SPUTTERING TECHNOLOGY

for Multiple Applications such as Solar, Display, Semiconductor & 3D-Substrates
SINGULUS TECHNOLOGIES
Sputtering Competence

SINGULUS TECHNOLOGIES has delivered far more than 8,000 vacuum sputtering machines since its foundation in 1995. It ranges 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 data storage, decorative coatings and other applications.

SINGULUS TECHNOLOGIES develops technologies for economical and resource-efficient production processes. The core competencies are vacuum thin-film technologies, wet-chemical processes, surface technologies and thermal processing technologies.

SINGULUS TECHNOLOGIES taps new work areas with these competencies and develops innovative solutions.

For all processes and applications, SINGULUS TECHNOLOGIES uses its know-how in the segments automation and process technologies as well as the integration of production steps and works on transferring these solutions to additional areas of application.

SINGULUS TECHNOLOGIES is a renowned manufacturer of advanced thin-film deposition equipment. It is the trusted partner in the respective industry and extends its leadership in the thin-film deposition technology for these applications. SINGULUS TECHNOLOGIES operates as a driver of innovation in technologic areas with high growth potential.
Main Features of SINGULUS TECHNOLOGIES Sputtering Technology

- Over 20 years sputtering experience
- Over 8,000 sputtering devices worldwide in the field
- Systems provide high throughput & high uptime
- In-house cathode design with magnetron development
- Simulation of sputtering processes with lab equipment in-house
- In-house software development
- Cooperation with scientific institutes e.g. Fraunhofer, Inplas, Centre Suisse d’Electronique et de Microtechnique, CSEM, University of Konstanz as well as institutes in USA, China, Singapore.
- Systems for vertical and horizontal substrate transport orientation
- Magnetron sputtering in diverse modes like DC, pulsed DC, bipolar and RF available
- Modular process chamber configuration

Positioning in New Markets

SINGULUS TECHNOLOGIES builds machines for economical and resource-efficient production processes for solar, semiconductor, medical technology, consumer goods and optical disc.

SINGULUS TECHNOLOGIES’ strategy is based on the use and expansion of its existing core competencies. The application areas include coating technology, surface processing, wet-chemical applications as well as the related chemical and physical processing steps. The company’s target is to reach a technologically leading position in the Solar division.
VISTARIS Sputtering Systems

The SINGULUS TECHNOLOGIES systems with the brand name VISTARIS and GENERIS PVD had been developed for the requirements in the photovoltaic industry. Inline sputtering systems are important in today’s CIGS & CdTe thin-film solar cell production. These systems had been designed to enhance the efficiency of thin-film solar cells, while cutting production costs by using the state-of-the-art technologies. For photovoltaic technology, SINGULUS TECHNOLOGIES develops and manufactures coating systems which can apply special layers and layer systems on different substrates. Examples are transparent front or metallic back contact layers as well as multilayered precursors with a broad range of different materials. The main advantage of the system is that it can be used for vertical vacuum-based coating of glass substrates in solar and display industry. In the market for thin-film photovoltaic SINGULUS TECHNOLOGIES adds another production stage to its range of processing systems for the manufacture of CIGS cells.

Typical Performance Characteristics

- Modular configuration
- Ideally suited for wafers & large substrates
- Parallel processing of several substrates
- Possibility of carrier as well as carrier free transport system
- Low cost of ownership
- Temperature processing before and during deposition available
- Vacuum base pressure: \(< 1 \times 10^{-6} \text{ mbar}\)
- Typical process pressure: \(2 - 5 \times 10^{-3} \text{ mbar}\)
- Temperature range for deposition: up to 200 °C
- Usage of rotatable cylindrical magnetron
- Highest utilization of target material
- Sputtering material: ITO, AZO and metallic layers like Mo, Al, Cu, Ag, NiV etc.
One main focus during the solar cell production is the efficiency. Heterojunction cell technology (HJT) achieves conversion efficiencies of more than 22% as well as reduced manufacturing costs. The GENERIS PVD system is a horizontal inline sputter tool designed for the special requirements in photovoltaic high efficiency cell production.

Heterojunction cells are coated on both sides with transparent conductive oxide (TCO) layers by PVD (physical vapor deposition). The GENERIS PVD is ideally suited for challenging layer stacks i.e. TCO layers like ITO and AZO providing maximum optical transmittance, matched refractive index, optimum electrical conductivity as well as charge carrier mobility, which are key-parameters in heterojunction cell technology. Sputter damage to the amorphous silicon layer stack does not occur. A full substrate temperature control during the whole process enables optimum layer performance at temperatures ≤ 200 °C.

With the GENERIS PVD sputtering system, contact layers can be deposited on the front and rear of the Si wafers without the need to turn the wafers between coating processes and without vacuum interruption. Annealing of sputtered layers is integrated optionally. Also full area metal coatings, e.g. Ag can be deposited within the same system. By using rotatable sputtering magnetrons, highest target utilization is achieved and offers lowest production costs.

Other typical applications include anti-reflection layers, barrier layers and precursor layers but also different metallic layers such as Al, Cu, NiW, etc. The GENERIS PVD is using an inline process in which the substrates are transported on specially designed carriers, providing edge isolation simultaneously. The carrier return system is located below the machine under clean environmental conditions. Different automation options for loading and unloading are available.

**Typical Performance Characteristics**

- Sputtering materials: ITO, AZO and metals like Ag, NiW, Cu, Al etc.
- Parallel processing of several substrates (Si wafers)
- Available in 3 versions:
  - GENERIS LAB
  - GENERIS PVD 3000 for approx. 2600 wph
  - GENERIS PVD 5000 for approx. 5200 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 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
HISTARIS Inline Sputtering Systems with Horizontal Substrate Transport
Modular System for Different Applications

The SINGULUS TECHNOLOGIES HISTARIS system was developed for the requirements in the photovoltaic industry but also for applications in large area sputtering like architectural glazing, fuel cells and mobile devices. In photovoltaics the Inline sputtering systems are important in today’s CIGS & CdTe thin-film solar cell production.

The HISTARIS system was designed to enhance the efficiency and cutting production costs by using the state-of-the-art technologies. The modular design includes process chambers equipped with rotatable magnetrons for the sputter deposition of high-performance TCO layers or several other materials, such as metals and metal oxides. Pre-treating modules for cleaning or etching can be added. With its unique modular design, the HISTARIS system is ideally suited for challenging layer stacks and flexible product mixes.

Examples are transparent front or metallic back contact layers as well as multilayered precursors with a broad range of different materials. The main advantage of the system is that it can be used for horizontal vacuum-based coating of glass substrates in solar and display industry. Typical applications include anti-reflection layers, barrier layers and precursor layers but also different metallic layers such as Al, Cu, Ni, etc.

For photovoltaic technology, SINGULUS TECHNOLOGIES develops and manufactures thin film deposition systems which can apply special layers and layer systems on different substrates. In the market for thin-film photovoltaic SINGULUS TECHNOLOGIES adds another production stage to its range of processing systems for the manufacture of CIGS & CdTe thin-film solar cells.

The HISTARIS is using an inline process in which the substrates are transported on specially designed carriers or directly on a customized roller drive system. Different automation options for loading and unloading are available.

Main Features HISTARIS

→ Modular machine concept
→ Integrated power supply design
→ Horizontal substrate transport – with and without carrier
→ Usage of rotatable cylindrical magnetron for highest utilization of target material
→ Highest deposition rates
→ Temperature processing before and during deposition available
→ Gas separation by dynamic slit valves and/or by individual lock chambers
→ Easy maintenance, low CoO
→ Fast target exchange, use any vendor target
→ Vacuum base pressure: < 1 x 10⁻⁶ mbar
→ Typical process pressure: 2 - 5 x 10⁻³ mbar

The Modularity of the HISTARIS System Allows a High Degree of Flexibility

Lab system for R&D applications
DECOLINE II
Inline Coating of 3-dimensional Parts for both Decorative and Functional Applications

DECOLINE II – Enhanced Metallic Layers on 3-Dimensional Parts

SINGULUS TECHNOLOGIES offers the second generation of inline coating solutions for fully automated handling and coating of 3-dimensional parts which are used e.g. in the automotive, as interior-lighting, head- and rear lights, automotive mirrors or mobile phones and packaging used in the cosmetics industry. Coated 3-dimensional parts are typically made of plastic (injection molded), glass or metal.

The DECOLINE II inline coating system is the next development level in vacuum coating and product handling:

- Brilliant layers on 3-dimensional parts
- Individual design variety
- Elimination of batch processes
- UV curing for protection lacquer
- Inline spray coating & metallization
- Fully automated processing
- High productivity and flexibility
- Low cost of ownership
- Environment-friendly

DECOLINE II automates the production process and considerably reduces costs, logistical efforts as well as the personnel intensity and amortizes itself in a very short period of time.

Base Coat Lacquering System (Optional)
- UV-base lacquering system
- Solvent allowance up to 20 %
- Recycling of lacquering material
- Significant cost reduction by most efficient material consumption

PolyCoater – 3-Dimensional Sputtering
- Cycle time per carrier: down to 6 seconds
- Up to 18 parts on one carrier, cycle time < 0.5 s
- Rotation of parts during sputtering process
- Equipped with two high rate cathodes
- Target materials e.g.: Al, Cu, Cr, Zr, CuAl, Ag, Au, stainless steel
- Perfect layer uniformity and high deposition rates
- Reliable and clean sputtering process
- Highest coating quality, high uptime and no environmental impact

Top Coat Lacquering System
- UV-base lacquering system
- Clear lacquer application
- Colored lacquer application
- Solvent allowance up to 20 %
- Highest uptime and productivity

The different spray coating modules and the vacuum sputtering module of the DECOLINE II are interlinked by an innovative flexible inline concept. The DECOLINE II distinguishes itself from the traditional batch processes and satisfies with its inline concept all the prerequisites to revolutionize the existing production of 3-dimensional parts. By high-quality coatings the decorative and functional properties of the coatings are significantly improved.
POLYCOATER
Inline Sputtering of 3-Dimensional Parts for Multiple Applications

POLYCOATER Static Sputtering Systems
The POLYCOATER is a sputtering production system for the fully automatic coating of 3-dimensional plastic parts. The sputtering module can be interlinked with different innovative handling concepts, which also provide the possibility of incorporation of additional production modules (e.g. lacquering module, robot handling systems). The POLYCOATER system is designed as system for production use.

The system can integrated into existing production flow. An integrated exchange handling system is loading new parts and is unloading the metallized parts to an interface position. The POLYCOATER is the result of the combination of proven coating technologies, high-performance expertise and unique experience bundled with a revolutionary concept for the application of 3-dimensional coating onto parts.

Not only decorative, but also functional layers could be applied. Possible approaches are antibacterial coatings, EMV-shielding, electrical conductive layer (e.g. on electroplating components before the actual electroplating) or antennas. Each electrical conductive and non-magnetic metal and its alloys can be used as a metallic layer. This is a clear unique selling point, compared to batch processes, in which the selection of possible coating materials is much more limited.

The POLYCOATER offers a reproducible layer uniformity and high deposition rates with highest coating quality and a high uptime through to permanent sputtering process control. The cycle time per carrier is down to 6 s with up to 18 parts on one carrier.

POLYCOATER Features
→ Cycle time down to 6 seconds
→ Rotation of parts during sputtering process
→ Target materials e.g.: Al, Cu, Cr, Zr, CuAl, Ag, Au, Stainless Steel and TCO
→ Equipped with two high rate cathodes designed by SINGULUS TECHNOLOGIES
→ Reproducible layer uniformity and high deposition rates, even on complex 3-dimensional parts
→ Reliable and clean sputtering process
→ Highly and unique integrated design
→ High quality coating and cost effective technology
→ Minimum floor space required
→ Excellent maintenance and service accessibility
→ The POLYCOATER is equipped with a distance support interface. Software support will be done via internet connection and support software
PTM Sputtering Unit

In 2014 SINGULUS TECHNOLOGIES continued to emphasize on the new and further development of production equipment for new applications. Parallel to the development efforts in the three segments Solar, Optical Disc and Semiconductor SINGULUS TECHNOLOGIES works on opening new application areas with existing process and machine know-how. Several other new applications, such as the new vacuum coating for the use in battery technology or the cleaning and coating processing for the enhancement of surfaces in display technology, were also extensively worked on in 2014. The core competence of SINGULUS TECHNOLOGIES is the development of new vacuum coating systems for use in mass production, pilot production and laboratory applications. The implementation of individual customer requirements are tested in R & D and as well as pilot systems and the results are transferred to inline production systems.

Single substrates deposition machines are used for R & D and testing of new applications for display and touch screen devices with applications like ITO coatings, AR coatings, EMI shielding and coatings for so called one glass solution technology. The transfer from R & D to inline sputtering machines secures the use of layers systems of high conductivity and transparency and various other metal coatings at the same time.

Typical Performance Characteristics

- 3 independent process stations
- DC and RF process is available
- SMART CATHODE technology, 170 mm diameter
- Vertical sputtering
- Carrier transport
- Typical sputtering material Cu, Ag, Si layer, Al, Cr, etc.
- Plug and play installation
- Vacuum base pressure: < 5 x 10^-6 mbar
- Manual horizontal loading and unloading
ROTARIS Universal Sputtering System

The ROTARIS ultra-high vacuum system is a modular platform for fast, precise and fully automated thin-film sputter deposition. The ROTARIS is a bridge system for 200 mm and 300 mm wafer processing. Its main deposition chamber RSM (Rotating-Substrate-Module) can house up to 12 physical vapor deposition (PVD) cathodes with a target diameter of 100 mm.

The ROTARIS design provides in particular a rotating substrate deposition technology with the additional capability to tilt the substrate. Additional features for R&D are “Co-sputtering” with up to four cathodes, DC-, pulsed DC-, RF-sputtering, wafer heating, and an in-situ aligning magnetic field. The installation of an ion source as alternative equipment allows for surface treatment and smoothing, ion milling and side wall cleaning.

Four additional different process modules are available to configure a ROTARIS system according to customer needs to cover their challenging R&D applications. These modules include industry proven modules like the Oxidation-Process-Module (OPM), Pre-Clean-Module (PCM), Combi-Process-Module (CPM) and Static-PVD-Module (sPVD-M).

ROTARIS Configurations for Different Applications

1. ROTARIS Basic
ROTARIS Basic sputtering system for processing up to 200 mm wafer. Example of configuration:
- 1x Rotating-Substrate-Module RSM
- 1x Manual wafer load lock

2. ROTARIS Advanced
ROTARIS Advanced sputtering system with additional modules for processing up to 200 mm wafer. Example of configuration:
- 1 x Rotating-Substrate-Module RSM
- 1 x Combi-Process-Module CMP
- 1 x MX400 Central-Transport-Module CTM

3. ROTARIS Diversity
ROTARIS Diversity sputtering system with six modules for advanced processing up to 200 mm wafer. Example of configuration:
- 3 x Rotating-Substrate-Module RSM
- 1 x Combi-Process-Module CMP
- 1 x Small-Thermal-Process-Module sTPM
- 1 x MX700 Central-Transport-Module CTM
TIMARIS
Deposition of Ultra-thin Metallic and Insulating Films
down to a Thickness of one Nanometer and below

TIMARIS Cluster Tool

SINGULUS has already established and qualified the second generation of the TIMARIS PVD Cluster Tool platform in the market and is offering a complete portfolio of process modules for different applications.

As of today, more than ten process modules are available to configure a TIMARIS system according to customer needs. These modules include the Multi-Target-Module, Oxidation-Process-Module, Pre-Clean-Module, Combi-Process-Module, Four-Target-Module and Static-Deposition-Module as well as the Rotating-Substrate-Module. The RSM is the core module of the ROTARIS platform, our sputtering system for special R&D applications. The TIMARIS PVD modules incorporate the full scope of sputtering techniques as: DC magnetron sputtering, pulsed DC magnetron sputtering and RF magnetron sputtering as well as combinations of these modes are selectable by recipe.

1. TIMARIS II for 300 mm MRAM Wafer Production with Full Throughput
2. TIMARIS III High Throughput Deposition for Mass Production of MRAM and other Semiconductor Applications
3. TIMARIS II including one RSM System for R&D Purposes and/or Low Volume Production for 200 mm or 300 mm Wafers
4. PVD Cluster Tool – Deposition Systems for R&D and Production
SINGULUS TECHNOLOGIES – Innovations for New Technologies

SINGULUS TECHNOLOGIES has built equipment for the Semiconductor, Solar, Optical Disc, Decorative Coatings, and Medical Technology industries for more than 20 years, satisfying the high-quality requirements of each industry. The core competencies of SINGULUS TECHNOLOGIES include vacuum coating, surface processing, wet-chemical and thermal production processes. SINGULUS TECHNOLOGIES' machines incorporate the latest technological developments and follow the guiding principles of industry 4.0, the current trend of automation and data exchange in manufacturing technologies.

SINGULUS TECHNOLOGIES builds innovative machines and systems for efficient and resource-friendly production processes. For all of its machines, processes and applications, SINGULUS TECHNOLOGIES demonstrates its automation and process technology expertise with quick, substantial return on investment.