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Si, SiGe and Ge Epitaxial CVD Systems

To Whom It May Concern

This is an RFQ (Request for Quote) document for procurement of an epitaxial CVD system along with attachments as part of a tender for the Centre for Nano Science and Engineering (CeNSE) at IISc, Bangalore. The CVD reactor will be primarily used to deposit thick layers of for Si, SiGe and Ge for MEMS and electronics devices.

CeNSE is a multidisciplinary research department at IISc that houses a 14,000 sq. ft. cleanroom and characterization facility used by 50 faculty members from various disciplines at IISc. CeNSE also runs a program called Indian Nanoelectronics Users Program (INUP) which has allowed 4200 participants from more than 700 universities and institutes all over India to use the facilities at CeNSE. Consequently, any tool in CeNSE receives significant exposure to scientific community at IISc and beyond. The vendors are requested to factor in the utility of this exposure in the quotes.

Procedure:

1. Vendors are required to submit a technical proposal and a commercial proposal **in two separate sealed envelopes**. Only vendors who meet the technical requirement will be considered for the commercial negotiation.
2. The decision of purchase committee will be final.
3. The technical proposal should contain a compliance table with 5 columns. The first column must list the technical requirements, 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 “No” the third column should provide the extent of the deviation (please provide quantitative responses). The fourth column should state the reasons for the deviation, if any. The fourth column can be used to compare your tool with that of your competitors or provide details as requested in the technical requirements table below.
4. Any additional capabilities or technical details, that you would like to bring to the attention of the purchase committee, can be listed at the end of the technical table.
5. The **deadline for submission of proposals is the 26th of July 2018, 5:30 pm Indian Standard Time**. Proposals should arrive at the office of Dr. Saurabh Chandorkar, FF-08, Centre for Nano Science and Engineering, Indian Institute of Science, Bangalore 560012, India, by the above deadline.
6. The **quotes should be CIF Bangalore, India.** Please include cost of shipping.
7. If multiple systems can fulfill the requirements, vendors can submit multiple bids.
8. The technical requirements are listed for Si, SiGe, Ge epitaxy. If Si/SiGe and SiGe/Ge need separate chambers, such a configuration is acceptable as long as the combined system can share the gas manifold, pumping systems, the burnbox, and control system.

9. Please provide itemized quotes for the tool and any extra options/attachments/packages. Vendors are encouraged to quote for as many options as their tool portfolio permits.
10. Please indicate the warranty provided with the tool. Longer (3 year) warranty periods are preferable.
11. As an option, please provide cost of annual maintenance contract (AMC) for 3 years after warranty, The AMC must cover 2 scheduled and 1 emergency visit per year. It must also indicate who will service the AMC, an Indian agent or the OEM. The AMC cost must also include an itemized list of spares that are essential for the scheduled visits.
12. Please provide an itemized cost for spares expected over 2 years of use. These shall be used to estimate life-cycle cost of the tool.
13. Vendors are encouraged to highlight the advantages of their tools over comparable tools from the competitors.
14. Any questions or clarifications can be directed to: Dr. Saurabh Chandorkar
    FF-08, Centre for Nano Science and Engineering, Indian
    Institute of Science, Bangalore 560012
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Technical Specifications

NNfC has a requirement for Si, SiGe, Ge epitaxy CVD system. If Si/SiGe and SiGe/Ge need separate chambers, we will prefer a common gas-manifold, load-lock, pumping system, burnbox, and control panel. If combining the two chambers is not possible, vendors can offer individual systems, either or both.

Chamber configuration

	Si, SiGe, Ge
Chamber Temperature	Atleast 450-1200 C
Deposition Pressure	6-60 Torr
Base Pressure	50 mTorr
Deposition Rate (max)	> 0.5 um/min Prefer > 1 um/min
Deposition thickness during an uninterrupted run	From 50 nm to 60 um
Number of wafers/run	1
Wafer size	4''. Prefer ability to do 2'', 3" and coupons
Cleanliness	ISO Class 3 (See acceptance test for further specification)
Hot/Cold Walled Chamber	Cold walled strongly preferred. If vendor suggests hot walled chamber, provide justification.
Film thickness uniformity across wafer when depositing (100%*sigma/mu)	<1%
Film thickness variation across runs	Equal Means with alpha = 0.05 for n = 15 runs Equal sigma with alpha = 0.05 for n = 15 runs
Selective Deposition (Silicon dep on SiO2/Silicon dep on Si)	~0 (using HCl flow, for example, to achieve selectivity)
Matching crystal orientation from growth on single crystal	100%

Heteroepitaxy	Si on Si; Si on SiGe; SiGe on Si; SiGe on SiGe
Run-to-run cross contamination after running purge/clean recipe	10ppm
Dopant uniformity measured using sheet resistance measurement wafer (100%*sigma/mu)	<2% across

General specifications:

Required Item	**Further specification**
Burn Box Included	Reactive
Gas panel	Required (including setup for liquid precursors)
Load lock	Required
Wafer Loading	Automatic preferred
Weight	To be specified
Size	To be specified
EMO (soft for software reset) and a button for hard reset	Yes
Tool status lamp	Yes
Process interlocks as per recipe	Generally: >5% deviation from set point triggers interlocks
Process parameter log	Every parameter sampled at ~1Hz Data retained for 100 runs. Logs recorded in chunks of 10MB or less with appropriate
Tool log	Software log recorded in chunks of 10MB or less
Multi-step recipe creation	**C**ontrol flow rates of all gasses, chamber pressure, temperature and other process step parameters
Computer interface showing current status of gas flows, chamber status, load lock status etc.	In addition, Tool errors should be clearly articulated with appropriate pop up messages as well as logged.
Tool interlock	Tool must accept external interlock so that it can interface with NNfC reservation system

Tool uptime/availability over the course of a year	95%

Gas Specification

Gas		**Concentration**	**Suggested** Max **Flows** Minimum flow= 2% of Max
Purge	H_2 *	100% (5N5)	80 SLM
Purge	N_2*	100% (4N8)	80 SLM
Deposition	SiH_4*	100% (6N)	500 SCCM
Deposition	GeH_4*	100% (5N)	50 SCCM
Deposition	$SiCl_2H_2$*	100% (3N)	500 SCCM
Dopant	B_2H_6*	2% (balance 5N5 H_2)	500 SCCM
		100 PPM (balance 5N5 H_2) To be diluted using H_2 and the 2% B_2H_6	500 SCCM
Dopant	PH_3*	1% (balance 5N5 H_2)	500 SCCM
		100 PPM (balance H_2) To be diluted using H_2 and the 2% B_2H_6	500 SCCM
Dopant	AsH_3*	100 PPM (balance 5N5 H_2)	500 SCCM
Etchant for selectivity	HCl**	100% (5N)	500 SCCM
1 Extra gas line	Spare**		500 SCCM
1 extra bubbler Loop	Spare**		Implied 0.2 SCCM

* Gases that are already available in NNfC. The concentration of these gasses is fixed.
**New gas lines that need to be added. The concentration/specification of these gasses can be changed.

Recipe Requirements

- Purge/Clean recipe to remove deposition on chamber walls. Please mention the cadence at which the purge recipe must be run.
- Selective deposition on Si vs SiO2 (no deposition on SiO2) with a minimum deposited film thickness of 2um on Silicon
- Recipes for depositing 50nm, 500nm, 5um and 50um Si films
- Recipes for depositing 50nm, 500nm, 5um and 50um SiGe (50%-50%), SiGe(25%-75%), SiGe(75%-25%) films.

- Recipes for depositing 50nm, 500nm, 5um and 50um Ge films
- Recipe for thermal hydrogen annealing
- If present, robot testing functionality to carry out repeated cycle testing (picking wafer from the load lock, placing it in the chamber, retrieving the wafer from the chamber and placing it back in the load lock

Source Inspection

Vendors are required to send a complete hierarchical bill of materials (including mechanical, electrical, pneumatic, hydraulic parts and shipping crates) before the source inspection will be carried out. The Vendor is to notify IISc thirty (30) days in advance of factory final testing. An IISc representative may be dispatched to the Supplier for Source Inspection. The purpose of the Source Inspection is to:
- Observe testing of all ordered equipment.
- Check for equipment compliance with this specification or configuration specification.
- Check for functionality of interlocks.
- Check for manufacturing defects.

Tool aspect being tested	**Test**	**Spec**
Go over the BOM to verify presence of all components	Verify appropriate assembly of various parts in BOM	All parts should be present
Load Lock loading	25 consecutive load and unload steps in all chambers	No failures
Continuous operation of tool with no failures	5 successive recipe runs for 100 nm of Si, SiGe and Ge films	No failures
Selective Epitaxy Test	i) 2μm Deposition of Epitaxial Silicon on a Si substrate using selective recipe (may need a HF dip before deposition at the vendor's facility) ii) Deposition of 2μm Epitaxial Silicon using selective recipe on a Si substrate with 250nm thermal oxide coating	2μm deposition of Silicon substrate No Silicon deposition on SiO_2
Nonselective Epitaxy Test	i) 2μm Deposition of Epitaxial Silicon on a Si substrate using non-selective recipe (may need a HF dip before deposition at the vendor's facility) ii) Deposition of 2μm Epitaxial Silicon using non-selective recipe on a Si substrate with 250nm thermal oxide coating	2μm deposition on both Silicon substrate and Silicon substrate with silicon dioxide coated on it

Tool acceptance tests

Tool aspect being tested	**Test**	**Spec**
Load Lock loading	25 consecutive load and unload steps in all chambers	No failures
Continuous operation of tool with no failures	5 successive recipe runs for 100 nm of Si and SiGe films	No failures
Homoepitaxy of Si	3 runs of 1) XRD Si substrate 2) Deposit 50nm Si 3) Check in XRD 4) Deposit 5um Si 5) Check in XRD 6) Deposit 50um Si 7) Check in XRD	1. Match the substrate orientation 2. Phi-scan to guarantee epitaxy 3. Rocking curve <100 arc sec
Deposition uniformity (within wafer)	Test 1: Deposit 50 nm of Si, SiGe (50%-50%), Ge	9 point check; Mu/sigma <0.01 with alpha = 0.05, beta = 0.05
Deposition uniformity (across runs)	5 runs of Test 1: Deposit 50 nm of Si, SiGe (50-50), Ge each Test 2: Deposit 50 um of Si, SiGe (50-50), Ge each	9 point check (mean value to be used for each wafer) Matching means with alpha = 0.05, beta = 0.05
Cross contamination after running purge recipe	5 runs of alternating Si and SiGe runs interspaced with purge recipe	10 ppm cross contamination in films checked using XPS/EDS

Cleanliness test	For each film: Measure number of particles on a wafer -> Carry out 1 hour long epitaxial growth of film at the highest deposition rate, Repeat 5 times-> Measure number of added particles by comparing to be	1 particles>1um in entire wafer excluding region <=7mm from the edge of the circumference
Doping uniformity test	For each film (5 runs of): Test 1: Deposit 50nm of Si, SiGe(50-50),with 10^{17} /cc (split 1) and 10^{19} /cc doping levels (split 2) Test 2: Deposit 50um of Si, SiGe(50-50), 10^{17} /cc (split 1) and 10^{19} /cc doping levels (split 2)	9 point check for within wafer variation Mu/sigma <0.02 with alpha = 0.05, beta = 0.05 Across runs variation: Matching means with alpha = 0.05, beta = 0.05

Other instructions

- List of required utilities must be provided by the vendor.
- Tool must be UL or CE certified
- Tool must adhere to safety code (SEMI S2-0200, SEMI S8-0999)
- Local support person is required (Must be technical support and preferably in Bangalore)
- Complete manual (hardware and software) should be provided
- Complete tool specification document including but not limited to all interlocks, complete set of circuit diagrams, top level bill of materials etc.
- Provide suitable Warranty Period (minimum of 3 years) and clear warranty terms
- Provide after warranty budget for 3 year AMC + required AMC kit/spares
- 3 references, preferably Indian, from people using this system need to be furnished with the bid
- Detailed preventive maintenance requirements and procedures are to be provided
- Include installation costs and training costs. Training can be on-site or at vendor location.
- Shipping: Bangalore CIF