Solar Grade Polysilicon

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Report Abstract
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INTRODUCTION

Polysilicon is a highly purified form of silicon. It is primarily used for its semiconducting properties, as a material for the production of electronic chips and solar photovoltaic cells.

Polysilicon production is essentially the process of purifying metallurgical silicon (MG-Si) feedstock to levels ranging from 99,999,999 percent silicon content (defined as 9N) to over 99.999,999,999 percent (11N). Production is dominated by the Chemical Vapor Deposition (CVD) process originally developed by Siemens. While alternative production routes have attained limited niche positions, the CVD process has benefited from higher purity levels, relatively standardized technology and, in recent years, economies of scale.

For much of the last decade, the polysilicon industry has been in a period of transition, moving away from its roots in relatively small scale, regionally concentrated semi-conductor supply, and towards a position as a larger scale, geographically diverse industry that is mainly geared towards the solar sector. This process is by no means complete as of 2013, and it is likely that many existing operators will not be able to survive the fundamental changes that it will entail for the economics and competitive landscape of the industry.

Polysilicon producers face a number of challenges, led by sharp growth in global capacity and uncertain demand trends linked to the policy-driven nature of the solar market. In the short to medium term, this combination looks set to support continued oversupply and depressed polysilicon prices, certainly compared to the peak prices seen in 2008.

Ultimately, survival in the face of these challenges will depend on the ability of competitors to drive down their production costs and meet the quality requirements of consumers, which are increasingly prioritising high purity product. Key factors in withstanding these challenges are discussed in this PERP report.

On the upside, for those players that do manage to ride out the current situation, long term trends appear positive, with a likely recovery in profitability resulting from the on-going shake out of existing capacity.

A high level strategic analysis of the business is given, including key consideration for companies (both from the perspective of a new/recent entrant to the business and from the perspective of an established player). The report also includes a summary of the leading technology owners (licensors and major producers) as well as key business developments in recent years.

The report gives detailed discussion of the following:

- Process technology employed in the production of polysilicon
- Cost of production estimates using different technologies
- Supply/demand analysis of the polysilicon market
TECHNOLOGY

Polysilicon production entails the conversion of metallurgical silicon to a liquid or gaseous form which can then be converted to the solid end product by well proven techniques common to the chemical industry.

The major commercial processes involved in the manufacture of polysilicon discussed in the report include:

- Chemical Vapor Deposition (CVD)
- Fluidized Bed Reactor (FBR)
- Upgraded Metallurgical Grade Silicon (UMG-Si)

Nexant has reviewed patents, scientific and trade journals, and other publically available literature published in the last twenty years, and has summarized the most interesting alternative and developing technologies. Of particular interest are:

- Direct Metallurgical Processes (SOLSILC)
- Vapor to Liquid Deposition (VLD)

The development of these alternative technologies is mainly focused on tackling shortfalls of the currently prevalent CVD technology, including high energy consumption and its time-consuming and batch-wise deposition process.

PROCESS ECONOMICS

The report includes detailed cost tables for the following:

- Production of polysilicon via the chemical vapor deposition (CVD) process using trichlorosilane (China, Japan, Middle East, N.W. Europe, and U.S. location bases)
- Production of polysilicon via the fluidized bed reactor (granular) process using monosilane (U.S. location basis)
Sensitivity analyses to assess the impact of variation in electricity price, metallurgical silicon feedstock price, and plant scale on polysilicon cost of production via the CVD process are included.

The detailed cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities consumed (electrical energy, cooling water, fuel etc.), direct and allocated fixed costs, by unit consumption and per metric ton and annually, as well as contribution of depreciation to arrive at a cost estimate. Capital costs are broken down according to inside battery limits (ISBL), outside battery limits (OSBL), other project costs, and working capital.

COMMERCIAL MARKET REVIEW

Polysilicon has two primary commercial applications, acting as the main feedstock for both electronic semiconducting chips and silicon-based solar photovoltaic cells. Therefore, the material is indirectly a major element in the supply chain for effectively all modern electronic devices, and the great majority of current solar power generation.

While consumption was historically driven by end-users in the electronics industry, the last decade has seen the solar power sector emerging as the primary outlet for the product. This shift has been the result of very significant growth in the solar power sector, encouraged by the adoption of renewable energy targets, mandates and supporting incentive programs, by numerous governments and international organizations.

The major role played by the solar sector means that demand for polysilicon has increasingly become concentrated in those markets that dominate the production of solar cells, led by China. Supply, however, is more diversified, with some of the largest producers (such as Wacker Chemie, Hemlock Semiconductor, MEMC and others) located in the U.S. and Europe.

In the solar power sector, polysilicon is almost exclusively used to produce a single product, the solar photovoltaic (PV) cell. Accordingly, the markets that dominate solar cell production account for the majority of estimated polysilicon demand. The major growth of China as a solar powerhouse in recent years has concentrated the great majority of demand in Asia, as shown in the Figure below:
Photovoltaic technology entails the direct conversion of solar radiation into electricity by semiconducting materials. These materials are used to produce solar, or photovoltaic, cells, which are assembled (in most cases) into modules (solar panels).

Solar PV technology is essentially divided between two main types; crystalline silicon (c-Si) and Thin Film (TF), within which a range of different applications are in use. These applications vary in terms of both efficiency – the proportion of solar radiation hitting a cell that is converted into electricity – and cost of production. The report gives an overview of commercial applications of solar photovoltaics, including value chain and market status in terms of capacity and power generation).

The report includes market analysis as follows:

- Global supply, demand, and trade for polysilicon
- In addition, supply, demand and trade data is given and discussed according to key regions, i.e., Asia, Europe, and North America – and for each region, tables giving all production plants known to Nexant showing specific plant capacities, owning company and location.