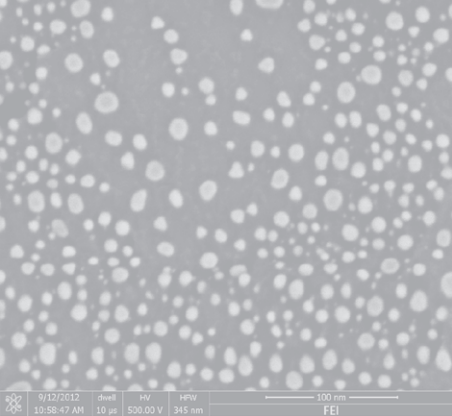




Verios 460 / 460L System Acceptance Test



VERIOS

Jul-2014



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Certificate

System Acceptance Test: Verios

Revision history

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Revision	Description of revision	Date
D	Stacom replaced by SWIFT, GDStoDB software removed	June 2014
C	Company logo changed	July 2013
B	New document	Feb-2013

1 | System Acceptance Test: Verios

1 Introduction

This publication is valid for the following type of microscope:

- Verios 460
- Verios 460L

1.1 System Acceptance Test Certificate

The System Acceptance Test certificate is at the end of the document. Provide a copy to the customer and the local FEI organization.

NOTE *To keep track of the progress, sign each portion of the test as you complete it. This is also useful if the test is interrupted for any reason or if the participants change.*

1.2 Specimens required

To carry out these acceptance tests, you need a basic, fully installed system and the following specimen.

Table 1-1: Overview of specimen needed

Specimen	Order code	Factory code
Delivered with the system:		
High resolution specimen S168-P	5322 695 15527	4022 198 14321
Ultra high resolution specimen S1987	4022 268 02244	4022 297 18831
Standard system test sample for SEM	4035 272 74851	4035 272 74851
4 inch wafer holder	4022 268 01488	4022 261 92422
High resolution TEM specimen S128B (with STEM 3+)	5322 695 14749	4022 198 10341
Provided by the service engineer:		
Magnification calibration specimen 2160 lines/mm and 19.7 lines/mm	5322 695 14975	4022 198 11771
Tin balls specimen	5322 695 14448	4022 197 04482

NOTE *Do not use High Resolution Specimen **S168** during System Acceptance Test but use Ultra High Resolution Specimen **S1987**!*

1.3

Terminology

The table below shows terms that are used in this document.

Table 1-2: Terms and description

Term	Description
Mode I	Magnetic lens mode (HR)
Mode II	Immersion lens mode (UHR)
BDM	Beam Deceleration mode

2 | System Acceptance Test: Verios

2 Electron Optics

2.1 Elstar UC electron optics

2.1.1 Image shift between Mode I and Mode II

This test checks the image shift between Mode I and Mode II for the high tension values.

Time required:

- 30 minutes

Materials required:

- Tin balls specimen or mapping wafer

Preconditions:

- UC-mode OFF
- Working distance 4 mm
- Magnification 5 000x in quad view
- Detector: ETD

To test the image shift:

1. Select Mode I, set the electron beam to 1 kV, 50 pA and find out the recognizable feature.
2. Switch to Mode II.
3. Optimize the image
4. Measure the image shift and fill out the value in the table below.
5. Repeat the procedure for 5 kV - 0.10 nA / 10 kV - 0.20 nA / 15 kV - 0.20 nA.

Voltage / Current	Specification [μm]	Measured [μm]
1 kV / 50 pA	≤ 10	
5 kV / 0.10 nA	≤ 10	
10 kV / 0.20 nA	≤ 10	
15 kV / 0.20 nA	≤ 10	

Not Applicable ☐

Passed ☐

Failed ☐

Waived ☐

FEI Service Engineer Date Completed

2.1.2 Magnification accuracy Mode II

Time required:

- 30 minutes

Materials required:

- Test sample 1031427 (or 5322 695 14975), sample with 2 160 line per mm.
(Do not use the standard system test sample!)

Preconditions:

- UC-mode OFF
- BD OFF
- Mode II
- Dwell time 3 μ s
- Scan rotation 0°
- Magnification 20 000x in quad view (1536 x 1024)

To test the magnification:

1. Set the working distance (WD) / high voltage (HV) / current as shown in the table.
2. Measure the value of 10 blocks in X- and Y-direction.

WD / HV / Current	Specification	Measured [μ m]
1 mm / 1 kV / 3.1 pA	measured value for X (between 4.54 μ m and 4.72 μ m)	
	measured value for Y (between 4.54 μ m and 4.72 μ m)	
2 mm / 2 kV / 6.3 pA	measured value for X (between 4.54 μ m and 4.72 μ m)	
	measured value for Y (between 4.54 μ m and 4.72 μ m)	
4 mm / 10 kV / 0.20 nA	measured value for X (between 4.54 μ m and 4.72 μ m)	
	measured value for Y (between 4.54 μ m and 4.72 μ m)	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed.....

2.1.3 Magnification accuracy Mode II with BD

Time required:

- 30 minutes

Materials required:

- Test sample 1031427 (or 5322 695 14975), sample with 2160 line per mm.
(Do not use the standard system test sample!)

Preconditions:

- BD ON, landing energy = 500 V, stage bias = 3 500 V
- Mode II (TLD detector selected)
- Probe current = 0.20 nA
- Stage tilt = 0°
- Scan rotation = 0°
- Dwell time 3 μ s
- Magnification 20 000x in quad view (1536 x 1024)

To test the magnification:

1. Set the working distance (WD) / high voltage (HV) / current as shown in the table.
2. Measure the value of 10 blocks in X- and Y-direction.

WD / HV / Current	Specification	Measured [μ m]
2 mm / 0.20 nA	measured value for X (between 4.49 μ m and 4.77 μ m)	
	measured value for Y (between 4.49 μ m and 4.77 μ m)	

Not Applicable ☐

Passed ☐

Failed ☐

Waived ☐

FEI Service Engineer Date Completed.....

2.2 High resolution measurement

High resolution specification of a scanning electron microscope is traditionally defined by visual separation of two gold grains on a carbon substrate. In order to achieve this a very high magnification is used (above 400 000x), that will give some image noise but allows clear measurements between the two respective particles. Although this method has been used for decades it remains extremely subjectiveness to interpretation.

In order to assure high standards in the FEI factory system assembly and test procedure, FEI has defined a new process of high resolution specification determination that aims at removing the subjectiveness from the final assembly and test procedure.

The process is as follows:

1. Images are made under certain conditions.
2. The sharpness of the gold grain edges in the reference images is measured with FEI software. This program calculates the resolution across the edge of all gold grains in the image. The edge resolution depends on the contrast threshold values set in the program. An example of a threshold setting is 35/65. Threshold 35/65 was found to produce resolution values that correspond best to the resolution values determined by the visual separation method.
3. For the system acceptance test, collect high resolution images from the instrument and measure them with the software (threshold 35/65) - press Ctrl+R. If the outcome of the calculation is equal to or less the value of the specification in table below, then the system passes the high resolution test. Proper measurement must consist the image quality evaluation (CTRL-Q) that assesses how reliable the measured resolution is. The values must correspond to following:
 - a. Clipping > OK
 - b. Resolution measurement > Valid
4. System (chamber and resolution specimen) has to be clean without any contamination. If not clean chamber at first, then clean specimen. Contamination significantly degrade resolution especially at low kV. Refer to the Installation Manual how to measure contamination and how to clean chamber and specimen.
5. Use Cryocleaner to improve vacuum level - if pressure is lower noise level in the image is lower as well and thus final image quality is better. High resolution image should be taken under chamber vacuum $\times 10^{-5}$ Pa. Refer to Installation manual how to use Cryocleaner.
6. Vibration (flags) should not be visible in image at 600 000 magnification. Refer to Installation manual how to check image for flagging.

2.2.1 High resolution measurement TLD/BD 1 kV

Time required:

- 60 minutes

Materials required:

- Ultra High Resolution Specimen **S1987**

Preconditions:

- Scan preferences
 - Dwell time 10 μ s (10-30 μ s)
 - Resolution 1024 x 884
 - Integrate 1x
 - Line integration 4x
- Conditions
 - Mode II (UHR), Tilt: 0°
 - UC Mode ON
 - Magnification: 600 000x – 900 000x in single view
 - Electron beam 1kV, 1.6 - 6.3 pA, BD = 1 kV
 - Working distance: 0.8 - 1.5 mm
 - Detector: TLD-SE
 - Locate small particles
 - Vacuum should be within $X.10^{-5}$ Pa

To measure the resolution:

1. Make an image and save it c:\xT\images\SAT\TLD_1kV_1mm_SNxxxxxxx.tif (SNxxxxxxx.tif means Serial-Number of system).
2. Start the image quality program (image.exe) on the supporting computer. Use only version 1.05.00 build 022, or higher, to evaluate image resolution and quality.
3. Open the stored image and measure the quality and resolution.
4. Write down the measured resolution value in the table of [2.2.4 “High resolution measurement results”](#)

2.2.2 High resolution measurement TLD 2 kV

Time required:

- 60 minutes

Materials required:

- Ultra high resolution specimen **S1987**

Preconditions:

- Scan preferences
 - Dwell time 10 μ s (10-30 μ s)
 - Resolution 1024 x 884
 - Integrate 1x
 - Line integration 4x
- Conditions
 - mode II (UHR), Tilt: 0°
 - UC Mode ON
 - Magnification: 900 000x – 1 200 000x in single view
 - Electron beam 2 kV, 1.6 - 6.3 pA, BD OFF
 - Working distance: 0.7 - 1.5 mm
 - Detector: TLD-SE
 - Locate small particles
 - Vacuum should be within $X.10^{-5}$ Pa

To measure the resolution:

1. Make an image and save it c:\xT\images\SAT\TLD_2kV_1mm_SNxxxxxxx.tif (SNxxxxxxx.tif means Serial-Number of system).
2. Start the Image quality program (image.exe) on the supporting computer. Use only version 1.05.00 build 022, or higher, to evaluate image resolution and quality.
3. Open the stored image and measure the quality and resolution.
4. Write down the measured resolution value in the table of [2.2.4 "High resolution measurement results"](#)

2.2.3 High resolution measurement ICD 500 V

Time required:

- 60 minutes

Materials required:

- Ultra High Resolution Specimen **S1987**

Preconditions:

- Scan preferences
 - Dwell time 3 μ s (3-30 μ s)
 - Resolution 1024 x 884
 - Integrate 1x
 - Line integration 25x
- Conditions
 - mode II (UHR), Tilt: 0°
 - stigmator alignment and UHR lens alignment completed
 - UC Mode ON (UC centering aligned)
 - Magnification: 600 000x – 900 000x in single view
 - Electron beam 500 V, 1.6 - 13 pA, BD = 4 kV
 - Working distance: approx. 1.5 mm
 - Detector: ICD
 - Locate small particles
 - Vacuum should be within $X.10^{-5}$ Pa

To measure the resolution:

1. Make an image and save it c:\xT\images\SAT\ICD_500V_1mm_SNxxxxxxx.tif (SNxxxxxxx.tif means Serial-Number of system).
2. Start the image quality program (image.exe) on the supporting computer. Use only version 1.05.00 build 022, or higher, to evaluate image resolution and quality.
3. Open the stored image and measure the quality and resolution.
4. Write down the measured resolution value in the table of [2.2.4 "High resolution measurement results"](#)

2.2.4 High resolution measurement results

Specification NO waiver signed	Measured [nm]
TLD, UC-mode ON, 1 mm / 1 kV, measured value ≤ 0.7 nm	
TLD, UC-mode ON, 1 mm / 2 kV, measured value ≤ 0.6 nm	
ICD, UC-mode ON, 1 mm / 500 V, measured value ≤ 1.0 nm	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed

3 | System Acceptance Test: Verios

3 UHR Stage

3.1 X and Y repeatability at 0° tilt

The repeatability test measures the difference between starting point and returning point for a specified set of stage movements. After completion of all movements the standard deviation is calculated for X and Y directional moves.

Time required:

- 20 minutes.

Materials required:

- For systems without flip stage: 4 inch wafer (4022 261 92421)

Preconditions:

- 0° stage tilt
- Magnification: 5 000x in Quad view
- Mode I
- Electron beam 10 kV, 0.80 nA

To test the repeatability:

1. Start Swift and open recipe:
 - SAT_omni_repeatability_0deg_4inch.xml
2. Align wafer and adjust image
3. Start the script and follow the instructions on the screen

Specification	Measured [µm]
X: 85% tolerance interval ≤ 0.5 µm from average	
Y: 85% tolerance interval ≤ 0.5 µm from average	
X: Average of absolute ≤ 0.3 µm	
Y: Average of absolute ≤ 0.3 µm	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed

3.2 Tilt eucentricity

With the tilt eucentricity test you can check if the turn over axis and the middle of the screen are correctly aligned.

Time required:

- 15 minutes

Materials required:

- Sample: Standard system test sample, item 4: piece of mapping wafer.

Preconditions:

- TLD detector, default settings
- Working Distance: eucentric
- 0° to 52° stage tilt
- 0° scan rotation
- Mode II
- Electron beam 15 kV, 0.20 nA
- Magnification: 5 000x in quad view

To measure the tilt eucentricity:

1. Move the Z-axis to the eucentric position
2. Go to 0 ° tilt and mark a feature in the center of the screen.
3. Tilt the specimen to 26° and measure the displacement in Y. Fill out the value in the table below.
4. Tilt the specimen to 52° and measure the displacement in Y. Fill out the value in the table below.

Specification	Measured [µm]
≤ 5 µm at 26° tilt in Y	
≤ 5 µm at 52° tilt in Y	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed.....

3.3 Compucentric rotation

This test checks the accuracy of the compucentric rotation. With compucentric rotation you can view an off-center sample area from different viewing angles.

Time required:

- 30 minutes

Materials required

- Multistub holder or mapping wafer

Preconditions

- Use the electron beam
- Mode I
- Magnification 2 500x in quad view

To test the compucentric rotation:

1. Make an image
2. Position a recognizable feature under the center cross.
3. Rotate the sample by 180°.
4. Measure the offset for the X- and Y-direction. Fill out the values in the table below.

Specification	Measured [μm]
$\leq 50 \mu\text{m}$ at 0° tilt in X	
$\leq 50 \mu\text{m}$ at 0° tilt in Y	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed

4 | System Acceptance Test: Verios

4 Loadlock

4.1 Loadlock

4.1.1 Specimen load \ unload time

Time required:

- 10 minutes

Materials required:

- Stopwatch

Preconditions:

- High tension OFF
- Chamber pressure $\leq 7 \times 10^{-4}$ Pa
- "Vacuum spec OK" before you switch ON the HT.

To check the load-lock pump down time:

1. Write down the chamber pressure in the table below.
2. Vent the load-lock using dry N₂ for 2 minutes.
3. Start the "Clamp" and "Load" command and time the load cycle. Write down the time in the table below.
4. Press the "Unload" button or command and time the "Unload" cycle, until the Loadlock lid can be opened. Write down the time in the table below.

NOTE

This specification is void if anything other than dry nitrogen is used for venting. Continuous pumping must be enabled (set in Alignment 105).

Specification	Measured
Chamber pressure $\leq 7 \times 10^{-4}$ Pa	Pa
"Load" time to $\leq 6.5 \times 10^{-3}$ Pa: ≤ 100 seconds	sec
"Unload" time till lid can be opened: ≤ 100 seconds	sec

Not Applicable

☐

Passed

☐

Failed

☐

Waived

☐

FEI Service Engineer Date Completed

5 | System Acceptance Test: Verios

5 Accessories Acceptance Test

5.1 Retractable STEM detector

5.1.1 STEM3+ image resolution

Time required:

- 15 minutes

Materials required:

- High resolution TEM sample S128B (PN 5322 695 14749)

Preconditions:

- STEM centering alignment completed
- Stage tilt: 0°
- Flip position: 90° (normal to electron beam)
- Magnification: 750 000x in single view
- Electron beam Mode 2,30 kV, 13 pA
- Dwell time 10 - 30 µs
- Line integration 4
- Working distance: 4.6 mm
- Choose an area containing gold particles only.
- Select STEM3+ Custom Annular – combine all DF segments (DF1+DF2+DF3+DF4).

1. Acquire an image and save it to disk.
(c:\xT\images\SAT\SEM_STEM resolution_SNxxxxxxx.tif).
(SNxxxxxxx means Serial-Number of system).
2. Start the image quality program (image.exe) on the supporting computer.
3. Open the stored image and measure the quality.
4. Write down the measured value in the table below.
5. Save the evaluation of the image resolution
(c:\xT\images\SAT\SEM_STEM resolution_AU35_65_SNxxxxxxx.tif).

Specification	Measured [nm]
Resolution < 0.6 nm	

Not Applicable ☐ Passed ☐ Failed ☐ Waived ☐

FEI Service Engineer Date Completed