICAL SENSOR MARKET BY REGION</i>	81
NORTH AMERICA	81
MARKET DYNAMICS	82
Drivers	82
Technological Advancement in Health Care and the Internet of Things	82
Restraints	82
Reduced CO2 Emissions Decreasing the Demand for CO2 Sensors	82
Opportunities	82
Optical Sensors as a New Dimension to Security	82
<i>TABLE 28 NORTH AMERICAN OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	83
<i>TABLE 29 NORTH AMERICAN EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	83
<i>TABLE 30 NORTH AMERICAN INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	84
<i>TABLE 31 NORTH AMERICAN OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	84

TOPIC	PAGE NO.
<i>TABLE 32 NORTH AMERICAN OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	85
<i>TABLE 33 NORTH AMERICAN OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)</i>	85
EUROPE	86
MARKET DYNAMICS	86
Drivers	86
Growth in Passive Optical Networks	86
<i>FIGURE 32 NUMBER OF HOUSEHOLDS IN EUROPEAN REGION: FIBER-TO-THE-HOME FORECAST, 2007-2017 (THOUSANDS)</i>	87
Restraints	88
High Cost in R&D	88
Opportunities	88
Touchless Multimodal Biometrics in the Automotive Industry	88
<i>TABLE 34 EUROPEAN OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	89
<i>TABLE 35 EUROPE EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	89
<i>TABLE 36 EUROPEAN INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	90
<i>TABLE 37 EUROPEAN OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	90
<i>TABLE 38 EUROPEAN OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	91
<i>TABLE 39 EUROPEAN OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)</i>	92
ASIA-PACIFIC	93
MARKET DYNAMICS	93
Drivers	93
Economic Growth in Emerging Markets	93
Restraints	93
Lower Acceptance of Product Due to High Price	93
Opportunities	94
Development of Smart Cities	94
<i>TABLE 40 ASIA-PACIFIC OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	94
<i>TABLE 41 ASIA-PACIFIC EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	94
<i>TABLE 42 ASIA-PACIFIC INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	95
<i>TABLE 43 ASIA-PACIFIC OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	96
<i>TABLE 44 ASIA-PACIFIC OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	96
<i>TABLE 45 ASIA-PACIFIC OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)</i>	97
REST OF THE WORLD	98
MARKET DYNAMICS	98
Drivers	98

TOPIC	PAGE NO.
Increasing Applications of Optical Sensors Across Different Sectors	98
Restraints	99
Over-Reliance on Technology	99
Opportunities	99
Opportunity for New Entrants with Enhanced Product Quality	99
<i>TABLE 46 REST OF THE WORLD OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	100
<i>TABLE 47 REST OF THE WORLD EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	100
<i>TABLE 48 REST OF THE WORLD INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)</i>	100
<i>TABLE 49 REST OF THE WORLD OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)</i>	101
<i>TABLE 50 REST OF THE WORLD OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)</i>	102
<i>TABLE 51 REST OF THE WORLD OPTICAL SENSOR MARKET BY REGION, THROUGH 2020 (\$ MILLIONS)</i>	103
CHAPTER 8 INDUSTRY STRUCTURE AND COMPETITIVE ANALYSIS	105
MARKET SHARE ANALYSIS	105
<i>TABLE 52 SHARE OF GLOBAL OPTICAL SENSOR MARKET BY KEY PLAYERS, 2014 (%)</i>	105
PORTER'S FIVE FORCES	105
<i>FIGURE 33 PORTER'S FIVE FORCES FOR OPTICAL SENSORS</i>	106
BARGAINING POWER OF SUPPLIERS	106
BARGAINING POWER OF BUYERS	107
THREAT FROM SUBSTITUTES	107
THREAT FROM NEW ENTRANTS	107
DEGREE OF COMPETITION	108
CHAPTER 9 COMPANY PROFILES	110
ABB LTD.	110
OVERVIEW	110
PRIMARY BUSINESS	110
FINANCIALS	110
BUSINESS STRATEGIES	111
Business Expansion	111
Expansion through Mergers and Acquisitions	111
DEVELOPMENTS	111
<i>TABLE 53 DEVELOPMENTS OF ABB LTD., 2014-JULY 2015</i>	111
ALPHASENSE	112
OVERVIEW	112
PRIMARY BUSINESS	112
FINANCIALS	112
BUSINESS STRATEGIES	112
Improving Production Capacity	112
DEVELOPMENTS	113
<i>TABLE 54 DEVELOPMENTS OF ALPHASENSE, 2013</i>	113
ANALOG DEVICES INC.	113

TOPIC	PAGE NO.
OVERVIEW	113
PRIMARY BUSINESS	114
FINANCIALS	114
BUSINESS STRATEGIES	114
Focus on Research and Development	114
DEVELOPMENTS	114
<i>TABLE 55 DEVELOPMENTS OF ANALOG DEVICES, 2013-MAY 2015</i>	114
AVAGO TECHNOLOGIES LTD.	115
OVERVIEW	115
PRIMARY BUSINESS	115
FINANCIALS	115
BUSINESS STRATEGIES	115
New Product Development	115
Research and Development	116
DEVELOPMENTS	116
<i>TABLE 56 DEVELOPMENTS OF AVAGO TECHNOLOGIES LTD., 2014-MAY 2015</i>	116
BALLUFF GMBH	116
OVERVIEW	116
PRIMARY BUSINESS	117
FINANCIALS	117
BUSINESS STRATEGIES	117
Innovation through Technological Advances	117
DEVELOPMENTS	117
<i>TABLE 57 DEVELOPMENTS OF BALLUFF GMBH, 2012-2014</i>	117
CIENA CORP.	118
OVERVIEW	118
PRIMARY BUSINESS	118
FINANCIALS	118
BUSINESS STRATEGIES	118
Strategic Partnership	118
Expanding Overseas Business Operation	119
DEVELOPMENTS	119
<i>TABLE 58 DEVELOPMENTS OF CIENA CORP., 2014-MAY 2015</i>	119
CITY TECHNOLOGY	119
OVERVIEW	120
PRIMARY BUSINESS	120
FINANCIALS	120
BUSINESS STRATEGIES	120
Innovative Product Offerings	120
DEVELOPMENTS	121
<i>TABLE 59 DEVELOPMENTS OF CITY TECHNOLOGY, 2011-2012</i>	121
COHERENT INC.	121
OVERVIEW	121
FINANCIALS	121
PRIMARY BUSINESS	122
BUSINESS STRATEGIES	122
Research and Development Initiatives	122

TOPIC	PAGE NO.
Vertical Integration	122
Strategic Expansion	122
DEVELOPMENTS	123
<i>TABLE 60 DEVELOPMENTS OF COHERENT INC., 2014</i>	123
CROSS MATCH TECHNOLOGIES	123
OVERVIEW	123
PRIMARY BUSINESS	124
FINANCIALS	124
BUSINESS STRATEGIES	124
Product Development	124
DEVELOPMENTS	124
<i>TABLE 61 DEVELOPMENTS OF CROSS MATCH TECHNOLOGIES, 2013-2014</i>	124
DRAGERWERK AG & CO. KGAA	125
OVERVIEW	125
PRIMARY BUSINESS	125
FINANCIALS	125
BUSINESS STRATEGIES	125
Investment in R&D	125
DEVELOPMENTS	126
<i>TABLE 62 DEVELOPMENTS OF DRAGERWERK AG & CO. KGAA, 2012-2013</i>	126
EMCORE CORP.	126
OVERVIEW	126
PRIMARY BUSINESS	127
FINANCIALS	127
BUSINESS STRATEGIES	127
Strategic Agreements	127
DEVELOPMENTS	127
<i>TABLE 63 DEVELOPMENTS OF EMCORE CORP., 2014-MARCH 2015</i>	127
FINISAR CORP.	127
OVERVIEW	128
PRIMARY BUSINESS	128
FINANCIALS	128
BUSINESS STRATEGIES	128
New Product Development	128
DEVELOPMENTS	128
<i>TABLE 64 DEVELOPMENTS OF FINISAR CORP., MARCH 2015</i>	128
FIGARO ENGINEERING INC.	129
OVERVIEW	129
PRIMARY BUSINESS	129
FINANCIALS	129
BUSINESS STRATEGIES	130
Global Expansion	130
DEVELOPMENTS	130
<i>TABLE 65 DEVELOPMENTS OF FIGARO ENGINEERING INC., 2012-MAY 2015</i>	130
HAMAMATSU PHOTONICS K.K.	130
OVERVIEW	131
PRIMARY BUSINESS	131

TOPIC	PAGE NO.
FINANCIALS	131
BUSINESS STRATEGIES	131
Investing Worldwide in Infrastructure and Capacity to Capitalize on Customer Demand Trends	131
DEVELOPMENTS	132
<i>TABLE 66 DEVELOPMENTS OF HAMAMATSU PHOTONICS K.K., MARCH 2015-MAY 2015</i>	132
INFINEON TECHNOLOGIES AG	132
OVERVIEW	132
PRIMARY BUSINESS	133
FINANCIALS	133
BUSINESS STRATEGIES	133
Expansion through Acquisition	133
DEVELOPMENTS	134
<i>TABLE 67 DEVELOPMENTS OF INFINEON TECHNOLOGIES AG, 2013-JANUARY 2015</i>	134
KISTLER INSTRUMENTE AG	134
OVERVIEW	134
PRIMARY BUSINESS	134
FINANCIALS	135
BUSINESS STRATEGIES	135
Product Enhancement through Investment in R&D	135
DEVELOPMENTS	135
<i>TABLE 68 DEVELOPMENTS OF KISTLER INSTRUMENTE AG, 2014</i>	135
NEMOTO & CO. LTD.	135
OVERVIEW	136
PRIMARY BUSINESS	136
FINANCIALS	136
BUSINESS STRATEGIES	136
Expansion through R&D and Product Development	136
DEVELOPMENTS	137
<i>TABLE 69 DEVELOPMENTS OF NEMOTO & CO. LTD., 2012</i>	137
NEWPORT CORP.	137
OVERVIEW	137
PRIMARY BUSINESS	137
FINANCIALS	138
BUSINESS STRATEGIES	138
Strategic Expansion	138
DEVELOPMENTS	138
<i>TABLE 70 DEVELOPMENTS OF NEWPORT CORP., 2011-2013</i>	138
OMNIVISION TECHNOLOGIES	139
OVERVIEW	139
PRIMARY BUSINESS	139
FINANCIALS	140
BUSINESS STRATEGIES	140
Expansion through Product Applications	140
DEVELOPMENTS	140
<i>TABLE 71 DEVELOPMENTS OF OMNIVISION TECHNOLOGIES, JUNE 2015</i>	140
OMRON CORP	141

TOPIC	PAGE NO.
OVERVIEW	141
PRIMARY BUSINESS	141
FINANCIAL	142
BUSINESS STRATEGIES	142
New Product Development	142
DEVELOPMENTS	142
<i>TABLE 72 DEVELOPMENTS OF OMRON CORP., 2013</i>	142
PANASONIC CORP.	142
OVERVIEW	143
PRIMARY BUSINESS	143
FINANCIALS	143
BUSINESS STRATEGIES	143
New Product Development	143
DEVELOPMENTS	144
<i>TABLE 73 DEVELOPMENTS OF PANASONIC CORP., 2014-JULY 2015</i>	144
ROBERT BOSCH GMBH	144
OVERVIEW	144
PRIMARY BUSINESS	145
FINANCIALS	145
BUSINESS STRATEGIES	145
New Product Development	145
DEVELOPMENTS	145
<i>TABLE 74 DEVELOPMENTS OF ROBERT BOSCH GMBH, 2014-JULY 2015</i>	145
STMICROELECTRONICS NV	146
OVERVIEW	146
PRIMARY BUSINESS	146
FINANCIALS	146
BUSINESS STRATEGIES	147
Focused Research and Development	147
DEVELOPMENTS	147
<i>TABLE 75 DEVELOPMENTS OF STMICROELECTRONICS NV, 2011-2012</i>	147
TE CONNECTIVITY	147
OVERVIEW	147
PRIMARY BUSINESS	148
FINANCIALS	148
BUSINESS STRATEGIES	148
Expansion through Mergers and Acquisitions	148
DEVELOPMENTS	148
<i>TABLE 76 DEVELOPMENTS OF TE CONNECTIVITY, MAY 2015-JUNE 2015</i>	148
TELEDYNE DALSA INC.	149
OVERVIEW	149
PRIMARY BUSINESS	149
FINANCIALS	149
BUSINESS STRATEGIES	149
Product Development	149
DEVELOPMENTS	150
<i>TABLE 77 DEVELOPMENTS OF TELEDYNE DALSA, MAY 2015-JUNE 2015</i>	150

TOPIC	PAGE NO.
TEXAS INSTRUMENTS INC.	150
OVERVIEW	150
PRIMARY BUSINESS	150
FINANCIALS	151
BUSINESS STRATEGIES	151
New Product Development and Innovation	151
DEVELOPMENTS	151
<i>TABLE 78 DEVELOPMENTS OF TEXAS INSTRUMENTS INC., 2014-FEB. 2015</i>	151

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE GLOBAL MARKET FOR OPTICAL SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	7
TABLE 1 GLOBAL MARKET FOR EXTRINSIC SENSORS BY TYPE, THROUGH 2020 (\$ MILLIONS)	39
TABLE 2 GLOBAL MARKET FOR EXTRINSIC SENSORS BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	41
TABLE 3 GLOBAL MARKET FOR EXTRINSIC SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	42
TABLE 4 GLOBAL MARKET FOR EXTRINSIC SENSORS BY REGION, THROUGH 2020 (\$ MILLIONS)	43
TABLE 5 GLOBAL MARKET FOR INTRINSIC SENSORS BY TYPE, THROUGH 2020 (\$ MILLIONS)	44
TABLE 6 GLOBAL MARKET FOR INTRINSIC SENSORS BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	45
TABLE 7 GLOBAL MARKET FOR INTRINSIC SENSORS BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	46
TABLE 8 GLOBAL MARKET FOR INTRINSIC SENSORS BY REGION, THROUGH 2020 (\$ MILLIONS)	47
TABLE 9 GLOBAL MARKET FOR OPTICAL SENSORS IN MILITARY AND LAW ENFORCEMENT BY REGION, THROUGH 2020 (\$ MILLIONS)	53
TABLE 10 GLOBAL MARKET FOR OPTICAL SENSORS IN NIGHT VISION CAMERAS BY REGION, THROUGH 2020 (\$ MILLIONS)	54
TABLE 11 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOMETRICS BY REGION, THROUGH 2020 (\$ MILLIONS)	55
TABLE 12 GLOBAL MARKET FOR OPTICAL SENSORS IN PARTIAL DISCHARGE DETECTION BY REGION, THROUGH 2020 (\$ MILLIONS)	57
TABLE 13 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOLOGICAL IMAGING BY REGION, THROUGH 2020 (\$ MILLIONS)	58
TABLE 14 GLOBAL MARKET FOR OPTICAL SENSORS IN CHEMICAL SENSING BY REGION, THROUGH 2020 (\$ MILLIONS)	59
TABLE 15 GLOBAL MARKET FOR OPTICAL SENSORS IN OTHER APPLICATIONS BY REGION, THROUGH 2020 (\$ MILLIONS)	61
TABLE 16 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY TYPE, THROUGH 2020 (\$ MILLIONS)	66
TABLE 17 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY REGION, THROUGH 2020 (\$ MILLIONS)	67
TABLE 18 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY TYPE, THROUGH 2020 (\$ MILLIONS)	68
TABLE 19 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY REGION, THROUGH 2020 (\$ MILLIONS)	69
TABLE 20 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY TYPE, THROUGH 2020 (\$ MILLIONS)	71
TABLE 21 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY REGION, THROUGH 2020 (\$ MILLIONS)	71
TABLE 22 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY TYPE, THROUGH 2020 (\$ MILLIONS)	73
TABLE 23 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY REGION, THROUGH 2020 (\$ MILLIONS)	74
TABLE 24 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY TYPE, THROUGH 2020 (\$ MILLIONS)	75

TABLE HEADING	PAGE NO.
TABLE 25 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY REGION, THROUGH 2020 (\$ MILLIONS)	76
TABLE 26 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY TYPE, THROUGH 2020 (\$ MILLIONS)	78
TABLE 27 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY REGION, THROUGH 2020 (\$ MILLIONS)	79
TABLE 28 NORTH AMERICAN OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	83
TABLE 29 NORTH AMERICAN EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	83
TABLE 30 NORTH AMERICAN INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	84
TABLE 31 NORTH AMERICAN OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	84
TABLE 32 NORTH AMERICAN OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	85
TABLE 33 NORTH AMERICAN OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)	85
TABLE 34 EUROPEAN OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	89
TABLE 35 EUROPE EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	89
TABLE 36 EUROPEAN INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	90
TABLE 37 EUROPEAN OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	90
TABLE 38 EUROPEAN OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	91
TABLE 39 EUROPEAN OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)	92
TABLE 40 ASIA-PACIFIC OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	94
TABLE 41 ASIA-PACIFIC EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	94
TABLE 42 ASIA-PACIFIC INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	95
TABLE 43 ASIA-PACIFIC OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	96
TABLE 44 ASIA-PACIFIC OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	96
TABLE 45 ASIA-PACIFIC OPTICAL SENSOR MARKET BY COUNTRY, THROUGH 2020 (\$ MILLIONS)	97
TABLE 46 REST OF THE WORLD OPTICAL SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	100
TABLE 47 REST OF THE WORLD EXTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	100
TABLE 48 REST OF THE WORLD INTRINSIC SENSOR MARKET BY TYPE, THROUGH 2020 (\$ MILLIONS)	100
TABLE 49 REST OF THE WORLD OPTICAL SENSOR MARKET BY APPLICATION, THROUGH 2020 (\$ MILLIONS)	101
TABLE 50 REST OF THE WORLD OPTICAL SENSOR MARKET BY INDUSTRY END USER, THROUGH 2020 (\$ MILLIONS)	102

TABLE HEADING	PAGE NO.
TABLE 51 REST OF THE WORLD OPTICAL SENSOR MARKET BY REGION, THROUGH 2020 (\$ MILLIONS)	103
TABLE 52 SHARE OF GLOBAL OPTICAL SENSOR MARKET BY KEY PLAYERS, 2014 (%)	105
TABLE 53 DEVELOPMENTS OF ABB LTD., 2014-JULY 2015	111
TABLE 54 DEVELOPMENTS OF ALPHASENSE, 2013	113
TABLE 55 DEVELOPMENTS OF ANALOG DEVICES, 2013-MAY 2015	114
TABLE 56 DEVELOPMENTS OF AVAGO TECHNOLOGIES LTD., 2014-MAY 2015	116
TABLE 57 DEVELOPMENTS OF BALLUFF GMBH, 2012-2014	117
TABLE 58 DEVELOPMENTS OF CIENA CORP., 2014-MAY 2015	119
TABLE 59 DEVELOPMENTS OF CITY TECHNOLOGY, 2011-2012	121
TABLE 60 DEVELOPMENTS OF COHERENT INC., 2014	123
TABLE 61 DEVELOPMENTS OF CROSS MATCH TECHNOLOGIES, 2013-2014	124
TABLE 62 DEVELOPMENTS OF DRAGERWERK AG & CO. KGAA, 2012-2013	126
TABLE 63 DEVELOPMENTS OF EMCORE CORP., 2014-MARCH 2015	127
TABLE 64 DEVELOPMENTS OF FINISAR CORP., MARCH 2015	128
TABLE 65 DEVELOPMENTS OF FIGARO ENGINEERING INC., 2012-MAY 2015	130
TABLE 66 DEVELOPMENTS OF HAMAMATSU PHOTONICS K.K., MARCH 2015-MAY 2015	132
TABLE 67 DEVELOPMENTS OF INFINEON TECHNOLOGIES AG, 2013-JANUARY 2015	134
TABLE 68 DEVELOPMENTS OF KISTLER INSTRUMENTE AG, 2014	135
TABLE 69 DEVELOPMENTS OF NEMOTO & CO. LTD., 2012	137
TABLE 70 DEVELOPMENTS OF NEWPORT CORP., 2011-2013	138
TABLE 71 DEVELOPMENTS OF OMNIVISION TECHNOLOGIES, JUNE 2015	140
TABLE 72 DEVELOPMENTS OF OMRON CORP., 2013	142
TABLE 73 DEVELOPMENTS OF PANASONIC CORP., 2014-JULY 2015	144
TABLE 74 DEVELOPMENTS OF ROBERT BOSCH GMBH, 2014-JULY 2015	145
TABLE 75 DEVELOPMENTS OF STMICROELECTRONICS NV, 2011-2012	147
TABLE 76 DEVELOPMENTS OF TE CONNECTIVITY, MAY 2015-JUNE 2015	148
TABLE 77 DEVELOPMENTS OF TELEDYNE DALSA, MAY 2015-JUNE 2015	150
TABLE 78 DEVELOPMENTS OF TEXAS INSTRUMENTS INC., 2014-FEB. 2015	151

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE GLOBAL MARKET FOR OPTICAL SENSORS BY INDUSTRY END USER, 2014-2020 (\$ MILLIONS)	7
FIGURE 1 VALUE CHAIN OF OPTICAL SENSORS	10
FIGURE 2 OPTICAL SENSOR MARKET BY TYPE	35
FIGURE 3 GLOBAL SHIPMENTS OF SMARTPHONES, 2014-2019 (BILLIONS)	36
FIGURE 4 GLOBAL MARKET FOR EXTRINSIC SENSORS BY APPLICATION, 2014-2020 (\$ MILLIONS)	41
FIGURE 5 GLOBAL MARKET FOR EXTRINSIC SENSORS BY INDUSTRY END USER, 2014-20200 (\$ MILLIONS)	42
FIGURE 6 GLOBAL MARKET FOR EXTRINSIC SENSORS BY REGION, 2014-2020 (\$ MILLIONS)	43
FIGURE 7 GLOBAL MARKET FOR INTRINSIC SENSORS BY APPLICATION, 2014-2020 (\$ MILLIONS)	45
FIGURE 8 GLOBAL MARKET FOR INTRINSIC SENSORS BY INDUSTRY END USER, 2014-2020 (\$ MILLIONS)	46
FIGURE 9 GLOBAL MARKET FOR INTRINSIC SENSORS BY REGION, 2014-2020 (\$ MILLIONS)	47
FIGURE 10 OPTICAL SENSOR MARKET :APPLICATION	50
FIGURE 11 GLOBAL MARKET FOR OPTICAL SENSORS IN MILITARY AND LAW ENFORCEMENT BY REGION, 2014-2020 (\$ MILLIONS)	53
FIGURE 12 GLOBAL MARKET FOR OPTICAL SENSORS IN NIGHT VISION CAMERAS BY REGION, 2014-2020 (\$ MILLIONS)	54
FIGURE 13 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOMETRICS BY REGION, 2014-2020 (\$ MILLIONS)	55
FIGURE 14 GLOBAL MARKET FOR OPTICAL SENSORS IN PARTIAL DISCHARGE DETECTION BY REGION, 2014-2020 (\$ MILLIONS)	57
FIGURE 15 GLOBAL MARKET FOR OPTICAL SENSORS IN BIOLOGICAL IMAGING BY REGION, 2014-2020 (\$ MILLIONS)	58
FIGURE 16 GLOBAL MARKET FOR OPTICAL SENSORS IN CHEMICAL SENSING BY REGION, 2014-2020 (\$ MILLIONS)	59
FIGURE 17 GLOBAL MARKET FOR OPTICAL SENSORS IN OTHER APPLICATIONS BY REGION, 2014-2020 (\$ MILLIONS)	61
FIGURE 18 GLOBAL OPTICAL SENSOR MARKET: INDUSTRY END USER	63
FIGURE 19 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY TYPE, 2014-2020 (\$ MILLIONS)	66
FIGURE 20 GLOBAL OPTICAL SENSOR MARKET FOR AEROSPACE AND DEFENSE BY REGION, 2014-2020 (\$ MILLIONS)	67
FIGURE 21 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY TYPE, 2014-2020 (\$ MILLIONS)	68
FIGURE 22 GLOBAL OPTICAL SENSOR MARKET FOR UTILITIES BY REGION, 2014-2020 (\$ MILLIONS)	70
FIGURE 23 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY TYPE, 2014-2020 (\$ MILLIONS)	71
FIGURE 24 GLOBAL OPTICAL SENSOR MARKET FOR CONSTRUCTION BY REGION, 2014-2020 (\$ MILLIONS)	72
FIGURE 25 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY TYPE, 2014-2020 (\$ MILLIONS)	73
FIGURE 26 GLOBAL OPTICAL SENSOR MARKET FOR CHEMICAL INDUSTRY BY REGION, 2014-2020 (\$ MILLIONS)	74
FIGURE 27 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY TYPE, 2014-2020 (\$ MILLIONS)	75

FIGURE TITLE	PAGE NO.
FIGURE 28 GLOBAL OPTICAL SENSOR MARKET FOR OIL AND GAS BY REGION, 2014-2020 (\$ MILLIONS)	77
FIGURE 29 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY TYPE, 2014-2020 (\$ MILLIONS)	78
FIGURE 30 GLOBAL OPTICAL SENSOR MARKET FOR OTHER INDUSTRY SECTORS BY REGION, 2014-2020 (\$ MILLIONS)	79
FIGURE 31 OPTICAL SENSOR MARKET BY REGION	81
FIGURE 32 NUMBER OF HOUSEHOLDS IN EUROPEAN REGION: FIBER-TO-THE-HOME FORECAST, 2007-2017 (THOUSANDS)	87
FIGURE 33 PORTER'S FIVE FORCES FOR OPTICAL SENSORS	106