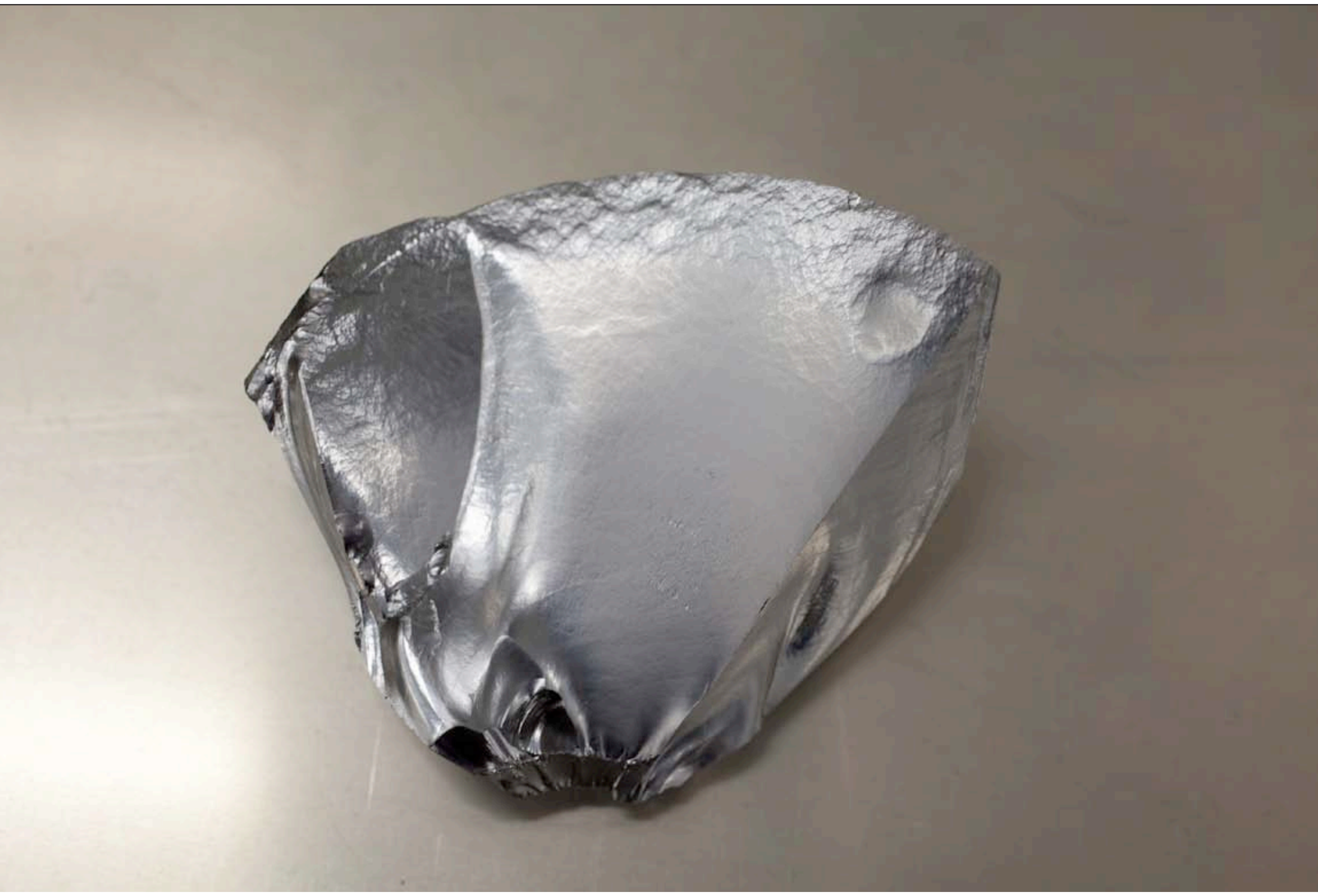

Photos: Schmid Silicon Technology

Schmid Silicon Technology's polysilicon has a high purity level that corresponds to 11N, 99,999.999.999% and can be applied in a broad range of industries.

Sustainable investment

Integrated solar busines: Burkhard Wehefritz, Director Sales Development Department at Schmid Silicon Technology (SST), explains how Schmid's integrated business model "Polysilicon to Power" can quickly make solar power production profitable, especially in the Middle East, North Africa and Southeast Asia.

Only very recently attention has been given to the fact that the levelized cost of electricity (LCOE) generated by solar photovoltaic technology already dropped below that of electricity from conventional sources. Integrated business concepts along the solar PV value chain, from upstream polysilicon production to ingot, wafer, cell and module production, have made sustainable electricity generation feasible. As soon as the LCOE is lower than the local electricity price, investments in such a business model begin to be profitable. One requirement in the middle- to long-term perspective is a consistent and reliable policy framework in the respective country of location.

MENA countries (in the Middle East and North Africa) for example have up to now mostly relied on their extensive fossil fuel reserves to generate electricity. Prices for domestic electricity were subsidized to a level where renewable energies simply couldn't compete. In the face of rising petroleum prices, increasing energy demand due to a steadily growing population, and growing environmental concerns, many governments in the region recently have introduced programs and initiatives to push the development of sustainable power generation.

Costs of a polysilicon plant

The investment costs of a polysilicon plant are mainly determined by equipment (approx. 40%) and non-equipment costs (approx. 60%), such as engineering, building and piping. The key equipment costs of a polysilicon plant of a given technology are globally more or less the same as this equipment is produced by qualified suppliers in a very cost effective environment, as is the case with the monosilane-based polysilicon produc-

Schmid Silicon Technology's polysilicon production plant in Saxony, Germany.

tion technology from SST. This practice moreover provides a clear advantage with respect to IP protection, and also guarantees high quality products from high quality equipment.

The non-equipment costs however change according to local factors. Financing also plays an important role: in regions with lower interest rates significant savings can be achieved. These factors have to be looked at in detail to help select the best location for a polysilicon plant. With subcontracting ("localization") of installation and EPC services to Middle Eastern local companies, in total up to 25% in further savings can be achieved in the EPC costs.

Operating costs

Operating costs in a polysilicon production plant are mainly determined

SST utilizes the monosilane process, which according to the company is easier to run than the conventional TCS-Siemens process: In the first step, the hydrochlorination, trichlorosilane (TCS) is produced from metallurgical silicon and feed material (STC, mgSi and H2) in a fluidbed-reactor. In the second step, the catalytic disproportionation, TCS is converted into monosilane and silicon tetrachloride. In the last process step, the monosilane chemical vapor deposition, the monosilane gas is heated, and high-purity polysilicon is deposited on heated rods, after which the high-end polysilicon can be harvested.

by electricity, labor and feedstock material. Feedstock material prices don't differ significantly in a global perspective, as the main component, metallurgical silicon (mg-Si), is widely used in the steel industry.

In contrast, energy is a different matter. Lower electricity rates and a stable supply situation, e.g. in the MENA region, compared to regions like India or some parts of South East Asia contribute significantly to reducing the operating costs to a globally competitive level. Low electricity price regions like the Middle East offer optimal preconditions as a premium production site to integrate the upstream sector of a solar value chain. With the monosilane-based technology as offered by SST, the total costs in this economic environment can be reduced to well below US$17 per kilogram of a monosilane based polysilicon. The low energy prices also provide an excellent condition to set up ingot production, which itself is a very energy intensive process.

Another precondition for the continuous production process in an efficiently working polysilicon plant is an adequate energy infrastructure. In the Middle East and North African countries, electricity and to some extent water are provided by a good infrastructure, and often seawater can be used for cooling purposes. Water is needed both for the polysilicon plant and for wafer production. Therefore, low cost and an easily accessible water resource is a basic requirement. In other countries, water often has to be transported over longer distances, generating additional logistics costs.

Even with the high-end, R&D-backed and proprietary polysilicon processing technology SST provides, polysilicon production remains a labor intensive manufacturing process. Labor costs can vary significantly and constitute up to 10% of the operating costs per kilogram polysilicon. A difference in monthly per capita wages of US$1000 results in considerable variations of up to US$1 per kilogram polysilicon. MENA regions provide a wage environment that still allows for profitable polysilicon, as well as ingot and wafer production.

Downstream integration

Schmid's wafer, cell and module factory solutions can be established nearly anywhere in the world. Even countries with medium solar irradiation can be considered as relevant and competitive locations. Still, site selection is crucial for maximizing cost efficiency and sustainability.

Real estate and labor: When planning a large-scale integrated PV factory, the availability of land and labor has to be considered. For example a 1.3 GW plant including logistics, offices, training center needs 480.000 square meters of land and gives work to 3-4,000 people. Finding skilled labor and offering them an attractive location are real challenges that must not be neglected.

Solar radiation: Areas with high irradiation will shorten the energy payback time which is a main indicator for ecological sustainability. Payback time is the time in which a PV system generates the same amount of energy that has been needed for its production from silicon to module. In MENA or Southern Asia, for example, the energy payback time for a PV module produced with Schmid Technology is only six months.

Wage levels: Wage levels in Southern Asia are still relatively low in global comparison. The operation and maintenance of PV systems, on the other hand, are more labor-intensive than the operation of the upstream sector of the solar value chain. In East Asia for example, wage levels are even lower, but the annual solar radiation is about 1000kWh/year less than in Southern Asia. In combination with its excellent irradiance levels of approximately 1700-2200kWh/year, Southern Asia therefore is a preferable target region for downstream integration.

Energy availability and costs: As mentioned above, energy availability and costs play an important role for an efficiently working polysilicon plant. This is also true for downstream production. However, for module selling and the construction of power plants, energy availability and costs for residential and small commercial consumers are far more crucial. Eastern and Southern Asia are interesting areas because energy retail prices usually exceed the PV LCOE that starts below US$0.10/kWh in these areas. Diesel generated power for off-grid homes exceeds these costs by far and confirms PV as the best possible off-grid solution.

In regions where the LCOE is not below retail prices, PV power can still be cost efficient when there is a general lack of energy. This applies for many Asian, African and South American regions.

Balance of system costs (BOS): As the solar LCOE depends to a large degree on BOS costs, the achievable electricity price is strongly influenced by the extent to which components can be acquired locally, by the pricing for commodities like cabling and mounting structures, as well as labor costs.

Political framework: PV power needs a stable framework committed to sustainable energy. This does not necessarily mean the availability of feed-in tariffs – they are not needed in most regions. It's more about a reliable roadmap that defines the role of finite energy sources as supportive to sustainable energy and sets a clear exit date and strategy. The framework should strengthen the implementation of sustainable energy, e.g. by investing in research and development, by lowering administrative barriers for residential PV installations and PV power plants and by supporting innovations like the use of storage systems.

Level of factory integration: Another factor that strongly contributes to maximizing sustainability is the level of factory integration. An analysis that only looks at the wage level and irradiation level could support the decision of splitting polysilicon production and downstream processes to different regions. But a "from polysilicon to power" factory solution with its optimal alignment of production processes itself is a key for low consumption and total cost. It is obvious that the integration of infrastructure, logistics and distribution leads to synergies that cut down effort and costs and ultimately lead to higher quality and yields. Examples for integration synergies are reduced footprints, an increase in purchasing volumes, and no need for transportation, just to name a few.

Technology and modularity

The commitment to increase module efficiency and processes that reduce the use of rare materials secures sustainability for the future. With about 250 research and process engineers and by cooperating with universities and independent institutes, Schmid has made the necessary efforts to reach its roadmap goals. These goals are: to increase the wafer output of a factory solution by manufacturing thinner wafers and using efficient wafer cleaning processes; to significantly reduce the amount of silver by using highly efficient metallization technologies; rear passivated solar cells with an efficiency of nearly 21%; high module efficiency by using the multi busbar module design. New Schmid EPC services for PV power plants empower investors to successfully establish a module business. Individual assistance and long-term support form the basis of cooperation while the technical highlight is a desert PV module with optimized power output at high temperatures.

In the Schmid Group technology portfolio, including Schmid Silicon Technology, the technology for each production step inside the solar value chain is offered on a modular basis. This means, in line with the group's continuous R&D achievements, that the technology of every single unit in the value chain can be upgraded easily by exchanging only this one unit. This facilitates efficient modification without having to upgrade the entire system, and guarantees that every Schmid or SST plant can operate with state-of-the-art technology.

For the integrated business model "Polysilicon to Power" to succeed, the chosen location should provide a few basic requirements as mentioned above. However, compared to other solar generation technologies like CSP, the general site requirements of a fully integrated PV value chain are in fact minimal.

The rewards for industries and governments, on the other hand, are large: investing in an integrated PV value chain comes with a whole array of benefits for the economy and the environment. A 600-MW integrated fab, for example, creates US$12 million per year in carbon credits. Furthermore, 100 MW of solar power translates into a contribution to a state economy's GDP of about US$600 million, ten times more than fossil fuels could achieve. A 600-MW fully integrated PV value chain provides 10.000 jobs in the economy and supports the lives of approximately 50.000 people. In one year, 687,000 BOE (barrels of oil equivalent) can be saved for energy and higher value chemicals generation.

The shift to sustainability

Schmid's integrated fab solutions help to reduce the levelized cost of electricity (LCOE). In most regions of the world the LCOE is already below the residential retail electricity price. But at the same time the rapidly growing power demand is still met by diesel power generation. Its annual increase is higher than annual PV installation and could reach 82 GW by 2018, according to Pike Research. Factory Solutions is a real chance for policymakers to start reaching their goals in shifting to sustainable energy sources and in creating industry jobs. ◆

Burkhard Wehefritz

Platzhalter