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From: Director, CSIR-NPL
Tender No. 14-VI/AK(1103)22PB/T-92 Dated: 18.09.2023

CORRIGENDUM

With reference to NPL's Global Tender ID: **2023_CSIR_724923_1**, Pre-Bid Conference (PBC) was concluded on 05.09.2023 for "Inductively Coupled Plasma Reactive Ion Etching". Consequent upon the outcome of PBC, **some changes have been made in the technical specification of captioned tender. Revised specifications are as follows:**

Inductive Coupled Plasma Reactive Ion Etching (ICP-RIE) Specifications

1. General description

1.1. The plasma etching system should design for modularity and process flexibility in the area of Si, semiconductors, metals and dielectrics (like SiOx, SiN, NbN, TiN, NbTiN, GaN) processing.

1.2. Required gases: SF_6, CHF_3, C_4F_8, BCL_3, Cl_2, O2, He, N_2 and Ar

1.3. The substrate electrode should be offered to accept 6" diameter and which cab ne upgraded up to 8". There should be provision to hold small samples as well.

1.4. Supplier must supply guaranteed processes for etching of listed materials: e.g. specify the etch rate, uniformity over 6" wafer, selectivity to mask and profile and show example SEM results.

1.5. Remote field controller should be used for the real-time control of all components. PC with proper operating software must be used for the process control, for interlock against operator error, for visualization etc.

1.6. The Inductively Coupled Plasma Reactive Ion Etching (ICP-RIE) machine should be used for producing smooth etched waveguide sidewalls with low ion damage for metals and electronic material etching.

1.7. The machine must be able to achieve smooth side walls with a vertically etched profile at sub-micron dimensions.

1.8. The machine must have a substrate holder capable of providing substrate electrode temperatures from -20 °C or 150 °C or higher during etching processes.

1.9. All gas lines should be equipped with MFC with provision to adjust set-points, particle filter (≤2 micron) and cut off valve.

1.10. Gas lines for Cl2 and BCl3 should come with heated MFC and bypass.

2. Plasma sources:

2.1. ICP source for up to 6" wafers

2.1.1. ICP type: Helical or Spiral

2.1.2. The ICP should have an operating frequency of 13.56 MHz or 2 MHz with automatic matching and the power of ICP source should be optimum to demonstrate the process parameters defined in section 3.1.6.

2.1.3. The source diameter should be suitable to achieve uniformity over 6" samples.

2.1.4. It should be continuously adjustable. Suitable automatic power matching technique need to provide to minimize reflected power. Vendor has to provide details about technique /method.

2.1.5. Mechanism to prevent/minimize capacitive coupling.

2.2. RIE power supply to substrate electrode

2.2.1. Continuous power range of up to 600W or higher. The frequency of operation should be 13.56 MHz Generator.

2.2.2. Minimum: 100 W RF with automatic matching impedance network with preset and pre-selected variable Capacitor positions (from the PC, for each step)

3. Process chamber, Load lock and vacuum system

3.1. Process Chamber

3.1.1. Process Chamber made from a single full block with suitable ports for Plasma source, pumping unit, load-lock, and viewing. The view ports should have UV protection coating and in addition RF protective coatings or equivalent arrangement for RF protection.

3.1.2. Pumping flange and tee >= 200 mm for very high effective pumping speed

3.1.3. Heating up to 60°C using heating liners for chamber. Heating should be provided, if required, to avoid deposition in the vacuum line.

3.1.4. The system design of the plasma source and pumping must ensure best uniformity over a wide parameter range over the wafer.

3.1.5. Two sets of removable liners provided with the system

3.1.6. Material etching parameter for demonstration of the quality as acceptance criteria:

Material	Etch rate	Etch depth	aspect ratio	Selectivity to PR	Selectivity to SiO2	Profile	Uniformity for 6" with 7mmEE
Si	500 nm/min	10 micron	<2.5:1	5:1	3:1	90±4°	±5%
GaN	500 nm / min	10 micron	<3:1	1:1	5:1	90±4°	±5%

3.2. Load Lock

3.2.1. Vacuum loadlock

3.2.2. The load lock chamber must be able to be pumped down to approximately 75mTorr suitable for typically wafer transfer to the main process chamber within approximately 10 minutes or less with separate pump for load lock.

3.2.3. The loading mechanism should be software driven and fully automated with a robotic transfer mechanism to move the wafer from loadlock into process chamber and back on execution of a process recipe. There should be an option to manually override the transfer.

3.3. Vacuum system

3.3.1. Pumping speed and conductivity of the vacuum system should match to standard etching processes for silicon, GaN, NbN and other materials.

3.3.2. A suitable magnetically levitated and corrosion resistant turbo ($\geq$ 1300 LPS) that can guarantee the chamber pressure requirements specified must be included. The ultimate chamber pressure must <10-6 Torr. Suitable protection measures for preventing the wafer pieces from being sucked into the turbo must be provided.

3.3.3. The roughing vacuum pump for main chamber should be dry pump 90 m3/hr or better for process gases with suitable N2 purge stand by option. The pump must be resistant to corrosive gases.

3.3.4. Automated arrangement like Standby mode for the nitrogen purge should be provided for starting and stopping from a preset time.

3.3.5. Appropriate Penning and other vacuum gauges.

3.3.6. Base pressure < 10-6 Torr

3.3.7. The pump must include a microprocessor based diagnostic accessory for quick identification of faults that may occur from time to time.

4. Substrate Electrode

4.1. Substrate electrode for up to 6 inches wafers

4.2. Must provide 02 numbers of clamps, one each for 6-inch and 4-inch wafers along with two suitable carriers for smaller and irregular size wafers and samples.

4.3. Substrate electrode should have automated heating and cooling provisions.

4.4. The helium cooling is pressure controlled which must be set as a process parameter.

5. Scrubber System

Scrubber system should be supplied with a point of use scrubber for the abatement/disposal of Fluorine and Chlorine based by-products. The scrubber should have following:

5.1. Chemisorption reaction based dry scrubbing technology.

5.2. At the outlet of scrubber, the Fluorine (F2) and Chlorine (Cl2) gas concentration should be below their universally accepted Threshold Limit Values (TLVs).

5.3. At the outlet of the scrubber, it should have detectors to detect minimum gas concentration of their universally accepted TLVs.

5.4. It should allow for safe refilling / replacement of cartridges / consumables when lifetime of the granulates expire

5.5. The scrubber should operate at room temperature, should have cabinet, safety bypass procedure, no secondary emission.

5.6. The Scrubber should come with one year warranty.

6. Control Software

6.1. Should be equipped with programmable logic controller or equivalent.

6.2. The operation software should allow recipe as well as step wise processing of the plasma tool. Main parts of the software should mimic diagram for status control of the whole system, parameter window for setting and checking of parameters, recipe editor for preparation of automatic mode of tool and data logging of the monitoring of all parameters during the etch process.

6.3. A user should be able to watch the command execution, or the process run on the monitor, following a schematic flow or the data logging graphics. The executed recipe steps should be marked and the state of the system should be displayed. The settings and the actual values of all analogue parameters should be displayed

6.4. A process runs should run in both automatic and manual modes.

6.5. It should have capability to maintain power-on between process steps

6.6. Software should have password-controlled user login.

6.7. Copy of complete software along with DLL files and a clone hard disk or perpetual license with extra back-up hard disk must be included.

7. Electrical supply

Electrical supply: Electrical supplies available at the institute are Three phase 400V (+6% 10%)/50Hz (±1%) and Single phase 230V (+6% 10%) / 50Hz(±l %). If power conditioning equipment (for example, voltage transformer) is required in order that the equipment to be supplied by the Vendor will work from the electrical supplies available at the Institute , then the equipment to be supplied by the Vendor must come with the power conditioning equipment.

8. Safety

8.1. The warning should be indicated when the following abnormal conditions occur,

- 8.1.1. Low or no cooling water supply
- 8.1.2. Low air pressure
- 8.1.3. Abnormal chamber pressure
- 8.1.4. Abnormal pump operation
- 8.1.5. Abnormal RF power
- 8.1.6. Abnormal heater temperature
- 8.1.7. Abnormal process parameters

8.2. There should be an emergency stop switch on the panel.

8.3. All the valves should be interlocked to prevent errors in operation.

8.4. All the pumps should be interlocked to prevent errors in operation.

8.5. There should also be RF Interlock

9. Installation, commissioning and demonstration

9.1. The vendor is required to provide hardcopy and softcopy (PDF) of gas and electrical schematics along with system operations, bill of materials shipped, recommended spare parts, assembly drawings, component and maintenance manuals for each system.

9.2. Instruction, maintenance and OEM component manual should be provided.

9.3. The vendor is required to work with NPL Delhi to assure that the system will meet process requirements, facility layout, services and all applicable fire and safety codes in effect when installed at the Institute. These include but are not limited to proper connections to gas cabinets, scrubbers and other building facilities and the possible interactions of such connections with other machines. Vendor must ensure proper installation before machine testing.

9.4. The number of Three phase and Single phase electrical supplies according to those listed above, as well as the current required for each supply, must be defined by the Vendor.

9.5. Preventive maintenance kit (O-rings and accessories) must be provided along with the system. Also, provide the list of PM kit items.

9.6. Utility services required for the equipment to be supplied must be specified in detail in the tender submission. The tenderer is required to be accurate and specific in specifying the actual equipment consumption/emission ratings (for example, electrical input current rating, water supply, compressed air supply, specialty gas supply, exhaust ratings, etc., as applicable).

9.7. The company should agree to provide AMC after the completion of warrant and should provide separate quotation for 3 year AMC.

9.8. Factory Functionality test certificate should be provided with the system.

9.9. Provision should be there for pre-shipment instrument inspection and acceptance of the complete system at the factory by the CSIR-National Physical laboratory. The expenditure may be borne by the CSIR-National Physical laboratory.

9.10. The vendor should provide 'Original Equipment Manufacturers (OEM)' certificate of complete RIE system, according to international standards with supporting documents.

9.11. Essential spares parts listed below should additionally be provided with the system.

9.11.1. One viewing glass set for chamber

9.11.2. One set of UV/RF and particle filters

9.11.3. One set of spare MFCs for hazardous gases (Cl_2 and BCl_3)

10. Training

10.1. The vendor must provide operating, supervisory and maintenance training covering safety, process theory and problem diagnosis to Institute personnel along with actual operation training.

10.2. The vendor must provide "Super User" level training on process engineering, such as methods and optimization strategies for materials etching or deposition utilizing the machine and in-depth knowledge of the machine operational principles and safety.

10.3. The vendor must provide training for up to at least 5 institute personnel during system installation, commissioning and acceptance at the Institute. The training must be as follows:

10.4. Machine operation including all processes required in the acceptance test.

10.5. Process engineer training for tool operation, creating recipes and optimization techniques and safety.

10.6. Maintenance engineer level training for understanding the tool operation, Safety, vacuum and electrical structure and simple troubleshooting.

10.7. During training and trial runs at the institute, the system will be demonstrated to meet all system specifications.

10.8. The list of the R&D users of international repute in last five years, in India and abroad with their contact details should be provided.

11. Shortlisting criteria for ICP-RIE tool

11.1. OEM should have 5 installations in India.

11.2. OEM should provide list of similar installed systems in India.

12. High Purity Gas Distribution general points

12.1. Distribution system with all necessary controls and safety features to be installed for the gases: SF_6, CHF_3, C_4F_8, BCL_3, Cl_2, O2, He, N_2 and Ar

12.2. All gas lines should be Stainless steel (SS316L) electro-polished lines with surface roughness of less than or equal to 10 µm (RMS) and must be welded orbitally for 10^{-9} mbar l/s leak rate and coupled with VCR connectors.

12.3. Gas Cabinets will be required for all Hazardous gasses

12.4. All gas lines should be tested for industrial standard leak test for leak rates of the order of 10^{-9}mbar l/s.

12.5. Firm to build gas distribution line from each gas cabinet to process tool with appropriate components.

12.6. One time supply of Gasses

Sl. No	Type of gases	Gas Purity	Gas content (approx.)	Quantity
1	Cl_2	Semiconductor grade (>99.999%)	45-50 kg	One
2	BCl_3	Semiconductor grade (>99.999%)	45-50 kg	One
3	CHF_3	Semiconductor grade (>99.999%)	45-50 kg	One
4	SF_6	Semiconductor grade (>99.999%)	45-50 kg	One
5	C4F8	Semiconductor grade (>99.999%)	45-50 kg	One
6	O2	Semiconductor grade (>99.9999%)	7-8 m^3 at STP	One

7	N2	Semiconductor grade (>99.999%)	7-8 m^3 at STP	One
8	Ar	Semiconductor grade (>99.9999%)	7-8 m^3 at STP	One
9	He	Semiconductor grade (>99.999%)	7-8 m^3 at STP	One
10	N2	General grade (>99.99%)	7-8 m^3 at STP	Eight

13. Specification of Gas Cabinets and lines for Hazardous gasses (Cl_2 and BCl_3)

13.1. HMI display panel/touch panel console
13.2. Adequate exhaust duct with differential pressure sensor
13.3. 7 valve primary pressure control panel with pneumatic shut off valves
13.4. Sprinkler
13.5. Excess flow switch
13.6. View glass with wire mesh
13.7. Weighing scale
13.8. Helium leak test port
13.9. Pressure transmitter
13.10. In-line Filter gasket
13.11. Alarm and control unit for flow purge integrated in cabinet door console.
13.12. 2-channel safety barriers for explosion-proof according to ATEX or equivalent
13.13. SEMI S2 standard for the integration and testing
13.14. 7 valve panel should be have: One number 3-valve upstream purge assembly with pressure rating of min. 200bar NC with integrated cylinder connectors.
13.15. Upstream diaphragm isolation valve and 3-way downstream diaphragm isolation valve for process outlet and with LP and HP vents
13.16. Waste gas high pressure vent valve
13.17. SS316L EP pigtail with CGA/DISS connectors
13.18. High pressure pre filter (~0.5 micron) and Low pressure fine filter 0.003 micron
13.19. Pressure regulator compatible with cylinder pressures for both inlet pressure and outlet pressure.
13.20. Vacuum generator unit should consist of vacuum generator, check valve, vacuum gauge and nitrogen purge inlet valve
13.21. Emergency shut off valve (ESO)) with pneumatically operated solenoid valve
13.22. Co-axial pressure switch (vacuum monitoring) with two port diaphragm valve for co-ax filling/evacuation
13.23. Self-suction type leak detector. The detector should detect the gas concentration in ppm level or better.
13.24. The gas cabinet and other elements should be compatible with process gas and should be equipped with air filters and supporting brackets and holders for cylinders.
13.25. Single walled gas line with thermal heat tracing for BCl3, and coaxial line with monitoring switch for Cl_2 with internal core- SS316LEP and outer Core- SS316BA.

14. **Gas cylinder supply Panel for SF_6, C_4F_8, CHF_3, Ar, O_2, N_2, He**

14.1. Single Cylinder supply Panel for SF_6, CHF_3, C_4F_8, O_2, N2, Ar, and He(i.e. 7Nos.).

14.2. Panel should consist of regulator (SS316) with isolation valve. It should also have purge und relief valve and compatible cylinder connector with pigtail.

14.3. N2 purging and high pressure vent of gas lines carrying corrosive gases is mandatory.

14.4. Panels should have high pressure isolation valve, high pressure purge facility, high pressure vent valve, process isolation valve, Safety Relief Valve, 0.4 micron filter at inlet side and 0.003 micron filter at outlet side of supply panel, SS316L.

14.5. He leak check port to be provided.

14.6. Should have Single stage regulators, SS316L.

14.7. All fittings should be micro fittings. No block assembly will be allowed from maintenance point. Each and every components should have VCR end connection only.

14.8. All panels shall be tested for particle content (less than 10 particles for size above 0.1 micron).

14.9. Panel shall be tested and for Trace moisture & Trace oxygen content

14.10. All panels must be Helium leak test at leak rate of 10^{-9}mbar lt/s.

15 Exhaust system

15.1 Exhaust ducting with isolation dampers to be provided wherever required in the exhaust system. It should be of SS304 of 2mm thickness and approx. length ~10m

15.2 BCI_3& Cl_2 exhaust lines should be separately hooked-up to the acidic exhaust.

15.3 Tool exhausts should be hooked to scrubber.

15.4 Scrubber output should be hooked to the exhaust system.

15.5 Water lines and vent lines connections for each of gas cabinets.

15.6 High pressure water line with valves to be connected to the equipment (SS 304).

15.7 All the Hazardous gas lines vent and acid exhaust should be connected to scrubber and tested.

15.8 Suitable blower for exhaust, compatible for toxic and corrosive gases, should be installed.

16 Nitrogen and CDA manifold

16.1 Panels must have pressure regulator, high pressure isolation valve, high pressure vent valve, SS316L.

16.2 All panels must be Helium leak test at leak rate of 10^{-6} mbar l/s.

16.3 Panel should be 4x4 auto change over type.

17 Water distribution system

17.1 Complete Supply and return water line interconnecting all the required points to make system functional.

17.2 If system requires any chilled water supply for RF cooling for pumps cooling, a suitable size chiller must be supplied

18 Site Visit

Vendors can request for site visit before submission of their bid.

19 Alarm system with centralized controller for hazardous gases

19.1 The alarm system should be provided inside as well as outside the room (in the corridor). If any gas leakage takes place in the gas cylinder, indication should reach to the user working on the system.

19.2 All gas cabinets should be integrated to the centralized controller with HMI.

19.3 Repeater panel should be provided inside cleanroom near to the equipment.

20 Testing and validation of gas distribution system should be completed as per SEMI S2 standards

21 Documentation requirement for UHP gas cylinders

21.1 Purity certificate of each gas (mentioning major expected impurity levels).

21.2 The firm should provide drawings of the gas cabinets, manifolds and gas panels.

21.3 The firm should provide complete set of maintenance and service manuals. All necessary electrical drawings should also be supplied.

22 Acceptance Criteria of gas distribution system

22.1 Control platform for the gas cabinets should meet all standards as per the SEMI S2 guidelines

22.2 No physical damage of received stores after visual inspection.

22.3 The firm has the sole responsibility to follow all the applicable safety

22.4 Instructions/guidelines regarding import, manufacture, inspection & certification, filling, storage and transportation of cylinders and gases. Any precautions and safe handling guidelines to be explicitly communicated to CSIR-NPL before shipping of items.

22.5 The firm has the sole responsibility to obtain necessary clearances for import, inspection & certification, filling, storage or transportation of cylinder and gases from Govt. of India or any other organization/ agency designated by it for this purpose.

22.6 The firm should provide the startup and training which include proper cylinder changing, controller operation, diagnostic evaluations and troubleshooting, at CSIR-NPL.

22.7 The vender should perform Helium leak test, pressure test and trace (oxygen, moisture & particle) after the complete installation of the gas line, cabinets and all other components. The vender should also demonstrate the desire detection limit for the detectors.

22.8 The firm should provide one year warranty of the orbital welding gas line and all the parts such as regulators, valves, detectors, switches etc.

22.9 Firm should have experience of installation of Cl_2&BCl_3 gas distribution system.

22.10 Firm should provide user list of similar job works carried out for the installation of gas cabinet/ gas distribution system in different places. If required, vendors may be asked to produce completion certificate of similar work executed minimum 3 places of reputed at Industry/Academia/R&D establishments.

23 Warranty

23.1 ICP-RIE tool and gas distribution system should have a minimum **three year** on-site comprehensive warranty, which should commence from the date of the successful installation, commissioning and acceptance.

23.2 Preventive maintenance (including changing of O-rings) should be performed during second and third year warranty period.

23.3 The ICP-RIE OEM should ensure the availability of spare parts, consumables and etc. for 10 years.

Therefore, following extension in due date of submission & date of opening of the said tender may be read exactly as follows:

Due date & time of tender submission
For : 26.09.2023 up to 3:00 PM (IST)
Read as: 10.10.2023 up to 3:00 PM (IST)

Date & Time of Tender Opening
For : 27.09.2023 at 3:00 PM (IST)
Read as: 11.10.2023 at 3:00 PM (IST)

All other terms & conditions of said tender will remain the same.

Sr. Controller of Stores & Purchase

Minutes of Pre-bid conference for Inductive Coupled Plasma Reactive Ion Etching System

05.09.2023

The Pre-Bid conference meeting was held on 05/09/2023 in online mode through the MS team link at 12 noon to finalize the specifications of Inductive Coupled Plasma Reactive Ion Etching (ICP-RIE) System. The meeting was organized under the chairmanship of Dr. H. K. Singh, Chief Scientist and the following members were present.

Sr. No.	Name	Role
1.	Dr. H.K. Singh	Chairman
2.	Dr. Anjana Dogra	Scientific member
3.	Dr. Sachchidanand Singh	Scientific member
4.	Dr. Sangeeta Sahoo	Domain Expert
5.	Dr. Ajeet Kumar	Indentor

A total of five firms participated in the pre-bid meeting.
Mr. Samik Pal and Mr. Anoop Kumar (Lab India Pvt. Ltd on behalf of Sentech Instruments GMBH), Mr. Gurpal Singh (Oxford Instruments), Mr. Sanjay Bisht (AIMIL Ltd. on behalf of Plasma-Therm, LLC), Mr. Abhyudey Sharma (Edgetech Sci. on behalf of Samco Inc.) and Mr. Vishnu Naik (CCD Technical Solutions) attended the meeting. All the representatives participated in the technical discussion and gave their respective suggestions. The TSC deliberated over their suggestions and the technical requirements of IO and finalized the specifications accordingly. The amended specifications are attached as Annexure 1A.

The chairman briefed the respected companies' representatives and invited them to bid. The purchase section is requested to do the needful and upload the revised specifications.