

Specifications for an Atomic Layer Deposition System

Scope: This specification describes the minimum technical requirements and the minimum acceptable performance standards for an Atomic Layer Deposition System (ALD) to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. The ALD system will be placed in a multiple user facility and shall provide ease of operation and safety to those in the facility.

Installation Site: The system will be installed in the NRL Institute for Nanoscience (NSI) Bldg. 250 Device Fabrication Facility, Class 100 cleanroom at the Naval Research Laboratory, Washington DC 20375.

Description: The ALD system shall be configured for Thermal and Plasma enhanced ALD deposition of metals, metal oxides and nitrides. The ALD system shall be provided with a high temperature electrode (400° C) for Thermal ALD processing as well as a remote (ICP) plasma source for Plasma ALD processing. In addition to providing access to a much broader range of process chemistries and materials deposited, the remote plasma source shall also be capable of use for pre-treatment of the substrate and plasma cleaning of the chamber.

1.0 System Features:

1.01 The system shall provide a universal base console that houses the electronic sub systems, control units and pneumatics.

1.02 The system shall provide a computer system utilizing a Windows™-based environment for user login, operator interface of process control, wafer handling, data logging, and recipe management.

1.03 The ALD process chamber shall have a pumping port with a minimum size of 100mm, provide electrical heating cartridges, precursor injection flanges, ports for in-situ spectroscopic ellipsometry and an additional KF40 analytical port for future use.

1.04 The ALD system shall have a minimum 240mm electrically-heated (400°C) lower electrode with a wafer lift mechanism. The system shall provide a means of depositing onto small sample sizes.

1.05 The system shall provide a remote Inductively Coupled Plasma (ICP) high density source with 13.56MHz 600W RF Generator and automatic matching unit.

1.06 The system shall provide a capacitance manometer for process control with a penning gauge for base pressure measurement.

1.07 The system shall provide an Automatic Pressure Control (APC) valve with a built-in pressure controller. The APC shall be mounted directly onto the pumping tee. The APC valve opening and closing time shall be less than 0.20 seconds.

1.08 The system shall provide the capability to mount a minimum of six rapid-bubbled metal precursors individually heated up to 200°C. The system shall be delivered with controls and fast ALD dosing valves for a minimum of three metal precursors (up to 200g contents each). In addition, the system shall be able to accommodate two separate precursor delivery modules that house standard bubbler sizes of up to 500g (contents). Each of these modules shall contain fast ALD dosing valves, heated delivery lines and a fan assisted oven with air heating up to 200°C for uniform heating of all bubbler sizes. During all precursor changeovers the operator shall be protected by a glove-panel or glove-box.

1.09 The system shall have a water delivery pot close-mounted to the chamber. The water delivery pot shall include a fast acting ALD valve and delivery lines.

1.10 The system shall have a stainless steel source gas pod with a minimum of 3 mass-flow-controlled (MFC) process gas lines. Those MFC's shall include O₂, H₂, N₂, as main source gases. Argon shall be supplied as a gas for bubbling and purging and controlled by a MFC separate of the source gas pod.

1.11 The system shall include a fully automatic wafer insertion load lock chamber for vacuum loading of a single wafer into the process chamber. The load lock shall be provided with an active Pirani gauge. The load lock shall be provided with a turbo-molecular pump backed by a rotary vacuum pump suitable for oxygen service (Fomblin fluid) or a dry pump. The system shall include a thermal break between the chamber and the load lock.

1.12 The process chamber shall be pumped by a minimum 400L Magnetically Levitated Turbomolecular Pump backed by a rotary vacuum pump suitable for oxygen service (Fomblin) or a dry pump.

1.13 The manufacturer shall provide system commissioning, operator training and process verification which shall be conducted by a factory trained Field Service Technician and/or a Process Engineer.

1.14 The manufacturer shall provide access to their existing process library as well as processes developed in the future. The manufacturer shall provide interactive process development support through conventional media and regular user workshops held within North America. In addition, the manufacturer shall provide experimental evidence of plasma process results as well as proof of any guaranteed processes licensed through the ASM with the response.

2.0 Optional Items:

- 2.01 One additional precursor delivery module with heated lines and ALD valve.
- 2.02 One additional MFC gas line for Thermal ALD processes.
- 2.03 Upgrade to a larger backing pump for process chamber.

3.0 Documentation:

- 3.01 The system shall be shipped with one (1) complete set of operation and maintenance manuals printed on plain paper as well as electronic versions.

4.0 Acceptance Criteria:

- 4.01 System performance will be measured by test depositions of:

Al₂O₃ deposited at 25°C with refractive index >1.56, carbon <2%
Al₂O₃ deposited at 200°C with refractive index >1.62, carbon <2%
HfO₂ with refractive index ~ 2.0, carbon <2%
TiN deposited at 350°C with resistivity < 220μΩcm

Films shall be deposited with typical film thickness uniformity <±1% 4", <±1.5% 6", <±2% 8".

The Contractor shall provide a Certificate of Compliance guaranteeing that all the requirements of this specification have been met.

5.0 Warranty:

- 5.01 The system shall be provided with a 1-year factory warranty that covers all parts, labor and travel expenses for on-site support of the equipment. The warranty period shall begin on the date of system acceptance. In addition, the Contractor shall register all equipment requiring separate warranty by other manufacturers; such warranties shall also be effective from the date of system acceptance.