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

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Technical Specifications for Field Emission Gun Scanning Electron Microscope (FEG- SEM)

Sr.No.	Features	Specifications
1.	Resolution	• Resolution of 0.7 nm or better at 15KV or 20KV. • Resolution with 1.3 nm or better guaranteed at 1 KV. • Resolution claimed must be supported with pre-printed literature.
2.	Analytical Resolution	• Resolution of 3.0 nm or better guaranteed at 15KV, probe current 5 nA or better at analytical working distance of 10 mm. • Resolution claimed must be supported with pre-printed literature.
3.	Magnification	• Direct Image magnification range from 10X to 1,000,000X**.**
4.	Accelerating voltage	• 10V to 30KV
5.	Probe Current	• Probe current from 1pA to 300 nA at 30KV or from 1 pA to 100 nA or better at 5KV. • Variation of probe current should be ± 1 % or less in 24 hours.
6.	Electron Gun	• Thermal Schottky field emission gun from 200 V to 30 KV, in steps of 0.1 kV or less throughout the whole range. • The emitter should be covered under 3 years warranty or replaced as and when required within 3 years free of cost. • The gun should be positioned in the field of the first condenser lens to maximize the current generated into the probe. • The anode must be of conical design to minimize image shift and gun alignment when changing accelerating voltage.

		• Dedicated back-up power supply for ion pumps that provides power for at least 200 hrs continuously to eliminate the need for gun bake-out and realignment. This is separate back-up in addition to external UPS.
7.	Electron Optics	• Sturdy electron column with provision for isolation of gun area from rest of the instrument for creating vacuum and venting. • System should consist of a dual condenser lens to allow changes in beam current. • The condenser lens should be coupled with additional lens to minimize system spherical aberration and optimize the convergence angle to ensure minimum focus change at all beam currents. This lens should be computer controlled and fully automatic to provide the smallest probe diameter at low beam currents and the optimum probe geometry for high resolution analytical performance at high beam currents. • The beam current delivered to the sample should range continuously between 1pA to 300nA. • The objective lens (OL) aperture strip should contain four externally selectable, (able to align in X/Y directions) apertures plus an open position. • The apertures should be in the front focal plane to ensure optimum spot size as a function of beam current. • The objective lens should be highly conical to allow high tilt at short Working distance. • The Objective lens should be a hybrid type lens with both electrostatic and electromagnetic components for ultra-high-resolution imaging with beam acceleration and deceleration within the lens to reduce aberration and improve probe diameter. • The in-column detectors must not reside within the OL field and should be placed above the objective lens outside the lens field. • There must be no OL electromagnetic leakage flux below the lens allowing imaging of magnetic or paramagnetic samples at short working distance and preventing pattern distortion while carrying out analysis. • There should be a dedicated lens setting for ultra-long depth of focus for the wide area analysis using beam Scan.

8.	Electron Optical Engine	FESEM should be equipped with electron optical control system for stable observation while adjusting various microscope parameters. The electron optical control system should have following features: • Automated control and adjustment of electron lenses in real time. • Correction of electron trajectories in real time auto alignment. • Enhanced auto functions (focus, brightness/contrast, astigmatism).
9.	Vacuum System	• Fully automatic PC controlled vacuum system with status display for Vacuum. • Turbo Molecular Pump backed up by rotary pump for secondary pumping and two sputter ion pumps for FE Gun. • Automatic protection of vacuum system against failures of power, water supply and pump.
10.	Specimen Chamber	• Specimen exchange should be through draw out mechanism. • Minimum 10 ports for future expansion of accessories. • The chamber should be mounted with colored CCD camera for the specimen navigation and seamless transition from optical to SEM image. • Chamber camera must be provided for coloured and monochrome image. • The chamber must also be capable of accommodating multiple EDS detectors simultaneously and accommodating CL and EBSD simultaneously. The EDS and EBSD detectors should be coplanar. The stage tilt should be perpendicular to the dedicated EBSD port. The chamber must have dedicated fully focused inclined WDS Port to facilitate CL or WDS.
11.	Specimen Stage	• The sample stage should be a large goniometer with mechanically fully eucentric tilt at all Z positions and tilts. • High Precision 5 axis fully eucentric motorized stage movements should be atleast 70 mm or more in X direction, 50 mm or more in Y direction, rotation of 360° and , 2 mm to 38 mm in Z direction. The tilt

		range must be -5° to +70° with the tilt axis perpendicular to dedicated EDS and EBSD ports. • All 5 stage Axes (X, Y, R, T, Z) should be motorized and include computer eucentric rotation. • The stage should be capable of meeting all resolution specifications without a stage lock. • The stage should be capable of having a bias voltage of up to 2KV. Beam deceleration should be able to apply at any gun accelerating voltage. • The stage automation system should be controlled through mouse control, programmable trackball and magnification linked touch pad and allow the following functions: a. Computer eucentric rotation b. Continuous movement with the speed linked to magnification. c. Click centre and zoom d. Stage return to location of any stored image
12.	Specimen Holder	• It is preferable to have a multi-specimen holder.
13.	Stage Navigation System	• Stage Navigation System must be supplied to move to an area of interest easily and quickly by locating the ROI from a color image on the monitor.
14.	Detectors	• A secondary electron detector system consisting of in-chamber E-T type detector. • Upper Electron Detector - A through the lens detector with a user controllable energy filter for collection of topographic (SE) contrast or atomic number (BSE) contrast. • RBED (Retractable Solid-State BSE Detector) - The backscattered electron detector should be a pneumatically retractable (from the GUI). The detector should be divided into 5 segments for detection, making it possible to select the signal suitable for the observation purpose.
15.	PC/Workstation	• Computer of latest model and associated hardware and software capable of working in Microsoft Windows 10 based workstation. • User friendly software with easy retrieval of data. • Data should be compatible with MS office programs.
16.	User Interface	• Keyboard, mouse, Control Panel having multifunctional operations for the control and adjustment of frequently used SEM parameters. • Manual Joystick control for stage axis.

		• The microscope should employ an auto-alignment correcting procedure that automatically presents all the lens parameters for ultimate imaging and analytical performance. By pressing an AUTO button, the user should be able to auto-focus, auto-stigmate and automatically adjust the brightness/contrast ratio of the image.
17.	Display	• 24” LCD Display
18.	Image Processing for SE and BSE images	• Linear and nonlinear grayscale processing. • Colour selection and contrast enhancement routines. • Histogram equalization. • Image processing filters. • Text annotations on images. • Image output in bmp, tiff, giff, png and jpg formats. • Image gallery with thumbnail format display. • Live conditions of operating parameters, holder graphics and airlock status should be visible on GUI.
19.	Water chiller	• Recirculating water chiller for lens and peripheral cooling must be supplied.
20.	Safety Devices	• Safety devices against power/vacuum/water/air/gas failures to be provided.
21.	Power Supply	• All power supplies should be Indian type 230+/-10% Volts, 50Hz, with Indian standard plugs. If Indian plugs are not available, suitable converters must be provided. • The electronics system of the FESEM should be highly stable, well ventilated, reliable and easily replaceable and should be rated for 230V, 50 Hz supply.
22.	UPS	• 2 nos of 5 kVA each (i.e total 10 kVA) advanced online UPS for FESEM, EDS, CL and chiller with One-hour maintenance-free battery back-up. • UPS should come with a warranty of two years.
23.	Gas Gauges	• Gauges for calibration and nitrogen gas cylinder.
24.	Compressor	• Compatible compressor for air supply for the operation of pneumatic parts, if needed.
25.	Pre-installation	• The machine and all its electronics should be rugged, sturdy and suitable for Mumbai climate. • Compliance certificate must be diligently prepared. Any false information will lead to disqualification of the bidder.

		• Before installation of the FESEM, the site would be tested and certified by the supplier in respect of stray magnetic field, ground vibration, and quality of air (humidity), water and electricity.
26.	Spares	• Supply of spares for 5 years should be guaranteed.
27.	Low Vacuum System and Detectors	• FESEM should be equipped with Retractable Low vacuum system. • The switching from HV to LV should be possible through fully automatic software-controlled LV orifice without breaking the chamber vacuum and manual insertions. • The low vacuum BSE detector should be a part of LV Orifice. Dedicated LVSE detector should be provided for the Secondary electron imaging. • The Low Vacuum pressure should be adjustable in the steps. The Pressure range should be 10 Pa to 300Pa or better. • The Retractable LV system should allow Low Vacuum EDS and EBSD without any limitation.
28.	LN2 free EDS Detectors with Automated mineral characterisation	• The EDS system should be state of art system designed to work with any make of FESEM. • The supplier would be responsible for the supply of all the necessary hardware and software to prove field integration of Automated Minerology Dual EDS systems with the FESEM. • The EDS system should include latest hardware and software that comply with ISO 15632/2012 specifications. • The EDS system should include two LN2 free, vibration free, maintenance free Peltier cooled, Silicon Drift Detector (SDD) having SDD sensor area of at least 40 mm^2 each or more. • The detectable element range should be from Beryllium (Be) onwards. • The EDS detector movement should be motorized with manual as well as software control. • Facility to monitor spot size with beam current and operating voltage. • Motorized drive for insertion / retraction with suitability to view samples at high working distance. • EDS detector Energy Resolution: $\leq$ 127eV or better at Mn-kα, $\leq$ 65eV or better at F-kα and $\leq$ 58eV or better at C-kα.

		• Detector calibration should be User accessible. Operator should be able to calibrate the system without the help from manufacturer. • The detector should be capable of handling a count rate of at least 500,000cps or higher. • The EDS system hardware should be extremely stable guaranteeing <1eV shift in Peak position and Resolution over the entire count rate range. • The detector should be optimized for low energy X-ray transmission for light element analysis apart from heavy elements. • Operator should be able to check the detector parameters like detector temperature, peak deviation and resolution for any given element in spectrum. • The vendor should supply the standards for the energy calibration. Operator to have an access to calibrate the system with Standards for the detector. • Ultrathin polymer or silicon-based window. • The EDS system should be able to acquire the FESEM images with high resolution up to 8000pixel wide. The X-ray mapping resolution should be at least 4000pixel wide. • Standard geological reference samples (SRTMs)-Geo Mk-II Block containing 28 standards in 32 mm diameter stub to be provided. • Suitable computer to run the software and hardware.
29.	EDS System Software	• The EDS system software should have 'Live Mapping display feature in real time mode' wherein the X-max should instantaneously follow the sample movements. • The EDS system software should allow user to use standards to enhance the accuracy of quantitative analysis. • The EDS server and analysis software should be capable of performing data acquisition, storing and transfer, multitasking type based on latest operating system and comprising with monitor, CPU etc. and necessary cables and connectors to link with existing FESEM. • Compatible latest software for qualitative and quantitative analysis with full features for online and offline analysis. The software should have following features: ➢ Navigator based design for ease of use.

		➢ Auto Identification without any forbidden element list. ➢ Module for eliminating elemental contribution due to peak overlap. ➢ Auto/ Manual Background removing technique, Pulse pile up processing, tilt correction, drift correction, deconvolution of peak etc. ➢ Qualitative and Quantitative techniques with latest XPP or Phi-rho- Z absorption corrections. ➢ Point/Line/grid/area Scanning. ➢ Multi-element mapping (qualitative and quantitative) with spectral imaging. Should be able to fetch EDS spectra stored with the mapped image. ➢ Beam Measurements. ➢ Image co-related elemental analysis. • Automated Mineralogy: The EDS system should include additional software for automatic detection, analysis and classification of various particles of the sample based on the morphology and chemistry from single and multiple fields. The data acquired from multiple fields should be able to combine and stitch during the acquisition to present the data over larger sample size. • For higher throughput analysis single large area SDD EDS detector or dual SDD EDS detector should be included in the EDS system. • The feature/particle of the size of atleast 200nm or less should be detected and analysed automatically. • The software should be capable of doing Automated Mineral Characterisation and classifications for various applications such as Liberation studies, process yield characterisation, etc. • The software should include the post-processing functions and extensive database with the composition of a large range of minerals supporting the Mineral Characterisation and classifications. • The software should be able to generate various reports such as cumulative liberation yield, locking and minerals associations, particle grain size and distributions, model minerology, etc. These reports should be exported to other software such as Microsoft Excel for further data processing.
30.	Cathodoluminescence (CL) System and Detectors	• The CL system should be state of art system designed to work with any make of FESEM.

		• The supplier would be responsible for the supply of all the necessary hardware and software to prove field integration of CL system with the FESEM. • The CL system should have following features: a. Panchromatic imaging with high spatial resolution. b. Spectral response: 185 – 870 nm. c. Spectral differentiation and RGB color imaging, using integrated motorized filter wheel. d. Ultra-smooth, parabolic mirror, enhancing reflectivity, decreasing measurement time and reducing artifacts. e. 87% collection efficiency from a Lambertian source. f. Automated control and alignment of mirror stage. g. Advanced open-source software for data acquisition and in-depth analysis. • The system should be upgradable to high performance wavelength -resolved (hyperspectral) CL imaging in future.
31.	Hardware Specifications for CL system	• Mirror Mount a. Precision translation stage with mirror mount. b. Stepper motors with computer-controlled drivers. c. x,y accuracy < 1 µm. d. Automated mirror alignment. e. Controlled waviness diamond-turned, aluminium half-parabolic precision mirror. f. collection angle 1.46 sr., surface roughness <20 nm. g. Unlimited sample size and movement. • Optical analysis system a. Lightweight optical boards in light-tight enclosure with SEM mounting assembly b. High efficiency optics, covering 185 – 870 nm c. Optional exchangeable optical module for optimized VIS/NIR performance available • Detector a. Photomultiplier tube for fast intensity mapping b. Integrated power supply and signal amplifier

		c. Spectral response: 185-870 nm d. High speed detection: minimum pixel dwell time of 0.8 μs • Other hardware a. Design of a dedicated flange and mount assembly for integration of the system with SEM. b. Computer for read-out of signal and alignment detectors, interfacing with SEM x-y external input, c. controlling mirror stage d. Drivers and power supplies for piezoelectric stepper motors, photomultiplier tube
32.	Software Specifications for CL system	• Data acquisition a. Fast inspection mode b. Acquisition of intensity maps based on point by point scans c. Drift correction • Data analysis a. Easily visualizable 3D CL data as a 2D MAP or pixel by pixel graph. b. Overlay of intensity maps and SEM images. c. Export of data to, for example MATLAB for further analysis. d. Automated control and alignment of mirror stage. e. Read-out of camera and PMT • The source code for the analysis software should be provided for further upgradation.
33.	Coating unit	• Carbon coater.
34.	Installation	• Installation and commissioning at the site. • All expenditures to be borne by the vendor. • Vendors should include their tender, provision for maintenance tools and initial stock of maintenance spares as are essential for the proper operation and maintenance of the equipment. Full particulars of spare parts should be included. • The vendor should be fully responsible for the manufacturer's warranty in respect of proper design, quality and workmanship of all the equipment accessories etc. covered by the tender. • The vendor should have trained service personnel to provide efficient after-sales service support. Names of three personnel, along with their training

		certificates, should be furnished along with quotation. • Trained service engineers in India or directly from OEM must be available to resolve technical problems within a week. • Door to door duty delivery paid for all components. IIT Bombay will provide the exemption certificates as applicable. • All legal issues will be dealt with under the Indian Penal Code.
35.	Warranty	• Two years from the date of installation.
36.	AMC	• **AMC for three years after the warranty period should be quoted separately**.
37.	Qualification Criteria	• The vendor should comply with all the technical specifications with valid proof. • The vendor should have supplied over 10 FESEM units in reputed Indian Institutes (e.g IITs, IISERs), Universities or research laboratories during the past decade, to justify reliability of equipment performance and service capabilities. • The vendor should provide proof of after sales-service and availability of spares and accessories. • Only models launched after January 2019 those provide the latest technology should be quoted. • The vendor must provide the release note from the principal.