

Anode Material Market Research Report

Date: January, 2024

Author: Brendan Jephcott

Prepared by:

GOLDEN DRAGON CAPITAL



Table of Contents

| | |
|--|----|
| Executive Summary | 2 |
| 1.0 Introduction | 13 |
| 1.1 Role of the Anode Material | 13 |
| 1.2 Anode Material Product Types..... | 14 |
| 2.0 Principal Production Methods | 17 |
| 2.1 Processing Flowsheets..... | 17 |
| 2.1.1 Natural Graphite Anode Material..... | 19 |
| 2.1.2 Synthetic Graphite Anode Material..... | 23 |
| 2.1.3 Soft Carbon and Hard Carbon | 26 |
| 2.2 Product Specifications | 26 |
| 2.2.1 China National Product Standard (GBT 24533-2019)..... | 26 |
| 2.3 Raw Materials..... | 27 |
| 2.3.1 Natural Graphite Anode Material..... | 27 |
| 2.3.2 Synthetic Graphite Anode Material..... | 30 |
| 3.0 Rise of Graphitisation..... | 36 |
| 3.1 Graphitisation Principal Processing Methods | 36 |
| 3.2 Graphitisation Commercialisation | 41 |
| 4.0 Pricing..... | 45 |
| 5.0 Commercialisation | 46 |
| 5.1 Market Demand | 46 |
| 5.2 Market Supply..... | 48 |
| 5.3 Competitive Landscape | 51 |
| 5.3.1 BTR New Material Group Co., Ltd | 59 |
| 5.3.2 Shanghai Putailai New Energy Technology Co., Ltd | 63 |
| 5.3.3 Ningbo Shanshan Co., Ltd..... | 68 |
| 5.3.4 Hunan Zhongke Electric Co., Ltd | 71 |
| 5.3.5 Shenzhen XFH Technology Co., Ltd (Xiangfenghua)..... | 76 |
| 5.3.6 Guangdong Kaijin New Energy Technology Co., Ltd | 81 |
| 5.3.7 Shijiazhuang Shangtai Technology Co., Ltd..... | 82 |
| 5.3.8 Overseas (South Korea and Japan)..... | 89 |
| References..... | 90 |
| Disclaimer | 92 |

Table of Figures

| | |
|--|----|
| Figure 1: Schematic diagram of a lithium-ion battery (top) and battery package formats (bottom) — (a) coin, (b) cylindrical, (c) prismatic, (d) pouch..... | 13 |
| Figure 2: Anode material used in lithium-ion batteries (illustrative) | 14 |
| Figure 3: Types of anode material used in lithium-ion batteries | 14 |
| Figure 4: Lithium-ion battery anode material industry chain | 15 |
| Figure 5: Performance comparison of different anode materials | 17 |
| Figure 6: Principal processing flowsheets of graphite anode materials used by various companies | 18 |
| Figure 7: Natural graphite anode material processing flowsheet | 19 |
| Figure 8: Process flowsheet for spherical graphite production from mine site (red) to spherical plant (blue) | 20 |
| Figure 9: Microscopic images of natural flake graphite (left) and uncoated graphite spheroids (right) | 20 |
| Figure 10: Chinese SPG plant..... | 21 |
| Figure 11: Anode production for lithium-ion battery | 22 |
| Figure 12: Synthetic graphite anode material processing flowsheet | 23 |
| Figure 13: Graphite lattice formation with increasing heat | 25 |
| Figure 14: Synthetic graphite manufacturing process | 25 |
| Figure 15: Soft carbon structure (left) and hard carbon structure (right) | 26 |
| Figure 16: European flake graphite prices | 29 |
| Figure 17: Chinese flake graphite prices | 29 |
| Figure 18: Chinese uncoated spherical graphite price (1USD~7CNY)..... | 30 |
| Figure 19: Classification of synthetic graphite raw materials..... | 30 |
| Figure 20: Needle coke industry..... | 31 |
| Figure 21: Needle coke (illustrative)..... | 32 |
| Figure 22: Petroleum coke (illustrative)..... | 32 |
| Figure 23: Needle coke price CNY per tonne (1USD~7CNY) | 34 |
| Figure 24: Average purchase price of coke from synthetic graphite anode material companies (1USD~7CNY) . | 34 |
| Figure 25: China petroleum coke prices (CNY per tonne)..... | 36 |
| Figure 26: Graphitisation structural change process | 36 |
| Figure 27: Graphitisation furnace loading profile..... | 37 |
| Figure 28: Graphitisation furnace loading plan..... | 38 |
| Figure 29: Schematic diagram of a graphite crucible | 38 |
| Figure 30: Schematic diagram of the structure of Putailai's (Zichen) box furnace..... | 39 |
| Figure 31: Schematic diagram of a continuous graphitisation furnace | 40 |
| Figure 32: Proportion of graphitisation cost of Putailai (2021)..... | 43 |
| Figure 33: Graphitisation price in China (CNY per tonne) | 44 |
| Figure 34: Natural graphite anode material prices in China | 45 |
| Figure 35: Synthetic graphite anode material prices (CNY per tonne) | 46 |
| Figure 36: Global lithium-ion battery production (2017 to 2021) | 47 |
| Figure 37: China lithium-ion battery production by product (2017 to 2021)..... | 47 |
| Figure 38: Global lithium-ion power battery shipments (2017 to 2021) | 48 |
| Figure 39: Global new energy vehicle sales (2017 to 2021) | 48 |
| Figure 40: China anode material production 2016 to 2022 | 49 |
| Figure 41: China anode material production by product 2016 to 2022..... | 49 |
| Figure 42: China natural graphite anode material production 2017 to 2021..... | 50 |
| Figure 43: China synthetic graphite anode material production 2017 to 2022 | 50 |
| Figure 44: Distribution of China anode material production 2022..... | 51 |
| Figure 45: Distribution of global anode material production capacity (2022)..... | 51 |
| Figure 46: Distribution of China Anode Material Production (2022)..... | 52 |
| Figure 47: Comparison of major Chinese anode material production volumes (2021)..... | 52 |
| Figure 48: Revenue comparison between anode material companies..... | 53 |
| Figure 49: BTR — Natural graphite anode material products | 61 |
| Figure 50: BTR — Synthetic graphite anode material products | 62 |
| Figure 51: Putilai — synthetic graphite anode material principal processing flowsheet | 64 |
| Figure 52: Putailai – Anode material revenue and gross profit margin (1USD~7CNY) | 65 |
| Figure 53: Putailai – Graphitisation processing revenue and gross profit margin (1USD~7CNY) | 65 |

GOLDEN DRAGON CAPITAL

| | |
|---|----|
| Figure 54: Profit margins of major Chinese anode material companies | 66 |
| Figure 55: Putailai — Anode material net profit 2017 to 2021 (1USD~7CNY)..... | 66 |
| Figure 56: Putailai — Anode material production cash cost 2017 to 2020 | 67 |
| Figure 57: Putailai — Cost proportion of anode materials 2017 to 2020 | 67 |
| Figure 58: Shanshan — Anode material production bases | 68 |
| Figure 59: Shanshan — Anode material sales volume 2016 to 2021..... | 70 |
| Figure 60: Shanshan — Net profit per tonne of material 2016 to 2021 (1USD~7CNY)..... | 70 |
| Figure 63: Zhongke Electric office building in Changsha, Hunan Province, China..... | 72 |
| Figure 62: Zhongke Electric — Company revenue structure (2018 to 2022) | 72 |
| Figure 63: Zhongke Electric — Production and sales of anode material (2019 to 2022)..... | 74 |
| Figure 64: Zhongke Electric — Anode material sales revenue 2018 to 2022 (1USD~7CNY) | 75 |
| Figure 65: Zhongke Electric — Anode material unit sales price and gross profit margin 2018 to Q3-2021 (1USD~7CNY) | 75 |
| Figure 66: Shenzhen XFH Technology Co., Ltd | 76 |
| Figure 67: Xiangfenghua — Anode material production capacity (2016 to 2022) | 77 |
| Figure 68: Xiangfenghua — Natural graphite anode material unit price and unit cost 2017 to 2019 (1USD~7CNY) | 77 |
| | 77 |
| Figure 69: Xiangfenghua — Synthetic graphite anode material unit price and unit cost 2017 to 2019 (1USD~7CNY) | 78 |
| | 78 |
| Figure 70: Xiangfenghua — Natural graphite anode material unit cost breakdown 2017 to 2019 (1USD~7CNY) 78 | 78 |
| Figure 71: Xiangfenghua — Synthetic graphite anode material unit cost breakdown 2017 to 2019 (1USD~7CNY) | 79 |
| | 79 |
| Figure 72: Xiangfenghua — Graphitisation planned processing capacity 2018 to 2021E (1USD~7CNY) | 79 |
| Figure 73: Xiangfenghua — Main customers by revenue in 2020..... | 80 |
| Figure 74: Shangtai Technology — Synthetic graphite anode manufacturing processing flowsheet..... | 84 |
| Figure 75: Shangtai Technology — Customer structure in H1-2022 | 87 |
| Figure 76: Shangtai Technology — Production and sales volume from 2018 to 2022 | 88 |
| Figure 77: Shangtai Technology — Anode material sales structure | 88 |
| Figure 78: POSCO Future M Co., Ltd synthetic graphite anode material plant (completed in December 2021) ... | 89 |

GOLDEN DRAGON CAPITAL LIMITED

Address: 9QRC, 9 Queen's Road Central, Central, Hong Kong, China
Telephone: +852 4647 0122
All correspondence to email: bjepcott@goldendragoncapital.com
Website: www.goldendragoncapital.com

List of Tables

| | |
|--|----|
| Table 1: Performance comparison of different anode materials | 16 |
| Table 2: Graphite anode material product specifications (China National Standard GBT 24533-2019) | 26 |
| Table 3: Classification of Natural Graphite with its Characteristics | 27 |
| Table 4: Natural flake graphite size fractions | 28 |
| Table 5: Classification of petroleum coke and needle coke | 33 |
| Table 6: Anode material enterprises cooperation with upstream raw material suppliers | 35 |
| Table 7: Degree of increasing graphitisation as temperature increases | 37 |
| Table 8: Degree of increasing graphitisation under same temperature but increasing heating time | 37 |
| Table 9: Calculation of output of single furnace of different manufacturers under the crucible furnace process ... | 38 |
| Table 10: Process transformation of box furnace to increase production capacity | 39 |
| Table 11: Comparison of the advantages and disadvantages of different graphitisation furnace types | 40 |
| Table 12: Comparison of crucible method, box method, and continuous method | 41 |
| Table 13: Graphitisation process of anode material enterprises | 41 |
| Table 14: Cost structure of synthetic graphite | 42 |
| Table 15: Graphitisation expansion plans of mainstream anode material manufacturers | 43 |
| Table 16: Anode material cost split (end-2022) | 44 |
| Table 17: Estimation of graphitisation self-supply rate of some anode material companies | 44 |
| Table 18: Major Chinese anode material companies and their competitive landscape | 53 |
| Table 19: New customer development process for anode materials | 54 |
| Table 20: Major customers of major anode manufacturers | 54 |
| Table 21: Supply relationship between Chinese anode companies and global lithium-ion battery companies | 55 |
| Table 22: Comparison of Chinese synthetic graphite anode material product specifications | 56 |
| Table 23: Major Chinese anode material companies — Planned production capacity (2019 to 2023E) | 57 |
| Table 24: New entrants to the anode material industry | 58 |
| Table 25: BTR — Natural graphite anode material planned production capacity | 59 |
| Table 26: BTR — Synthetic graphite anode material and graphitisation planned production capacity | 59 |
| Table 27: Performance comparison of different graphitisation methods | 60 |
| Table 28: BTR — Natural graphite anode material product specifications | 60 |
| Table 29: BTR — Synthetic graphite anode material product specifications | 61 |
| Table 30: Putailai — Anode material and graphitisation planned production capacity (2018 to 2024E) | 63 |
| Table 31: Putailai — Synthetic graphite product specifications | 64 |
| Table 32: Shanshan — Anode material production bases and capacity 2021 | 68 |
| Table 33: Shanshan — Anode material and graphitisation planned production capacity (2021 to 2025E) | 69 |
| Table 34: Shanshan — Synthetic graphite product specifications | 69 |
| Table 35: Shanshan — Technological advantages lead | 71 |
| Table 36: Zhongke Electric — Anode material and graphitisation planned production capacity (2020 to 2024) | 73 |
| Table 37: Xiangfenghua — Anode material product series | 76 |
| Table 38: Kaijin Energy — Anode material product series | 81 |
| Table 39: Shangtai Technology — Anode material planned production capacity (2021 to 2025E) | 82 |
| Table 40: Comparison of graphitisation costs in the anode industry | 82 |
| Table 41: Shangtai Technology — Single tonne selling price and cost breakdown of anode material | 83 |
| Table 42: Shangtai Technology — anode products and graphitisation design production capacity | 83 |
| Table 43: Shangtai Technology — core technologies related to anode materials | 84 |
| Table 44: Average price of electricity purchased by the company (unit: CNY/kWh) | 85 |
| Table 45: Shangtai Technology — Anode material product specifications | 86 |
| Table 46: Japan and South Korea anode material production capacity | 89 |