	INDIAN INSTITUTE OF TECHNOLOGY BOMBAY **MATERIALS MANAGEMENT DIVISION** **Powai, Mumbai 400076**

Reference No. 124 PR No. 1000018307 (Rfx No. 6100000812)

Detailed Technical Specifications for Reactive Ion Etching System (RIE)

1. Key Generic Requirements:

a. The tenderer must provide an installation scheme showing the physical space (footprint) of the machine(s) as well as space required for routine access and all installations including the gas lines, MFCs, and other related accessories.
b. The vendor should have installed similar types of systems in centrally funded technical institutes or government research labs. Purchase order (PO) and user list should be provided as supporting evidence.
c. The compliance sheet should be provided by the vendor. The absence of the compliance sheet may result in the cancellation of the purchase order.
d. For each compliance, supporting evidence such as manuals, SEM images, AFM results and other necessary and supporting documents needs to be provided.
e. The vendor should have an Indian representative which can take care of the urgent troubleshooting or any process related queries on an urgent basis.
f. Safety features like interlocks to prevent errors in operation, Gas leakage interlock, RF interlock, emergency shut-down options along with necessary protocols should be separately mentioned.

2. (a) Technical Specifications (Generic):

a. The system must be clean room compatible with all the necessary support systems such as vacuum systems, cooling systems, power supply systems, computer hardware, and software provided.

b. The machine must be software controlled with appropriate software and hardware interlocks to protect the machine from any possible operational or non-operational failure thereby ensuring the safety of the operator as well as the machine.

c. The process is required to contain all the necessary sensors and control to aid in safety monitoring, performance monitoring, automatic operation, and diagnostic of the system. A complete set of system operation and maintenance manuals must be provided.

d. A library of process recipes for materials that can be processed by the machine well documented by the company must also be included.
e. Suitable gauges calibrated as per international traceable standard must be provided for monitoring vacuum in the process chamber as well as load-lock and providing feedback for controlling process pressure in the chamber. Further, pressure gauges to monitor the lines between chamber and turbopump, and turbopump to backing pump should be included to ensure the best possible vacuum performance.

f. The process pressure control in the reactor chamber should be automatic and closed-loop through software-controlled throttle valves.
g. The control computer system/PLC should be a state-of-the-art system with a pre-loaded operating system and the software required for running the machine. The control panel must contain all the buttons required to operate the machine.
h. The software must allow for configurable user groups with different access privileges. Three different modes operator, engineer, and admin should be provided for easy and safe handling of the tool.
i. The software must allow the user to write and edit machine recipes.
j. The software must provide full system monitoring and recording of full system states in log files.
k. The system must provide access to sample process history and security protocols.
l. The system must provide system fault detection and diagnosis.
m. Automatic and manual control modes should be available in the software.
n. Installation, training, and Silicon, Diamond, SiN, SiO2 etch process demonstration.

2.(b) Technical Specifications (Specific):

a. The system is targeted towards Silicon (Si), Diamond, SiN, SiO2 etching through standard processes.

b. The system should be capable of carrying out etching on small pieces mounted on a suitable and compatible carrier wafer. The source diameter should be suitable to achieve uniformity over a 4-inch wafer diameter also. The chamber diameter and load-lock transferring mechanism should be able to accommodate 2 and 4-inches wafers

c. The wafer mounting chuck should enable mechanical/electrostatic clamping.

d. Standard MFCs controlled 8 lines CHF_3, Cl2, BCl3, Argon, O2, N2, C_4F_8/CF4 and SF6 should be closely coupled to the plasma source to enable minimum cycle time. Provisions for more gas lines to be able to hook up with the system to enable future upgradations, if any, should be provided.

e. The reaction chamber should be machined from a single metal block (preferably aluminum) with an anodized inner surface for chlorine processes. A separate air-inlet port (for by-products protection), as well as a viewing port, should be provided with the main reaction chamber.

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

g. The substrate should be cooled using through Helium backside circulation. The helium flow rate and pressure are considered process parameters. The flow rate/pressure should be controlled through a software-controlled MFC.

h. The substrate electrode temperature should be from -20 ^{0}C to +200 ^{0}C settable with the stability of 1-2 ^{0}C or better.

i. The system should come with provisions for separate pumps for the reaction chamber (RC) and the load lock chamber (LLC). Altogether there should be 3 pumps, 1 Turbomolecular pump with a pumping speed of 1300 litres/sec or better, 2 dry pumps (one each for RC and LLC) with a pumping speed of 1500 litres/min and 600 litres/min or even better respectively.

j. The load lock chamber vacuum pumps must be able to pump the load lock chamber down to approximately 10^{-1} Torr. suitable for typical wafer transfer to the main process chamber within approximately 10 minutes. It should be able to pump down to 5×10^{-5} Torr. with overnight pumping.

k. **The main chamber must be able to reach (in half an hour) and maintain a vacuum level (base pressure) of less than 5 x 10-6 torr. Process pressure should be in range 2-100 mtorr "**

l. Oil-free dry backing pump with 1300 lpm or more rating with N2 purge standby to minimize N2 usage when no etching is in progress. The backing pump must be resistant to corrosive gases.

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

n. **The plasma should be inductively coupled with an operating frequency of 2 MHz or 13.56 MHz.** The plasma generator power/bias rating should be 2 KW/600 W. Suitable matching techniques should be provided to minimize reflected power (less than 5% reflected power). The vendor should also provide detail about techniques/methods.
o. The power supply cooling can be either air-cooled or water-cooled. Any specific requirements for this (ex: Chiller) should be mentioned as a mandatory item along with the system.

p. The RF coupling to plasma should be done through Alumina, AlN, or, any other suitable dielectric.

3. (a) Process demo:
The system is going to be extensively used for etching of Silicon (Si), Diamond, SiN, and SiO2. The demo process of etching on samples provided from IITB (Details of the sample mentioned below) should be carried out to develop the process. The process recipe needs to be replicated by the installation engineers on a similar set of samples after the installation of the machine is completed at the IITB site.

Vendor should provide measurement results of factory etch profiles, like SEM images, AFM results and profilometry step height and it should later match with onsite etch and measurement profiles, using IITBBNF inhouse SEM, AFM, and profilometer for side wall angle, roughness, and etch rate parameters.

Packaging and shipment

1. Each Package should not exceed 900mm W, 1900mm D and 1900mm H

Acceptance Criterion

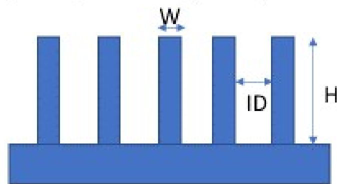
1. Leak Check < 3mTorr/min
2. Leak Rate 1e-10 Torr L/sec

3. Etch test
    a) Pattern: 1um etch depth, 250 nm diameter, 500 nm pitch
    b) Test on Al pattern on Si wafer with F chemistry
    c) Samples:
        a. Gross test with Photolith wafer
        b. Fine test with EBL wafers
    d) 85 degrees sidewall angle
4. Chuck thermal uniformity 200 degC <3%
5. Etch rate: 20-2000 nm / min (better than 5% NU)

Application Details

The application for the system is given below. However, that is not added to the acceptance criterion but such a capability will be considered advantageous for the tendering.

1. Si micro/nanopillar using SiO_2/SiN hard mask with 1D and 2D pillar arrays



1D or 2D pillar arrays
IPD: Interpillar distance
H: Pillar height
W: Pillar diameter

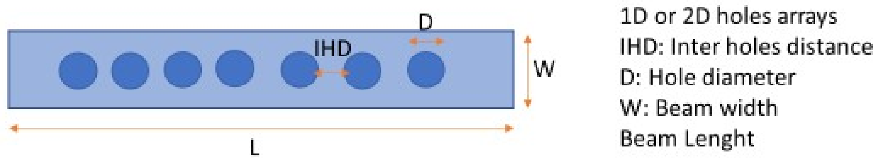
Acceptable etch specifications #:

- Min /Max range of H : 1-20 µm, W: 100 nm- 1 µm, IPD: 50 nm- 500 nm; with aspect ration W/H= 1:15
- RMS roughness < 3nm, pillar sidewall should be 87-90 degree vertical with possibility of slanting depending on recipe used.
- Controllable etch rate in the range of 50 nm/min to 2um/min maintaining uniformity of profile in 3 inches wafer area
- Acceptable standard deviation in as set parameters 5% (max)
- Onsite verification of Processes at minimum, room and maximum substrate temperature mentioned in Technical Specifications (Specific).

Suggestive recipe: Gases: SF_6 and C_4F_8 simultaneous flow with 1:3 ratio (e.g. SF_6 30 sccm and C_4F_8 90 sccm)

ICP: 500-600W, RF: 20-50 W; Pressure: vendor specified to maintain reasonable etch rate and uniformity

2. SiN nanobeam etching with EBL/ Photo resist mask (e.g. ZEP, HSQ) with 1D and 2D holes arrays



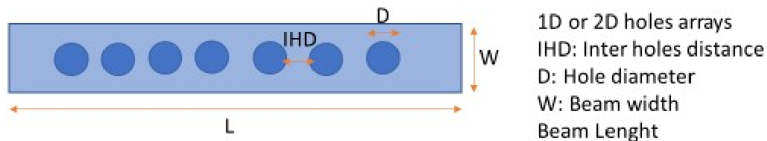
Acceptable etch specifications #:

- Min /Max range of D : 1OOnm- 500 nm, W: 200 nm- 1 µm, IHD: 50 nm- 300 nm; L: 20- 50 µm
- RMS roughness < 5nm, holes inner wall and beam sidewall should be 87-90 degree vertical.
- Controllable etch rate in the range of 20 nm/min to 200/min maintaining uniformity of profile in 2 inches wafer area
- Acceptable standard deviation in as set parameters 5% (max)

Suggestive recipe: Gases: CF4 and Ar/O2 simultaneous flow (e.g. CF4 50 sccm and O2 5 sccm)

ICP: no ICP, RF: 200-400 W; Pressure: vendor specified to maintain reasonable etch rate and uniformity

3 . SiO2 hard mask opening/etching with EBL/ Photo resist mask (e.g. ZEP, PMMA) with 1D and 2D holes arrays



Acceptable etch specifications #:

- Min /Max range of D : 1OOnm- 500 nm, W: 200 nm- 1 µm, IHD: 50 nm- 300 nm; L: 20- 50 µm
- Near Vertical etch profile (87-90 degree).
- Controllable etch rate in the range of 20 nm/min to 200/min maintaining uniformity of profile in 2 inches wafer area
- Acceptable standard deviation in as set parameters 5% (max)
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Suggestive recipe: Gases: CHF3 and Ar/O2 simultaneous flow (e.g. CHF3 50 sccm and O2 5 sccm)

ICP: no ICP, RF: 200-400 W; Pressure: vendor specified to maintain reasonable etch rate and uniformity