Annexure - 1

CVD SYSTEM SPECIFICATIONS

Technical specifications for dual Zone Chemical Vapor Deposition (CVD) system to grow hexagonal Boron Nitride (hBN) and Graphene.

The CVD system should be GLP & GMP compliant Non-rust Textured Stainless Steel Casing table top 2-zoned tube furnace of T-Max. 1400 °C or more & with Continuous Operation temperature: 1350 °C. Other technical details of the system are given as below.

1. Furnace should have 2 zones:

   (i) Furnace Zone 1: should have a quartz tube of DIMENSIONS (60x55x450mm (ODxIDxL)) for heating the solid precursor (Ammonia Borazane) with a working temperature of up to 200^0C. Heating arrangement should be movable jacket type zone. This chamber should have an arrangement to contain a filter mesh paper to block the solid particles from entering into the furnace zone-2.

   (ii) Furnace Zone 2: The furnace zone-2 should have the arrangement to have quartz or alumina tube of DIMENSIONS (75x65x750mm (ODxIDxL)) for keeping the substrate. Working temperature should be 1350^oC with alumina tube and 1100^0C with quartz tube. The furnace should have provision to change the tube of zone-2 (change of quartz to alumina or vice versa) without much sophistication.

2. Heated zones of Length 200 mm or above for each zone. Length Constant Temp. ΔT 5^oC: ≥ 60 mm or more. Rate of heating of furnaces should be from 2 deg C per minute to 10 deg C per minute with control accuracy of +/- 1 ^{o}C.

3. Quartz tube of zone 1 and Alumina (or quartz) of zone 2 tube should be mounted with their respective water-cooled SS flanges and are connected to each other by valves and coupling.

4. Length of single furnace should not more than 400 mm

5. PID based Microprocessor temperature controller integrated with Lab View based process control software.

6. System should have the provision to show status messages not as codes but as clear texts. With start time configurable; Operating hour counter; auto tune function; Temperature variable as °C & °F; Real time clock; Skip-button for segment jump.

7. Temperature control Accuracy of ± 1 °C or better & Temperature and time value input in steps of Per Deg C or per sec or better respectively. Gas flow value input is steps of sccm or better.

8. The display should have Program status, Menu bar, Extra functions, Information lines, Page display, Data bar, controller lock, heating status.

9. The controller should be equipped with Controller Lock during a Running Program to prevent intentional and unintentional interventions in the running of a heating program.

10. The PID Programmer Controller should have the facility to auto start & resume the ongoing programme after a power outage / power failure.

11. The controller should be equipped with minimum 2 extra function to support additional functions such as solenoid valves, optical and acoustic signal etc.

12. The controller should have option for retrieving recorded data on an external drive & recording of process data with USB Flash Drive.

13. A fully functional Graphical User Interface (GUI) built in LabVIEW software. This GUI will allow full control of each system parameter, load and save custom growth recipes, and enables "1-click" unattended operation via an auto process feature.

14. Pressure should be manually set between 0.05 to 30 torr during growth cycle.

15. Software controls gas inputs, temperature, gas flow, writable recipe, process storage allowing remote access with safety interlocks.

16. The system should have the facility of writing Programs & Generating the reports on PC through external flash drive/pen drive.

17. High-quality fiber insulation material which are not classified as carcinogenic according to TRGS 905, class 1& 2 are used for furnace chamber insulation for the high working temperature

18. Heating rods installed parallel to tube.

19. Type S thermocouple; Silent Solid State power control Relays. Control system & switchgear built into furnace base.

20. Active cooling case for low surface temperature.

21. Should meet applied harmonized international standards or better EN 61010-1, EN 60519-1, EN 60519-2, EN 61000-6-2, EN 61000-6-4 or equivalents BSEN61010or equivalent or better.

22. Gas supply system for non-flammable protective or reactive gases/vacuum operation (upto 10-5 mbar). The standard long vacuum tight working tube of quartz in a gas/vacuum-tight version with stainless steel flanges design. Flange should be with easy sample loading and unloading hinge type flange closing system. It should have the following:

I. 2 vacuum-tight, water-cooled stainless steel flanges with O rings & seals with fittings on the outlet side. Mounting support system with Brackets for the flanges.

II. 4 number MFCs integrated with furnace control panel for remote automatic flow control for Ar, H_2, CH_4, NH_3. Each MFC supplied with necessary valves, manifold for fine dosing (volume 0-200 sccm, except Ar *i.e.* 1000 sccm) with electro polished SS tubing connected to furnace flange. Gas-supply programmable via mass-flow controllers.

III. Argon inlet should have a provision to bypass the borazane furnace, directly feeding the argon into the main chamber (zone 2) or the argon can pass through the borazane chamber

and then into the main chamber carrying the borazine gas. Other gases lines can be directly connected to zone-2

23. Heating capacity less than 9 kW with Voltage supply of : 400 V AC / 50 Hz / 3-Phase

24. Weight should not be more than 90 kg.

25. Foot print of the complete system : 1.4 m (L) x 1.5m (H) x 0.80m (D)

26. Dry Rotary Vacuum Pump (upto 10^{-3} mbar) with minimum pumping speed of 250 LPM compatible to fit with furnace & all the Necessary fitting, digital gauges, liquid nitrogen cooled trap control valves & connection Kit for the Vacuum Operation must be quoted.

27. A chiller unit (of capacity 20-30 liter tank) to chill the water to circulate the SS fittings for the tubes for better vacuum and air purging is required. It should have an automatic on/off Digital temperature controller with set temperature. Working temperature range of 5-10 ^{o}C for secondary coolant (water). The water chilling plant should be constructed with the wheel to move the equipment easily. It should have an independent control for chilling plant and water circulation pump.

28. The local vendor of OEM must have supplied minimum two similar Furnaces to IITs and IISERs. Please attach a reference list of supplies (of similar system) in last 5 year with contact details.

29. The company should be an Original equipment manufacturer of the furnace, please attach exclusive authorization certificate specific for this tender with quote without which bid will be rejected. This criteria is proof of accountable service support by vendor & OEM.

30. The manufacturer must be an ISO9001 company. Please attach certificates. The equipment should be CE certified.

31. Vendor must provide a complete brochure of the system mentioning all the technical details.

32. Vendor must attach a compliance sheet mentioning point by point their comply level. Complying sheet should contain all the technical details of the offered system.

EXTRA		
1	Training to operate the equipment to personnel who uses the system	at the institute premises immediately after completion of installation of equipment for duration of seven days free of cost
2	Manual	One set of operating and service manual with detailed drawing and circuit diagram in English
3	Pre fabrication approval	Design approval by user before start of fabrication
4	User List	Supplier must have installed similar furnaces at least in 15 institutions in India. Supplier should provide the contact details (address, email id, phone number) of all these users.
5	Payment terms	100% payment will be made only after installation and demonstration of h-BN growth at the IIT Madras
6	Warranty	Machine should come with 3 year warranty from date of supply. AMC for 2 years post warranty must be quoted for the system.