May 8th, 2021

Domestic Tender

Development of a metal organic chemical vapor deposition (MOCVD) reactor for deposition of epitaxial β-Ga_2O_3 (beta gallium oxide)

This is an RFQ (Request for Quote) to **develop and build a metal organic chemical vapor deposition (MOCVD) reactor for deposition of epitaxial β-Ga_2O_3 (beta gallium oxide)** including **installation and commissioning of the system** at CeNSE (IISc), as part of a limited tender for the Centre for Nano Science and Engineering (CeNSE) at Indian Institute of science (IISc) Bengaluru.

CeNSE is a multidisciplinary research department at IISc that houses a 14,000 sq. ft. cleanroom and characterization facility used by 200 faculty members from various disciplines at IISc. CeNSE also runs a nationwide program which has allowed 4200 participants from more than 700 universities and institutes all over India to use the facilities at CeNSE. Consequently, any utility/facility at CeNSE receives significant exposure to scientific community at IISc and beyond. The vendors are kindly requested to factor in the value of this exposure in their quotes.

Procedure

I. Quote should come only from Indian Original Equipment Manufacturer (OEM) or their Indian authorized distributor.

II. The quotations should be on FOR-IISc Bangalore basis in INR only.

III. Vendors will be required to submit their technical proposal and their commercial proposal in **two separate sealed envelopes**. Any violation of this will lead to cancellation of the proposal.

IV. **The deadline for submission of proposals is the 3 weeks from the date of release of this tender, which is 30th June, 2021, 5:30 pm Indian Standard Time.** Proposals should arrive at the Main office, GF-20, Centre for Nano Science and Engineering, Indian Institute of Science, Bangalore 560012, India, by the above deadline.

V. The decision of purchase committee will be final. The purchase committee can rescind, amend, cancel the tender without any explanation.

VI. The technical proposal should contain a compliance table. The first column must list the technical requirements and scope of work in the order that they are given in the technical configuration below. The second column should describe your compliance in a “Yes” or “No” response. If “yes” the third column should provide the make and type of system. If “No” the fourth column should provide the extent of the deviation (please provide quantitative responses). The fifth column should state the reasons for the deviation. Sixth column can be used for highlighting advantages of the system in third column.

VII. Vendors are encouraged to highlight the advantages of their tools over comparable tools from the competitors.

VIII. Only vendors who are compliant with the technical requirements will be considered for commercial comparison. The bid is awarded to the lowest cost vendors (referred as L1)

IX. The commercial comparison is done as per Government of India rules, specifically GFR 2017. Note that GFR has recently been amended. We shall follow the GFR rules as they stand on the date the tender has been released.

X. As per recent edits to the GFR, there are three classes of vendors distinguished by their "local content". **In the cover letter, vendors must mention the "Class" that applies to them**:

   a. Class 1 supplier: Goods and services have a local content of equal to or more than 50%
   b. Class 2 supplier: Goods and services have a local content more than 20% but less than 50%
   c. Non-local supplier: Goods and services have a local content of equal to or less than 20%

XI. **This is domestic tender, in which only Class 1 and Class 2 suppliers can participate.**

XII. In the commercial bid, please provide itemized cost of the items in the bill of material (BOM) required to develop the MOCVD reactor.

XIII. As an option, please provide itemized cost for any *suggested* accessories/add-ons that may enhance the usability, capability, accuracy or reliability of the system.

XIV. Please indicate the warranty provided with the Equipment. Warranty of 3 year is required.

XV. Payment will be within 30 days, against a tax invoice after work is completed successfully/ complete supply, installation and commissioning is done to the satisfaction of the IISc user department.

XVI. For any question, please contact Prof. Digbijoy N Nath, Centre for Nano Science and Engineering, Indian Institute of Science, Bangalore 560012, India. (digbijoy@iisc.ac.in)

XVII. IISc is a DSIR recognized research organization, hence eligible for concessional GST@5%, since the items are required for research purposes only. The successful vendor may ask for GST exemption certificate after submitting invoice.

No.	Specification	Response
1.	Reactor capable of continuous operation at 1000°C for 5 hours	
2.	Reactor should have a closed loop pressure control, in closed atmospheric range, capable of controlling and operating at pressures from 10 to 760 Torr (± 2 Torr).	
3.	Nominal growth rate of Ga_2O_3 = 1 µm/hour, Size of wafer (or sample) = 2-inch diameter Thickness variation in Ga2O3 grown over 2" sapphire substrate with 5 mm edge exclusion should be < 5% of the film thickness (±2.5% of average)	
4.	**Reactor & hardware details**: (see details in spec sheet)	
5.	**Gas Manifold: (**see details in spec sheet**),**	
6.	**Computer control**: (see details on spec sheet sent)	
7.	**Reactor Exhaust:** (see details on spec sheet sent)	
8.	**Safety features and interlocks: (**see details on spec sheet sent)	
9.	**Installation and commissioning: (**see details on spec sheet sent)	
10.	The footprint of the system shall be provided by the vendor.	

MOCVD reactor for deposition/growth of Ga_2O_3:

Reactor & hardware:

1. Heating source: to be designed by the vendor (RF Induction heating preferably), of suitable capacity with a nominal temperature ramp-up of 50°C/min and same shall be explained in the bid with supporting design documents. PID should be tuned to ± 1°C within 10 seconds
2. Chamber: suitable design of chamber with reactor cooling rate of 5°C/min to be supported with design document
3. Susceptor must be non-contaminating and it should be able to rotate at 0 to 30 rpm. The distance between the susceptor to the shower head should be adjustable with respect to

shower head position. Distance should be such that growth rate mentioned above is possible. Distance should enable a uniformity mentioned in # 3.

4. Precursor entry: Through a suitably designed shower head, enabling delivery of precursors close to wafer with minimal gas phase reaction between the Ga (or III component) and oxygen containing species before it reaches the wafer.
5. End flanges: Differentially pumped and water-cooled with differential pressure sensors, water flow and temperature sensors for monitoring.
6. All hardware like gas leak detectors, flame detectors, excess temperature rise, box exhaust detectors – must be provided with the system along with necessary interlocks for safe operation of the reactor.
7. As part of the technical bid vendor should describe capability to model and simulate the flow patterns, temperature distribution and concentration gradients in the reactor. Such modeling and simulation will be used to identify the optimal deposition conditions.

Gas manifold:

8. MO precursor flow rates: 0-100 µmol/min controlled through MFCs.
9. Precursors (metal-organics): Two regular and one double dilution bubbler loops, with temperature control of -30 to 100°C in the bubbler bath and pressure control in the bubbler of up to 2000 Torr or as required to obtain the required fluxes of the main precursors TMG and TMA.
    - Provision for one more optional liquid source
    - Heating of MO lines to be offered as optional.
    - Bubblers to be connected to an appropriate carrier gas.
10. Carrier gases and other sources:
    - ✓ Ar (Carrier/Push Gas)
    - ✓ H2 (Carrier/Push Gas)
    - ✓ O2 (Reactive Gas)
    - ✓ N2 (Carrier/Push Gas)
    - ✓ Diluted silane. (Dopant source) (Optional)
    - ✓ (Optional) Gas cabinet for dilute silane
    - Shall be controlled through gas panels placed outside the facility and hooked to gas manifold of reactor through MFCs of 0-2000 sccm.
    - All carrier gases shall have MFC range 0-10 lpm, which is used for bubblers and as purge gas.

11. All gas delivery and MO delivery system will come with complete safety system with interlocks that manage all operational contingencies. The system must have an auto-run mode where the system is intelligently running the system.

12. The system should have cause-effect logic that automatically responds to alarm states to put the system in a safe state.

13. All gas manifold panels for gas delivery into the reactor MFC manifold/gas box shall be part of scope of supply. All components shall be internally electropolished with face seal fittings/VCR connections assembled in class 100 cleanroom with compliance to SEMI standards. The same be supplied with due validation for Helium leak integrity, below $4x10^{-9}$ sccs of He, trace gases, particle count as per SEMI standards. Stainless steel 316 electropolished.

Computer control:

14. Valves, mass flow controllers, pressure controllers on metalorganic lines, pressure control of growth chamber and temperature control should be capable of being operated through an automated interface working in a stable software environment, MS Windows or otherwise.

15. A graphic user interface should be provided to monitor process status during a typical run i.e. it should enable continuous monitoring of temperature, pressure, gas flow and time in the user interface**.**

16. The supplier shall provide process management software and all control instrumentation of the reactor shall be achieved through PLC and SCADA. The HMI touch screen shall be industrial PC.

17. The control system shall have the capability to configure recipe using Segment and Sequence combination to enable users to configure the recipe with ease and yet not deviate any safety requirements.

18. Software should also have a “manual mode” in which the analog/digital inputs to the CVD system can be provided manually when it is not in the recipe mode. In such a manual mode, system should not allow flow of reactive gases unless a certain set of pre-conditions are met as per the cause-effect logic to ensure safe operation.

19. In the recipe mode, an option should be present to pause the system and change set points manually before allowing it to continue.

20. In the recipe mode the software should allow one to pause a recipe that is running, run segment loops and allow forwarding of the recipe from the segment it is in, to any other future segment.

21. In the recipe mode, the system should initiate a recipe only after ensuring that there are no alarms.

22. System should allow opening of the reactor only after an **admin controlled** recipe segment has been run as part of **EVERY** recipe.

23. The software and hardware shall provide necessary recipe data storage facility for each run along with tables to enter the results achieved in the run for easy collaboration of data.

Reactor exhaust:

24. The reactor shall be integrated with suitable dry scroll pump to achieve 10^{-3} Torr of absolute vacuum in less than 1 minute and it shall maintain 10 Torr with gas ballast. The pumping speed shall be enough to ensure pressure control down to 100 Torr with the maximum flow rates expected in the reactor of about 10-20 slpm of H_2.
25. There shall be a provision to connect to Turbo/Molecular pump as optional upgrade in the future where in dry pump will become roughing/backing pump. There should be a provision of this upgrade in the software.
26. The entire equipment shall come with suitable capacity of box exhaust connections.
27. The entire equipment shall be designed and built, in accordance with and compliance to SEMI standards for semiconductor equipment.
28. There shall be provision to connect the outlet of vacuum pump to dry scrubber.
29. Optional items to be quoted:
    a. Dry scrubber capable of scrubbing gases used in this system
    b. Purifiers for gases: each gas precursor and purge gas shall come with purifiers (for removing impurities like moisture, oxygen, hydrocarbons, CO, CO2)

Safety features and interlocks:

30. Necessary safety interlocks to ensure flammable gases are isolated in the event of any malfunctioning of the system, must be provided.
31. An emergency STOP button should be provided.
32. In case of emergency, the system should have cause-effect logic that shuts down. The vendor shall show/explain this cause-effect logic built into the system. In particular, the following interlocks and alarms are required:
    a. System Over pressure to shut gas supply panels with relief valve (or gate) opening to scrubber
    b. High temperature to trip furnace heating. Low temperature to shut down deposition (due to heater failure)
    c. Thermocouple failure to trip furnace heating
    d. Excess flow to shut gas supply panels
    e. Vacuum pump failure to shut gas supply and trip furnace heating
    f. Chiller failure to trip furnace heating and shut gas supply panel.

g. Exhaust failure to provide audio alarm with an option to manually shut down the system in safe mode.

h. Scrubber failure to shut down the gases and the heater.

i. Gas leak to shut down the system

j. Prevent venting if hazardous gases are still present. This should be in cause-effect logic provided by the vendor.

k. Recipe management should be fool proof to avoid human errors like allowing non-compatible process conditions to be sequenced.

Installation & Commissioning:

Vendor shall install and commission the system at CeNSE, IISc, which will include

a) demonstration of crystalline β-Ga_2O_3 growth (> 1 µm thick) and characterized by the client within time frames agreed upon.

b) training of a certain number of personnel agreed upon between the client and vendor. Trained personnel will run the reactor independently and be certified by vendor representatives that they are satisfied with the level of training.

c) Vendor will provide at the time of installation a detailed manual that includes all drawings- electrical, mechanical, pneumatic, installation, design-, operational details and software details.

Pre-requisites for vendor qualification:

i. Vendor should make presentation of their design and capabilities to build the above equipment and explain the design rationale to achieve the objectives along with Fail Safe considerations of equipment design

ii. Detailed Equipment/Exhaust/Gas Manifold/Control System/Chamber design including reactor design along with simulation studies for all aspects of temperature, pressure, flow and safety to be provided along with the bid.

iii. Vendor should have developed CVD equipment and installed in govt. institutions such as IITs/IISc/TIFR/NITs/IIITs or other govt. national labs in India. Documentary proof of such equipment installation needs to be enclosed along with bid submission. They should provide reference list (institute name, users' names and email/phone) of such equipment installations in India for IISc to independently verify the satisfactory performance of vendor's equipment.

iv. Similar equipment installed by the vendor should be working satisfactorily for the last 36 months from the date of tender published.

v. Vendor must be a registered enterprise for the last 5 years and provide account statements. Vendor must have turn-over of 5 crore INR or more.

vi. Vendor should preferably have a fully functional service office in Bangalore, Karnataka for after-sales support.

Special Conditions:

- The growth of β-Ga_2O_3 on 2-inch wafer must be demonstrated by the vendor once the equipment is installed to qualify for the payment as per the payment terms mentioned.
- Optional items price shall be considered in evaluation of L1.