Sputtering Systems
Over 20 Years of Know-how in Physical Vapor Deposition

Sputtering Technology at a Glance

SINGULUS TECHNOLOGIES, founded in a classic buy-out from the former LEYBOLD in 1995, is a corporation since 20 years with worldwide operations headquartered in Germany’s Rhein-Main region. SINGULUS TECHNOLOGIES is solidly positioned as an innovator and active participant in different markets and has attained the world market leadership position for optical data storage replication lines.

The goals of the company are targeted on achieving a technological market leadership in relevant markets and to thus sustainably increase the business volumes and to generate stable, profitable results. SINGULUS TECHNOLOGIES develops innovative technologies for economic and resource-efficient production processes and the strategy is based on the use and expansion of its existing core competencies. SINGULUS TECHNOLOGIES offers a high level of expertise in a combination with process-technological and scientific know-how coupled with complex solutions for machines and plant engineering. The application areas include vacuum technology, surface coating and thermal processing as well as the related chemical and physical processing steps.

SINGULUS TECHNOLOGIES has delivered far more than 8,000 vacuum coating machines since its foundation in 1995. It ranges from compact systems for optical disc replication to ultra-high vacuum coating machines applying extremely thin layers of around 0,2 nm for the semiconductor industry as required for the manufacturing of MRAM chips. 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.
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
- High throughput, high uptime
- In-house cathode design
- Magnetron development
- Simulation of sputtering processes
- Sputtering lab equipment in-house
- In-house software development
- Cooperation with scientific institutes e.g. Fraunhofer, Inplas
- 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**

The core competence of SINGULUS TECHNOLOGIES is the know-how in vacuum thin-film and plasma technology, wet-chemical processing as well as thermal process technology.
Inline Sputtering Systems with Vertical Substrate Transport
Modular System for Different Applications

**VISTARIS Sputtering Systems**

The SINGULUS TECHNOLOGIES system with the brand name VISTARIS was developed for the requirements in the photovoltaic industry. Inline sputtering systems are important in today’s CIGS & CdTe thin-film solar cell production. The VISTARIS system was 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/CIS cells.

**Typical Performance Characteristics**

→ Typical sputtering materials like ITO, AZO, CuGa, Cu, In, AZO, i-ZnO etc.
→ Integrated power supply design
→ No carrier return system necessary
→ Fully vertical substrate transport
→ Special designed carrier transport system
→ Load and Unload of substrate from the same side of the machine
→ Usage of rotatable cylindrical magnetrons for highest utilization of target material
→ Temperature processing before and during deposition available
→ Gas separation by dynamic slit valves and/or by individual lock chambers
→ Smallest machine footprint thru turn chamber technology
→ Easy maintenance, low CoO
→ Fast target exchange, use any vendor target
→ Easy expansion possible
→ Vacuum base pressure: < 1 x 10⁻⁶ mbar
→ Typical process pressure: 2 - 5 x10⁻³ mbar
HISTARIS Sputtering System

The HISTARIS is a horizontal inline sputter-coating tool designed for special needs. The system can be configured for various substrate sizes and is ideally suited for challenging layer stacks and flexible product mixes. Typical applications include e.g. solar control, anti-reflection, barrier, buffer and precursor layers such as copper-gallium, indium, and i-ZnO, but also different metallic layers like Mo, Al, Cu, Ag, and NiV etc. as well as transparent conductive oxide layers like ITO, AZO which are necessary for new heterojunction cell technology. The systems use an inline process in which the substrates are transported on a special designed conveyor system on flat carriers through the system. The carriers can be configured flexibly for different substrate formats and materials e.g. solar wafers. Different automation options for loading and unloading are available.

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
→ Top down and bottom up sputtering possible
→ Temperature processing before and during deposition available
→ Vacuum base pressure: < 1 x 10^{-6} mbar
→ Typical process pressure: 2 - 5 x 10^{-3} 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.
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 new 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

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.

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 special designed high rate cathodes
- Target materials e.g.: Al, Cu, Cr, Zr, CuAl, Ag, Au, stainless steel
- Perfect layer uniformity and high deposition rates, even on complex 3-dimensional substrates shapes
- 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
MODULUS Inline Sputter Deposition System
The SINGULUS TECHNOLOGIES inline sputter deposition system is designed for production with loading and unloading of the substrates from one side and processing in a minimized footprint. Depending on the requirements, the system can be configured with an advanced transport solution. As a modular inline sputter system this machine is ready for applications in display and consumer electronic applications. In the different process modules, plasma treatment, RF sputtering and DC sputtering can be implemented as well as cooling & heating modules. The cooling stations are special designed to maintain a low temperature without compromising on throughput. Essential is the exact temperature control which is required processing plastic substrates.

Typical Performance Characteristics
→ Modular configuration
→ Up to 13 independent process stations
→ DC and RF process stations available
→ SMART CATHODE technology, 170 mm diameter
→ Special vertical carrier orientation
→ Static deposition
→ Special designed substrate cooling station
→ Cycle time up to 3.5 s
→ Typical sputtering material Cu, Ag, SiN, Al, SS, etc.

Nowadays typical applications can be found in the emerging touch panel industry:

One Glass Solution Technology
Modular inline physical vapor deposition sputter systems provide process solutions for dedicated coating processes on glass like the deposition of Nb, SiO2 or ITO. The systems from SINGULUS TECHNOLOGIES are fully automated innovative and modular coating tools for the industrial production of modern touchscreen applications. The systems provide several customizable vacuum chambers for different processes. Scratch resistant coatings provide glass with durability and increased longevity. A high quality hard coating assures the best scratch resistance. Mobile display cover glass has to meet the requirements of crystal clear images, withstand every day application and allow smooth touch screen use.

Electro Magnetic Shielding for Mobile Applications
Mobile applications demand also a very high functional density for electromagnetic shielding interference. Cover shields do not provide the shielding quality required for the next generation of products. SINGULUS TECHNOLOGIES offers modular vacuum sputtering system providing the best solution to produce high quality metal layers in a cost effective and economical way. Electromagnetic shielding is the practice of reducing the electromagnetic field by blocking the field with barriers made of conductive or magnetic materials. Shielding is typically applied to enclosures to isolate electrical devices from the outside world. A commonly used shielding method, especially with electronic goods housed in plastic enclosures, is to deposit the inside of the product with a relatively thick copper layer to provide the best device shielding solution from high frequencies.
TIMARIS

Deposition of Ultra-thin Metallic and Insulating Films down to a Thickness of one Nanometer and below and Stacks of such Films with very Precise Material Thickness and High Uniformity Specifications

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
**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
Sputtering Technology at a Glance
R & D and Process Development with Single Substrate Deposition Systems

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
SINGULUS V Metallizer
The SINGULUS V Metallizer serves for all major areas of optical disc replication, such as CD, DVD and Blu-ray Discs.

Continuous improvements have been made to the metallizers since their introduction to the market in 1995 and they are more compact and faster than ever. The range of SINGULUS TECHNOLOGIES metallizers today is able to address all major applications. With high yields and high reliability, the system continues the SINGULUS metallizer legacy.

The SINGULUS V is equipped with an advanced drive technology, featuring servo drives for handling and transport. Touch screen user interface facilitates easy operation of the unit and, coupled with the PC, controls all components including the layer thickness measuring device and all sputter processes. The metallizers are equipped with the unique and patented SMART CATHODE and a process control system for the deposition of various target materials, such as aluminum, silver, gold or silicon, with high uniformity. In addition to the permanent magnetic field a variable magnetic field created by electro-magnets is superimposed. Electrically powered coils are located at the rear of the target.

Typical Performance Characteristics
- One process station
- DC and pDC process is available
- SMART CATHODE technology, 170 mm diameter
- Horizontal sputtering
- Typical sputtering material Al, Ag, Au, CuAl, Cu, SiN
- Plug and play installation
- Cycle time 1.5 s per substrate
SINGULUS TECHNOLOGIES develops innovative technologies for economic and resource-efficient production processes. SINGULUS TECHNOLOGIES’ strategy targets the use and expansion of its existing core competencies. This includes process technology and scientific solutions combined with mechanical and plant engineering. The core competence of SINGULUS TECHNOLOGIES rests on vacuum thin-film and plasma technology, wet-chemical processing as well as thermal process technology.

SINGULUS TECHNOLOGIES is expanding this expertise in its core segments and is transferring the know-how to new application areas: consumer goods, entertainment, energy, mobility and semiconductors.