## Specifications for NRL NanoScience Institute PECVD System

**1.10 Scope**. This specification describes the minimum technical requirements and the minimum acceptable performance standards for a Plasma Enhanced Chemical Vapor Deposition (PECVD) system to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. The PECVD system will be placed in a multiple user facility and must provide ease of operation and safety to those in the facility.

**1.20 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 Representative (COR). The laboratory space will have 110 Volts alternating current (VAC) and 220 VAC, single phase, 60 Hertz (Hz) electrical power and all required facilities within a class 100 clean-room. The contractor shall connect the system plumbing, gas lines, and electrical fixtures which will be available in the designated location. The contractor shall install the system in a manner consistent with typical clean-room operating procedures.

**1.30 Description and Primary System Components**. The tool must be capable of deposition of $SiO_2$, $SiN_x$, $NH_3$-free $SiN_x$, $SiON_x$, amorphous Si, and SiC as indicated in the process specifications section of this document. The tool must be configured to be upgradable to TEOS $SiO_2$ process. The system is to be installed within class 100 clean-room and must be compatible of 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 and be user-friendly.

### 2.00 Required System Features

2.01 PC controlled system with necessary software providing a Windows™-based environment for operator interface of process control, wafer handling, data logging, and recipe management.

2.02 PECVD process chamber must be provided with at least 150mm pumping port, electrical heating cartridges, view port, and an additional port for end-point-detection of chamber clean process.

2.03 Process chamber pumping must be provided by a corrosive-resistant roots/rotary pump with a pumping speed at least 60 l/s configured for PECVD processes (i.e. Alcatel RSV33/301BF or equivalent).

2.04 The automated pressure control (APC) and isolation gate valves connecting the process chamber with roots/rotary pump set must have at least 60mm port opening to provide sufficient gas flow.

2.05 PECVD should be equipped with electrically-heated (400$^{o}$C) aluminum lower electrode with wafer lift mechanism.

2.06 A 2 Torr temperature-stabilized capacitance manometer must be included for process control and base pressure measurement.

2.07 For stress-controlled deposition the PECVD system should be equipped with dual frequency RF power sources:

a) High Frequency (13.56 MHz) RF generator (at least 600 W) connected to the upper electrode through a close-coupled automatic matching unit.

b) 50 kHz-460 kHz generator (at least 500 W), and mixing filter to top electrode

2.08 System shall be provided with a stainless steel gas pod capable of holding 12 mass flow control (MFC) units, but configured with 7 mass-flow-controlled process gas lines and a separate MFC-controlled gas line for plasma cleaning the chamber. All non-hazardous gas lines can use elastomer-sealed MFC's. All hazardous gas lines must use metal-sealed MFC's.

2.09 MFC controllers should be calibrated to accommodate the following list of gas lines to support process specifications listed below:

a) 100% $SiH_4$
b) $H_2$
c) $N_2$
d) $NH_3$
e) $CH_4$
f) $N_2O$
g) Ar
h) cleaning gas – $CF_4$,$O_2$ mixture

2.09 PECVD should be configured with a single-wafer load lock with dedicated turbo pump (at least 80 l/s).

2.10 System is to include all necessary tools required to handle 3" & 4" wafers

2.11 A 4" aluminum carrier plate with recesses for handling various size substrates should be supplied with the system.

2.12 System must include fixed wavelength end-point detector to terminate chamber cleaning process.

**3.00 Processes specifications**

3.01 $SiO_2$

| | |
|---|---|
| Stress tunable in the range | $-300 < \sigma < 0$ MPa |
| Cross-wafer thickness uniformity | 3% |
| RI | 1.47 ± 0.02 |
| Cross-wafer RI uniformity | 0.005 |
| Step coverage | 60% |

3.02 $SiN_x$

| | |
|---|---|
| Stress tunable in the range | $-800 < \sigma < 300$ MPa |
| Cross-wafer thickness uniformity | 3% |
| RI | 1.98 ± 0.02 |
| Cross-wafer RI uniformity | 0.005 |

3.03 $SiON_x$

| | |
|---|---|
| Stress tunable in the range | $-300 < \sigma < 200$ MPa |
| Cross-wafer thickness uniformity | 3% |
| RI | 1.465 - 1.8 |
| Cross-wafer RI uniformity | 0.005 |

3.04 Ammonia-free $SiN_x$

| | |
|---|---|
| Deposition temperature | < 150 C |
| Stress tunable in the range | $-400 < \sigma < 250$ MPa |
| Cross-wafer thickness uniformity | 3% |
| RI | 2. ± 0.1 |
| Cross-wafer RI uniformity | 0.02 |

3.05 $\alpha$-Si

| | |
|---|---|
| Deposition temperature | 200 C < T < 250 C |
| Cross-wafer thickness uniformity | 3% |
| RI | 3.5 - 4.1 |
| Cross-wafer RI uniformity | 0.01 |

3.06 SiC

| | |
|---|---|
| Cross-wafer thickness uniformity | 3% |
| RI | 2.4 – 2.7 |

**4.00 Options:**

4.01 Contractor must provide a gas delivery system with heated lines for use with liquid gas source (TEOS).

4.02 Contractor must provide a silane furnace (burn box) installed in pumping line to react residual silane.

4.03 Contractor must provide the installation of 4 additional metal-sealed mass flow controllers (MFC) in the stainless steel gas pod and incorporate this into our existing software.

**5.00 Documentation:**

5.01 The PECVD System must be shipped with one (1) complete set of operation and maintenance manuals printed on CD-ROM and one copy printed on clean-room paper.

Documentation should contain:

a) Full operational instructions suitable for use in teaching new users.
b) Gas, water, air, and vacuum schematics.
c) Electrical wiring schematics.
d) Complete mechanical schematics suitable to guide future modifications and repairs.
e) Troubleshooting manual for common servicing and repairs of electrical, mechanical, and computer software problems.

**6.00 Training:**

6.01 Contractor must provide basic training to NRL for five representatives following installation at NRL.

**7.00 Acceptance Criteria:**

7.01 Unless otherwise specified, process performance will comply with process specifications enumerated in this document.

**8.00 Installation and Commissioning:**

For installation and commissioning the following steps are to be carried out:

8.1Contractor Support Engineer will unpack the system, inventory it’s contents and ensure that all packages have been received, supervise the placement of the system in it’s final location and prepare it for your staff or contractor to install.

8.2 Contractor will permanently attach the system to the floor, install power, gas lines, exhaust lines, etc.

8.3 Contractor Support Engineer will be dispatched to verify the installation and facilities readiness. He will then power up the system and verify that all hardware and software are functioning properly.

8.4 Contractor applications engineer will be dispatched for a minimum period of 2 weeks to work with NRL process engineers to complete the process verification.

**9.00 Warranty:**

9.01 Contractor shall provide a standard commercial warranty from the date of installation and acceptance at the NRL site, including all parts and labor and 24-hour response to breakdown.