



Perovskite Solar Cells: *Materials, Fabrication, and Global Markets*

February 2018

Margareth Gagliardi

Report Code: EGY144A

Table of Contents

Chapter 1: 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
Market Breakdown	4
Analyst’s Credentials.....	8
Related BCC Research Reports.....	9
Chapter 2: Summary and Highlights	11
Chapter 3: Market and Technology Background	15
Perovskites.....	15
Solar Cell Industry	19
Milestones in the History of Perovskite Solar Cells	20
Applications of Perovskite Solar Cells	23
Construction/Architectural	24
Infrastructure	24
Electronics	25
Transportation.....	25
Space	25
Defense.....	25
Chapter 4: Technology	27
Introduction	27
Basic Configuration of Perovskite Solar Cells.....	27
Perovskite Materials for Solar Cells	28
Alkali Metal Halides.....	28
Organic-Inorganic Halides	29
Polymer-Modified Halides.....	30
Double-Perovskite Halides	31
Other Materials for Perovskite Solar Cells.....	32
Bottom Transparent Conductive Layer	32
Hole-transporting Layer	32
Electron-transporting Layer	33
Hole-Blocking Layer	34
Top Conductive Layer	34
Fabrication Process for Perovskite Solar Cells	35
Physical Processes	39
Chemical Processes	39
Hybrid Processes	40
Film Thickness and Deposition in Perovskite Solar Cells.....	40
Perovskite Solar Cell Efficiency	42
Tandem Solar Cells	44
Double-Perovskite Solar Cells.....	45
Single-Junction Solar Cells	46

Perovskite Nanowires.....	47
Perovskite Quantum Dots	48
Advantages and Disadvantages of Perovskite Solar Cells.....	48
Latest Technological Developments, 2015 to Present.....	50
Perovskite Layer for Solar Cells with Composition Gradient	51
Tin-based Hybrid Perovskite/Silicon Tandem Solar Cell.....	52
Chalcopyrite-Perovskite Tandem Cell	53
Perovskite Solar Cell with Back Contacts	54
High-Efficiency Organic-Inorganic Perovskite Solar Cell	55
Other Relevant R&D Activities	56
Chapter 5: Global Markets	62
Analysis Outline	62
Global Market Summary	62
Current Market Status	65
Market by Solar Cell Type.....	65
Market by Application	68
Market by Region	69
Market Growth Trends	71
Industry Growth	71
Industry Trends	86
Regional Trends.....	91
Market Forecast.....	91
Market by Solar Cell Type.....	92
Market by Application	95
Market by Region	96
Chapter 6: Global Industry Structure	99
Leading Players in Perovskite Solar Cell Development and Manufacturing	99
Other Industry Players	104
Company Profiles	107
Chapter 7: Patent Analysis	125
Introduction	125
Summary of Recently Awarded Patents	125
General Trends.....	139
Trends by Country and Region.....	141
Trends by Assignee	143
Trends by Patent Category.....	147
Trends by Solar Cell Type	148
Trends by Material Type	149
About BCC Research.....	152
About BCC Research.....	153
BCC Membership	153
BCC Custom Research	153

List of Tables

Summary Table: Global Market for Perovskite and Other Thin Film Solar Module, by Type, Through 2022 (\$ Millions)	12
Table 1 Common Perovskite Compounds.....	18
Table 2 Global Production of Photovoltaic Modules, by Type, Through 2022 (GW).....	19
Table 3 Technological Milestones for Perovskite Materials and Solar Cells.....	21
Table 4 Applications of Perovskite Solar Cells	23
Table 5 Perovskite Materials for Solar Cells.....	31
Table 6 Thin Film Deposition Methods, 2017	35
Table 7 Perovskite Solar Cell and Module Efficiency	42
Table 8 Other Relevant R&D Activities	56
Table 9 Global Market for Perovskite and Other Thin Film Solar Modules, by Category, Through 2022 (\$ Millions)	64
Table 10 2 nd and 3 rd Generation Solar Cells	65
Table 11 Global Market for Perovskite and Other Thin Film Solar Modules, by Type, Through 2017 (\$ Millions)	67
Table 12 Global Market for Perovskite and Other Thin Film Solar Modules, by Application, Through 2017 (\$ Millions)	68
Table 13 Global Market for Perovskite and Other Thin Film Solar Modules, by Region, Through 2017 (\$ Millions)	70
Table 14 Global Production of Energy, by Type, Through 2022 (Mtoe)	71
Table 15 Global Market for Tablets, Smartphones, and Calculators, by Type, Through 2022 (\$ Billions) .	76
Table 16 Global Market for Sensors, by Type, Through 2022 (\$ Billions).....	80
Table 17 Global Market for Automotive Electronic Controls, by Type, Through 2022 (\$ Billions).....	82
Table 18 Global Market for the Aerospace Industry, by Region, Through 2022 (\$ Billions)	84
Table 19 Nanotechnology Industry, 2017	88
Table 20 Global Market for Nanotechnology, by Type, Through 2022 (\$ Billions).....	90
Table 21 Global Market for Perovskite and Other Thin Film Solar Modules, by Type, Through 2022 (\$ Millions)	92
Table 22 Global Market for Perovskite Solar Modules, Through 2027 (\$ Millions)	95
Table 23 Global Market for Perovskite and Other Thin Film Solar Modules, by Application, Through 2022 (\$ Millions)	95
Table 24 Global Market for Perovskite and Other Thin Film Solar Modules, by Region, Through 2022 (\$ Millions)	97
Table 25 Leading Players in Perovskite Solar Cell Development and Manufacturing	99
Table 26 Leading Players by Product/Activity Type	101
Table 27 Leading Players, by Product/Activity and Region (Number)	103
Table 28 Other Industry Players.....	104
Table 29 Perovskite Solar Cells-Worldwide Patents, 2017	126
Table 30 Perovskite Solar Cells-Worldwide Patents, 2016	133
Table 31 Global Patent Trend for Perovskite Solar Cells, Through 2017 (Number)	140
Table 32 Global Patent Trend for Perovskite Solar Cells, by Region, Through 2017 (%).....	142
Table 33 Assignees of Global Patents Related to Perovskite Solar Cells (Number).....	145

List of Figures

Summary Figure: Global Market for Perovskite and Other Thin Film Solar Module, by Type, 2015-2022 (\$ Millions)	13
Figure 1 Perovskite Crystal Structure.....	15
Figure 2 Perovskite Types	16
Figure 3 Global Production Share for Photovoltaic Modules, by Type, 2022 (%).....	20
Figure 4 Perovskite Materials and Solar Cells: Worldwide Patent Applications and Patent Issued, 2000-2016 (Number).....	23
Figure 5 Basic Configuration of a Single-Junction Perovskite Solar Cell	27
Figure 6 3D versus 2D Perovskites	30
Figure 7 Mesoscopic vs. Planar Perovskite Solar Cell Structure	34
Figure 8 Basic Configuration of a Stacked All-Perovskite Tandem Cell.....	45
Figure 9 Basic Configuration of a Monolithic All-Perovskite Tandem Cell.....	46
Figure 10 Normal vs. Inverted Perovskite Solar Cell Construction	50
Figure 11 Global Market for Perovskite and Other Thin Film Solar Modules, by Category, 2015-2022 (\$ Millions)	64
Figure 12 Global Market Share for Perovskite and Other Thin Film Solar Modules, by Type, 2017 (%)....	67
Figure 13 Global Market Share for Perovskite and Other Thin Film Solar Modules, by Application, 2017 (%)	69
Figure 14 Global Market Share for Perovskite and Other Thin Film Solar Modules, by Region, 2017 (%)..	70
Figure 15 Global Production Share for Energy, by Type, 2022 (%).....	72
Figure 16 Global Market Share for Tablets, Smartphones, and Calculators, by Type, 2022 (%)	77
Figure 17 Global Market Share for Sensors, by Type, 2022 (%).....	81
Figure 18 Global Market Share for Automotive Electronic Controls, by Type, 2022 (%)	83
Figure 19 Global Market Share for the Aerospace Industry, by Type, 2022 (%)	84
Figure 20 Global Market Share for Nanotechnology, by Type, 2022 (%)	90
Figure 21 Global Market Perovskite and Other Thin Film Solar Modules, by Type, 2022 (%).....	93
Figure 22 SWOT Analysis for Perovskite Solar Cells.....	94
Figure 23 Global Market Share for Perovskite and Other Thin Film Solar Modules, by Application, 2022 (%)	96
Figure 24 Global Market Share for Perovskite and Other Thin Film Solar Modules, by Region, 2022 (%)..	97
Figure 25 Leading Players, by Product/Activity and Region (Number).....	103
Figure 26 Global Patent Trend for Perovskite Solar Cells, 2014-2017 (Number)	141
Figure 27 Global Patent Share for Perovskite Solar Cells, by Region (Number/%).....	142
Figure 28 Global Patent Share for Perovskite Solar Cells, by Country, 2016-2017 (Number/%).....	143
Figure 29 Global Patent Share for Perovskite Solar Cells, by Patent Category (Number/%).....	147
Figure 30 Global Patent Share for Perovskite Solar Cells, by Cell Type (Number/%)	149
Figure 31 Global Patent Share for Perovskite Solar Cells, by Material (Number/%)	151



About BCC Research

About BCC Research

With our unparalleled 45-year history, BCC Research provides comprehensive analysis of global market sizing, forecasting and industry intelligence, covering markets where advances in science and technology are improving the quality, standard and sustainability of businesses, economies and lives.

BCC Membership

From market sizing and forecasts, to opportunity assessments and competitive analyses, our ever-expanding library gives you the data, insights and intelligence required to ensure your project is a success. Members benefit from ongoing, unlimited access to the category or collections of their choice, and most membership packages pay for themselves within two to three reports being accessed.

Did you buy this report? You may qualify to apply your purchase price towards a full membership. Call 866/285-7215 or email info@bccresearch.com to request a demo.

BCC Custom Research

Our experts provide custom research projects to those working to identify new markets, introduce new products, validate existing market share, analyze competition and assess the potential for products to impact existing markets. With impressive academic credentials and broad and deep knowledge of global industrial markets, our independent analysts and consultants develop the facts, figures, analysis and assessments to inform the decisions that will move your company ahead. Confidential inquiries to: custom@bccresearch.com or 781/205-2429.

DISCLAIMER

The information developed in this report is intended to be as reliable as possible at the time of publication and is of a professional nature. This information does not constitute managerial, legal or accounting advice, nor should it be considered as a corporate policy guide, laboratory manual or an endorsement of any product, as much of the information is speculative in nature. BCC Research and the author assume no responsibility for any loss or damage that might result from reliance on the reported information or from its use.

ISBN: 978-1-62296-637-0
February 2018