# Specifications for a Chlorine Inductively Coupled Plasma Reactive Ion Etcher System (ICP RIE)

**1.10 Scope.** This specification describes the minimum technical requirements and the minimum acceptable performance standards for a Chlorine Inductively Coupled Plasma Reactive Ion Etching ($Cl_2$ ICP - RIE) System to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. The $Cl_2$ ICP - RIE 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 system will be installed in the Bldg. 250 Device Fabrication Facility, Class 100 cleanroom at the Naval Research Laboratory, Washington DC 20375.

**1.30 Description and Primary System Components.** The tool must be capable of dry etching a wide variety of materials including GaN, GaSb, InSb, AlGaN, InGaAs/InAlAs, InP, InAs, AlN, Al, and AlAs/AlGaAs. The tool must meet the specifications as indicated in the process specifications section of this document. The system is to be installed within an existing Class 100 cleanroom at the NRL Nanoscience Institute and 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 Universal base console housing the electronic sub systems, control units, pneumatics, and turbomolecular pump.

2.02 Operating system providing a Windows XP™-based environment for operator interface of process control, wafer handling, real time data logging of process parameters, machine status and recipe management. System must provide a user logon requirement.

2.03 ICP process chamber which must be equipped as follows:

- a pumping port with dia. of 150 to 250 mm.
- electrical heating cartridges for heating all process chamber walls to reduce condensation of process effluents
- view port and end-point-detection ports for optical emission and laser interferometer

2.04 System must have a lower electrode made of Al with a dia. of 175 – 210 mm. The system must be capable of operation while the wafer is being cryo ($LN_2$) cooled or while the wafer is heated (temperature range -150$^{o}$C to +400$^{o}$C). System must have 3” and 4” single wafer capability with active helium cooling and an integrated sputter guard.

2.05 System must include all required tooling for etching a 3”& a 4” wafer.

2.06 System must have a remote high-density plasma source of at least a 180mm inside diameter with the following features:

- a maximum output of no less than 3kW RF power @13.56MHz.
- an automatic matching unit that is close-coupled to the source.
- the source is to use an electrostatic shield to produce a purely inductive plasma

2.07 Substrate bias to be provided by an independent RF generator, with a minimum of 600W, connected to the lower electrode through a close-coupled automatic matching unit.

2.08 A100-millitorr (mT), temperature-stabilized capacitance manometer with isolation valve must be provided for process control. An active penning gauge is to be provided for base pressure measurement.

2.09 The pumping port is to be fitted with a variable gate valve for chamber isolation and automatic process pressure control. An electrical heating jacket must be provided for the pump-down pipe to reduce condensation of process effluents.

2.10 System must have stainless steel gas pods that provide a minimum total of 8, independently controlled, mass-flow-controlled process gas lines, five of which must be capable of handling toxic and corrosive gases. All toxic and corrosive process gas lines must be double walled and use metal-sealed mass flow controllers (MFC’s). The three gas lines that are both non-corrosive and non-toxic may use elastomer sealed MFC’s. Each line must be provided with a mass-flow-controller for the accurate control of gas flows.

2.11 System must include load lock chamber for vacuum loading of a single 3” or 4” wafer into the process chamber. The load lock is to be provided with its own turbo and rotary pump set.

2.12 Process and base-pressure pumping must be accomplished by a magnetically levitated turbo pump with a minimum pumping capacity of 1300 l/s. A backing pump for the above turbo pump must be capable of pumping oxygen. It must use perfluoropolyether (PFPE) type pump oil.

**3.00 Minimum Process specifications:**

3.01 Process: **AlGaN/GaN ICP etch with $Si_3N_4/SiO_2$ Mask**
Process gases $Cl_2$/Ar or $BCl_3/Cl_2$
Etch rate 0.5-1mm/min.
Selectivity 5-10:1 depending on etch rate and etch chemistry
Uniformity <±2% on a 4" wafer.

3.02 Process: **GaAs/AlGaAs Etch**
Process gases $SiCl_4$, Ar
Clean gases $SF_6$, $O_2$
Etch rate > 0.3µm/min.
Uniformity < ±4% on 4" wafer.
Selectivity > 10:1 to SiO2 or SiNx mask, > 5:1 to photoresist
Profile control Vertical 90° ± 2°

3.03 Process: **InP/InGaAsP Etch**
Process gases Cl2, CH4, H2, Ar
Clean gases SF6, O2
Etch rate > 1.5µm/min.
Uniformity < ±4% on 4" wafer.
Selectivity > 15:1 to SiO2 or SiNx mask
Profile control Vertical 90° ± 1°

**4.00 Optional Items:**

The following items must be offered as options and must be field retrofittable to the tool.

4.01 Laser end-point-detector integrated with system controller.

4.02 Optical Emission (full spectrum) end-point-detector integrated with system controller.

4.03 Increase the number of Mass flow Controllers (MFC) to 12 MCFs. This must include the space within the existing gas cabinet and the gas line connections at the system.

**5.00 Documentation:**

5.01 The contractor must provide all documentation, drawings and schematics necessary for full operation, troubleshooting, servicing and repair of the system and its components

5.02 The System must be shipped with one (1) complete set of operation and maintenance manuals printed on cleanroom paper and an electronic version on CD-ROM.

## 6.0 Acceptance Criteria:

6.01 Unless otherwise specified, process performance will comply with process specifications enumerated in sections 3.01, 3.02 and 3.03 of this specification. This process performance is to be demonstrated after installation of the system at the NRL. During this process performance demonstration the Contractor must provide training on maintenance and operating procedures for the system.

## 7.00 Installation and Commissioning:

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

- It is recommended that the Offeror visit the installation site. After delivery, the Contractor support engineer will unpack the system, inventory its contents and ensure that all packages have been received, advise on the placement of the system in its final location and prepare it for installation.
- Government will be responsible for attaching the system to the building site utilities. The contractor will be responsible for advising the government of all of the utilities needed for the proper installation.
- Contractor support engineer will assist the Government in the verification of the installation and facilities readiness and power up the system and verify that all hardware and software are functioning properly according to the equipment manufacturer's original specifications.
- Contractor applications engineer will assist the Government in the complete verification of system and process performance.

## 8.00 Warranty:

8.01 All equipment shall be warranted in accordance with standard commercial practices. The warranty shall begin after acceptance of the system.

8.02 Contractor shall offer a maintenance option/agreement that would start after the initial warranty period. This option/agreement would be exercisable anytime during the original warranty period.