

Technical specifications of ‘single-zone Chemical Vapor Deposition (CVD) furnace’ to grow 2-dimensional (2D) transition metal dichalcogenides

Overall requirements:

- A single-zone CVD furnace having horizontal reaction tube with gas inputs, temperature and pressure controllers and vacuum pump is required. We aim to use solid precursors for the 2D-Transition-metal dichalcogenide growth.
- Furnace should have a table-top design and should be capable of having pre-programmed recipes and process storage controlled with computer and PLC allowing remote access.

In detail, the CVD furnace should have the following specifications:

Sl. No.	Sub-components description
1	<p>Furnace design and construction:</p> <ul style="list-style-type: none"> ○ Horizontal single-zone CVD furnace. ○ Furnace should have a compact, table-top design. ○ Furnace should have dual body construction with GLP and GMP compliant non-rust, corrosion resistant, CRC powder coated steel. ○ Furnace should have operating temperature up to 1200 °C. ○ Furnace should have a highest working temperature of at least 1100 °C. ○ Furnace should have heating jacket to heat solid powder precursor up to 200 °C. ○ Rate of temperature rise: Up to 8 °C per minute. ○ Furnace should be provided with an active cooling case for low surface temperature (< 60 °C) at operating temperature of 1050 °C. ○ Provision for split-furnace configuration.
2	<p>System and heating zone dimensions:</p> <ul style="list-style-type: none"> ○ Length of furnace should not be more than 1400 mm. ○ Heating jacket length should not be more than 150 mm. ○ Hot zone quartz Tube should have Outer Dia: 70mm, Inner Dia: 65mm and Length: 1200 mm. ○ Hot zone length: 300 mm. ○ Uniform hot zone (+4 °C): 100 mm.
3	<p>Voltage and utility requirements:</p> <ul style="list-style-type: none"> ○ Power supply should be through a separate control panel. ○ Max. power rating should be 6KW, with 3Ø, 4 wire. ○ Weight of the voltage supply unit should be below 200 kg. ○ Dimensions of the unit should not exceed 2.5m (W) x 1.50m (H) x 0.80m (D).
4	<p>Insulation:</p> <ul style="list-style-type: none"> ○ 1 no. of insulation. Ceramic fiber board insulation should be used for making furnace. Only those fiber materials are to be used which are not classified as carcinogenic according to TRGS 905, class 1 or 2. ○ Hot face insulation rating should be 1400 °C. ○ System should have 2 numbers of insulation layers. ○ Last insulation layer should be 99.95% fused silica insulation.
5	<p>Heating elements and thermocouple:</p> <ul style="list-style-type: none"> ○ Heating elements should be of suitable type, supported on Alumina tube and partially 1/3rd embedded in Fiber boards. ○ 2 no.s of thermocouple of type K, calibrated by NABL certified lab, housed in protective

	Inconel sheath, simplex; and in-situ temperature measurement.
6	<p>Process control interface:</p> <ul style="list-style-type: none"> ○ The system should have a PID based controller integrated with a process control software. ○ The system should have a user-friendly, fully functional GUI that allows control of the vacuum pumping system and the process parameters such as gas flow and temperature. The PID temperature controller should have a minimum of 16 segments with data entry allowed by touch screen, key pad and jog dial. ○ The system should provide a temperature control resolution of ± 1 °C or better. ○ The software should allow the user to create and save customized recipes; load and run such recipes in automated mode. ○ The controller should be able to auto-start and resume a process after power outage. ○ The controller should be equipped with locking mechanism to prevent unwanted intervention during runtime of a process. The controller should also provide over-current & temperature protection with alarms through system interlocks through PLC. ○ The GUI should provide useful information regarding the process such as status messages in terms of clear texts, process parameters in runtime. ○ The GUI should allow retrieval of process data and saved recipes through external USB drive.
7	<p>Flanges:</p> <ul style="list-style-type: none"> ○ SS flanges with appropriate double O-ring for leak tightness. ○ Flanges with provision for vacuum and gas purging. Vacuum provision with KF 25 vacuum port. ○ Flange specially designed for easy sample loading and unloading with hinge type support. ○ Flanges and tube to have heavy duty support. ○ Flange to have provision for carrying thermocouple for in-situ temperature measurement of samples. ○ Flange should have provision to move sample boat inside the hot zone under vacuum during operation of furnace.
8	<p>Gas flow system:</p> <ul style="list-style-type: none"> ○ 2 Numbers of vacuum-tight, water-cooled, stainless-steel flanges with O-rings and seals with fittings. ○ Mounting support with brackets for the flanges. ○ 1 number of MFC integrated with the furnace control panel for remote automated flow control. ○ MFC flow Rate-0-200SCCM, 0-24 V DC. ○ Electro polished SS316 tubing connected to furnace flange. ○ Needle valves.
9	<p>Vacuum system:</p> <ul style="list-style-type: none"> ○ Rotary Vacuum Pump of reputed make, Double stage, Direct Drive, Pumping Speed 100 liters per min. ○ 1 number of SS bellow, 25 mm diameter for with KF 25 end flange. ○ 1 number of 1-inch butterfly valve suitable for $\times 10^{-2}$ mbar vacuum. ○ 1 number of Pirani Gauge. ○ 1 set of KF-25 Clamps, ring, center ring. ○ 1 set of KF-10 Clamps, ring, center ring. ○ SS flanges with appropriate double O-rings.
10	<p>Spares:</p> <ul style="list-style-type: none"> ○ SS rod to place sample at the center of hot zone. ○ 4 numbers of Quartz boat of length 10cm for sampling handling. ○ 2 sets (8 numbers) of O-rings for flanges. ○ 2 sets of SSR for furnaces.
14	Warranty:

	<ul style="list-style-type: none"> ○ Standard warranty for one year and extendable for two years (optional). ○ On-site periodic checking/maintenance of the system after installation at least twice in a year during the warranty period. ○ AMC for 2 years post-warranty period must be included in the quotation.
15	<p>Operating manual:</p> <ul style="list-style-type: none"> ○ Both electronic and hardcopy should be provided. ○ The documentation/manual shall include all drawings, schematics, spare-parts catalogues and also sub-vendor's manuals.
16	<p>Installation/commission:</p> <ul style="list-style-type: none"> ○ The system shall be installed / commissioned at customer site. The quotation shall be inclusive of all charges, if any, for installation and commissioning of the equipment by the vendor. ○ Extensive operation and maintenance training of at least three persons for two days at the customer site after the installation should be included. ○ The system shall conform to the Indian power supply standards, i.e. 230V ± 5%, 50Hz, Single Phase. ○ Vendor shall provide a list of at least ten Institutions in India along with the email addresses and other contact details (addresses and phone numbers), where similar systems have already been installed. ○ Only reputed original equipment manufacturer (OEM) should submit the tender. Warranty Certificates from manufacturer for bought out items like Power Supplies, Vacuum Pumps with Serial Numbers will have to be provided along with system documentation. ○ 100% payment will be made only after installation of the system at IIT Madras.
17	<p>Optional items:</p> <ul style="list-style-type: none"> ○ Reputed make dry scroll pump (displacement capacity of 100 liters per min). ○ Chiller unit with 20-30 liters tank capacity, automatic on/off digital temperature controller with set temperature, automatic cooling on/off, 10 lit/min water circulation and wheel mounted design. ○ Spare Quartz tube (70 mm OD x 65 mm ID x L 1200 mm). ○ Split furnace provision.

Additional Requirements:

- OEM should have an authorized service centre in Chennai, with resident service engineer to provide repair, maintenance, calibration and upgradation facility (OEM should provide necessary service of operation certificate).
- The manufacturer must be an ISO9001 company. Please attach certificates. The equipment should be CE certified.