

TECHNICAL SPECIFICATIONS for Thermal Chemical Vapor Deposition unit for 2D Materials

Description and Technical Specifications:

The CVD Furnace system should consist of

- a fused quartz tube furnace,
- a precision mass flow gas control station,
- atmospheric as well as low pressure station,
- metal enclosure with exhaust port,
- with safety interlocks,
- and other assembling parts for the 2D materials growth.

Maximum temperature of this workstation should be 1200°C or higher. The system should be able to achieve desired vacuum (10^{-3} torr or lower) to grow monolayer materials. The mass flow gas control station should be able to mix two or more different gases together and input the mixed gas into a fused quartz tube inside the furnace. The individual gas flow rates should be precisely controllable. The system should offer wide range of material deposition including chalcogenides, perovskites, oxides and other nanowires/2D materials.

The system should have the following general specifications and accessories.

S.No.	Item Specifications	
1.	Tube Furnace	
a.	Maximum Temperature	Resistance Furnace High quality Research Grade Split Tube Furnace Max Temperature 1200 °C or more Uniform working temperature of up to 1100°C in 150 mm. Mid zone must be ensured in the quartz tube reactor.
b.	Temperature Accuracy	±1°C in the entire temperature range during both heating and cooling.
c.	Heating Rate	Temperature Ramp Up rate (Programmable) 20°C per min
d.	Cooling Rate	Temperature Ramp Down rate (Programmable) 20°C per min
e.	Number of Zones	Two
f.	Heating Zone	300 mm or more (constant temperature zone 150 mm)
g.	Temperature control	Precision temperature controllers with PID function and 30 segments programmable. Thermocouple Port with preferable K Type should be included One extra temperature monitor should be built in to shut down power when temperature goes out of control by accident.
h.	Vacuum sealing & flange kit	Stainless Steel Water Cooling Flanges
i.	Electrical Power	Single Phase 200-230 V, 50 Hz
2.	Sample Holder System should be capable of handling different substrates such as silicon wafer, quartz wafer, glass substrates of given dimensions.	

a.	Reaction Chamber	<p>Quartz Reaction Tube of suitable size with at least 80mm OD × 1300mm L to enable laminar flow. 2D materials should be grown on 1 inch × 1 inch specimen. One additional quartz tube should be provided. Additional quartz tube may be quoted (optional). Provision for using different size (diameter) quartz tube is a must.</p> <p>Customized water-cooled flanges and water chiller should be provided. Water tank with 10-20 liters capacity and appropriate pump with over flow protection should be included.</p> <p>The water chilling plant should be constructed with the wheel to move the equipment easily. Automatic on/off Digital temperature controller with set temperature, automatic cooling on/off facility 5-10 °C for secondary coolant (water) ~10 lit/min. Independent control for chilling plant and water circulation pump.</p>
b.	Sample/ component size	<p>Variable, but the maximum size can be 100 mm (L) × 20 mm (H) × 30 mm (W) and minimum size can be 10 mm (L) × 10 mm (H) × 2 mm (W).</p> <p>Reduction of working zone size should be possible for carrying out coating deposition on small sized samples (Optional).</p>
c.	Sample Mounting	<p>Furnace handle stainless steel hook (2 numbers)</p> <p>Alumina Crucibles (of different sizes; 12 numbers)</p> <p>Two pair of Thermal Gloves</p>
3.	Vacuum Station: Vacuum station should consist of Double Stage Rotary Vane pump with complete accessories including vacuum gauge, SS vacuum bellows, digital display, ball valves etc. The system should be able to run at both low pressure and atmospheric pressure.	
a.	Pump-1	<p>Heavy duty rotary (oil less) pump. To evacuate process chamber to $\sim 5 \times 10^{-2}$ Torr (Ultimate Vacuum 5×10^{-3} Torr). Pumping Speed 250 liters per min.</p> <p>2 stage exhaust with pressure of 10^{-3} torr.</p>
b.	Pump-2 (Optional)	Turbo Pump with pressure of maximum 10^{-6} torr, with needle valve and connecting accessories (Optional).
c.	Cleaning of Chamber (Purge Line)	Pump should enable N ₂ or Ar purging for cleaning Process tube (Reaction chamber). After deposition, to flush with Ar/N ₂ separate line should be provided.
d.	Accessories	Two Anti-corrosive, gas independent pressure gauge ($\sim 10^{-3}$ to 10 Torr, and 1-1000 torr measurement range), digital display, high accuracy, and reproducibility at atmosphere, easy to exchange plug & play sensor element.
4.	Gas Supply System	
a.	Gas Supply Chamber	Gas feed system shall be provided with Mass flow controller, Controls, Regulators, Valves, 316 steel corrosion resistance tubing and Flow monitoring devices and digital read out. Gas handling system should be non-corrosive catering to feed and exhaust byproducts.

b.	Mass flow Controllers	4 Precision MFCs (Provision for 2 Extras). MFCs should be calibrated for, Ar, H ₂ , O ₂ , N ₂ . Should have a response rate of <1 sec, to flow controlled mass of gases Optional Gases: C ₂ H ₂ , CH ₄ Control Range:1-1000 sccm Accuracy: ≤ ± 0.02% of Full Scale Material: Stainless Steel (316L), Non Magnetic. Control Stability: ≤ ± 0.1% of Full Scale Control Valve: Closed Solenoid (Fast-Response) Readout and display for set point and actual flow. A control panel for operating MFC should be given.
c.	Solid source kit (Optional).	Solid Source Vapor Delivery Kit for Oxide Nanowire Growth (Optional).
5.	Operational Control System	
	Multiple Springless Diaphragm vacuum valves Digital Pirani Gauge for Vacuum Measurement from 10 ⁻³ to 1000 mbar Pressure control using self-contained closed loop electronic system with gauge Controller and display for pressure setting and actual pressure	
6.	Electrical System	
	Electrical Power Distribution and control panel accessories required for installation of CVD need to be provided. Voltage distributor for uniform power supply to all the components of the CVD system.	
7.	Supplier must have installed similar furnaces at least in 10 institutions in India. Supplier should provide the performance certificate contact details (address, email id, phone number,) of all these users.	
8.	Safety and other requirements	
	<ol style="list-style-type: none"> 1. The entire system should be thoroughly checked for leak (leak rate should be less than 10⁻⁶ cc/s). This should be shown at the time of inspection. 2. Gas delivery system must shut off the supply in the event of leak rate exceeds the desired limits. The sensors should be interlocked with PLC/PID controllers. PLC system shall also be linked with air delivery system. 3. Suitable audible and visual alarm should be provided in case of malfunction of CVD furnace like temperature shoot-up, high power drawing, vacuum loss and deviation from in water/gas flow rates. 4. Sensors with audible/visible alarms for dangerous gas leakage (like H₂) should be provided. 5. Thermal insulation for minimum heat loss (less than 5% of the reactor temperature) to the surrounding. 6. Vendor should specify the maximum power rating and weight of the furnace. 7. All the emergency procedures should be outlined and detailed document should be provided to IIT Madras. 	
9.	Installation and training	
	Complete installation should be done by the supplier at IIT Madras and it should be included in the estimated cost. Basic recipe to grow any 2D material should be provided to demonstrate all the functions of the system. On-site one week training for operation and application should be given to the users free of cost. IIT Madras will not bear any training or leaving expenditure in this regard.	

10.	<p>Warranty and maintenance</p> <p>The complete instrument should be under warranty for a period of at least two years from the date of installation. The vendor should be agreeable to enter into Comprehensive Annual Maintenance Contract with IIT Madras at a reasonable price, for maintaining the equipment in proper working conditions, after the warranty period is completed. Quote the cost of onsite annual maintenance for two years after warranty period.</p> <p>The CVD system provider/vendor must have service centre in India. In case of breakdown during the warranty period, a competent service engineer of the supplier should make as many visits as are necessary to rectify the problem and replace the faulty parts, without any liability of cost. Supplier should ensure to provide all spares required for making the instrument operational. The spares recommended for keeping in inventory along with the instrument may also be quoted.</p>
11.	<p>Spare parts</p> <p>The supplier should provide the list of accessories required for smooth running of the machine for 3-5 years and should quote all the necessary accessories. The supplier of the instrument must confirm in writing that the spares for the entire instrument will be available for a period of at least ten years after the model of equipment supplied has been phased out. For frequently required spares, there should be adequate inventory with the Indian agency.</p>
12.	<p>Manual</p> <p>One set of operating manual and service manual including detailed drawings and circuit diagrams (in English) should be provided with the instrument.</p>
13.	<p>User list with contacts</p> <p>Vendor should specify the exact quoted model number and provide the user list in India along with contact details so that IIT Madras can approach the contact person for any feedback. Also enclose the catalogue for the quoted model number. In case of any doubt about capability of the machine, the vendor will have to arrange demonstration at any site bearing the cost including the travel and other expanses of IIT Madras representative.</p>

Compliance Statement:

The supplier must submit technical brochures and proper application notes adequately explaining and confirming the availability of the features in the model of the equipment being quoted. The supplier must submit a table indicating the compliance of the features of the model of the equipment being quoted with those given in the indent. Features not matching – must be clearly indicated. Additional features and Features in the quoted equipment which are better than those in the indent – may be clearly explained.

Offered specification with Make & Model No. please specify any deviation if any. Please attach separate sheet if required

A detailed compliance statement should be included