

Siridion[®] – Photovoltaics



Siridion[®]

Where Siridion® makes all the difference

Evonik has decades of experience in the development, cost-efficient production as well as in the safe handling and transport of Siridion® monosilane and chlorosilanes, and is one of the largest suppliers of this product class worldwide. Although Siridion® products are also used as precursors for the production of other Evonik products such as fumed silica (AEROSIL®) and functional silanes (Protectosil®, Dynasytan®) as well as for an array of processes in various industries, such as chlorinating reactions, our main external customers come from four cutting-edge industries: optical fibers, flat panel displays, semiconductors and photovoltaics.

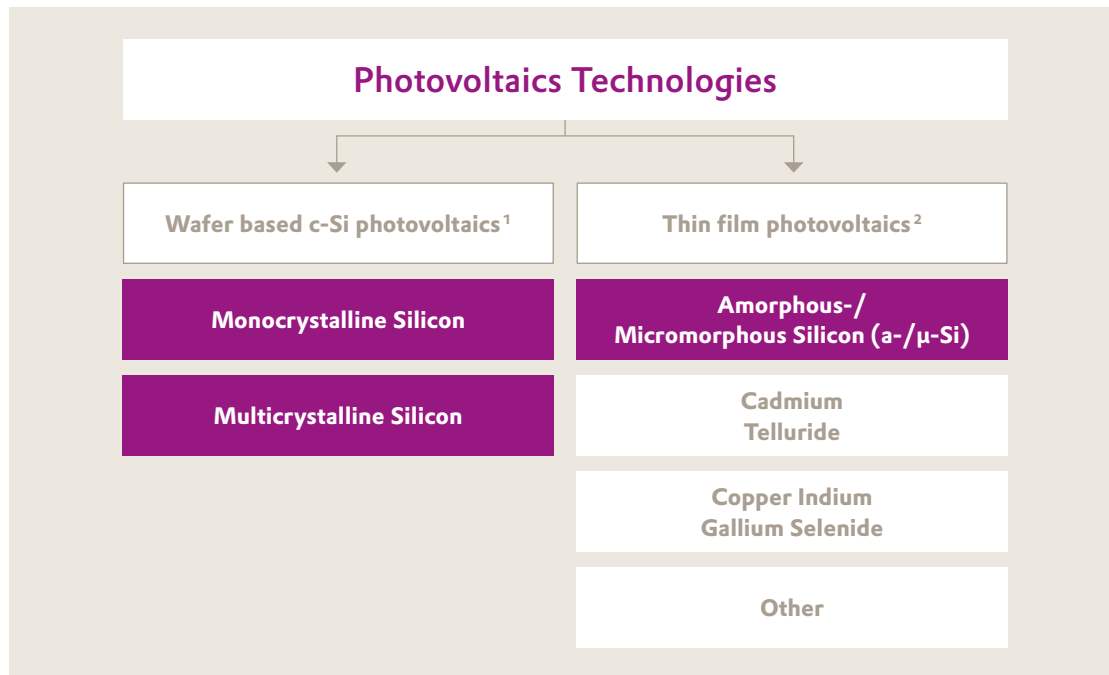


Wafer based photovoltaics

Siridion® for photovoltaics

The higher the purity of the chlorosilanes used to manufacture solar-grade silicon, the more efficient the solar cells will ultimately be in converting sunlight into energy. That is why ultrapure Siridion® chloro-

silanes and monosilane are a key resource in particular to manufacturers of polycrystalline silicon used for wafer based c-Si photovoltaics and manufacturers of silicon based thin film modules around the globe.



¹ Wafer thickness: 180 – 200 μm

² Photoactive layer thickness: < 2 μm



Thin film photovoltaics



Evonik's global Siridion® 'Verbund' and supply reliability for our photo

Evonik is one of very few manufacturers able to supply monosilane and chlorosilanes at ultrahigh purity levels on an industrial scale to customers in the photovoltaics industry.

Here, Evonik's strength is in its integrated network – the 'Verbund' – with manufacturing and processing sites for chlorosilanes and monosilane in Rheinfelden and Bitterfeld (Germany); Sinigo (Italy), Antwerp (Belgium) and Yokkaichi (Japan).

A strong CS 'Verbund' to support integrated supply

Together with partners in the photovoltaics industry, Evonik has in recent years developed a successful integrated concept. Here, we work very closely with the customer in designing a supply and production setup that integrates our respective strengths to minimize manufacturing costs and maximize productivity. Evonik's decades of experience in the operation of chlorosilanes plants also means that the technology is utilized efficiently from day one.

In addition, docking onto the Evonik 'Verbund' system enables the customer to realize substantial synergies and significantly improve cost structures. This way, the benefits of the 'Verbund' translate into real

competitive advantages for our customers. Evonik can ensure a high degree of supply and operational reliability – and the customer can count on full access to the resources of the 'Verbund.' Combining a highly integrated supply solution with the Evonik 'Verbund' creates additional flexibility – and cost savings potential – for efficiently processing any sidestreams along the production line. Depending on the setup, the 'Verbund' can for instance handle large quantities of hydrogen chloride generated as a by-product of manufacturing processes or contaminated silane-containing sidestreams that can't be utilized in polycrystalline silicon production.



ensures operational voltaics customers

This unique approach to integrated supply gives the customer the double advantage of being able to rely on Evonik's proven and cost-efficient chlorosilane technology, and achieving substantial cost savings through closed sidestream loops. In addition, no transportation costs have to be factored in because the resource is manufactured on site.

As part of the integrated concept – and in contrast to many other technology suppliers – Evonik not only provides customers with the necessary technology,

but also manufactures monosilane and chlorosilanes at the customer's site. This ensures not only seamless supply to the customer's production line, e.g. with chlorosilanes for the polycrystalline silicon deposition process, but also smooth processes and consistent product purity.

One of the key strengths of the integrated supply business model supporting the partnership with our customer is the fact that it can be precisely adapted to the customer's needs – with maximum flexibility.

A direct supply chain built on Responsible Care®

Evonik is also synonymous with efficient, reliable and secure logistics when it comes to direct supply of chlorosilanes to customers in the PV industry – a crucial advantage when compensating for chlorosilane losses in polycrystalline silicon production, for instance. Here, too, maintaining the highest safety

and quality standards is a top priority at every stage and in every aspect of the value chain. Evonik follows through on this commitment with hands-on assistance in correct and safe handling of the chlorosilanes supplied.

Best-in-class manufacturing tech

The most common method for producing PCS is the discontinuous Siemens process based on high purity trichlorosilane (TCS). High-purity silicon seed rods are exposed to TCS at high temperatures in the Siemens reactor; the TCS decomposes and deposits additional silicon on the rods until they reach a

certain diameter. These rods of ultrapure PCS are then broken down into chunks for onward processing. One advantage is that the STC generated as a by-product can be converted back into TCS through hydrogenation.

TCS & STC production by Evonik

Evonik has developed competitive fixed bed and fluidized bed reactor technologies for the production of chlorosilanes – trichlorosilane (TCS) and silicon tetrachloride (STC) – based on highest technological and operational excellence, from initial facility planning to construction, commissioning and operation. Both types of reactors have been in operation and continuously optimized at Evonik's chlorosilane

production sites for several decades, giving our customers the peace of mind that comes from tried and tested technology.

At the same, Evonik is always working on new technologies to further drive down polycrystalline silicon manufacturing costs – best-in-class STC conversion is already well along in the development pipeline.

Cost-effective chlorosilane synthesis with fixed bed reactor technology

Extensive practical experience has enabled Evonik to refine fixed bed reactor technology into a very reliable and robust process.

Although capital expenditure for a fixed-bed reactor is in the same range as for the fluidized bed type, the fixed-bed reactor can use cheaper metallurgical-grade silicon chunks as a feedstock. Silicon chunks in fact no longer have to be milled, and metallurgical-grade silicon quality can be as low as Si 96 – in contrast to the much higher qualities required for fluidized bed reactor technology (typically >Si 98).

The chunks are reacted with hydrochloric acid at around 1000 °C to produce a mixture of STC and TCS.

The high reaction temperature allows a high refeed rate for the different sidestreams containing impurities back into the reactor. Here, impurities from the silicon metal are concentrated into a rather small purge stream to be discharged from the plant for more efficient raw material utilization with low metallurgical to polycrystalline silicon ratios.

Therefore depending on the degree of integration, fixed bed reactor technology offers attractive investment aspects when taking into account the capital expenditure for the whole production setup.

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State-of-the-art fluidized bed reactor technology

Evonik possesses a high level of expertise in fluidized bed reactor technology for chlorosilane synthesis where metallurgical-grade silicon powder is reacted with hydrochloric acid to provide TSC and STC. If the

customer's existing production setup is already geared for mainly handling TCS streams, Evonik offers the flexibility of building an integrated supply based on fluidized bed reactor technology.

Cutting edge monosilane technology

In recent years, Evonik has developed a competitive monosilane production process based on the dismutation of trichlorosilane. Evonik operates two plants with this technology – in Rheinfelden, Germany, and

Yokkaichi, Japan. Evonik's monosilane process is key to silicon-based thin film photovoltaics and PCS production based on monosilane deposition.



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