

Specifications for Magnetron Sputter Deposition System

A SCOPE

This specification describes the minimum technical requirements and the minimum acceptable performance standards for a high vacuum magnetron sputter deposition system to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. This system will be used by NRL personnel to fabricate thin film coatings on wafers or substrates under high vacuum conditions. The magnetron sputter deposition system will be placed in a multiple user facility and must provide ease of operation and safety to those in the facility.

B INSTALLATION SITE

The contractor shall install the system in Bldg. 250, Naval Research Laboratory, Washington DC 20375, at a specific location to be designated by the Contracting Officer's Representative (COR). The laboratory space will have 110 and 220 volts alternating current (VAC, single phase, 60-Hertz (Hz) electrical power within a class 100 clean room. The contractor shall install the system to plumbing and electrical fixtures available in the designated location. The contractor shall also install the system in a manner consistent with typical clean-room operating procedures.

C DESCRIPTION AND PRIMARY SYSTEM COMPONENTS.

The magnetron sputter deposition system is to be used to deposit films of various materials, in high vacuum, onto conducting, insulating, and semiconducting substrates. These films are to be subsequently lithographically patterned into various electronic devices. The system is to be installed within a Class 100 clean room, and must be compatible with the requirements of that site. It is intended for use by multiple users within that site, therefore it must be computer controlled via menu-driven software, can be monitored from a location outside the clean room, and be user friendly. Complete mastery of use must be possible after one day of training.

DESCRIPTION

A CHAMBER

The following is required for the chamber:

1. Chamber material must be 304L Stainless Steel (SS), Grained and electro polished.
2. All vacuum flanging must be (ISO)-KF or ISO-Universal Standard or Conflat.
3. All seals must be viton or copper gasket.
4. All lids or doors must have an interlock switch.
5. Chamber purge gas and vent valve as required.
6. One sight ports for each chamber.
7. Minimum of two spare ports.
8. Two pressure gauge ports.
9. One high vacuum and rough pump port.

Load Lock Chamber

The following is required for the load lock chamber:

1. 14" diameter with lid opening.
2. One magnetic actuator port.
3. One high vacuum port.
4. One leak check port w/ manual valve.

Process Chambers

The following are additions for the process chamber:

1. Removable shields for easy cleaning.
2. Sputter Chamber must be Rectangular with hinged door. [~24"w x 24"l x 20"h].
 - a) Must have Hi-Vacuum capability, with a minimum of 1500 l/s pump capable of:
 - i) $>2 \times 10^{-7}$ Torr, 2 hour pump down from atmosphere.
 - ii) $>8 \times 10^{-8}$ Torr, clean and dry 12 hour pump down.
 - b) Must have a dedicated process pump port, rear.
 - c) View port shutter, front.
 - d) Four magnetron ports, bottom, 4.5" CF.
 - e) One substrate rotary table port, top 8" CF.
 - f) One heater power port and one heater water-cooling port.
 - g) One residual gas analysis (RGA) port, 2.75CF.
 - h) Instrumentation ports.

B FRAME

The following is required for the frame:

1. Frame Size: [~ 68"w x 52"d x 72"h]
 - a. Must be extruded aluminum with integrated electronics rack mount.
 - b. Must provide leveling capability with casters.
 - c. Must have removable side panels.

C VALVING

The following is required for the valving:

1. Material must be 304 SS on Hi-Vac side.
2. All Hi- Vac side valves must have ISO, VCR or Conflat fittings.
3. All seal material must be viton or copper.
4. All valves must be pneumatic. Except the leak check valve and load lock to process chamber.
5. Valves must seal to atmosphere in both directions.
6. All valves larger than 1 inch (") must have position indication.
7. Nupro, HPS, VAT or equivalent valves must be used.

Load Lock:

The following must be included:

1. One HPS NW-25 or equivalent valve for rough pumping.
2. One SMC or equivalent dual stage valve for vent and purge.
3. One HPS or equivalent manual vent valve, NW-25.
4. One VAT series 14 or equivalent, high vacuum isolation valve.
5. One manual VAT series 14 or equivalent, chamber isolation valve.

Process Chamber Valves

1. The sputtering must have the following:
 - a) One three position pneumatic process and isolation valve to process pump must be included:
 - b)
 - i) VAT series 64 or equivalent, 200 millimeter (mm).
 - c) One valve for vent and purge.
 - d) One manometer isolation VCR valve or equivalent,
 - e) One mass flow controller (MFC) gas ring VCR valve or equivalent,
 - f) Three MFC chamber inlet VCR valves or equivalent

D Substrate Table / Planetary / Holder:

1. The Two Stage Planetary must meet following requirements:
 - a) The two stage planetary must be capable of being configured in the following ways:
 - i) A fixed position center table for confocal sputtering must be supplied for up to 6" wafers with continuous back side heat up to 300°C
 - ii) A fixed position substrate table configured with four planets capable of rotating up to 4" diameter wafers in a fixed position or in planetary mode over any of the magnetrons.
 - b) Substrate table with radio frequency (RF) etch or direct current (DC) bias to be included. Mode of operation must be determined by programmable logic controller (PLC) / Computer. RF-VII 300W RF power supply with ATN-5/ matching network or equivalent to be used for sputter etches in the process chamber.
 - c) Both the center 6" wafer and the planet 4" wafers must be able to be loaded through the load lock. Additional loading must be through the main service door.
2. One gear motor per axis must be used for rotation, the motion must be bi-directional, typical speed must be 0-25 revolutions per minute (RPM) hub speed, jog and oscillation.
3. All substrate tables or planetary arrangements must be automated with. Ferro fluidic or equivalent.

E Pumping System and Parameters:

The following are the requirements for the pumping system and the parameters:

1. Load Lock must have the following :
 - a) The load lock must use a 60 liters per second (l/s) Pfeiffer turbo pump or equivalent with a 12 cubic feet per minute (cfm) Edwards seal or equivalent.
 - i) The oil sealed pump must be shared with the process chamber and cryo pump for roughing and regeneration.
 - b) One convectron type vacuum gauge for rough vacuum and one [1] bayard-alpert / convectron dual gauge.
2. Sputtering Chamber:
 - a) One cryo-pump with at least 1500 liter/sec pumping speed, CTI CT-8 brand name or equal, with automatic regeneration capability and an water cooled compressor, CTI 8500 series brand name or equal, will be supplied.
 - i) Sputtering chamber should reach vacuum equal to or lower than 8×10^{-8} Torr within 12 hour pump down from atmosphere.
 - ii) Sputtering chamber should reach vacuum equal to or lower than 2×10^{-7} Torr within 2 hour pump down from atmosphere.
 - b) All pump lines must be 304 SS.
 - c) Pumping systems must have a Grandville or MKS pressure instrumentation or equivalent. All must be "Mini" style, no rack electronics where possible.
 - i) One bayard-alpert /convectron dual type gauge for rough/hi-vac.
 - ii) One bayard-alpert type gauge for cryo cavity hi-vac
 - iii) One convectron types for rough vacuum.
 - iv) One MKS 627 heated manometer or equivalent.

F Process Gas Handling:

1. Sputtering Sub-System:
 - a) Upstream pressure control must have the following components:
 - i) One VAT Series 64, three-position shut off valve or equivalent.
 - a) Third position throttles the cryo pump for gross "Q", then controlled by MFC's with closed loop proportional in direction (PID) to the capacitance manometer.
 - ii) The system must be supplied with three MKS 1179A MFC's controllers / channels or equivalent. Two must have a range of 0-50 standard cubic centimeters per minute (sccm) and one must have a range of 0-100 sccm range.
 - iii) One MKS model 627 heated manometer or equivalent, 0-100m Torr w/isolation valve.
 - iv) PID loop must be through programmable logic controller (PLC).

- v) Integration to the control system with recipe control by layer is to be standard.

G Magnetron Sputter Sources and Power Supply's:

The magnetron sputter sources and power supply must have the following:

1. Four 3" magnetron sources/ guns supplied w/ shutters & chimneys.
 - a) Two guns supplied must have a Stage II magnet array.
 - b) 3" Angstrom Science magnetrons or equivalent are required.
 - i) The magnetrons must be able to be adjusted and locked in place at a user-selectable angle with respect to the plane of the substrate table. The angle must be read by an index.
 - ii) Magnetrons must use clamp on targets.
 - iii) Shutters must be controlled by the system's computer.
 - iv) Maximum power: 600W RF / 1000W DC
 - v) Magnetrons must be compatible with radio frequency (RF), direct current (DC), pulsed DC, mid and low frequency supplies.
2. Power Supply's:
 - a) One RF-VII 300W RF power supply with ATN-5/ Matching network or equivalent must be provided for sputter-etch.
 - b) One ENI RPG-50 pulsed-DC power supply or equivalent must be provided.
 - c) Each power supply must be able to connect uniquely to any of the magnetrons via computer-controlled switches.
 - d) The following must be integrated into the computer controlled system:
 - i) One ENI RPG-50 or equivalent
 - ii) One RF-VII 300W RF Supply ATN-5/ Matching Network or equivalent.
 - iii) One MDX series DC supply or equivalent.
 - iv) Up to two additional power supplies.
 - v) Power and voltage mode control must be configured.
3. One computer controlled power supply switch to select between bias and sputter etch mode must be included.

H Film Uniformity

The film uniformity must meet the following requirements:

1. Sputtering uniformity must be 2% or less over 120mm of a 150mm [6"] substrate using three-inch diameter magnetron guns in a confocal arrangement.
2. Planetary sputtering uniformity for pure metals must be 2%-5% or less and 85 mm of a 100mm [4"] substrate using three inch diameter magnetron guns parallel and offset to the substrate. The Contractor must establish offset value to achieve this uniformity.

3. In static planetary mode sputtering, uniformity for pure metals must be 8% or less over 85mm of a 100mm [4"] substrate using three inch diameter magnetron guns parallel and offset to the substrate. The contractor must establish offset value to achieve this uniformity.

Instrumentation:

All pressure instrumentation provided must be GP-Helix or MKS or equivalent.

1. One convectron type for rough vacuum, Rough Line.
2. Three Bayard-Alpert / Convectron Dual Types.
3. One MKS 627 manometer or equivalent.
4. One spare analog input and out channel must be provided.
5. Four spare digital inputs and outputs must be provided.
6. Three MKS 1179A MFC's or equivalent.

I Substrate Heat:

The substrate heat must meet the following:

1. Heat for Two Stage Planetary:
 - a) A backside substrate-heating configuration must be used.
 - b) 350⁰C maximum, 300⁰C continuous, +/- 5⁰C.
 - c) Witness thermocouple with Over Temperature, "K" type.
 - d) Omega 903 type PID temperature controller or equal.
 - e) Auto tune feature must be included.

J Electrical:

The electrical must meet the following:

1. Main Power must be configured as follows:
 - a) 208 Volts AC as the primary power; 120Volts AC, 1 Phase, 60 Hz.
 - b) An uninterruptible power supply [UPS] must be used for the PLC / Computer
2. The Contractor shall provide overload protection, fusing, power components, power and control wiring, wire ways, and enclosures.
3. System level digital I/O: +24 V DC and +5V DC.
4. System level analog I/O: 0- 5 or 10 V DC. Single point electrical connection w/ breaker box.

5. System must conform to the following regulations: Occupational Safety and Health Administration (OSHA); National Electric Code (NEC); Facilities Standards & Safety Guidelines Volume SEMI S2-93A, Safety Guidelines for Semiconductor Manufacturing Equipment; Facilities Standards & Safety Guidelines Volume SEMI S2-0200E, Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment; Facilities Standards & Safety Guidelines Volume SEMI S8-95A Safety Guidelines for Ergonomics/Human Factors Engineering of Semiconductor Manufacturing Equipment; and Facilities Standards & Safety Guidelines Volume SEMI F17-95, Specification for High Purity Quality Electro polished 316L Stainless Steel Tubing, Component Tube Stubs, and Fittings made from Tubing.
6. All systems must conform to Electrical Testing Laboratory (ETL) / Underwrites Laboratory (UL).

K Controls: PC Control:

The Contractor shall use "off the shelf", open Multi - level architecture hardware and software whenever possible. Remote I/O must be used at Level 1 [machine control] with a PC operator interface for Level 2. Supervisory Control and Data Acquisition (SCADA) or equivalent.

1. A Pentium 4 computer with 15" flat panel color touch screen monitor, network card, CDRW, UPS, and modem must be provided.
2. Level-1 control system must be implemented utilizing a remote input/output (I/O) interface for communicating with a combination of block I/O and chassis mounted I/O located throughout the system.
3. Level-1 control system must serve to provide sequential logic, recipe control, scaling I/O, Alarming, logic to support both hardwired and software interlocks, and interface to Original Equipment Manufacturer (OEM) equipment at Level-2 control system. Level-2 control system must implement software package to provide SCADA, with remote modem capabilities. PC / PLC-Based SCADA package interfaces to the Level-1 control system via data highway communications link.
4. Level-2 control must be served to provide a graphical user interface, recipe management, alarming, security, and data collection with report generation. Automated sequences are available through the SCADA screens:
 - i) Such as; Deposition, power set, auto pump down, & vent.
 - ii) Ratio, grading, and onboard automatic mass flow controller (MFC) calibration is standard.
5. The system must have three modes of operation, Manual mode [select interlocks], Service mode [only life threatening interlocks], and Automatic [full interlocks]. All functional machine control must be provided. The SCADA interface must handle:
 - i) Auto pump down / Turbo / Cryo regeneration.
 - ii) All interlocks.
 - iii) Read out for all pressure sensors.
 - iv) Cryo temperature.
 - v) Power supplies

- vi) Rate controller
 - vii) MFC's.
6. Both hardware and software interlocks must be incorporated to insure safe operation of the system.

L Nitrogen System:

The nitrogen systems must have the following:

1. The chamber must use nitrogen or argon for venting and purging.
2. All purging must use a shut off and a needle valve for control. Nupro ¼" or equivalent.
3. The main nitrogen line must have a pressure switch to indicate whether the pressure is below the system's required set point.

M Compressed Air System:

1. The main compressed air line must have a pressure switch to indicate whether the pressure is below the system's required set point.

N Water and Cooling System:

The water and cooling system must have the following:

1. The contractor must supply all secondary "machine" regulators and shut off valves.
2. The "master in" and "master out" valves must be manual.
3. Each water loop must be individual and have one each of the following:
 - a) A flow switch provided on the output side.
 - b) All "water in" valves are automatic.

O Documentation:

The contractor must provide two copies of each. (English Language)

1. Process and Instrument Diagram (P&ID) and chamber drawings and they must be loaded on the Personal Computer (PC).
2. Prints, on AutoCAD 14.
3. Electrical; [Also, Loaded on the PC]
 - a) Total power required.
 - b) Voltages and power by type.
 - c) Point to point Schematics
4. Operating instructions
5. Nitrogen, Water, Air, & Vacuum schematics. [Also, Loaded on the PC]

P Delivery and Training:

1. Government representatives must have the opportunity to visit the plant during manufacturing of the system. The Contractor shall provide training at their site before installation for a least four government representatives and training once the system has been installed.

Q Installation: General Installation Clarification:

1. Electrical hook up: The Contractor is responsible for wiring from equipment to control center. Example; vendor will install wiring to the pumps from the control center, Customer will supply from the facilities disconnect to the pump disconnect.
2. Mechanical: The Contractor is responsible for plumbing from equipment bibs to local equipment distribution. Example; vendor will install nitrogen purge and dilution to the pumps from the pump bib. Customer will supply from the facilities nitrogen line to the pump bib.

R Standard Commercial Warranty

1. All items proposed must be covered.

S. Maintenance Services Contract

1. Service Contract on parts and labor. Costs must include associated travel.

T Acceptance Testing:

The following is the acceptance testing procedure:

1. The system will be tested and functionally checked by the customer and vendor personnel at vendor's site, per customer specific requirements with final acceptance taking place on customer site after installation.
2. Sputtering uniformity must be 2% or less over 120mm of a 150mm [6"] substrate using three inch diameter Magnetron Guns in a confocal arrangement.
3. Planetary sputtering uniformity for pure metals must be 2%-5% or better over 85mm of a 100mm [4"] substrate using three-inch diameter Magnetron Guns parallel and offset to the substrate. The contractor must establish offset value to achieve this uniformity.
4. In static planetary mode sputtering, uniformity for pure metals must be 8% or less over 85mm of a 100mm [4"] substrate using three inch diameter Magnetron Guns parallel and offset to the substrate. The Contractor must establish offset value to achieve this uniformity.

U Options:

The contractor shall provide pricing for the following options:

- Option 1. Extra set of high field strength magnets for 3" Magnetron
- Option 2. Extra three inch Planar Magnetrons Gun supplied w/ shutters & chimneys by Angstrom Sciences or equivalent
- Option 3. VAT 64 Throttling gate valve w/ PID or equivalent
- Option 4. MeiVac / MKS 153 vane throttle valve w/ PID or equivalent
- Option 5. Pfeiffer TPU 521P Turbo Pump, 500 l/s. [Sputtering] or equivalent
- Option 6. Pfeiffer TPU 1001P Turbo Pump, 1000 l/s. [Sputtering] or equivalent
- Option 7. Edwards Dry rough / fore pump, GVSP30 [17.6cfm] or equivalent
- Option 8. Edwards Dry rough / fore pump, ESDP12 [8.8cfm] or equivalent
- Option 9. Advanced Energy MDX-1K, 1000W DC Supply or equivalent
- Option 10. Advanced Energy MDX-500, 500W DC Supply or equivalent
- Option 11. Polycold PFC 550 with 10' cryo line or equivalent
- Option 12. RGA, Inficon Compact [0-100AMU, FC/EM], w/ heat & integration or equivalent
- Option 13. RGA, Inficon [0-200 AMU, FC/EM], w/heat & integration or equivalent
- Option 14. Optional "Z" axis motion, 4" travel
- Option 15. Additional year service contract to cover travel, parts, and labor (Year Two)
- Option 16. Additional year service contract to cover travel, parts, and labor (Year Three)
- Option 17. Additional year service contract to cover travel, parts, and labor (Year Four)