Performed by :
Rebecca Bolt Ettlinger, **DTU**
[redacted]
Date: 11. March 2021, 12. March 20201, 17. March 2021

Appendix 3: Acceptance test

To verify the quality of the delivered tool, it must pass the test specified in this appendix as stated in paragraph 5 in the main body of the contract .
The Acceptance test will be carried out as a follows:

A machine assembling step and a Site Acceptance Test (SAT) conducted once the instrument is installed in its final location at DTU. This will be conducted by DTU personnel with on-line attendance and guiding by the manufacturer/supplier due to the present Covid-19 situation.

The system will be unpacked and installed by an engineer, qualified from KLA and most of the SAT-tasks will be performed during the training.
Hence, at least one Schaefer-engineer needs to be on-site for the installation (of course following all safety rules and restrictions due to the pandemic).
If needed and possible, one person of the DTU staff will host installation and SAT and the training and demonstration of oustanding tasks can be performed online and remotely with the host in front of the machine for the training of all other staff members.

Measurement reliability

ID	Test	Description	Specification	Test-Result
A1	Height measurement repeatability smaller step*	Measurement of standard trench of depth 917 nm	Std. dev. <3 nm	913,45 nm Std. Dev. 0,09 nm
A2	Height measurement repeatability larger step*	Measurement of standard step height 24.895 µm	Std. dev. <30 nm	24,988 µm Std. Dev. < 1,0 nm
A3	Height measurement reproducibility smaller step**	Measurement of standard trench of depth 917 nm	Std. dev. <12 nm	913,252 nm Std. Dev. 0,322 nm
A4	Height measurement reproducibility larger step**	Measurement of standard step height 24.895 µm	Std. dev. <150 nm	24,9873 µm Std. Dev. 2,37 nm

*Definition of repeatability	The standard deviation of 10 repetitions of the same standard step measurement carried out in sequence without moving the sample.

**Definition of reproducibility	The standard deviation of 10 repetitions of the same step height measurement in separate instances, where the sample is removed and replaced on the chuck between measurements

Scan tests

All scan tests are performed with the standard stylus with 2 µm radius and 60° cone angle

Samples:

Acpt1 = *"eves AZ 5214 E 2.2 µm"* (6" wafer, developed + cured photoresist on Si)

Acpt2 = *"eves DREM Theta 4 220 µm"* (4" wafer, Si trenches)

Acpt3 = *"eves DREM Theta 4 270 µm"* (2x2 cm chip, Si trenches)

Acpt4 = *"eves AZ nLOF2020 450 mJ/cm² + TiAu 100 nm"* (6" wafer w/ gold pattern)

Acpt5 = blank 6" double side polished Si wafer, thickness 500 µm

Acpt6 = wafer like Acpt5 with Si3N4 coating originally on both sides but etched from one side

Acpt7 = blank 6" single side polished Si wafer, thickness 675 µm

Acpt8 = wafer like Acpt7 with 100 nm Cr on one side.

ID	Test	Description	Specification	Test-Result
A5	200 mm scan length without stitching	ProCal Wafer	196 mm	PASS
A6	Step height measurement	Measure 1 mm scan across 100 µm width / 100 µm pitch and smaller trenches on sample Acpt1	Measure depth of 2 µm deep trenches	2,06 µm PASS
A7	Step height measurement, high aspect ratio	Measure 3 mm scan across 500 µm width / 500 µm pitch trenches on sample Acpt2	Able to reach bottom of 320 µm deep trenches	301 µm PASS
A8	Step height measurement, high aspect ratio, small chip	Measure 3 mm scan across 500 µm width / 500 µm pitch trenches on sample Acpt3	Able to reach bottom of 270 µm deep trenches	290 µm PASS
A9	Step height measurement, very thin film	Measure 1 mm scan across 50 µm width / 50 µm pitch and smaller trenches on sample Acpt4	Measure step height of 100 nm film	103 nm PASS
A10	3D-map	Measure sample in area of 1x1 cm, sample Acpt1, same starting point as A5	Resolution 1.0 x 500 µm	PASS

A11	Stress measurement 2D low stress	6“ single side polished Both sides with low stress nitride	Measure scans of 12 cm (120000 µm).	Pre: PASS Post: PASS
A12	Stress measurement 2D high stress	Sample Acpt7	Measure scans of 12 cm (120000 µm).	Pre: PASS Post: PASS
A13	Stress measurement 3D low stress	6“ single side polished Both sides with low stress nitride	Measure scans of 12 cm (120000 µm). Angular resolution 10°	Pre: PASS Post: PASS
A14	Stress measurement 3D high stress	Sample Acpt7	Measure scans of 12 cm (120000 µm). Angular resolution 10°	Pre: PASS Post: PASS

Automatic programming tests

ID	Test	Description	Specification	Test-Result
B1	Set automatic measurement sequence	The user defines a sequence of measurements based on coordinates	Pass/fail	PASS
B2	Manual deskew point recognition	1)Deskew points are recorded as part of an automatic measurement sequence 2) The wafer is taken out and a wafer with identical design is placed on the chuck 3) The deskew points are located by the user and the automatic measurement sequence proceeds as expected	Pass/fail	PASS Using 200 mm ProCal Wafer
B3	Automatic deskew point recognition	1)Deskew points are recorded as part of an automatic measurement sequence 2) The wafer is taken out and a wafer with identical design is placed on the chuck 3) The deskew points are located by the software	Pass/fail	PASS Using 200 mm ProCal Wafer

		and the automatic measurement sequence proceeds as expected		
B4	Die grid programming	1) Record the pattern associated with a die grid. 2) Let the user define a measurement location in the pattern. 3) The system recognizes repetitions of the pattern on the wafer 4) The user specifies where the measurement should be made and the system measures them 5)The sequence is saved and repeated for another wafer with identical design	Pass/fail	PASS Using 200 mm ProCal Wafer

Analysis using APEX software

ID	Test	Description	Specification	Test-Result
C1	Stress calculation 2D low stress	Carried out as part of A11		PASS
C2	Stress calculation 2D high stress	Carried out as part of A12		PASS
C3	Stress map 3D low stress	Carried out as part of A13		PASS
C4	Stress map 3D high stress	Carried out as part of A14		PASS
C5	Automatic step height detection	Demonstrate feature		PASS
C6	Scan leveling	Demonstrate feature		PASS
C7	3D-map	Show visualization of 3D map		PASS
C8	Roughness calculation	Calculate roughness on 2 cm scan of the wafer with metal coating		PASS
C9	Export of data	Export data in .txt format		PASS

Maintenance/hardware adjustment tasks

After the performance of these tasks by the vendor as part of the SAT, it must be clear to Nanolab staff how to repeat the tasks

ID	Test	Description	Specification	Refer to Technical specification
D1	Stylus exchange	Stylus has to be taken out of P17 completely and put back in	<30 minutes	Postponed
D2	Automatic force calibration	Automatic force calibration carried out after stylus replacement	<15 minutes	< 5 minutes PASS
D3	Vertical calibration	Demonstrate how to check and adjust vertical calibration after measuring a standard step	<30 minutes for all 3 measurement ranges	< 15 minutes PASS
D4	Automatic leveling	Demonstrate automatic stage leveling in x direction	Pass/fail	PASS
D5	Stylus position adjustment	Demonstrate how to calibrate stylus tip offset from crosshairs using calibration wafer	Pass/fail	PASS
D6	Switch to stress measurement	Switch from vacuum chuck to stress measurement setting	<10 minutes	< 10 minutes PASS

Demonstrations we'd like (not part of acceptance test)
Manual stage leveling in y direction: **Explained by** [redacted]
Tip cleaning: **Explained and theoretically shown by** [redacted]

Accepted wishes in the technical specifications
All accepted wishes in the Technical Specifications sections 2, 3 and 4 that are not listed above must be demonstrated according to their performance specifications.

Accepted options in the technical specifications
All accepted options in the Technical Specifications if included in the final contract must be demonstrated according to their performance specifications.

Criteria for fulfilled acceptance
The acceptance test (SAT) will take place at DTU after installation. A DTU representative will attend the test. In case of test failure the manufacturer will have two weeks to complete a new SAT. If a third SAT should be necessary (same conditions) and it fails, DTU can choose to cancel the order.