Government of India
Bhabha Atomic Research Centre
Laser & Plasma Technology Division
Trombay, Mumbai - 400085

REF: L&PTD/PPS/Works/AB/2022/ 36210 01/04 Date: 31/03/2022

Sub: **Invitation of quotations for Minor Fabrication**

Dear Sirs,

1. Quotations are invited for the **Fabrication and Supply of "RF-PECVD system for 4" substrate" as per the specifications given in Annexure D.**
2. Bidder shall quote for fabrication and supply of "RF-PECVD system for 4" substrate" as per the specifications given in Annexure D.
3. Taxes and excise duties shall be quoted separately.
4. The quotations must reach, ***Director, BTDG*** before 12th April, 2022 and must be sent in a sealed envelope *super scribed* with the above reference number and due date given above.
5. The address on the envelope should read:
   Director, Beam Technology Development Group
   Bhabha Atomic Research Centre, Trombay, Mumbai- 400 085.
   *(Attn.: **Dr. Arundhati Bute**)*
6. The bidder shall have to take insurance policy against any material issued to him by the purchaser.
7. As per accounts circular no. BARC/Accts/IFA/2014/144 dated 29/04/14, the bidder must submit Earnest Money deposit (EMD) of 2% of the bidder quoted value in the form of DD drawn in favor of Accounts Officer, BARC.
8. The fabrication work shall be subject to inspection by our engineer. The finished components shall not be dispatched prior to approval by our engineer at bidder's works. Necessary inspection facilities should be provided to our engineers during fabrication at bidder's premises.
9. The bidder shall deliver the finished product at **Room No. 314, Hall-9, BARC, Trombay within 4 months** from the date the firm work order is issued to the bidder.
10. Director, BTDG, BARC, reserves the right to accept/ reject any or all quotations without assigning any reason.
11. PAN number and VAT number must be given.

Encl.: As above.

Copy to:

1. Head SIRD, BARC
2. In charge, Notice Board, V. S. Bhavan, Anushaktinagar, Mumbai-94
3. BARC Site Notice Board.
4. AAO, Works, Account Division, BARC

31-3-2022

Dr. Archana Sharma
Director, BTDG
Email: arsharma@barc.gov.in

डॉ. (श्रीमती) अर्चना शर्मा / ARCHANA SHARMA
निदेशक / Director
किरणपुंज प्रौद्योगिकी विकास वर्ग
Beam Technology Development Group
भारत सरकार / Government of India,
भा.प.अ. केंद्र / B. A. R.C.
ट्रॉम्बे, मुंबई / Trombay, Mumbai - 400 085.

Annexure D

Scope of work:

The scope of work includes:

Fabrication of Plasma Enhanced Chemical Vapor Deposition (PECVD) system as per the specifications:

The vendor shall fabricate the PECVD system for 4" substrates consisting of following items:

Sr. No.	Item
1.	**Stainless-steel deposition chamber**
2.	**Ceramic insulator between substrate holder and substrate heater**
3.	**RF power delivery arrangement.**
4.	**Precursor heater, shower and precursor delivery system**
5.	**Ports**
6.	**Gas flow control (as per our specifications) with mass flow controllers, mixer and shower arrangements.**
7.	**Vacuum pumping assembly including a turbo molecular and rotary pump.**
8.	**RF-power supply with automated impedance matching network.**

During the commissioning, the vendor has to integrate the chiller and vacuum gauges provided by BARC at the user site.

The details of the PECVD system are given below:

1. **Stainless Steel Deposition Chamber:**

a) Stainless steel 304 double walled water-cooled chamber, cylindrical, 450mm id x 500mm height.

b) The chamber should have a double walled water-cooled 8" hinged door with a 150 mm id view port.

c) The fabricated chamber should provide and withstand a vacuum of at least 5 x 10^{-6} mbar. Maximum permissible individual leak rate is 1 x 10^{-8} std cc/sec.

d) The chamber, flanges, all ports, front hinged door, and all O ring grooves should be appropriately water cooled.

e) The chamber should be mounted on a powder coated m. s. stand.

f) The deposition chamber should have an arrangement for substrate heater inserted from the bottom flange. The **substrate heater** will be of 5-inch diameter and should be capable of reaching at least 850 C ± 10 C surface temperature. The heater must have radiation shield arrangement on the sides and at the bottom to reduce heat losses. The temperature on the substrate when kept directly on the heater surface should be uniform at 800 ± 10 degree centigrade on 4-inch diameter. Suitable programmable temperature controller should be provided for the substrate heater.

g) There should be provision to electrically isolate the substrate/ substrate holder from the grounded substrate heater surface with the help of a **ceramic insulator (annular)** in between capable of withstanding 850 degree centigrade. This arrangement should facilitate independent RF self-biasing of the substrate during deposition.

h) There should be an appropriate feed through provided at the bottom flange to feed the RF power to the substrate holder for biasing/ plasma generation purpose.

i) The distance between the RF biased substrate surface and precursor shower plate/ ring (described later) should be variable from at least 20 to 60 mm.

j) There should be gas feed arrangement for process gases with gas feed lines and gas shower ring inside the chamber.

k) There should be a provision to move the top flange with suitable mechanism (for example hydraulic) as and when required for substrate mounting and maintenance purpose.

l) There should be an appropriate arrangement to include the precursor feed line and the precursor shower (mentioned in section D later).

m) The chamber should have an air inlet valve for breaking the vacuum of the chamber.

2. Ceramic insulator between substrate holder and substrate heater:

1. A ceramic separator should be supplied to provide insulation between the RF substrate holder and the substrate heater.
2. The ceramic material should be able to handle temperature of at least 850 degree centigrade and capable of withstanding a vacuum of 5×10^{-6} mbar.
3. Material for the ceramic heater will be: machinable ceramic.
4. In addition, two (2) nos. spare should be provided for the ceramic separator.

3. RF Power delivery:

1. The RF biasing arrangement through the bottom flange should be properly insulated from the flange itself. The RF-biasing arrangement should be capable of providing connection to a 13.56 MHz RF power supply and should be able to handle up to 1kWatt power.
2. The connection from the RF power generator towards the RF feed line to the substrate holder should be through an N type RF co-axial cable connection.
3. The supplier should provide an RG 213 cable of suitable length for the RF power connection in the Power supply and matching network. The length of the cable should be at least 2 meters and it should be capable of handling upto 1 kilo-watt power.

4. Precursor bubbler, shower and delivery system:

1. **Precursor Bubbler:** There should be appropriate provision for precursor heating via a precursor bubbler made of ss 304 of 5" height and 1" diameter with integrated heater arrangement (or heating jacket made of silicone or fiberglass heater) and thermocouple. There should be a flange with O-ring on top of the bubbler. The O-ring should be capable of withstanding a temperature of 200 degree centigrade and the bubbler arrangement should be able to withstand a vacuum of 5×10^{-6} mbar. From that top flange of the bubbler there should be precursor delivery lines with integrated heating arrangement for delivery of the vapor phase precursor via into the chamber. At the end of the delivery line inside the chamber, there should be a precursor shower arrangement for uniform distribution of the precursor inside the plasma.
2. Suitable programmable temperature controllers (2 nos.) should be provided with the heating precursor heater and precursor delivery lines.
3. The precursor shower arrangement inside the chamber should also be heated with appropriate heating element to a temperature of 200 degree centigrade to avoid the condensation of the precursor. A suitable programmable temperature controller should also be provided with the heating element.

5. Ports:

1. The substrate heater port should be through the bottom flange. It should have provision to accommodate a 5-inch diameter heater with inbuilt/ embedded thermocouples and connection with the temperature controller.
2. The bottom flange should also have provision (preferably Wilson seal) to insert the RF biasing electrode arrangement.
3. The top flange or side ports of the chamber should have an arrangement to feed the precursors and process gases through a suitably designed precursor and gas shower uniformly on the 4-inch diameter substrate.
4. There should be additional 8 numbers of side ports, 6 nos. KF 25 and 2 nos. KF 16 ports. The ports should be appropriately blocked by blank flanges.
5. The chamber should have a dedicated port designed suitably to accommodate the vacuum pumping assembly.
6. There should be an 8-inch hinged door at the front for loading/ unloading of the sample and monitoring of the plasma during experiments. The front hinged door should be provided with a 150 mm dia. viewing port with toughened glass.
7. An additional KF 25 view port with a quartz plate window compatible with the deposition chamber should be included in the scope of supply for optical emission study purpose.

6. Gas flow control with mass flow controllers, mixer and shower arrangements:

1. The vendor should supply two numbers of mass flow controllers for Argon and Helium gases for flow of 0-100 sccm along with display unit.
2. The vendor should also provide the necessary stainless-steel tubing (1/4 inch od) for the gas feed system starting from the gas cylinders to the deposition chamber along with a gas mixer.
3. The mass flow controllers and the tubing should be steadily and compactly mounted on a panel.

The specifications for Mass Flow Controllers are given below:

Argon (Ar) gas:

1. Flow range: 0-100 SCCM

2. Resolution: 1 SCCM, Minimum adjustable flow rate: 1% of full scale
3. Accuracy and repeatability: +/- (0.5% of full scale + 0.25% of full scale)
4. Built-in LCD display for set up and operation
5. Should display: Mass flow rate, Set point, Total flow
6. User selectable Relay and output: at least one relay and output: 4-20 mA
7. 24 V DC operation with mating cable, RS-232 or RS-485 interface with software

Quantity required: 1 No

Helium (He) gas

1. Flow range: 0-100 SCCM
2. Resolution: 1 SCCM, Minimum adjustable flow rate: 1% of full scale
3. Accuracy and repeatability: +/- (0.5% of full scale + 0.25% of full scale)
4. Built-in LCD display for set up and operation
5. Should display: mass flow rate, Set point, Total flow
6. User selectable Relay and output: at least one relay and output: 4-20 mA
7. 24 V DC operation with mating cable, RS-232 or RS-485 interface with software

Quantity required: 1 No

General Specifications:

1. Material: Stainless steel AISI 306 with viton seals
2. Operating temperature: up to 45 ^{0}C maximum
3. Minimum expected upstream pressure: 1.5-2.0 Kg/cm^2
4. Maximum expected downstream pressure: 1.0 Kg/cm^2

Power Supply for mass flow controllers:

Quantity required : Two Nos (24 V DC)

This power supply should be capable of powering, controlling and monitoring mass flow controllers as described above. The operating voltage is: 230V /1 Phase / (± 10 %, 50 Hz)

G. Vacuum Pumping Assembly Including A Turbo Molecular and Rotary Pump:

1. Turbomolecular pump.

1. Bearing: Hybrid (Ceramic)
2. Compression ratio for Ar > 1×10^{11}
3. Compression ratio for He > 4×10^{7}
4. Compression ratio for N_2 > 1×10^{11}
5. Cooling method: Air / Water
6. Cooling water consumption: 100 l/h
7. Cooling water temperature: 15-35 °C
8. Flange (in): DN 160 ISO-K
9. Fore-vacuum maximum for N_2: 10 mbar
10. Gas throughput at full rotational speed for N_2: 3 hPa·l/s.
11. Interfaces: RS-485, Remote
12. Mounting orientation: Any
13. Operating voltage: 24 (± 5 %) V DC
14. Protection category: IP 54
15. Rotation speed: more than 49,200 rpm.
16. Tolerance in rotational speed: ± 2 % of the rotational speed.
17. Run-up time: 1.8 min or less
18. Maximum power consumption: 180 Watt
19. Weight: 10 kg or less.
20. **Pumping speed for Ar, He, N_2: 500 l/s for N_2**

Quantity required: One

Required additional accessories for the turbomolecular pump.

- **Suitable heating jacket for possible baking of turbomolecular pump with safety plug.**
  Quantity required: One

- **Copper seal DN 160 ISO-K**
  Quantity required: Ten Nos.

2. Backing Rotary pump

1. Flange (in) : DN 25 ISO-KF
2. Flange (out): DN 25 ISO-KF
3. Leak rate safety valve: 1 x 10^{-4} mbar l/s
4. Mains requirement: voltage 50 Hz 200-230 (± 5 %) V
5. **Pumping speed at 50 Hz: 30 m^3/h**
6. Ultimate pressure with gas ballast: 3 x 10^{-2} mbar
7. Ultimate pressure without gas ballast: 5 x 10^{-2} mbar

Quantity required: One

Any other accessories that are required for the assembly should be quoted separately.

H. RF-Power Supply with Automated Impedance Matching Network:

RF Power Generator 13.56 MHz, 600 Watts and an Impedance Matching Network (with control panel, power supply and all suitable cables for inter connections) for operating range up to 600 Watts at 13.56 MHz with following specifications and Features (for Plasma Processing Applications like thin film deposition, sputtering and RF biasing etc.):

1. Frequency :13.56 ± 0.005 % MHz
2. Maximum Output Power : 6-600 W into a 50 Ω load with operator selectable set point (Continuously variable). Note: any of the output terminal is required to be grounded during the actual use.
3. Reflected power limit : 200 W

4. Delivered power into mismatch: 20 % depending on the load impedance.
5. Load impedance : 50 Ω
6. RF Output connector : 50 Ω, N-type (fem)
7. RF power regulation mode : Forward power, delivered power And **DC self-bias. <u>Note: The RF power generator must have a DC bias control mode. The DC self-bias must be held CONSTANT during the entire deposition experiment. Without satisfactory performance this mode, the power supply will not be accepted.</u>**
8. Regulation (% of set point) : 1 % or 0.1 % of full rated power, whichever is greater, into a 50 Ω load.
9. Harmonic Distortion : All harmonics must be at least 50 dB below the fundamental at full rated power.
10. Spurious content : < 60 dB at full rated power
11. Pulse operation : 1-30 KHz
12. Pulse duty cycle : 1-99
13. Output Impedance : 50 Ω ± 2 Ω
14. Output Accuracy : 3 % of the reading
15. Forward and Reflected power accuracy: 3 % of maximum power
16. DC bias accuracy : 3 % of maximum dc bias input voltage.
17. Load Mismatch : Continuous operation into any load mismatch without failure.
18. Reflected Power limit : Automatic fold back arrangement when reflected power at the output exceeds preset limit
19. Protections : Against preset reflected power, over temperature,

DC overload and RF power limit.

20. Input Power : 230 VAC ± 10 %, single phase, 50 Hz
21. Operating Temperature : up to ~ 40 degree Centigrade
22. Humidity : 85 %
23. Cooling : Air
24. Mounting : Suitable for 19" rack mounting

Should have the following FEATURES:

1. Digital display of operation of unit.
2. Display of forward and reflected power, DC bias voltage, maximum available power and predetermined set point.
3. Display of DC bias level, load power based on operator provided signals.
4. Digital display of status reports like interlock failure, output enabled, arc detected, tuner mismatch.
5. Power supply should be protected against short circuits, preset reflected power, over temperature, DC overload and RF power limit.
6. Over current protection in ac input.

CONTROLS On Front Panel:

1. Mains On and OFF
2. LCD display for reading all operating conditions and power values
3. RF output ON and OFF switches
4. Display and SETPOINT switches for selecting parameters to be viewed.
5. RF Power control for controlling forward power and load power regulation control or DC bias in the external regulation control.

6. Matching Control to select operation of an external matching network in either automatic or manual tune control

STATUS INDICATORS on the Front Panel:

1. RF ON / RF OFF
2. Mode of REGULATION
3. Selected parameter values
4. Tuner / Generator impedance MISMATCH at SETPOINT
5. Tuner in Auto / Manual mode
6. DC bias value when the DC bias control is used
7. OUTPUT ON

QUANTITY REQUIRED: 1 No. (ONE NO)

Impedance Matching Network compatible with the RF Generator @ (1), (This unit should be able to operate manually and also in automatic mode from the front panel of the generator):

1. Operating frequency : 13.56 MHz
2. Maximum Power transfer : 1000 W
3. Input Impedance to Generator : 50 Ω
4. Max RF load Current into the load : 20-25 A (rms)
5. Max RF load voltage into the load : 4000 V (rms)
6. RF input connector to Generator : 50 Ω , N type (fem.)
7. Maximum Plasma DC self -bias voltage : 0-4000 V
8. DC self-bias monitor voltage : 0-10 V DC
9. Load impedance (resistive part) : 1-50 Ω
10. RF load connector : 50 Ω, 7/16 (fem.)
11. Location of RF load connector : Rear panel
12. Cooling : Air
13. Output Impedance range : 2 Ω to 2000 Ω

14. Operating Temperature	: upto 35-40 C
15. AC Input	: 230 ± 10 % V, 50 Hz, Single phase
16. Interface cables	: From generator control panel to tuner module (36 feet)
17. Operating Modes	: Auto and Manual (Fully automatic tuning without user interaction and Auto or Manual tuning via optional controller).

FEATURES :

1. Tune times ~ 3 seconds
2. Preset capability
3. Capacitor maximum / minimum range adjustment so as to reduce tuning time.
4. Indication of direction of tune for minimum reflected power.
5. Indicator display of either RF power or capacitor position.
6. Display of actual capacitor position.

QUANTITY REQUIRED: 1 No. (ONE NO)

1. **Connecting Cables:**

a) Input power connecting cable 15 feet length: 1 No

b) Cable for connecting RF generator to Auto / Manual matching network; RG 213 32.5 feet length: 1 No

c) Cable for connecting Matching network to the load, 5 feet length: RG 213, 1 No

AC Input for all units should be: 230 ± 10 % V, 50 Hz, Single phase

Note:

1. The vendor can have technical discussion with the I/O to clarify regarding the specifications of the aforementioned PECVD system. The vendor should provide a proper drawing of the PECVD system along with the quotation. The final work order will be placed only after approval of the drawing by I/O.
2. Spare O-rings, Allen key set, spanner set and all the necessary spares should be provided for maintenance of the PECVD chamber.

3. The tubing, cables and other electrical connections should be compact and neatly mounted on a support if required.
4. All the o-ring supplied should be viton o-rings.
5. The vendor must demonstrate the generation of stable and uniform RF-plasma with He and Ar gas in the chamber.
6. The vendor must integrate the vacuum gauges supplied by us at BARC.
7. The vendor has to integrate the chiller supplied by us at BARC.
8. The vendor has to demonstrate the stable, uniform plasma generation in the system before delivery and also after commissioning at the user's site.
9. The pump down time of the chamber should not exceed 20 minutes with rotary pump.
10. The supplier should supply one set of working manuals and circuit diagrams for all components and this should be a part of the quotation.
11. The unit will be accepted only after the satisfactory deposition run with typical precursor and substrates after installation at the user's laboratory.
12. Deviations from the tender specifications, if any, should be clearly mentioned.

For queries, kindly contact the following person:

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Bhabha Atomic Research Centre, Mumbai-400085
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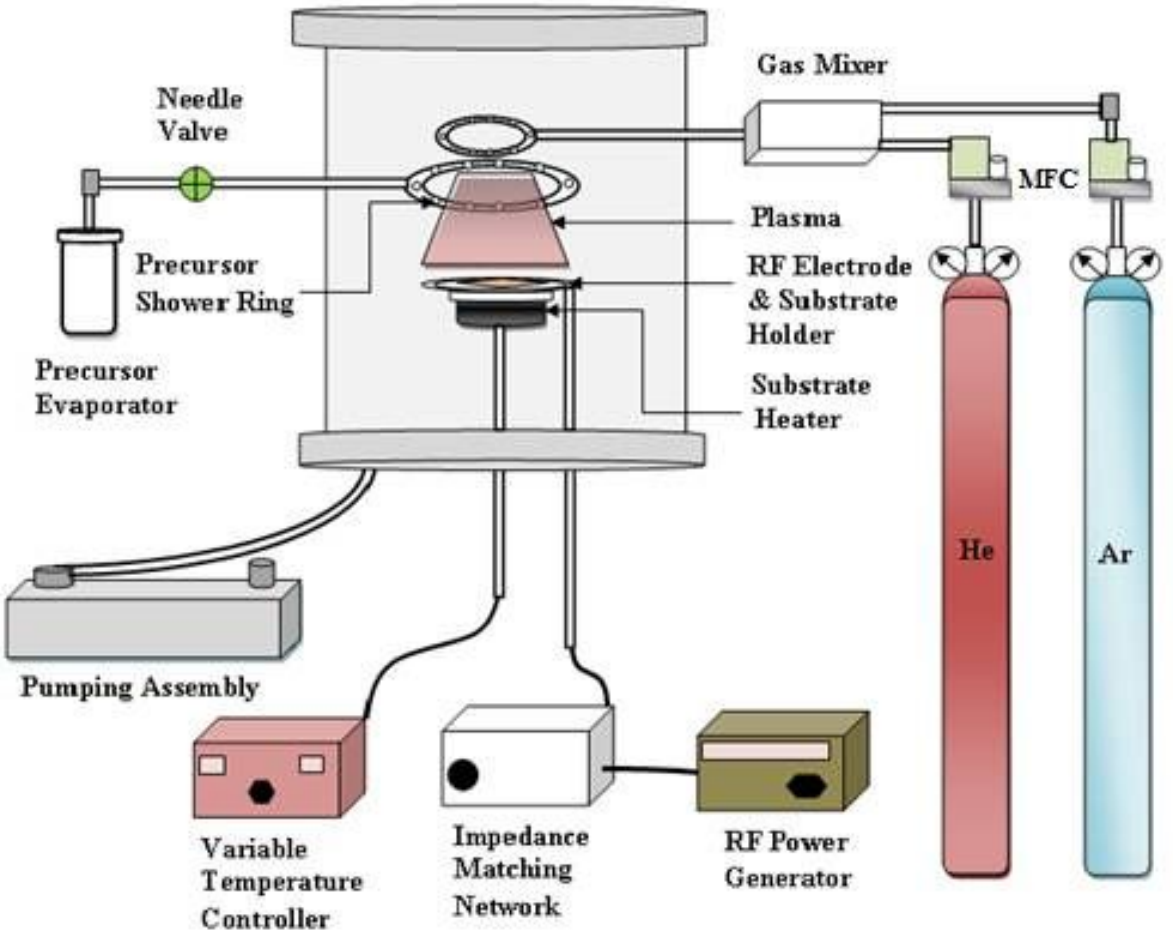

Figure: Simplified schematic of the RF-PECVD system