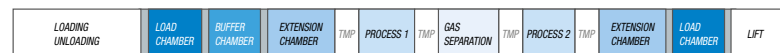


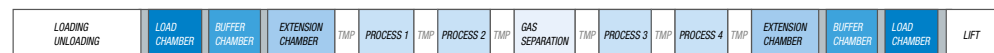
#### GENERIS Lab



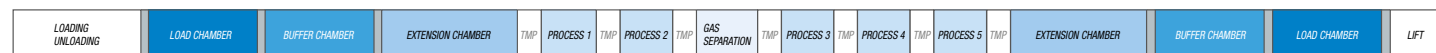
#### GENERIS PVD 3000



#### GENERIS PVD 6800



#### GENERIS PVD 10000



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



#### TYPICAL PERFORMANCE CHARACTERISTICS

- » Sputtering materials: TCOs and other reactively sputtered layers: ITO, AZO, NiO, TiO2 and metallic layers: Ag, Cu, Cr, Mo, Ni and more
- » Typical applications include anti-reflection layers, barrier layers, electrical contacting or insulating layers
- » Available in 4 versions:
  - › GENERIS LAB
  - › GENERIS PVD 3000 for approx. 3,000 wph (M6)
  - › GENERIS PVD 6800 for approx. 6,800 wph (M6)
  - › GENERIS PVD 10000 for approx. 10,000 wph (M6)
- » Carrier loading area: 1,400 mm x 1,600/2,000 mm
- » Typical tact time: 40 - 75 s per carrier
- » Parallel processing of substrates (e.g. display, glass, Si wafers) via carrier tray
- » High-speed automatization for carrier tray loading and unloading (single or double side)
- » Top down and bottom-up sputtering configurable – dual side sputtering without vacuum breakage
- » Full substrate temperature control
- » Low cost of ownership and high uptime
- » Sputter sequence configurable
- » Rotatable cylindrical magnetrons
- » Highest utilization of target material
- » Carrier return system (CRS) underneath of machine
- » Vacuum base pressure: <math>1 \times 10^{-6}</math> mbar, typical process pressure: <math>1 - 10 \times 10^{-3}</math> mbar

#### ROTARY MAGNETRONS WITH INTENSIVE COOLING AND HIGHEST MATERIAL/TARGET UTILIZATION

- » Target utilization about 80 % for rotatable cathodes compared with only 30 % for planar cathodes
- » Stable processes with ceramic targets
- » 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 products
Substrate size	M2, M4, M6, M10 and M12 & half cut formats
Cycle time	45 - 75 s/carrier, depending on configuration
Carrier size	80 wafers (M6) per carrier
Throughput (M6)	3,000, 6,800 and 10,000 wph, depending on configuration
Sputtering materials	TCOs and other reactively sputtered layers: ITO, AZO, NiO, TiO2 and metallic layers: Ag, Cu, Cr, Mo, Ni and more
Sputter orientation	Top down/bottom up
Vacuum base pressure	$1 \times 10^{-6}$ mbar
Variable configurations	Pretreatment solutions, gas separations, top-down and bottom-up deposition, multiple heating concepts

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#### SINGULUS TECHNOLOGIES - Thin-Film Coating and Surface Treatment

SINGULUS TECHNOLOGIES develops and assembles innovative machines and systems for efficient thin-film coating and surface treatment processes, which are used worldwide in the Photovoltaics, Semiconductor, Medical Technology, Packaging, Glass & Automotive as well as Battery & Hydrogen markets.

The company's core competencies include various processes of coating technology, surface treatment as well as wet-chemical and thermal production processes. SINGULUS TECHNOLOGIES sees sustainability as an opportunity to position itself with innovative products. In the focus are:

- » Environmental awareness
- » Efficient use of resources
- » Avoidance of unnecessary CO<sub>2</sub> pollution

SINGULUS TECHNOLOGIES attaches great importance to responsible and sustainable corporate governance.



# GENERIS PVD

Reliable Inline  
 Vacuum Sputtering  
 System with Horizontal  
 Substrate Transport



# GENERIS PVD

## Inline Sputtering System with Horizontal Substrate Transport

### Sputtering Competence

SINGULUS TECHNOLOGIES has delivered far more than 8,500 vacuum sputtering machines since its foundation in 1995. The machines range from ultra-high vacuum deposition machines applying extremely thin layers of around 0.2 nm for the semiconductor industry down to high-throughput sputter machines for metallizing of e.g. a lipstick cover in 0.3 s.

PVD Systems from SINGULUS TECHNOLOGIES are mainly used in photovoltaics, data storage, sensor technology and decorative coatings but also in other applications such as hydrogen, battery, automotive, electrical shielding and advanced packing applications.

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 China allow SINGULUS TECHNOLOGIES to participate and make use of the latest solar research results worldwide.

### GENERIS PVD – Sputtering System

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, 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.

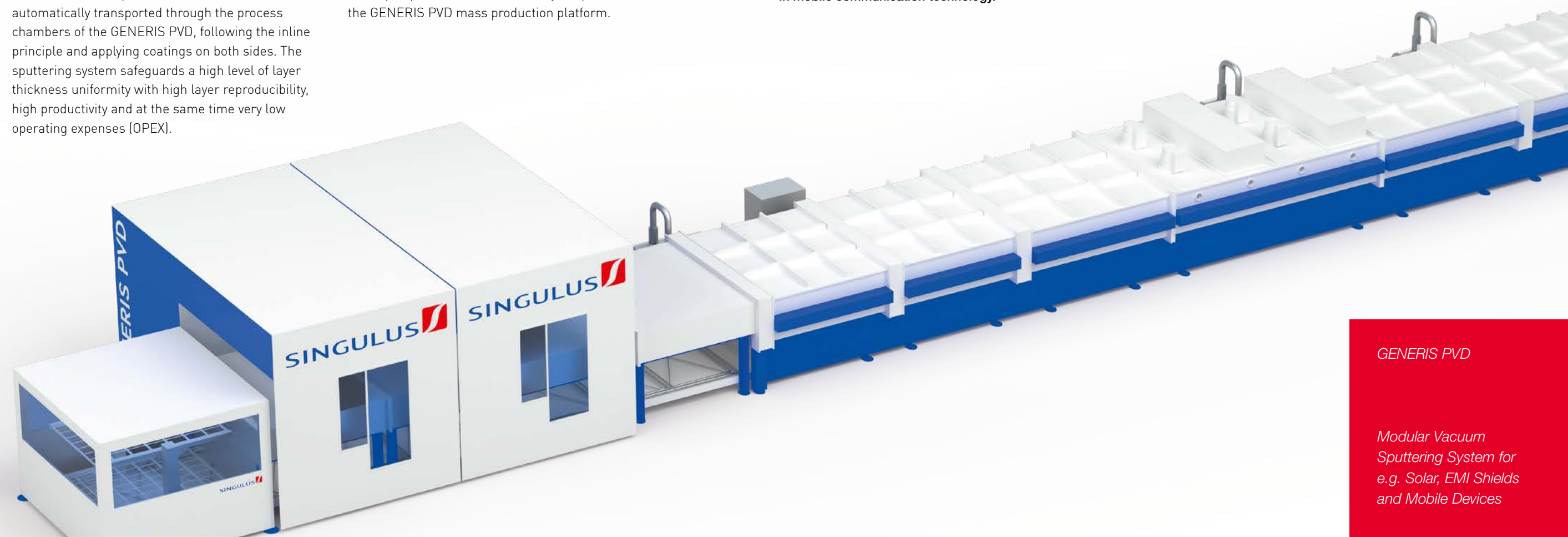
Numerous SINGULUS TECHNOLOGIES vacuum sputtering machines are in operation in the solar industry, where SINGULUS TECHNOLOGIES provides the GENERIS PVD as a high throughput inline sputtering system platform with horizontal substrate transport. The GENERIS PVD is engineered for the specific requirements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

Compared to conventional alternative processes like Reactive Plasma Deposition (RPD), a vacuum inline sputtering system offers a number of clear advantages. 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 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.



**GENERIS PVD 600**  
Sputtering System for the application of layers as part of transmission units in mobile communication technology.



GENERIS PVD  
Modular Vacuum Sputtering System for e.g. Solar, EMI Shields and Mobile Devices