Superior top dog

Thinning audience: The oversupply of polysilicon led to a drop in interest in the 8th Solar Silicon Conference in Stuttgart – attendance numbers halved compared to the previous year.

Photos (2): Johannes Bernreuter

Is the classic Siemens process the winner of the silicon industry's technology race? At the 8th Solar Silicon Conference in Stuttgart, Germany, it certainly seemed so. Upgraded metallurgical-grade silicon has a hard time during periods of oversupply, but could play a supporting role in the future.

As the 7th Solar Silicon Conference was being held by the trade magazine Photon in Munich in early March 2009, the polysilicon price had already completed 80 % of its downswing. On the spot market, the prices were roughly at 125 US$/kg after having amounted to 400 US$/kg in October 2008. Five of seven experts on the conference podium predicted spot prices of 30 to 100 US$/kg for the coming year (SUN & WIND ENERGY 5/2009). If there was an award for the best prognosis, it would go to Richard Winegarner, President of consulting firm Sage Concepts, who estimated a spot price of 55 US$/kg – almost exactly the trade average for April 2010. The Golden Raspberry would go to Michael Rogol, Managing Director of Photon Consulting; a year ago he predicted a price of around 275 US$/kg.

At the 8th Solar Silicon Conference in Stuttgart at the end of April, Rogol markedly held back with numbers and forecasts; in contrast to last year, he made no statements regarding future silicon prices or the development of photovoltaic installations worldwide. With a silicon production of 169,000 metric tons (MT) in 2010, Rogol is still over the estimates of other experts, but he drastically reduced his figures for 2011 and 2012 compared to the previous year: 260,000 instead of the former 389,000 MT in 2012 is not far away from the production volume estimated by Winegarner, market leaders Hemlock Semiconductor Corp., USA, and German Wacker Chemie AG or the current silicon report by Bernreuter Research.

The market is segmenting

Sunil Gupta, an analyst at the U.S. bank Morgan Stanley, put the silicon production for 2010 at about 140,000 MT. Of this total amount, however, only about 120,000 MT is produced at costs below 50 US$/kg by ten manufacturers, Gupta said in Stuttgart. He conservatively estimated the probable demand at around 95,000 MT while predicting a newly installed photovoltaic capacity of 10.5 GW worldwide this year. For 2011, the analyst expects a silicon production of about 200,000 MT, of which about 180,000 MT will come from 20 manufacturers with costs below 50 US$/kg, and a demand of about 115,000 MT (at a newly installed capacity of 13.1 GW) – thus a massive oversupply. "We will probably remain oversupplied for a while," said Gupta. It could

also be clearly seen that the situation on the silicon market has relaxed by looking at the number of conference participants: it nearly halved with 381 visitors compared to the 729 in the previous year.

According to Gupta, the spot price is to drop to 40 US$/kg by 2011; he considers a further drop well below that mark to be unlikely. Although growth will slow down in 2011 after the strong demand in Germany this year, the cost reduction potential of efficient silicon producers is limited and a large portion of the total production amount is not available to the spot market due to long-term contracts. Not all Chinese newcomers will be able to compete in this market environment: Charles Yonts, an analyst at CLSA Asia Pacific in Hong Kong, expects average production costs of 41 US$/kg in China within one year.

Gupta sees a segmentation into a three-tier market: polysilicon with a relative low purity of 99.9999 % (6N), where the producers have to accept price discounts, better material (7N and especially 8N) and electronic-grade polysilicon (9N and above). This development is driven primarily by the strong trend towards cell concepts with very high efficiencies, which Ravi Khanna, Director Corporate Affairs at Norwegian Scatec AS, the investment company of REC founder Alf Bjørseth, described in his keynote speech.

UMG silicon on hold

Silicon oversupply and high efficiencies are like poison for the producers of upgraded metallurgical-grade (UMG) silicon, which only has a purity of about 5N. Already before the conference, the Canadian company Timminco Ltd. had announced that its subsidiary, Bécancour Silicon Inc., had halted the production of UMG silicon. In Stuttgart, Dow Corning Corp., USA, confirmed the same for its UMG line in Santos Dumont in Brazil.

Both companies are now working on improving their production processes to create a purer material for their re-entry into the market. While Bécancour Silicon was able to cut the boron concentration to 0.56 parts per million by weight (ppmw), the phosphorus content of 1.61 ppmw is still pretty high. In the future, Timminco's affiliate, AMG Conversion Ltd., is to produce wafers using UMG silicon.

The goals of Dow Corning are more ambitious: less than 0.5 ppmw for boron and under 1 ppmw for phosphorus. So far, a pilot plant has achieved 0.5 respectively 1.2 ppmw. By 2012, the process is slated to be ready for production. "We still believe and hope that the market will come back," said Gaëtan Borgers, Global Industry Director for Dow Corning Solar Solutions.

Exception Calisolar

Roy Johnson, CEO of the Californian start-up company Calisolar Inc., demonstrated in his presentation that you can actually produce efficient solar cells using UMG silicon. Johnson largely confirmed the figures that his colleague Martin Kaes had first presented at the 24th European Photovoltaic Solar Energy Conference in Hamburg, Germany, in September 2009. While Kaes stated a peak efficiency of 16.2 % for the company's multicrystalline solar cells, this value has in the meantime become an

Looking ahead: Discussing the silicon market in five years time on the podium are (left to right) Michael Rogol (Photon Consulting), Roy Johnson (Calisolar), Yuepeng Wan (LDK Solar), Ken Hannah (MEMC) and the moderation team with Anne Kreutzmann (Photon) and Nick Sarno (obscured, Renewable Energy Technology Inc.).

average in production; according to Johnson, the best cells now reach over 17 %. Light-induced degradation is 1.2 to 1.6 %, only slightly above the 1.1 % of conventional multicrystalline cells from polysilicon, and the breakdown voltage is at the same level as that of the polysilicon competition.

In February, Calisolar took over the Canadian UMG silicon producer 6N Silicon Inc. and thus disposes of the complete production chain from feedstock to solar cells. Johnson revealed that his company works with a boron concentration of less than 0.3 ppmw and a phosphorus content of less than 0.6 ppmw, or is at least looking to reach those values. A boron content of 0.3 or 0.4 ppmw "is absolutely decisive", said the CEO.

With an average of 0.33 ppmw for boron and 0.72 ppmw for phosphorus, the Norwegian UMG silicon producer Elkem Solar AS comes up close to these specifications. At the presentation of its first quarter results, the parent company Orkla ASA announced that Elkem Solar had concluded a supply contract with Calisolar for 500 MT in 2010 and 1,000 MT each in 2011 and 2012. In addition, the Norwegians gained a "world leading" solar energy company, whose name was not mentioned, as a customer with a purchase quantity of up to 1,000 MT in 2010.

After initial difficulties, the factory in Kristiansand is to reach its nominal production capacity of 6,000 MT per year by the end of 2010, as Torgeir Ulset, Vice President of Supply Chain and Sales, said in Stuttgart. What Ulset did not mention: Elkem Solar adjusted its original cost target of less than 20 US$/kg to about 25 US$/kg. Thus, the company has virtually no advantage anymore over the best polysilicon manufacturers relying on the conventional Siemens process.

Siemens process: soon 20 US$/kg?

The standard process for polysilicon production involves the deposition of silicon from trichlorosilane onto thin silicon rods which are electrically heated up

to 1,150 °C while the reactor shell is cooled. Although developers of alternative technologies often conjure the disadvantage of high energy consumption, the Siemens process will retain its dominance for a long time to come – this was the real message of the conference. "The Siemens reactor will have a bright future. For the next ten years, there will be no alternative," said Hans-Dieter Riede, Managing Director of Engineering and Technology at the German equipment supplier Centrotherm Sitec GmbH. By means of larger and more efficient reactors, production costs of 20 US$/kg could be achieved within five years.

The fluidized bed reactor, praised early for its low energy consumption, is considered by Riede to be suitable only for experienced silicon producers who can afford several years of test production as this technology has its drawbacks: a narrow process window, the risk of contamination of the silicon by the reactor wall and difficult reactor engineering. Depositing polysilicon from monosilane instead of the usual trichlorosilane did not appeal to Riede at all: although less energy is consumed during the deposition process, the investment costs are 20 % higher compared to the traditional trichlorosilane route, he argued.

Dave Keck, Vice President Polysilicon at the competitor GT Solar Inc., USA, took the same line. He too considers it realistic that production costs will reach 20 US$/kg with the Siemens process in five years time. According to Keck, a 6,500 MT factory can already produce at 27 US$/kg, while a plant of the same size, but utilising monosilane-based fluidized bed reactors arrives at 32 US$/kg due to higher investment costs.

One should not take the projection of 20 US$/kg literally since Centrotherm Sitec and GT Solar want to sell new reactors. However, also Mark Dassel, Executive Director Engineering and Strategic Development at trichlorosilane specialist LXE Solar, USA, presented a detailed concept for a 5,000 MT polysilicon plant in China with production costs of 20 US$/kg, based on an electricity price of 0.07 US$/kWh. Calisolar CEO Roy Johnson was not impressed by all of this. Within five years time, he expects UMG silicon production costs of 12 US$/kg. Johannes Bernreuter

The author is the owner of Bernreuter Research and lead author of the current report "The Who's Who of Solar Silicon Production".

Further information:
Bernreuter Research: www.bernreuter.com
Sage Concepts: www.sageconceptsonline.com
Photon Consulting: www.photonconsulting.com
Morgan Stanley: www.morganstanley.com
CLSA Asia Pacific: www.clsa.com
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