

# ANNEX I

## TECHNICAL SPECIFICATION

**ENGLISH VERSION**

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### Object:

**Scanning Electron Microscope (SEM)** for high-resolution image acquisition and elemental chemical analysis system, with secondary electron detector (SE), backscattered electron detector (BSE), secondary electron detector for low-vacuum mode and water vapor (SE low-vacuum), beam flow detector with direct measurement and energy dispersive X-ray spectroscopy (EDS), installation and SEM operation training.

#### 1. General characteristics:

- 1.1. Tungsten-heated-cathode electron gun
- 1.2. Minimum magnification: 7x or smaller; maximum magnification 1.000.000x or bigger.
- 1.3. Secondary electrons images in High-vacuum mode, Low-vacuum mode and environmental mode.
- 1.4. Backscatter electrons images in High-vacuum mode, Low-vacuum mode and environmental mode.
- 1.5. Resolution of 3 nm at 30 kV or better in SE electron detector and High-vacuum mode.
- 1.6. Resolution of 4 nm at 30 kV or better in BSE backscatter electron detector in Low-vacuum mode.
- 1.7. The system must maintain high resolutions at all pressure ranges even at low voltages.
- 1.8. Analysis chamber capable of accommodating samples of 220 mm in diameter (or equivalent edge) or larger dimension and a sample height with a capacity of 80 mm or bigger.
- 1.9. Sample station with 5 concentric axes (with eucentricity in all work distances) with fully motorized and automated movements in all axis. X, Y, Z, R, T movements of 45mm, 45mm, 45mm, 360 degrees, -5 degrees (or lower) to +70 degrees (or superior), or higher range.
- 1.10. CCD camera and infrared illumination for the internal visualization of the chamber, showing the positioning of the sample in relation to the detectors and other elements that may possibly collide during the movement of the sample.
- 1.11. The camera must have 8 or more ports available for the installation of accessories and other detectors. In addition to the configuration already specified, it must allow future expansion, such as EBSD, WDS, Cathodoluminescence and X-Ray Micro fluorescence.
- 1.12. Water vapor introduction system for testing samples with high water content, controlled via the operating software.
- 1.13. Pressure range from 10 Pa to 2000 Pa, or upper range, containing these values.
- 1.14. Electron-beam's acceleration of 0,2 to 30kV or higher band containing these values.
- 1.15. Beam flow of 1 picoAmpère (pA) to 2 microAmpère (uA) or higher band containing these values.
- 1.16. The operative vacuum level must be reached within few minutes with rotary pumps and molecular turbo.
- 1.17. Resolution image generation of 3072 x 2304 pixels or higher.

- 1.18. The detectors must work simultaneously acquiring images from SE and BSE at independent high velocity with possibility of mixing signals SE and BSE.
- 1.19. Easy and quick exchange of openings by the operator with automatic beam alignment.
- 1.20. Micro-analysis system composed of EDS detector without need of liquid nitrogen use, to analysis all the elements in the range Be to U.
- 1.21. EDS detector with minimum resolution of 127 eV for Mn K $\alpha$ , with active detection area minimum 20 mm<sup>2</sup> and minimum count rate of 50.000 cps, reference Oxford, model X-MaxN-20, equivalent or superior.
  - a) Software for qualitative and quantitative analysis of selected areas or points in the sample. Spectrum acquisition by point, rectangle, ellipse or free area. Time acquisition: automatic, count defined by operator or time specified by operator.
  - b) Provide punctual mode, line and area for X-Ray analysis, automatic phase search, quantitative analysis of lines and formats for export and import.
  - c) EDS software system with multiple monitors support, images with resolution of 4092 pixels or higher.
  - d) Software must have several tools such as qualitative analysis with auto-identification, spectrum superposition, automatic element search, calculation of concentration during the analysis, automatic report generation and other tools.
  - e) Computer with Windows 7 or later operating system and 22" or higher LCD monitor for EDS analysis.
  - f) Spectral acquisition with 1024, 2048, 4096 or automatic with energy range selection of 10, 20 and 40eV. Map ordering by intensity, atomic number or alphabetic order. Images of layers with visualization consisting overlapping maps and associated to the electron image by color.
- 1.22. Microscope control must be via PC through mouse and keyboard control, 23" monitor or larger in the specific software on the Windows 10 platform. Accepted Windows 7 or 8 Operating System as long as the proponent agrees to provide for the period of 03 years, at no cost to ITAIPU, the update of the operating system whenever a new software update is launched.
- 1.23. Work desk with height and fit proportional to the microscope column.
- 1.24. Auto diagnostic system to facilitate operator troubleshooting. The software must allow remote access to the equipment through the network for remote maintenance and /or clarification of doubts and online training.
- 1.25. Peltier type sample cooling system with operation range of 0 to 70°C or higher.
- 1.26. The system/software must also have a tool that allows the display of platinum and sample in very low amplification aiming to facilitate the handling of large sample and/or to prevent collisions during the displacement of samples with complex geometries, including a tool that also provides the automated search of previously investigates regions of interest. A tool must be included allowing control via software of the displacement of a predefined detail to the center of the visual field, from an increase of magnitude.

- 1.27. The equipment must not use any water cooling for the vacuum system, electron column or any other part of the equipment.
  - 1.28. Pneumatic suspension of the electron gun with pressure control and automatic leveling for isolation of mechanic vibration of the environment through compressed air or another dry gas.
  - 1.29. Operative Software: Multi-user environment controlled by access password for each operator with saved personalized settings for each user including electron beam adjustment. Four levels of user access, depending of knowledge and responsibilities, and basic mode for fast analysis for operators without any experience through simplified and intuitive software.
2. Peripheral for coating samples:
- 2.1. Sample metallization system with gold target for non-conductor sample metallization. The dome must have 100 mm of diameter or wider and 100 mm of height or higher;
  - 2.2. The system must also be supplied with a carbon coating head, including carbon wire;
  - 2.3. It must be provided with a gold target plus the vacuum pump and accessories for the perfect performance;
  - 2.4. Control of the recoating process by electronic controller with human-machine interface with touch screen;
  - 2.5. The carbon coating must work on the same platform that the gold metallizer.
3. Consumables materials for operation:
- 3.1. 20 (twenty) units of W filament with a useful life above 200h each;
  - 3.2. Column aperture quantity = 2 (two);
  - 3.3. Final aperture quantity = 2 (two);
  - 3.4. Rotary vacuum pump oil = 1 liter;
  - 3.5. Rotary pump filter = 2 (two);
  - 3.6. Sample stub = 20 (twenty);
  - 3.7. Adhesive carbon tape of 10m = 1 (one);
  - 3.8. Set of tools for sample preparations including wrenches for stub fixation, tweezers, sample-holders for embedded samples, sample-holders for big samples;
  - 3.9. Supply of all consumable materials intended for operation of the microscope and the metallization for at least two years (4,000 hours of operation).
4. Installation and initial training:
- 4.1. The CONTRACTOR is responsible for the mounting, installation and placement of the equipment in perfect working order, at the place informed by ITAIPU.

- 4.2. The operational training will be provided as transfer of technical knowledge, containing theoretical instructions and practical activates of the techniques, handling and operation of the MEV and EDS.
- 4.3. The training must have a minimum of 08 hours/class, with the goal of promoting the full training of at least 06 (six) professionals involved in the operation of the equipment.
- 4.4. The travel expenses of the CONTRACTOR to ITAIPU, such as air o land tickets, lodging, transportation, food, car rent, equipment and tools freight, and others necessary for the execution of the services related to this Technical Specifications or that become necessary during the warranty time will run on the CONTRACTOR's account.

## 5. Warranty

- 5.1. The CONTRACTOR shall guarantee all the equipment provided for 12 months after the installation of the equipment.
- 5.2. During this period, all damaged parts, no misuse of same, are replace without additional cost to ITAIPU.