	INDIAN INSTITUTE OF TECHNOLOGY BOMBAY **MATERIALS MANAGEMENT DIVISION** **Powai, Mumbai 400076**

Purchase Requisition No. 1000012684 (SRM/RFX No. 6100000213)

Technical specifications for Dual Beam Focused Ion Beam Facility

The proposed Focused Ion Beam – Field Emission Gun Scanning Electron Microscope(FIB – FEGSEM) instrument, with Focused Ion Beam and Field-Emission Electron Beam columns is intended primarily for (i) high resolution imaging of variety of materials, including beam sensitive materials, (ii)high-quality specimen preparation for TEM and atom probe tomography, and (iii) three-dimensional modification of materials at sub-micrometer down to a few nanometers for fabrication of nanostructures for device applications. The instrument should be capable of:

- FIB milling and Deposition at a resolution of **50 nm** or better
- Simultaneous electron beam Imaging during FIB milling and accurate real time monitoring of progress during millingactions
- Prolonged programmable operation for pattern milling and deposition at nanometer scale
- Obtaining high resolution secondary electron(SE) and back scattered electron (BSE) images on the electron and ion column
- Three-dimensional microstructure analysis of Materials
- The system should also have the attachments of EDS, nanomanipulator, Gas Injection System.

Detailed Specifications

A. Electron Beam Column:

Sl. No.	Features	Specifications
1.	**Electron Source**	**Thermal Schottky Field-emitter**. Source lifetime should be guaranteed for 12 months or longer**.**
2.	**Accelerating Voltage**	Up to30kV continuously variable.
3.	**Probe current**	Continuously variable in the range of 10pA – 100nA
4.	**Electron Beam Resolution**	**≤ 0.6 nm @ 30 kV (STEM Mode)** **≤ 1.4 nm or better@ 1 kV** **≤ 0.7 nm or better @ 15 kV**
5.	**Beam deceleration/ retardation/booster**	Should be available

B. FIB Column:

Sl. No.	Features	Specifications
1.	**Accelerating Voltage**	**Up to 30 kV**, continuously variable
2.	**Ion Gun**	Should be **Gallium** liquid metal ion source.
3.	**Probe Current**	Should cover the range from**1 pA**to**65nA****or larger.**
4.	**Imaging Resolution**	Should be **3 nm or better @ 30 kV**
5.	**Automated FIB Milling and GIS Deposition**	Milling process should be automated with 5 or more axis computer controlled stage.
6.	**FIB induced deposition**	The minimum ion-beam deposition line-width obtainable should be 50 nm or better.
7.	**Gas sources for deposition and etch**	Ion and e-beam assisted deposition sources should include at least Platinum, Carbon and Insulator. At least one source (XeF_2) for gas assisted etching should be included. Should have Gas Injection System (GIS) control for automation.
8.	**Gas nozzle placement repeatability**	Should be **5 micron or better.** Adjustable nozzle position should be possible with respect to the specimen.
9.	**Ports attached to the Chambers**	The Chamber should be provided with **at least 20 chamber ports or more** for different Gas Injection needles, enhancing analytical capabilities of the instrument and future upgrade of in-situ manipulators.
10.	**TEM sample preparation**	• In situ micromanipulator for transmission electron microscopy (TEM)under computer control. • Drift:**< 50 nm / min** • Step size:**500 nm or smaller** • Repeatability:**<+/- 200nm or better**

C. Common to both Electron-beam and Ion-beam columns:

Sl. No.	Common Features	Specifications
1.	**Detectors**	• Should have secondary electron detector(Everhart-Thornley). • Should have a dedicated in lens /in column detector for Back scattered electron imaging. • Should have a dedicated in lens / in column detector for Secondary electron imaging. • Should have a dedicated Secondary Ion detector for Ion-column. • Should have retractable STEM detector for Bright Field/Dark Field and High-Angle Annular Dark-Field imaging (HAADF) imaging. • Should have an IR-CCD detector • Should have a Navigational camera

2.	**Stage**	• 5 or more axis Eucentric motorized stage. Should allow independent movements in x, y, z directions with rotation (360° continuous) and tilt capabilities, with motorized range as below: X: $\geq$150mm Y: $\geq$150mm Z: $\geq$10mm R: 360° continuous (including rotation, tilt) T: -10° or lower to +60°or higher • Stage movement should be controlled through mouse or joystick • Maximum specimen size should be mentioned by vendor • Maximum specimen height should be mentioned by vendor • Specimen exchange must be through airlock or load lock mechanism
3.	**Specimen holders**	• Holders for standard metallography should have mounts (0.5", 1" and 1.5"diameter) • Multiple specimen holder(s) should be with capability tomount9 or more SEM stubs. • Should have TEM grid holder with multiple grids.
4.	**Chamber**	• Should be large enough to accommodate the maximum specimen size mentioned above in item no.2. • Should have an IR-CCD camera for observing stage and specimens inside the chamber • Electron – and Ion – Beam coincidence point - please specify.
5.	**Vacuum System**	• Air-cooled turbo molecular pump (TMP) should be backed by dry scroll pump or diaphragm pump(s) • Fully automatic microprocessor should control high-capacity vacuum system • Should have status display on computer monitor
6.	**Image Processor**	• Resolution should be: Scanning pixel density to be up to 6144 x 4096 or better and should be selectable • Should provide a range of integration and averaging modes. • Should enable drift compensation during imaging in averaging mode. • Should enable saving of images to files of the following types: TIFF (8 or 16or 24– bit, selectable by user) and/or BMP and JPEG. • Image area selection should include – full frame, reduced raster, line X, line Y and spot modes, with independent setting of operational parameters such as line scan times, number of lines/frames etc.
7.	**Image Display**	• Preferably **24" LCD monitor or better** • Should have SVGA/XVGA/WUXGA 1920x1200 or better
8.	**Image Output / Recording Systems**	Should be with digital storage (in tiff, jpeg and/or other common image storage formats) through the control computer

9.	**System Control**	• Should have **Microsoft Windows** based operating system, network ready. The operating system, drivers and computer hardware should be supported for at least 5 years from the date of purchase. Any required upgrades during this time should be provided free of cost. • Appropriate microscope control software for alignment, image capture and archival etc. (system should be capable of automatic gun-alignment). • Should offer both automatic and manual control of features like focus, contrast, astigmatism correction etc. • Specimen current and vacuum should be indicated in the user interface. • Capability to save user settings and parameters for beam and scanning, patterns, detectors, user interface appearance should be available.

10.	**Image Analysis Software**	• Should provide at least the following basic features:
		  • Point, linear and area measurement
		  • Line profile
		  • Annotation
		  • Image saving and retrieval
		• SEM/FIB settings information should be included with each image as a text data

11.	**FIB software**	• Software capable for automated serial sectioning and imaging through a user-defined volume of a specimen should be quoted. The software should have capabilities to sequence the images captured to be compiled into a video, and provide 3-dimensional reconstruction of the sliced volume. • Software that allows for unattended TEM sample preparation and cross-sectioning with a Focused Ion Beam should be quoted. The software will be controlled through an intuitive user interface and setting up treatment of multiple samples that can be done quickly and easily.
12.	**Navigation camera**	It should be color, high resolution integrated with user interface for convenient navigation over the sample options for annotation and saving of the image.
13.	**Plasma cleaning**	In-situ sample and chamber cleaning by a plasma cleaner or similar technique should be available that is suitable to remove carbon and other contaminations from the surface.
14.	**Power supply**	The system and its accessories should be capable of operating at 220V (single phase), 50Hz power supply. The complete system must be properly shielded.
15.	**Air Compressor or, high- pressure N_2 supply**	The compressor which is used for operating the pneumatic valves should be noise-free and should come as a part of the entire FIB-FESEM system
16.	**Chiller**	Chiller should be included for the microscope if it is required for operation.
17.	**Future upgrade**	The quoted system should be capable of future upgradation to WDS and photoluminescence attachments.

EDS System should consist of the following capabilities:

1) The EDS system should be capable of doing collection and analysis at dual beam coincident point.
2) The EDS should be a **motorized insertion** and retraction capable.
3) The system should have a silicon drift detector **(SDD)**, pulse processor, and system computer.
4) Active area should be **≥90mm²**
5) Energy resolution at **Mn K alpha** should be ≤ **129 eV**
6) 1,000,000 x-ray input counts per second and 300,000 x-ray output counts per second
7) Detection should be from **Be – U**
8) System computer should be with a supported Microsoft Windows operating system, adequate storage hard drive, sufficient internal memory, LCD monitor, Microsoft Office and all necessary vendor software for operation, acquisition of data and data analysis and should be network ready. The operating system, drivers and computer hardware should be supported for atleast 5 years from the date of purchase. Any required upgrades during this time should be provided free of cost.

EDS software capabilities:

1) Should have capabilities of point analysis, area analysis, elemental mapping, line scanning, etc.,
2) Should have ability for quantification of spectra into weight and atomic percentage of the elements indexed.
3) User interactive qualitative and standard less/ standards should be possible based on quantification with K, L, M, N line database.
4) Quantification should be possible based on eZAF and PeBaZAF.
5) Automatic and manual determination of background correction should be possible for element identification and quantification.
6) Should have the grey scale map of total EDS counts

Other Requirements

- **Should provide warranty for 2 years and preventive maintenance along with breakdown maintenance for a period of 3 years (after 2 years warranty).**
- Installation and training at SAIF at IIT Bombay.
- Should include10 working days technical training for one SAIF, IIT Bombay employee at an applications center of the supplier.
- Must have done installation of dual beam FIB systems during the 5 years in the government academic institutions and R&D labs in India to be supported with installation reports obtained from the Institutions. The names and contact details of the Institutions where the instruments are supplied and installed should be given so that the Technical Committee can ascertain the veracity of the information provided and take that as an input to determine the vendor.
- The supplier should have a service center in India and a trained technician should be available in the country and available for at least 3 years.
- Door to door duty delivery paid. IIT Bombay would provide the exemption certificates as applicable.
- All other standard accessories required for the tool.
- Demonstration of imaging and sample preparation. The following 2 sample preparation and one imaging demonstrations should be arranged by the vendor for evaluation by the technical expert committee appointed by IIT Bombay. Benchmarking criteria mentioned
  in each case would be used for comparing the systems offered by vendors and bids may be rejected if any of the criteria mentioned below are not met. The demonstrations can be arranged by the vendors at any laboratory of their choice. The demonstrations should be done using the system model quoted by the vendor in this bidding process. The vendor should

demonstrate the same after installation of the system at IIT Bombay if they win the tender. The vendors should make arrangements for live video streaming of the demonstration sessions so that the technical expert committee constituted by IIT Bombay can monitor and assess the demonstration as it happens. Upon completion of the demonstration sessions, all relevant images and documents of the demonstration should be submitted by the vendors for benchmarking and documentation.

1

Sample: One-side polished p-type silicon wafer of surface orientation of (100) and resistivity of 4-7 Ohm. cm provided by IIT Bombay.

Mill a rectangular cuboid trench into the polished surface with a top area of 100 um X 30 um using ion beam of 65 nA current for 10 minutes. Images of the trench should be taken in such a way that the morphology of the sidewalls, and the morphology of the bottom of the trench can be assessed. Images for assessing the trench depth with evaluated trench depth should be provided.

Benchmarking criteria:

i. The trench depth demonstrated by any vendor should be larger than 80% of the largest demonstrated as part of this bidding process.
ii. The trench sidewalls should be smooth and with negligible material deposit on surfaces.

2

Sample: Steel samples cut from the same larger piece with at least one grain boundary provided by IIT Bombay.

Prepare less than 100 nm thin lamella of 10 µm X 10 µm dimensions including the grain boundary in the sample for TEM examination. The lamella prepared should have uniform thickness and not have any holes. The quality of the sample should be demonstrated by the vendor in the same session with STEM.

Benchmarking criteria:

i. The entire process of sample loading, sample preparation and STEM should be completed in 4 hours or lesser.
ii. Quality of the samples should be appropriate for high resolution TEM imaging and EELS analysis as revealed by STEM.

3

Sample: Mesoporous silica (SBA-15) imaging to reveal the fine features on the surface of the sample. The sample should be imaged with no coating on it. Samples would be provided by IIT Bombay.

Benchmark criteria:

i. The clarity of images which reveal all surface features of the mesoporous silica.
ii. Damage created on the sample by the imaging process should be minimal.