

Applications notes for SNS Gamma γ 1000C™ advanced sputter system

What makes the SNS Gamma γ 1000C a superior development tool?

Advantages a glance

Hardware

- UHV capable chamber 5 x 10⁻⁹ torr capability
- Load lock wafer degassing and substrate etching controlled pretreatment of substrate prior to entering process chamber, no contamination of chamber
- Spare load lock port for additional analysis or load lock system can be added.
- Ellipsometer ports fitted as standard
- Variable target to substrate geometry capability
- High deposition uniformity on metals and dielectrics
- Hardware/Software upgradeability on site made easy by Fieldbus control architecture
- Intuitive software with multi level protection
- Low maintenance and high reliability by design
- Ultra low cost of ownership

Advantages in depth

Hardware

Gas system

- True Ultra high purity system only made from orbital welded Electro polished construction
- Construction offers excellent control over potential particle/ moisture contamination of process chamber
- Digital Mass flow controllers for fast pump down times

Vacuum pumping system

High pumping for process advantages and low maintenance

- The Gamma tool uses non contact roots type roughing pump with 5 years between maintenance cycles.
- Oil free so no oil traps need to be used or changed.
- This pump produces almost no particles unlike scroll pumps
- The main sputter vacuum pump is a high specification cryo pump (turbo pumps suffer poor water pumping capability)
- A pumping system that is highly efficient for water vapour and hydrogen is absolutely key to repeatable reactive and metal mode deposition (H₂ is also not pumped easily by turbo pumps system)

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Magnetrons – Ease of use and low cost running

- Planar and run in balanced mode and are either run directly cooled, or indirectly cooled allowing high power metal mode deposition's without subjecting the target to large stresses.
- Changing dark space shields, targets and magnet modules takes less than a few minutes, requires no specialized knowledge.
- Provide optimal pin hole free ultra thin films from sub nanometer up to films microns thick with low stress over large areas.
- Confocal deposition running up to 4 targets at any time for complex binary and ternary, shape memory alloys, and dielectric materials
- High power target switching allows RF and DC to be distributed to all magnetrons with no cross talk at the same time as RF/DC bias is running on the substrate
- Target switching is after the auto match network only one match network required per RF power supply (per 4 magnetrons)

Wafer Chucks – High quality performance by design

- High uniformity and long life wafer heaters capable of running O₂/N₂ without contaminating the system with Co₂/CO during depositions.
- Key for reactive deposition and post fill annealing with out having to break vacuum and contaminate the film
- Post anneal in same hardware reduces the number of systems required in the lab
- Temperature ranges from 0-500, 850 and 1000 Deg C
- Wafer rotation driven by DC brushless servo gives precision and repeatable speed control every time!

Load lock – Featured to enhance your results

- Our load lock enables wafer degassing and substrate etching allows full computer controlled pretreatment of the substrate prior to entering the process chamber.
- Running these pre deposition processes in the load lock, the sputter chamber is kept contamination free and quality of results enhanced
- Systems that do this in the main process chamber introduce contamination to the process chamber...

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Software

1 – GammaSoft Control, Ease of use, intelligent analysis

- With Profibus control system architecture we have highly accurate and repeatable signal control to all sensors, power supplies and controllers like MFC's.
- Fully digital it avoids the shortcomings of Analogue control systems, such systems, based on lab view software and analogue pc cards, are unable to match performance and repeatability unless each analog channel is calibrated for a 'sweet spot', we avoid this issue.

2 – Ease of use

- Programming of recipes is intuitive and straight forward
- Our experience is that operators can be writing their own recipes with an hour of first using the software
- Automatic runs are used after developing a successful process and then wanting to repeat it over and over again, with good wafer to wafer repeatability

3 - Process variable trending

- Process variables are trended and capable of real time visualization in interrogation by the user
- Trends are archived and exported from the tool and can be imported to statistical data and analysis software like excel
- Each trend has a wafer identifier name so can be accurately tracked to end or developed product

4 – Protection and Control

- Control front end is security protected with passwords for operators, engineers and programmers, allowing usage to be tracked at any time
- Our GammaSoft software offers the user to have full manual and real time control of all process variables that are required to deposit a thin film
- Operators have full manual control – but - the GammaSoft system monitors each variable and action in real time and prevents the operator triggering a condition that is unsafe for the equipment
- This interlocking is both high and low level and operated at all times the system is running, unless commanded otherwise by engineering mode
- Touch screen control system removes the need for keyboards etc from the clean room, less real estate
- Full alarm reporting and logging for all hard and software alarms

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Fine Deposition control for advanced multi layer film creation

One of the benefits of our control system is the ability to offer some proprietary and unique features in the form of enhanced **strike rate control** and **tolerance control**.

Enhanced strike rate

- Allows deposition at low pressures down to 0.6 millitorr (metal dependent)
- Control system strikes the plasma at a higher suitable pressure, monitors its stability and then ramps the pressure down to required deposition pressure
- Allows difficult materials to be ignited easily and deposited at a more suitable pressure

Tolerance control

- The operator can design tolerance windows for process repeatability across a series of wafers.
- Users can define new tolerances for each process variable like pressure, voltage, gas flow etc, and the computer monitors for tolerance deviation
- If deviation occurs, depending on what tolerance has been created the process can be stopped, and alarm set or ignored depending on how critical the deviation.
- A key feature to wafer to wafer repeatability

Examples of deposition modes

Deposition mode 1 – gradient growth

- Allows gradient growth across the substrate by controlling power to dual or triple cathodes at any time. Each cathode can have its power ramped low or high during deposition to create true gradients both horizontal and vertical to be grown
- Process example 1: A vertical gradient can be pure chrome transitioning to pure copper over a few nanometers
- Process example 2: A super alloy of varying composition to be created at any point over the wafer surface

Deposition mode 2 – sequential control

- Allows sequential control of all cathodes singly or in co deposition mode in each layer deposited

Deposition mode 3 – continuous power

- Allows continuous power to all cathodes and applies control to the cathode shutters for high speed multi layer high stack rate thin film structures

Deposition mode 4 - Advanced reactive deposition control

- The control solution uses an optical spectroscopy system to scan the pure metal trend line of the target region defined in software
- Film stoichiometry is controlled by inputting a set point as a ratio of metal line to oxide or nitride concentration in the film
- The system controls reactant injection in real time to prevent target poisoning, or transition to metal mode deposition, resulting in tight control of film characteristics
- Deposition reactively from metal targets gives a far higher rate than from the oxide or nitride target. Control of film stoichiometry is also maintained to a tight tolerance.

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Process advantages

- Sputter down - no target contamination due to re deposited materials falling into the target plasma
- System configuration can run 1 x 150mm wafer or 1 x 100mm wafer or 3 x 75mm wafers, or 7 x 50mm wafers and smaller sample parts. Wafer holders are designed to place substrate in the most uniform area of deposition for the substrate size
- Hardware fully capable of Ar ion etch at high temperatures with significant etch rates (>20nm/min Si)
- Capable for co deposition with 4 targets running at the same time (with suitable power supplies), including RF, PDC and DC combinations.
- Extremely thin films from a few Nanometers up to microns can be achieved in a dense, pinhole free state.
- Metal deposition can give surface roughness better than < 0.35Nm Ra
- Typical uniformities from +/-5% to +/-0.5% are standard depending on materials and process conditions
- High temperature depositions up to 850 C during deposition and in situ post anneals are capable up to 1000C in some cases (hardware dependent)
- Wafer pre clean by etch also available in the load lock chamber. This can be used for native oxide removal and also in combination with wafer degas for water vapour removal.
- Proven track record for GMR/TMR/MR thin film structures used in magnetic media development and read write heads.
- Built in software routines for Ellipsometer data exchange during growth i.e. endpoint, thickness, psi and delta amongst others.
- Optical emission spectra data log and control system for metal line monitoring and argon sputter etched material during deposition
- High speed substrate rotation for very fast deposition times requiring high uniformity across the substrate.

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Simplicity in operation

- Chamber access is rapid: From reaching atmospheric pressure, access to the chamber internal parts takes less than 1 minute and is computer controlled
- All internal sputter shields cross contamination shields and target shutters can be changed over within minutes
- Wafer transfer between load lock and sputter chamber uses an LRP linear rack and pinion transporter system. This is a positively engage drive mechanism that gives repeatable manual or automatic wafer transport with out the potential to drop the wafer or rotate it
- LRP system gives 0.1mm repeatability with absolutely no rotation so the wafer cannot be dropped during transfer.

(By contrast magnetic transporters which can only be manual and require a high skill to operate without dropping the wafer)

- Software 'canned cycles' are included for operators who are not skilled in the use of deposition systems.
- Venting and pumping both the main chamber and load lock with a single touch of a button
- Valves and other components are automatically put in the correct state to allow successful pumping or venting to atmosphere or high vacuum
- Control system knows, and reports on, which valves need to be open or closed

Upgradable as research needs expand

- Spare load lock port for additional analysis or load lock system can be added
- Ellipsometer ports fitted as standard
- UHV capable chamber 5×10^{-9} torr capability with no external bakeout requirement and ultra fast recovery times from transfer
- Variable target to substrate geometry capability
- A variety of in site analysis tools can be supported (RGA, Spectroscopy, QCM)
- Upgradeability on site at later dates due to Field buss control architecture
- Software enables easy upgrades without need for new software release