Instrument

Electron Column/gun

1. Accelerating voltage from 0.2 to 30 kV in steps of 0.1 kV
2. Accelerating voltage variation less than ± 50 ppm in one hour over complete range.
3. Beam current range from 5x10-7 to 10-12 A.
4. Beam current variation ± 0.5 % in one hour.
5. Beam current variation ± 1 % in 12 hours.
6. Beam current programmable to any value from 0.5 nA to 200nA with an accuracy of ± 3%.
7. Current on the beam regulation aperture does not vary more than ± 0.2 % when the specimen alternated between B and Pb.
8. Beam focus maintained as accelerating voltage is varied.
9. Beam diameter of less than 0.15 µm at 10 kV and 100 nA. Diameter variation less than 0.05 µm in one hour.
10. Digital setting of the beam diameter over a range of values up to 250 µm.
11. Beam position variation less than ± 0.5 µm in 1 hour at 10 kV.
12. Beam position shift not perceptible when viewed through the light optics at a field of view of 500 µm in diagonal on a fluorescent sample as the current through the condenser lens is varied.
13. Beam position shift less than ± 0.5 µm as any spectrometer is moved from limit to limit.
14. Faraday cup and associated ammeter measurement ranges appropriate to the beam current with digital converter 15 bits. Full scale accuracy 0.006%.
15. After beam is blanked by the Faraday cup beam return to original position and intensity within 200 milliseconds.
16. Gun and vacuum system compatible with Field Emission source.
17. Automatic and/or manual control of column alignment, column focus, astigmatism correction, beam size, beam current, extraction voltage, source lens voltage and filament heating.
18. One electromagnetic stage condenser lens with automatic or manual condenser lens control.
19. Probe-forming lens with conventional solid body, electromagnetic mini-coil with water cooling, and six X-ray channels with backscattered electron leakage field traps to optimize X-Rays peak to background ratio.
20. Motorized final lens aperture device (aperture selection and centering). Aperture assembly with 1 beam regulation aperture system, a 200µm aperture for high current operation and 2 SEM apertures.
21. Beam current regulation through double aperture. Current monitoring with constant feedback. Range 0.5 to 200 nA.
22. Electrostatic beam deflection into the Faraday cup for beam current measurement.
23. Sample current monitored continuously and displayed when required.

24. Electron absorbing column liner tube (patented).

Secondar Electron Detection and Imaging (SEM)

1. Secondary electron detection system with permanently mounted multiguide collector (patented), scintillator, and photo-multiplier tube (PMT). Collector bias manual or automatic setting as a function of the signal.
2. Secondary electron detection efficiency entirely independent of sample size.
3. Secondary electron imaging mode point to point resolution of 6 nm on any sample up to 80 mm x 50 mm in size.
4. PM voltage variable from 0 to 1200 V in 1024 steps of ≈ 1 V/step.
5. SEM magnification range from 150x to 400 000x on a 20" LCD monitor. Actual magnification within 2.5 % of the indicated for both X and Y-axis.
6. Image distortion less than or equal to 1.5 % at a field of view of 60 µm and less than or equal to 3 % at a field of view of 600 µm.
7. Raster rotation 360 degrees in increments of 0.1 degree.
8. Raster rates from 20 milliseconds to 245 seconds/frame (for 50 Hz)
9. SEM images digitalization up to 2048 x 1536 pixels.
10. SEM image focusing automatic and manual.
11. Simultaneous display of up to 12 signals.
12. Recording of the following data: accelerating voltage, micrometer bar, signal, label.
13. Designation of a position for the electron beam on a presented image with an accuracy of better than 0.1 µm at a field of view of 20 µm.
14. Designation of two arbitrary locations on an image and direct reading of the distance between them.
15. Image averaging in real time and choice of 1 to 16 exponential image signal to noise ratio improvement.

Backscattered electron detector

1. Backscattered electron (BSE) detection system with topographical, compositional, and orientation modes with TV rate digitized display.
2. In BSE mode, atomic number resolution of better than or equal to 0.1 atomic number units at Z 29.
3. Spatial resolution in BSE mode of 15 nm or better at 25 kV.
4. BSE imaging of the sample from the point of view of any spectrometer (orientation)

Light optics

1. Reflected and optional transmitted light optical viewing system for simultaneous viewing and analysis of the sample at all times.
2. High magnification reflected optics, with Cassegrain light objective coaxial with the electron beam.

3. Continuous zoom with fields of view ranging from 0.25 mm to 1.75 mm.
4. Specimen stage compatible with optional transmitted light system including polarizer and analyzer independent of sample type, or size.
5. High-resolution color CCD TV camera. Alignment of light optics to ensure coincidence with electron beam
6. Illuminating sources with controls for bulb centring, intensity adjustment, and positioning.
7. Depth of focus of the light optical system less than 1 µm at highest magnification.
8. Optical resolution better than 0.7 µm. Light Optics Numerical Aperture of 0.40
9. Automatic Z-axis focusing over a wide range of reflectivity and roughness, returning the stage Z-position to optical focus to within +/-1 µm.
10. Real-time optical image grabber for image display, storage and processing on SUN or PC Workstation monitor.

Wavelength Dispersive X-rays Spectrometers

1. Spectrometer mounting in vertical or inclined orientation. Depth of X-ray focus of 1 mm with inclined mounted spectrometer.
2. Up to 4 diffracting crystals mounted in each spectrometer, chosen from LiF, PET, TAP, PC0 (2d = 4.5 nm), PC1 (2d = 6 nm), PC2 (2d = 9.5 nm), PC3 (2d = 20 nm) (High sensitivity crystals optionally available).
3. 6 X-ray ports with possible spectrometer configurations as follows:
    1) Up to 5 vertical spectrometers
    2) 1 inclined and up to 3 vertical spectrometers
    3) 2 inclined and 1 vertical spectrometers (All configurations compatible with 1 energy dispersive spectrometer).
4. Spectrometer Rowland circle radius of 160 mm.
5. Spectrometer take-off angle of 40 degrees.
6. Spectrometer range of at least 0.22 to 0.83 sin theta. (Optional: to 0.93 sin theta).
7. Spectrometer positioning by linear, closed loop optical encoders allowing exact positioning without need for repeaking element x-ray lines during quantitative analysis.
8. Direct gear drive type spectrometer drive mechanism.
9. Linear spectrometer movement for calibration of the spectrometer over its entire range by checking only one peak position per crystal.
10. Spectrometer prealigned and in-routine realignment not required.
11. Spectrometer resolution of 1 x 10-5 sin-theta.
12. Time to drive each spectrometer from limit to limit less than 18 seconds at a speed of 10 mm/sec.
13. Asynchronous spectrometer movement and counting.
14. Gas flow proportional counter with thin stretched polypropylene window for light element detection at 1 atmosphere gas pressure or thick Mylar or beryllium window for heavy element detection at up to 3 atmospheres gas pressure.

15. Gas flow meters for each spectrometer and manifold to supply all spectrometers from one gas bottle.
16. Crystal repositioning affects counting reproducibility typically by less than ± 0.5% at peak maximum (typical performance would be better than ± 0.1% for PET and PC crystals, and better than ± 0.2% for TAP and LiF crystals).
17. Crystal repositioning with crystal flipping affects counting reproducibility at peak maximum position by less than ± 1 %.
18. Choice of detector bias from 0 to 2000 V.
19. Amplifier gain for the pulse height amplifier adjustable in 4096 steps.
20. Base line and window of pulse height analyzer adjustable from 0 to 5 V in 255 steps.
21. System dead time for the detector, preamplifier, amplifier, and analyzer chain less than 3 microseconds
22. Dead times setting up to 64 microseconds.
23. Count rate display for each spectrometer on one ratemeter.
24. Automatic multi channel analyzer (MCA) set up routine for the optimization of PHA parameters. Pulse height analysis (PHA) distribution graphically presented during this routine as part of the standard spectrometer status display.
25.

Spectrometer Configuration

Spectrometer	1	2	3	4	5
Crystal	LTAP/LPC2	LPET/LTAP	LLiF/LPET	LiF/TAP/PC0/PC1	LLiF/LPET
Type	Vertical	Vertical	Vertical	Vertical	Vertical
Pressure	Low	Low	High	Low	High
Circle (mm)	160	160	160	160	160
Gaz Type	Argon	Argon	Argon	Argon	Argon
Time Pre-set	10000	10000	10000	10000	10000

Crystal Parameters

Name	TAP/LTAP	LiF/LLiF	PET/LPET	PC0	PC1	PC2
2D (Å)	25.745	4.0267	8.75	45	60	99.234
Element Ref	Si	Fe	Ca	O	O	O
Position Ref	27738	48084	38388	52962	39960	25413
Peak Search Width	260	260	260	1000	2000	2000
Dead Time (µs)	3	3	3	3	3	3

Energy Dispersive Spectrometry (EDS)

XFlash 5010 with electronics and software. It includes the new detector XFlash 5010 (SDD) with active surface of 10 mm², the electronics and the software for qualitative and quantitative analysis:

- Detection from B to U - Resolution: 129 eV for Mn Kalpha line (1 to 100 000 cps)
- Output counting rate: up to 275 kcps
- Super Light Element Window (SLEW) - NO LIQUID NITROGEN required
- Integrated preamplifier
- Acquisition board in the PC
- Qualitative and quantitative software (spectra calibration, spectra evaluation, standardless analyses)

Specimen chamber and stage

1. Specimen chamber and automated specimen stage with airlock, allowing the introduction of samples without venting the chamber. Sample exchange controlled by real time monitoring of airlock vacuum.
2. Stage movement in three orthogonal directions (X, Y and Z) with variety of substages and sample holders available to accommodate different types of samples. Shuttles and sample holders introduced through airlock.
3. Stage movement X-axis: 50 mm; Y-axis: 80 mm; and Z-axis: 1.5 mm.
4. Stage positioning using linear closed loop, axis mounted linear optical encoders.
5. Sample repositioning within 1.0 µm on any previously selected coordinate with backlash correction.
6. Smallest increment of movement 0.1 µm in imaging mode.
7. Store and recall of any number of points (X, Y, Z coordinates) for subsequent automatic stage positioning and analysis.
8. Stage movement speed 15 mm/sec.
9. Combined stage and electron beam positional drift less than ± 0.5 µm/hour. 10. Top referenced type sample holders.

Vacuum system

1. Automatic vacuum system with protection against power, water supply, or forepump failure. Isolation of the various circuits of the vacuum system to allow such operations as filament and sample exchange without venting the entire system. Schematic of the vacuum system, accessible during operation, providing an indication of isolation valve status and vacuum levels.
2. Electron gun pumping by 2 ion pumps providing an operating vacuum in the gun chamber and upper column better than 1x10-9 Torr, and differentially pumped with respect to sample chamber.
3. Electron gun is totally bakeable thanks to a dedicated baking device with controlled temperature. Gun must be baked during at least 48 hours to reach the ultimate vacuum.
4. Specimen chamber and lower column pumped by dedicated turbomolecular pump providing a working vacuum in the chamber of better than 10-4 Pa without the use of cold traps. Turbomolecular pump backed by dry pump.

5. Provision for venting the column and sample chamber with dry nitrogen.
6. Carbon contamination rate on a polished copper sample less than or equal to 0.2 %/min without use of optional cold plate, with a cold plate 0.025 %/min.
7. Pump down of sample chamber and spectrometers from atmosphere to vacuum ready to work in 45 minutes or less.
8. Sample exchange through the airlock in less than 3 minutes
9. All valves are pneumatic and computer controlled.
10. The valve between the gun and the chamber is pneumatic and computer controlled.

Others

1. Anticontamination attachment including liquid nitrogen cooled plate.
2. Transmitted and reflected polarised light attachment (requires thin section type specimen holder) Includes automated switching between modes.
3. Cathodoluminescence detector. Consists of mechanical and optical interface, detector and associated electronics. Includes photomultiplier cathode with flat response from visible to infrared wavelength.
4. Closed loop water-cooled chiller.
5. Plasma Cleaner outside interlock chamber.

System control, integration and automation

1. Hardware and software integration into multi-user, multitasking operating system.
2. Control of all SEM and WDS functions accomplished using 32 BIT microprocessor controllers, accessed via the system computer and a dedicated keyboard.
3. Dedicated keyboard with permanent controls for magnification, focus and stage movement. Four additional wheels to which other instrument controls could be assigned.

1. Totally digital control of:
    - ❖ filament heating
    - ❖ suppressor, extractor and source lens bias
    - ❖ electron gun accelerating voltage
    - ❖ beam current
    - ❖ column alignment
    - ❖ stigmator
    - ❖ SEM focus
    - ❖ Beam deflection in the Faraday cup
    - ❖ specimen stage position and movement
    - ❖ optical focus ♣ vacuum system
    - ❖ WDS positions and crystal selection
    - ❖ dead time
    - ❖ counter bias
    - ❖ counting time

- ❖ MCA threshold, window, amplifier gain
- ❖ PM voltage
- ❖ SEM raster scanning speed, density (lines/frame)
- ❖ SEM image magnification
- ❖ electron beam mode-raster, line, spot
- ❖ electron beam position
- ❖ video gain, contrast, and black level
- ❖ signals displayed: X-ray, SE, BSE, absorbed current, etc.
- ❖ images: gain, contrast, dark level.

4. Applications software written in high level language and run on single CPU under manufacturer supported, multitasking operating system. Messages regarding instrument control functions reported to user.
5. Instrument security
    - ❖ Instrument protected against misuse and unauthorized use. Local firmware protected by user definable password.
    - ❖ Utilities provided on the multi-tasking, multi-user 32-bit computer for account management and logging, and password security for all individual users. User files protected from accidental or unauthorized deletion, modification or execution.
6. "Lock screen" capability to prevent unauthorized access to application software and instrument control, while processes are running. 7. Ethernet net-working capabilities.