



GENERIS PVD

Inline Sputtering System
for High Performance
Solar Cells

SINGULUS 

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Inline Sputtering System for High Performance Solar Cells

Sputtering Competence

SINGULUS TECHNOLOGIES has delivered far more than 8,500 vacuum sputtering machines since its foundation in 1995. The machines range from standard sputtering systems to ultra-high vacuum deposition machines applying extremely thin layers of around 0.2 nm for the semiconductor industry as well as photovoltaic, data storage, decorative coatings and other applications. In addition, vacuum thin-film technology is used in modern sensory technology for medical uses and in vehicle technology as well as for piezoelectric materials in mobile phone technology.

A close cooperation with scientific institutes like Fraunhofer ISE, Helmholtz-Zentrum Berlin (HZB), and SERIS as well as with research organizations and institutes in the USA and in China allow SINGULUS TECHNOLOGIES to participate and make use of the latest HJT research results worldwide.

Sputtering Technology for High Performance Solar Cells e.g. Heterojunction Cells

Due to the high cell efficiency and the lower temperature coefficients, Heterojunction (HJT) modules deliver a higher average energy production performance compared to conventional silicon solar cells. A record efficiency of 25.11 % for a full size (244 cm²), both side contacted heterojunction solar cell has been reported in November 2019 by PV Magazine. A back-contact heterojunction cell with an efficiency of 26.7 % holds the record for single junction crystalline silicon solar cells. Today solar modules with HJT solar cells are commercially available with about 400-Watt rated capacity.

The SINGULUS TECHNOLOGIES GENERIS PVD has been especially designed for very thin substrates such as silicon wafers for the manufacturing of HJT solar cells. To generate and supply electric energy,



GENERIS PVD

*Dedicated Inline
Sputtering System for
Heterojunction Solar Cells*

thin-films of different electronic properties are deposited on the n-doped crystalline silicon wafer. The heterojunction and passivating structures are formed by dual-sided thin layers of intrinsic and doped amorphous silicon. On top of these silicon structures, thin and transparent conductive oxide films (TCO) are applied by a sputtering process as contact layers to conduct the generated electricity out of the cell.

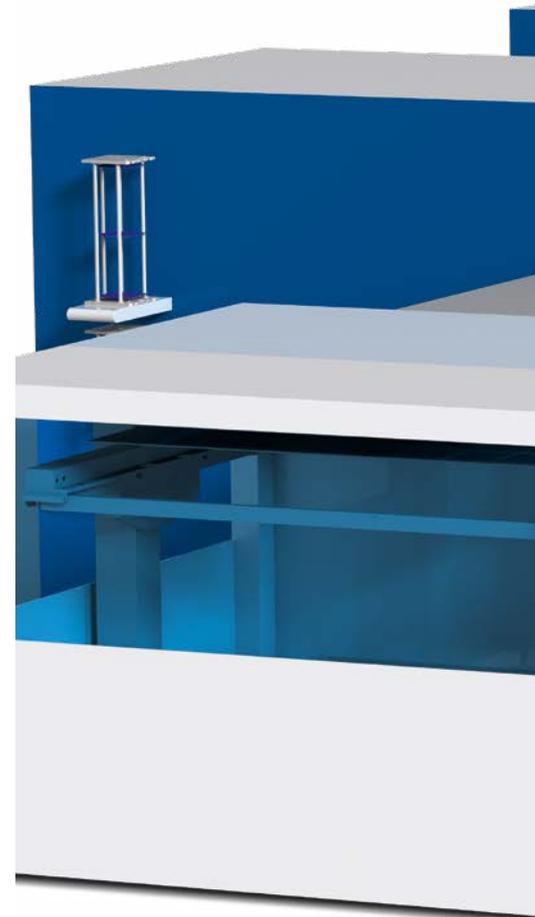
One of the most common approaches to grow thin films by sputter deposition is the use of a magnetron source, in which the plasma is confined and enhanced by a magnetic field. Positive ions are accelerated from the plasma into the target surface, where they release target material to be coated on the substrates. Well known sputtering methods are direct current (DC) sputtering for electrically conductive targets and radio frequency (RF) sputtering for nonconductive targets. Magnetron sputtering is available on the market in different modes like DC, pulsed DC, bipolar and RF. Due to its versatility, the convenient control of the process and the possibility to apply it on a large scale at low cost, sputter deposition or sputtering is widely used in different industries as well as in R&D applications.

Numerous SINGULUS TECHNOLOGIES vacuum sputtering machines are in operation in the solar industry, where SINGULUS TECHNOLOGIES provides the GENERIS PVD as a high throughput inline sputtering system platform with horizontal substrate transport. The GENERIS PVD is engineered 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 with respect to 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).

A full substrate temperature control during the whole process section enables optimum layer performance at temperatures ≤ 200 °C. Compared to conventional alternative processes like Reactive Plasma Deposition (RPD), a 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) is by far lower compared to RPD systems with a capacity of only 2,500 wph. With the latest system generation GENERIS PVD 10000, SINGULUS TECHNOLOGIES can assure capacities up to 10,000 wph leading to an annual equipment output of about 500 MW. 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. SINGULUS TECHNOLOGIES offers the GENERIS PVD with different throughput ranges of 3,000, 6,000 and up to 10,000 wafer per hour.

Based on long lasting experience, systems designed by SINGULUS TECHNOLOGIES offer high throughput and high uptime. SINGULUS TECHNOLOGIES takes advantage of in-house magnetron development, simulation and optimization of different sputtering processes and in-house component and process developed using state-of-the-art sputtering lab equipment at SINGULUS TECHNOLOGIES R&D center. Newly developed processes can be directly adapted to the GENERIS PVD mass production platform.



The Modularity of the GENERIS PVD System Allows a High Degree of Flexibility

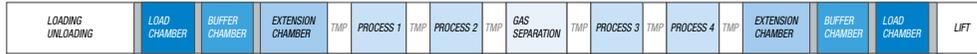
GENERIS Lab



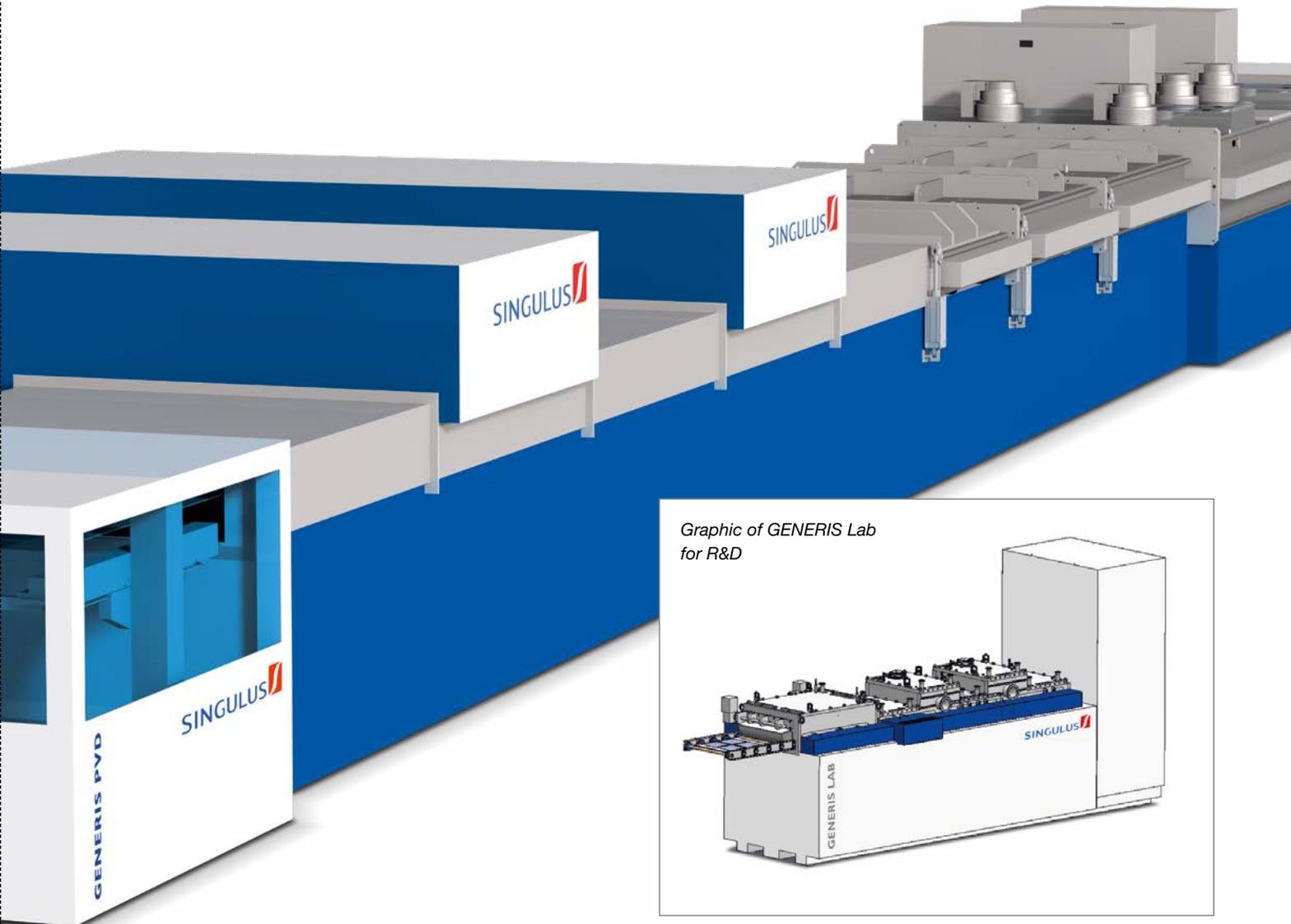
GENERIS PVD 3000



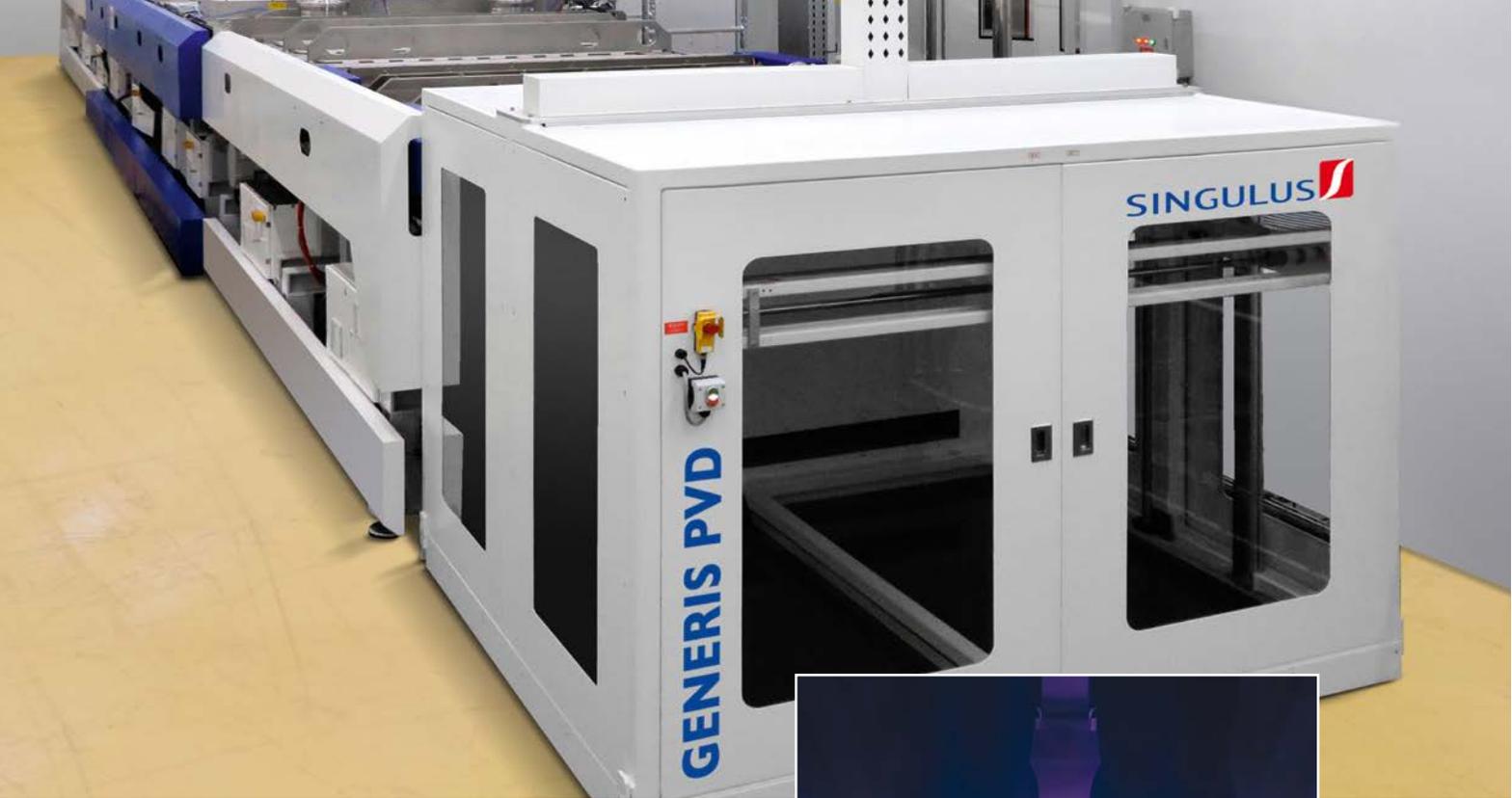
GENERIS PVD 6000



GENERIS PVD 10000



Graphic of GENERIS Lab for R&D



**Typical Performance Characteristics
GENERIS PVD**

- Sputtering materials: ITO, AZO and metals like Ag, NiV, Cu, Al etc.
- Parallel processing of several substrates (Si-wafers)
- Available in 4 versions:
 - GENERIS LAB
 - GENERIS PVD 3000 for approx. 3,000 wph
 - GENERIS PVD 6000 for approx. 6,000 wph
 - GENERIS PVD 10000 for approx. 10,000 wph
- Modular configuration
- Low cost of ownership and high uptime
- Top down and bottom up sputtering configurable
- Sputter sequence configurable
- Full temperature control throughout the whole process
- Rotatable cylindrical magnetrons for highest utilization of target material
- Single end and double end version selectable
- Manual or semi-automated lab versions on request

Rotary Magnetrons with Intensive Cooling and Highest Material/Target Utilization

- Target utilization about 80 % for rotatable cathodes compared with only 30 % for planar cathodes
- More stable process with rotatable cathodes because of less nozzle formation
- Long-life rotary seals
- Maintenance on customers' site
- Advanced water fill and drain features
- Flexible target attachment method and non-proprietary target design

GENERIS PVD

Technical Data

Application	Heterojunction solar cells & other high-performance cells
Cycle time	45 - 75 s/carrier, depending on configuration
Carrier size	~ 1,400 mm x 1,200 mm 64 wafers per carrier, depending on wafer size
Throughput	3,000, 6,000 and 10,000 wph, depending on configuration
Sputter material	ITO, AZO, Ag, NiV, Cu, Al, etc.
Sputter orientation	Top down/bottom up
Vacuum base pressure	1 x 10 ⁻⁶ mbar
Typical process pressure	2 - 5 x 10 ⁻³ mbar



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THIN FILM
DEPOSITION



SURFACE
ENGINEERING



THERMAL
PROCESSING



WET
CHEMICAL

SINGULUS TECHNOLOGIES – Innovations for New Technologies

SINGULUS TECHNOLOGIES develops and assembles innovative machines and systems for efficient and resource-saving production processes, which are used worldwide in the solar, semiconductor, medical technology, consumer goods and data storage.

The company's core competencies include various processes of coating technology, surface treatment and wet-chemical and thermal production processes.