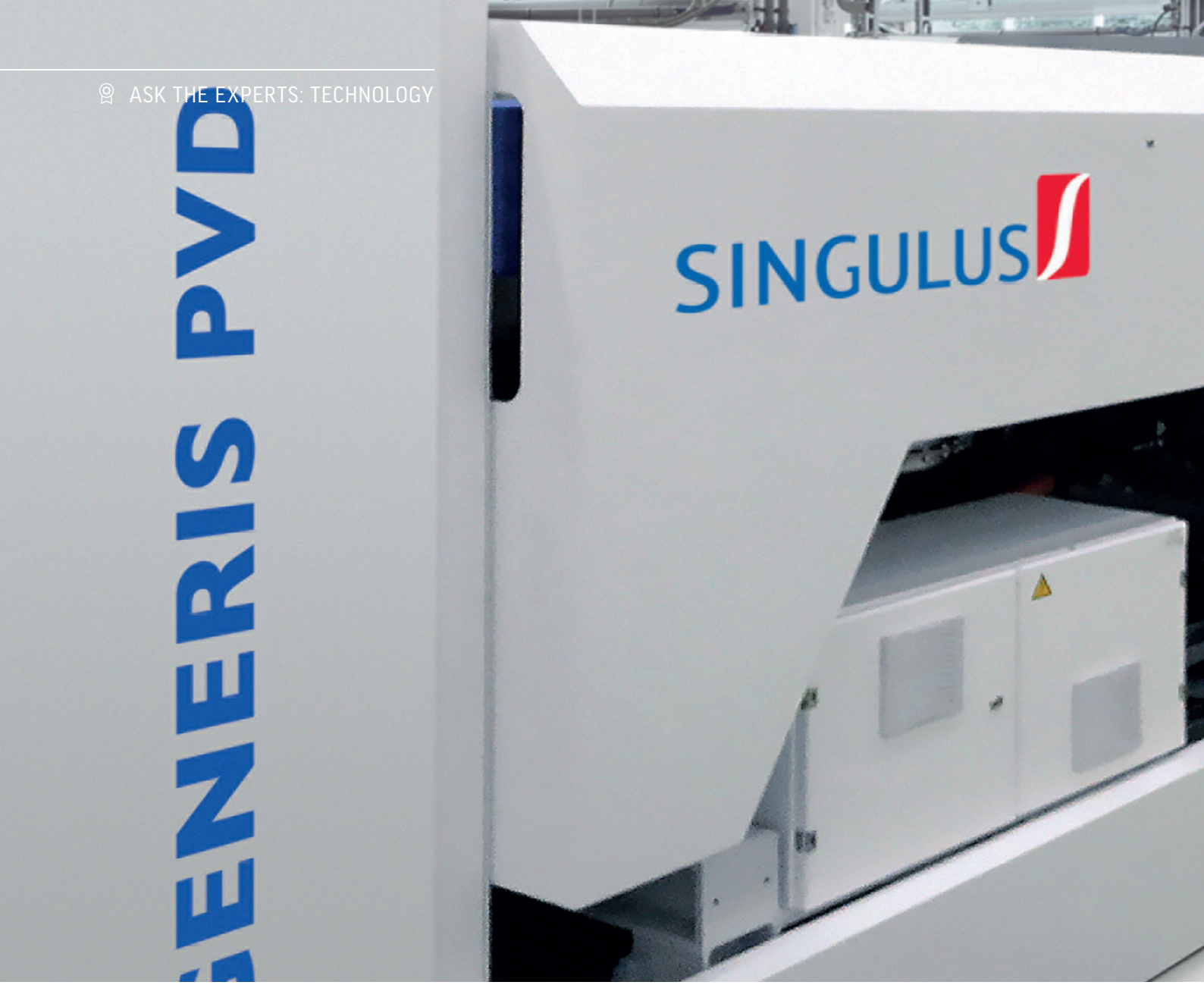



# Innovative, efficient new technologies

Dr.-Ing. Stefan Rinck, CEO at SINGULUS TECHNOLOGIES and PES go back a long way. This is a company at the forefront of technology. They develop and assemble ground-breaking machines and systems, resulting in efficient and resource-saving production processes, which are used world-wide in the solar/PV industry as well as in other market segments.

**PES: Welcome back to PES Solar/PV. It's a real pleasure to talk with you. For the benefit of our new readers would you like to begin by explaining a little about the background of SINGULUS TECHNOLOGIES and how you currently serve the solar industry?**

**Dr.-Ing. Stefan Rinck:** We thank you for your continued interest in SINGULUS TECHNOLOGIES and as always, look forward to interacting with PES.

The company was founded in 1995 as a spin-off from Leybold AG, Hanau, Germany. At that time, we started with one product: a small vacuum sputtering system for CDs. Complete turn-key lines were developed very quickly for all optical disc formats (CD, DVD and Blu-ray Disc). SINGULUS TECHNOLOGIES was and continues to be the world market leader in this segment.

In 2007 the company decided to invest in the solar area. The leading manufacturer of wet chemical cleaning, etching and coating systems, Stangl, with a plant near Munich, was acquired by our organization.

We initially focused on the development of various production systems for thin-film solar cells. With its sputtering and evaporation systems as well as the selenization systems of the CISARIS type, SINGULUS TECHNOLOGIES is now in a global leading position. We have also developed new production machines for crystalline high-performance solar cells that are in use all over the world.

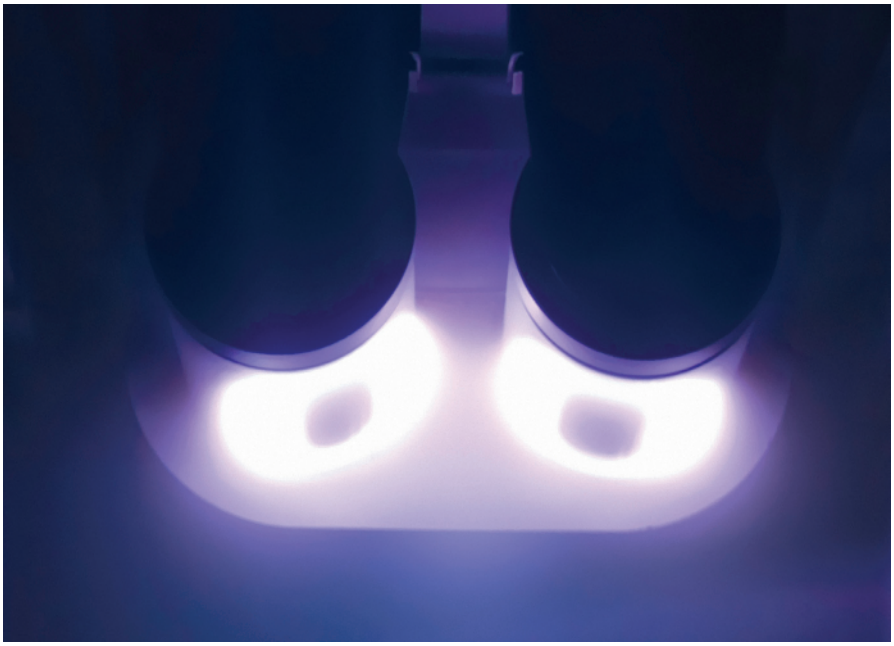
Today we develop and assemble innovative machines and systems for efficient and resource-saving production processes, which are used worldwide in the solar, semiconductor, medical technology as well as consumer goods and data storage sectors.

**PES: How would you say the current HJT market situation is globally? Are you seeing market expansion?**

**SR:** Heterojunction technology (HJT) is currently the first choice of the solar industry to increase solar cell efficiency and solar module power output to its highest levels. Former thin-film module producers have invested in HJT, but also new investments by well-established producers of silicon solar cells have been made during the past year and more investments are announced for 2020 and years to come.

Dr.-Ing. Stefan Rinck

HJT combines highest quality n-doped crystalline silicon wafers with best passivation and charge selective properties of amorphous silicon thin-film layers as well as highly transparent TCO contact layers with the aim to produce a high-power solar cell that surpasses the performance of conventional solar cells with diffused



emitters as e.g. PERC.

A lot has been done, by Meyer Burger and SINGULUS TECHNOLOGIES as well as others, to introduce newer machines with higher productivity and lower costs and that is helping HJT to pick up very fast.

**PES: Is this world-wide, or in certain areas? What do you see as the key drivers of this growth?**

**SR:** Compared to PERC or TOPCon cells, the production sequence of HJT solar cells is less complex, because of the significantly lower number of individual production steps required. Also, module power degradation is with 0.45 % per year dramatically better compared to 0.7 % yearly degradation for PERC modules. Due to the high cell efficiency and the lower temperature coefficients, HJT modules deliver a higher average energy production performance compared to conventional silicon solar cells.

**PES: We know you're a major player in HJT and were wondering if it's your most important technology offering currently?**

**SR:** SINGULUS TECHNOLOGIES has delivered production equipment in the past to many large solar cell manufacturers for HJT application. Wet processing systems as well as vacuum thin-film deposition systems are working in cell factories around the world. In 2019, we installed a large inline vacuum sputtering machine with the brand name GENERIS PVD for the production of heterojunction solar cells to a large tier 1 manufacturer of solar cells providing excellent production performance in the daily business.

**PES: Are you able to elaborate on any new projects and/or developments in the European markets?**

**SR:** Of course, we also follow the publications about the development of the solar market and we are looking at the numbers. Many studies have shown that the PV market will grow rapidly; up to 12 TW are expected to be installed by 2030 worldwide. This is an impressive increase compared to today's installed capacity of about 630 GW. By taking a leading role in providing sustainable PV, Europe would secure its economic future.

This vision of high-tech and sustainable PV production along the value chain in Europe can become a reality since R&D centers in Europe already provide efficient and more sustainable technologies compared to today's world market products. The study from Fraunhofer/VDMA has shown, that a competitive solar cell manufacturing in Europe is possible.

The 'Solar Manufacturing Accelerator', launched in May 2020 by SolarPower Europe, and coordinated with strategic partners ESMC, ETIP-PV, IPVF, and VDMA, aims to accelerate the deployment of solar PV manufacturing projects in Europe to strengthen European leadership in renewable technologies.

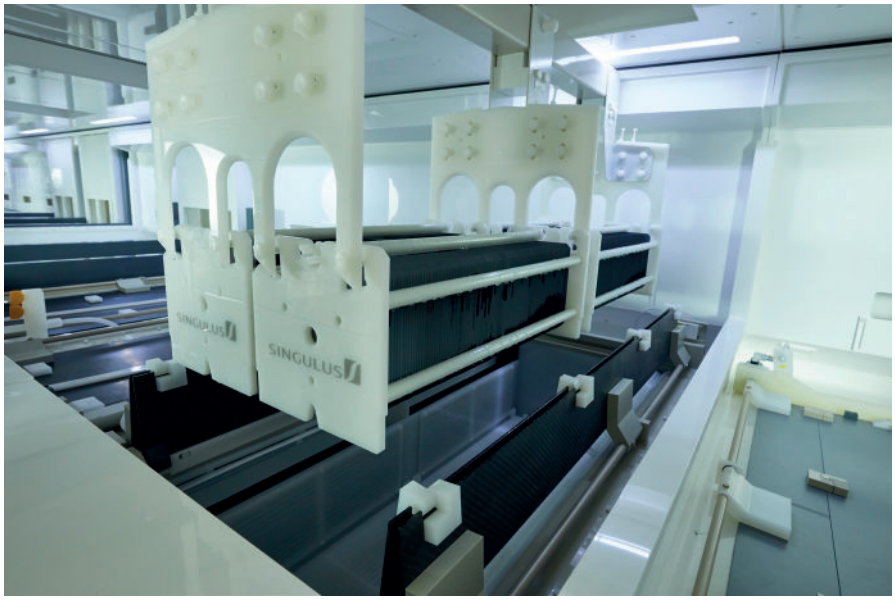
Ten European solar manufacturing projects, featuring manufacturing and innovation of cells, modules and wafers, which represents more than 20,000 new jobs in Europe are in discussion - and we can see already production in HJT cell technology in Italy, Germany, Russia and other countries in Europe.

**PES: And what about Asia? And China in particular?**

**SR:** We are seeing a growing interest in heterojunction in China, too. More and more companies are examining the possibility of investing in heterojunction or, if they have already started with heterojunction, to further expand their capacities.

**PES: We have been hearing about your other solutions, such as wet processing, physical vapor deposition (PVD) process and machine solution, please can you tell us about these? What makes SINGULUS products stand out from the competition, what are the benefits to the end user?**

**SR:** Wet processing, including ozone treatment, is an important key process step in the manufacturing of HJT solar cells. The process starts with saw damage etching and texturization. After texturing, several surface cleaning steps are required to remove organic and metallic impurities.




SINGULUS TECHNOLOGIES provides completely automated dry-in/dry-out solutions for wet-chemical treatment of silicon wafers in standard and high-efficiency cell lines. The modular SILEX II batch system offers a wide range of process options.

The SILEX II 12000 system achieves an output of over 12,000 wph HJT cells for an annual capacity of about 550 MW with very low scrap rates down to 0.01 % and a high process yield. It is designed to apply very fast, optimized texturing processes, offering substantial cost advantages compared to traditional etching systems. Compared to traditional wet tools with RCA cleaning, the SILEX II, which includes ozone technology enables producers of solar cells to implement a substantially more cost-efficient and environmental-friendly production step.

We have sold more than 30 SILEX II to HJT cell producers and supplied the systems to customers in the USA, Asia including China and Europe.

SINGULUS TECHNOLOGIES has been active for 25 years in the area of vacuum sputtering and has delivered more than 8,500 systems worldwide. Numerous SINGULUS TECHNOLOGIES vacuum sputtering machines are in operation in the solar industry, where we provide with the GENERIS PVD for the specific requirements of the production of high-performance HJT solar cells.

The GENERIS PVD ideally meets the key requirements of the heterojunction cell technology in respect of sophisticated transparent conductive oxide layers (TCO), such as ITO (Indium Tin Oxide) and AZO (Aluminum doped Zinc Oxide). The solar cells are automatically transported through the process chambers of the GENERIS PVD, following the inline principle and applying coatings on both sides. The sputtering system safeguards a high level of layer thickness uniformity with high layer reproducibility, high productivity and at the same time very low operating expenses (OPEX).

Compared to conventional alternative processes like Reactive Plasma Deposition (RPD), our vacuum inline sputtering system offers a number of clear advantages. Based on the calculation for a 1 GW production fab for HJT solar cells, the CAPEX for using a reduced number of high-throughput sputtering systems from SINGULUS TECHNOLOGIES, with a max. capacity of 10,000 wafers per hour (wph), leading to an annual equipment output of about 500 MW, is

by far lower compared to RPD systems with a capacity of only 2,500 wph. There are further savings due to the smaller footprint of the equipment and related smaller building and cleanroom space requirements.

In addition, RPD systems offer only bottom up, single-sided processes requiring a wafer flip which causes additional, unnecessary wafer handling. In comparison, the dual-sided processes of the GENERIS PVD require less wafer handling resulting in reduced wafer breakage, wafer damage and wafer marks.

**PES: How has the current coronavirus situation impacted on your business? How do you see this developing over the next 6-12 months?**

**SR:** The global impact of the COVID-19 pandemic was felt in nearly all of the company's segments in the first half of the year. While in the first quarter the impact of the pandemic was mainly limited to the business activities within China, this development accelerated further in the course of the second quarter.

All leading solar market analysts have significantly lowered their forecasts for the newly installed PV capacities for 2020 during the first months of the current year in connection with the COVID-19 pandemic. The largest short-term cuts were made by IHS Markit, which lowered its forecasts for 2020 from 142 GW provided in December 2019 to 109 GW in April 2020. This corresponds to a decline of 26 %. At the end of May the estimates of the analysts ranged from 106 GW (Wood Mackenzie) to 111 GW (Bloomberg NEF).

The current market analysis by SolarPower Europe forecast a base scenario of expected newly installed PV capacity of 112 GW for the year 2020. Compared with 2019 this would mean a market decline of 4 %. In particular, according to these market analyses the future development in China is of key importance for the future demand for PV capacities.

On the one hand, due to the global spread of the virus all key sales markets of the company were affected. On the other hand, due to the rigid implementation of long-lasting lockdowns in many countries, as well the resulting halt in travel, the operating course of business was additionally impacted.

**PES: What do you think will be the greatest opportunities and the greatest challenges, for solar/PV in general and SINGULUS TECHNOLOGIES in particular, over the next few years?**

**SR:** The biggest challenge for a company is always the time to market factor. That means having the right product for the right application ready for the market. We see numerous opportunities for healthy development in the coming years. Solar energy is the most accepted renewable energy source for the future and key technology to decarbonize the worldwide energy production.

On one hand, we are developing the various production sites for thin-film solar (CIGS/CdTe) with our key customer CNBM and on the other hand, we are positioning ourselves at the forefront of the most important cell format on the crystalline side, the heterojunction cell, for the expected investments in production capacity.

But also, with our new products for decorative 3D coatings, medical technology and semiconductor applications, we are also well equipped to open up these markets.

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