TIMARIS
PVD Cluster Tool for Magnetic Storage & Semiconductor Wafer Production

Smart Solutions to Drive the Future.
SINGULUS TECHNOLOGIES (SINGULUS), founded in 1996, continues to expand its activities in the segments Semiconductor, Solar and Optical Disc.

SINGULUS’ business unit Nano Deposition Technologies is a renowned manufacturer of advanced thin-film deposition equipment for MRAM and Thin-Film Head production. It is the trusted partner in the respective industry and extends its leadership in the thin-film deposition technology for Semiconductor applications.

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 today, seven different process modules are available to configure a TIMARIS system according to customer needs. These modules include the Multi-Target-Module (MTM), Oxidation-Process-Module (OPM), Pre-Clean-Module (PCM), Combi-Process-Module (CPM), Flexible-Target-Module (FTM) and Static-PVD-Module (sPVD-M) as well as the new Rotating-Substrate-Module (RSM).

The TIMARIS PVD modules (MTM, FTM, RSM, sPVD-M) 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.
All TIMARIS applications require the deposition of ultra-thin metallic and insulating film stacks down to a thickness of one (1) nanometer and below with very precise material thickness and high uniformity specifications.

The MTM is the key component of the TIMARIS platform; it incorporates the Linear Dynamic Deposition (LDD, US patent US 7,799,179 B2) technology in combination with ten (10) sputter targets in one vacuum chamber.

The FTM module uses Linear Dynamic Deposition in combination with up to four cathodes. The LDD technology is especially designed for deposition of ultra-thin films, magnetic films, high-quality metallic, conductive and insulating films and is the key to deliver world class material uniformity across large wafer sizes, combined with an exceptional precise control of ultra-thin layer thickness down to 1 % of a nanometer.
Linear Dynamic Deposition (LDD)

Deposition Technique:
Linear PVD Magnetron and linear movement of wafer

- Short target-substrate distance:
  - Best coating efficiency
  - Low cost of ownership

- Thickness adjusted by wafer speed:
  - Precise thickness control & repeatability
  - Ultra thin film < 0.1 nm; smallest thickness step: < 0.01 nm

- Special LDD capabilities
  - Deposition of thickness wedges
  - Preparation of concentration gradients

- Multi-directional coating:
  - Smooth films and interfaces

- Stationary Aligning Magnetic Field (AMF):
  - Magnetic pre-alignment of easy axis direction

- Leakage field of cathode parallel to wafer travel direction:
  - Ideal symmetry for magnetic film applications

- Robust and reliable design
Multi-Target-Module with 10 DC/RF Cathodes

Multiple film stack deposition, without the need to break ultra-high vacuum, is one of the key advantages of the MTM process module. Additional features as wafer heating for hot substrate deposition or a collinear Aligning Magnetic Field (AMF) can be activated to align the magnetic Easy Axis during deposition of ferromagnetic films.

The Linear Dynamic Deposition (LDD) technology enables the capability to deposit wedge films with a different film thickness across the wafer and to deposit alloy films with adjustable concentration gradients across one wafer. Both features allow a very cost effective development of film stacks and accelerate the devices development.

The LDD technology is the key to delivering world class material uniformity across large wafers and exceptional precise control of ultra thin layer thickness down to 1 % of a nanometer.

Details:
- DC/RF magnetron
- All sputter deposition modes selectable by recipe for all 10 cathodes
- LDD technology
- RF bias option
- Ultra-High-Vacuum technology, base pressure < 5*10^-9 Torr
- Wafer heating and cooling
Flexible-Target-Module (FTM)

Flexible-Target-Module with 4 DC/RF Cathodes

The Flexible-Target-Module (FTM) incorporates Linear Dynamic Deposition (LDD) technology in combination with up to four sputter targets in one vacuum chamber. The FTM incorporates the same functionalities like the Multi-Target-Module (MTM) as the substrate heating, the Aligning Magnetic Field and the capability to deposit wedge films with a different film thickness across the wafer and to deposit alloy films with adjustable concentration gradients across one wafer. The only difference of the FTM is the number of targets.

Details:
- DC/RF magnetron
- All sputter deposition modes selectable by recipe for all 4 cathodes
- LDD technology
- RF bias option
- Ultra-High-Vacuum technology, base pressure < 5*10^-9 Torr
- Wafer heating and cooling
The Rotating-Substrate-Module (RSM) is a dedicated PVD module for R&D for different Semiconductors and other applications.

Essential technical features are:
- Up to 12 PVD cathodes in one chamber
- Rotating substrate deposition
- Co-sputtering
- DC-, pulsed DC-, RF-sputtering
- Wafer heating
- Base pressure < 10⁻⁸ Torr
- In-situ aligning magnetic field
- Alternative equipment
- Ion source
- Surface metrology
- Low R&D costs
Pre-Clean-Module (PCM)

Pre-Clean-Module

The Pre-Clean-Module (PCM) is used to clean the wafer prior to deposition. This is a standard technique employing sputter etch technology by applying RF power to the wafer. Typically the process removes residual water and other molecules and native oxides by adjusting the etching process parameters. Optionally, this module can also be equipped with an ECWR plasma source. This additional plasma source provides a more flexible etching process (higher etch rates, lower etching energies). The module geometry (large plasma source, rotational symmetric pump system) ensures a high uniformity of the etching.

Details:
- Wafer cleaning, removal of native oxides by sputter etch
- ECWR plasma source as option
- Variable distance between and ion source
- Ultra-High-Vacuum technology, base pressure < 1*10⁻⁸ Torr
The Oxidation-Process-Module (OPM) is required to oxidize ultra-thin metallic films into insulating films of very high quality. Such films are required in Tunnel Magneto Resistance layer stacks as tunneling barriers. The barrier material of choice is nowadays MgO, but Al₂O₃ and other materials have been considered. The oxidation can be performed by using a remote plasma provided by a ECWR plasma source. This source generates oxygen ions and radicals of very low adjustable energy. Alternatively, the oxidation can be performed by the so-called natural oxidation by exposing the metal film to pure oxygen of low pressure (10 Torr down to 0.1 m Torr). The module geometry (large plasma source, rotational symmetric pump system) ensures a high uniformity of the oxidation. Other applications for the OM are surface treatment of wafers by different activated gases (e.g. N₂).

Details:
- Low energy remote plasma oxidation
- Natural oxidation
- Surface treatment by low energetic ions
- Variable distance between substrate and ion source
- Ultra-High-Vacuum technology, base pressure < 1*10⁻⁸ Torr
The Static-PVD-Module (sPVD-M) comprises a standard magnetron cathode with optimized target utilization for high rate sputter deposition of metallic and non-conducting materials for multiple applications. DC magnetron as well as RF magnetron sputter modes are selectable through a recipe menu. The module is envisaged to be used for deposition of films with high deposition rate that do not require the extremely high uniformity that can be achieved by the LDD technology.

Details:
- DC and RF sputter deposition selectable by recipe
- Variable distance between substrate and sputter target
- Ultra-High-Vacuum technology, base pressure < 1*10^-8 Torr
Combination-Process-Module (CPM)

The Combination-Process-Module (CPM) comprises both technologies, of oxidation and pre-clean in one module. This is a cost-efficient option, since only one module for two process steps is required. It is mainly envisaged for R&D purposes, where a high throughput is of less importance. The process performance is identical with the Oxidation-Module and the Pre-Clean-Module.

Details:
- Low energy remote plasma oxidation
- Natural oxidation
- Surface treatment by low energetic ions
- Wafer cleaning, removal of native oxides by sputter etch
- Variable distance between substrate and ion source
- Ultra-High-Vacuum technology, base pressure < 1*10^{-8} Torr
Typical TIMARIS configuration for 300 mm MRAM wafer production with full throughput, consisting of:

- 2 Multi-Target-Modules
- 1 Oxidation-Module
- 1 Pre-Clean-Module
- 1 Transport Module (Brooks) including two FOUP Loadports
- Multiple wafer handling
- Throughput: up to 20 Wafer
- Software integration: GEM/SECSII Interface

* standard MRAM layer stack

300 mm Wafer

Typical TIMARIS configuration for 150/200 mm Thin-Film Head wafer production. The footprint shown is for a tool for TMR (GMR) sensor fabrication and consists of:

- 1 Multi-Target-Module
- 1 Oxidation-Module
- 1 Pre-Clean Module
- 1 Transport Module (Brooks)
- Multiple wafer handling
- Throughput: 9 wafers for a standard TMR layer stack
- Software integration: GEM/SECSII Interface
- Variants: HMM film deposition (no oxidation module)

150 mm 200 mm Wafer
TIMARIS configuration for 300 mm MRAM and semiconductor wafer production, consisting of:

- 1 Multi-Target-Module
- 3 Flexible-Target-Modules
- 1 Pre-Clean-Module
- 1 Oxidation-Module
- 1 Transport Module (Brooks)
- including three FOUP Loadports
- Multiple wafer handling
- Software integration: GEM/SECSII Interface

Typical TIMARIS configuration for R&D purposes and/or low volume production. All wafer up to 300 mm wafer can be handled. The footprint shown consists of:

- 2 Rotating-Substrate-Modules
- 1 Combi-Process-Module
- 1 Transport Module
Worldwide Sales & Service Network

SINGULUS Serves Customers Worldwide

SINGULUS Headquarters, Kahl/Main
SINGULUS STANGL SOLAR, Fürstenfeldbruck