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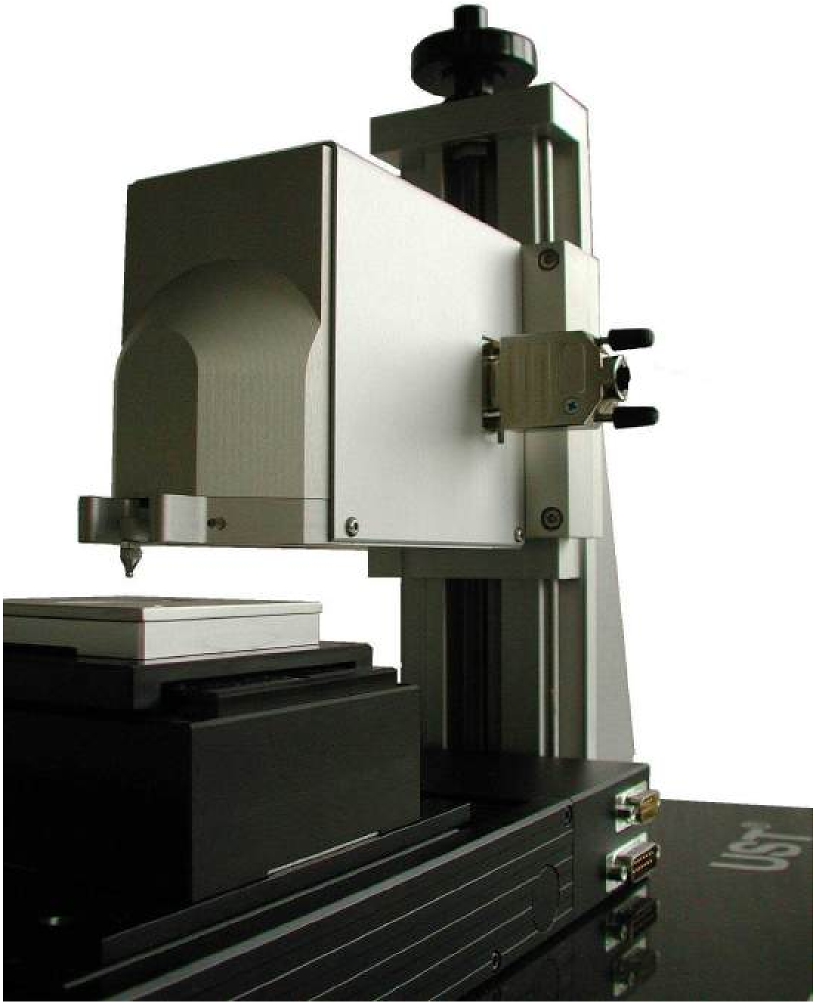
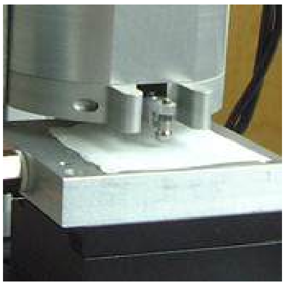
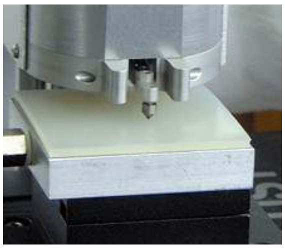
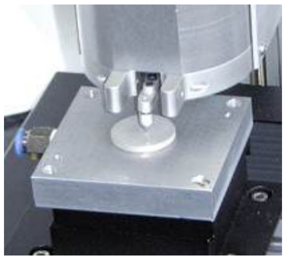
Test Report UST® - Universal Surface Tester









Würzburg, 2012-04-17

Customer:

Samples: Paper

Report no.:

Test engineer:

Report by:

Sign

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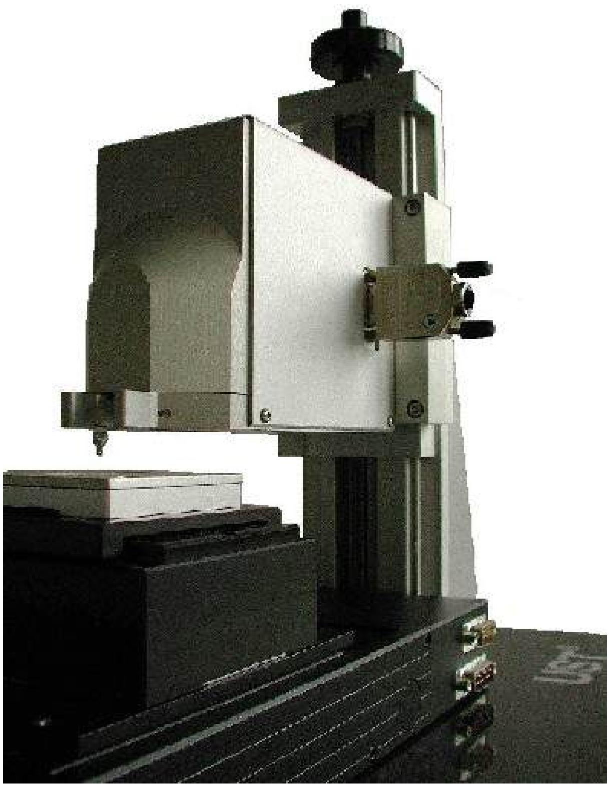
1. General description UST®

With the mechanical micro structure analysis (MISTAN®) procedure it is possible to determine mechanical, topographical and functional properties continuously on various surfaces.

The Universal Surface Tester UST® continuously determines the materials behavior and the corresponding deformation.

Therefore objective information can be obtained for the following material properties:

- Elasticity and plasticity
- Roughness and topography
- Total deformation
- Micro hardness
- Viscoelastic properties
- Scratch resistance
- Abrasion
- Softness/Haptics
- Compressibility
- Micro force measurement
- Material homogeneity



Universal Surface Tester UST®

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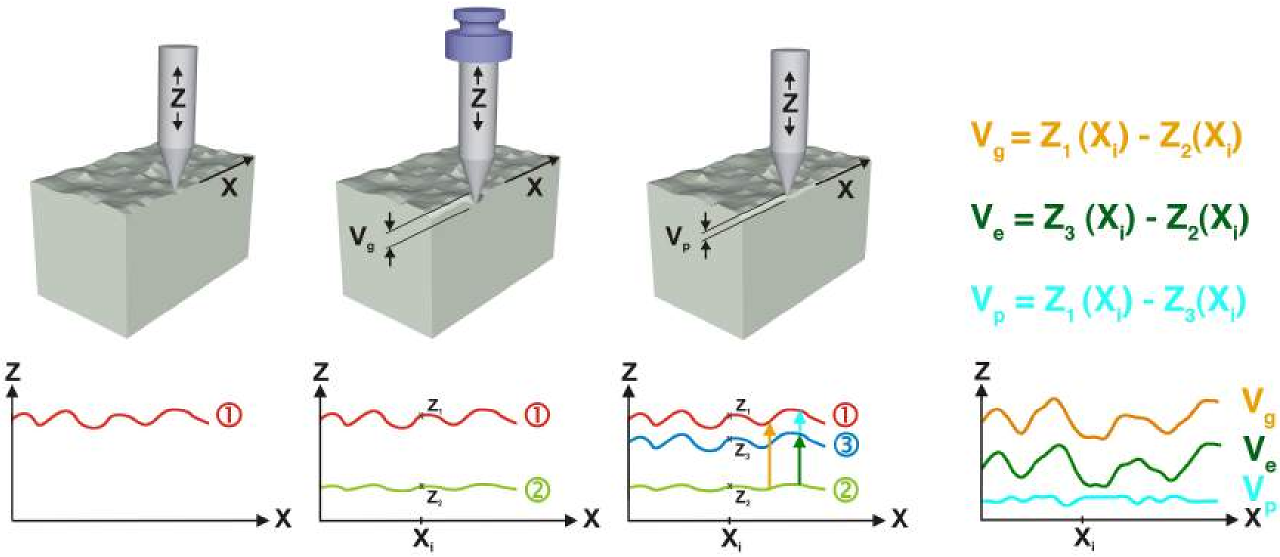
2. Measuring principle

2.1 Deformation measurement (UST® standard measurement)

The MISTAN®-procedure enables variable load range scanning. During the tactile measurement a stylus is moved linear on the material surface for three times.

The topography is recorded with a z-resolution of 60nm.



MISTAN® principle

First step (red)

> Scanning along a definite path on the material's surface with a minimum load of 1 mN. As a result the vertical deflection of the stylus and therefore the surface texture is continuously determined (virgin profile).

Second step (green)

> The same path is now scanned with the same stylus under a defined and constant load. A deformation of the surface occurs. This is called the total deformation V_g.

Third step (blue)

> Third In this step the same path is scanned again with a minimum load. The elastic part of the total deformation is now recovered, it is called V_e. The permanent deformation V_p is the part that does not recover.

Fourth step

> The local deformation values are calculated based on the differences between the surface and deformation profiles (step 1, step 2 and step 3) and shown in the second graph window.

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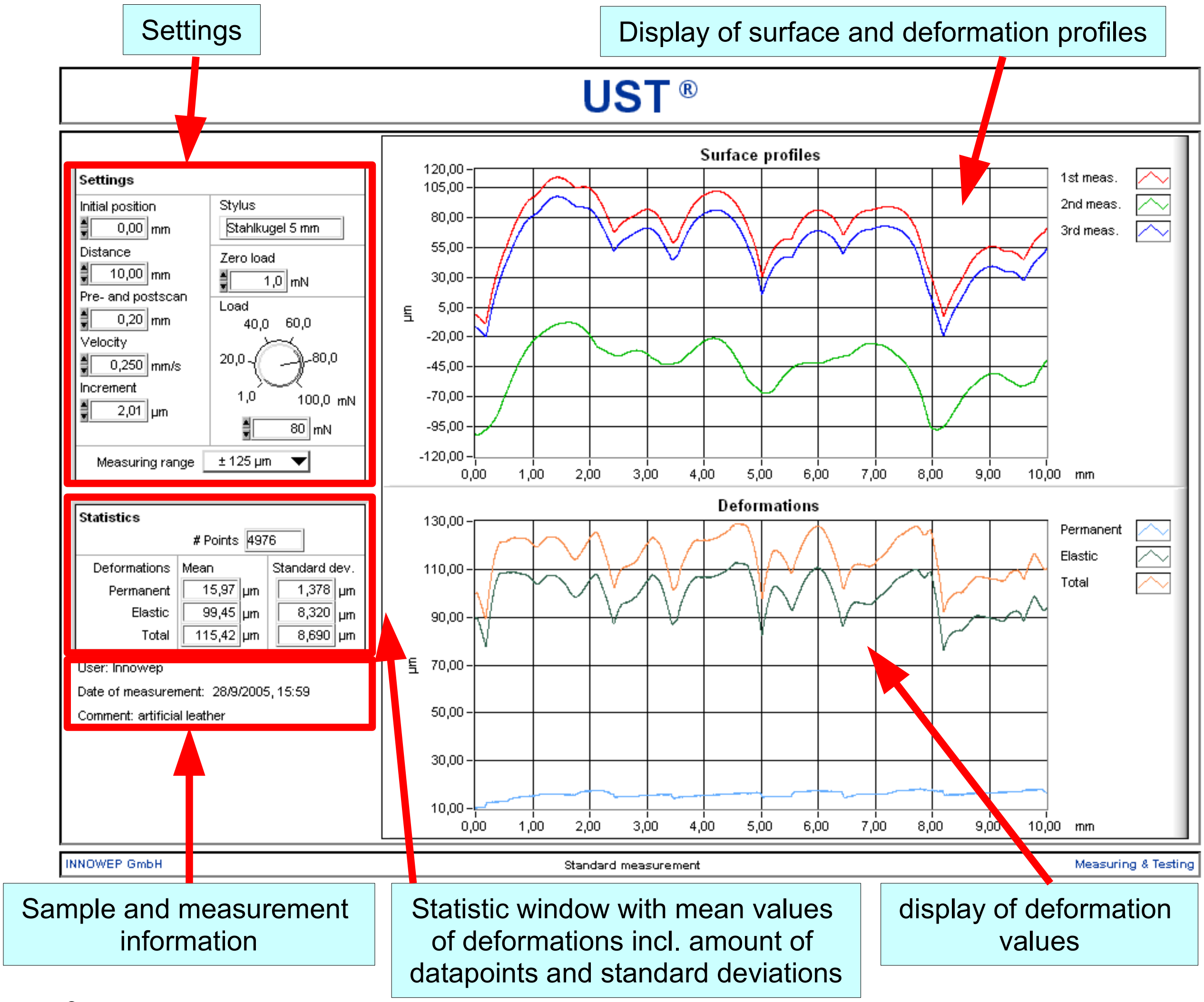
The measurement can be viewed online in the upper window. After it is finished the program calculates the deformation curves and displays them in the middle window.

Orange line	Total deformation
Green line	Elastic deformation
Light blue line	Permanent deformation



UST® software, 2D standard measurement

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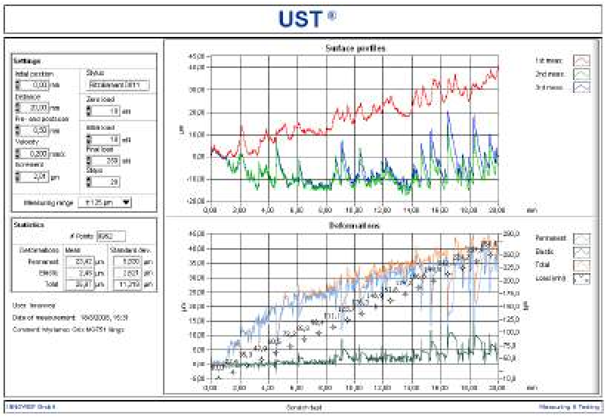
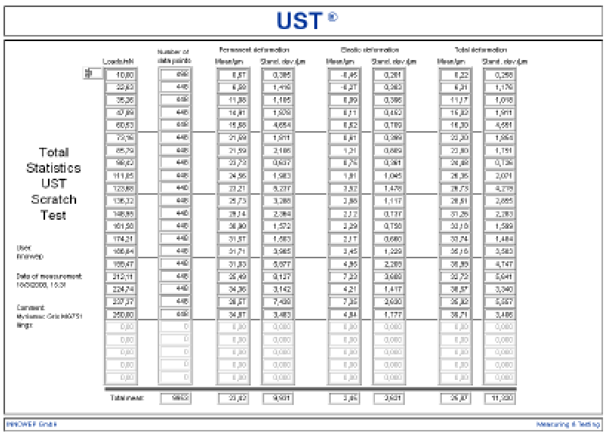
2.2 Scratch test

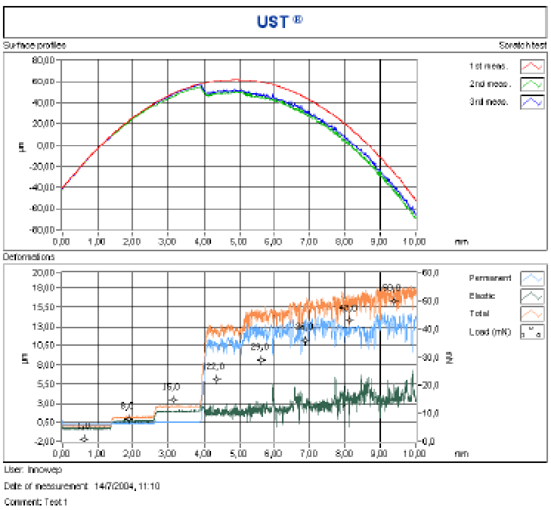
The scratch test module is based on the MISTAN® procedure. During the second step the load is increased stepwise to a final load. Depending on the UST® version there are start and final loads between 1 mN and 1000 mN possible. The number of load steps can be chosen from 1 to 100 steps.



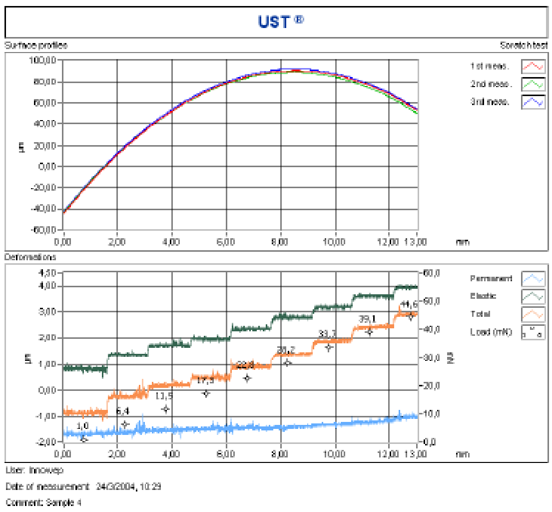
As a result the total as well as the permanent and elastic deformation values are given. Additionally, a statistic for each individual load step can be listed.



Formation of a scratch (loss of material)



Formation of a groove (no loss of material)



Examples for typical damages during a scratch test

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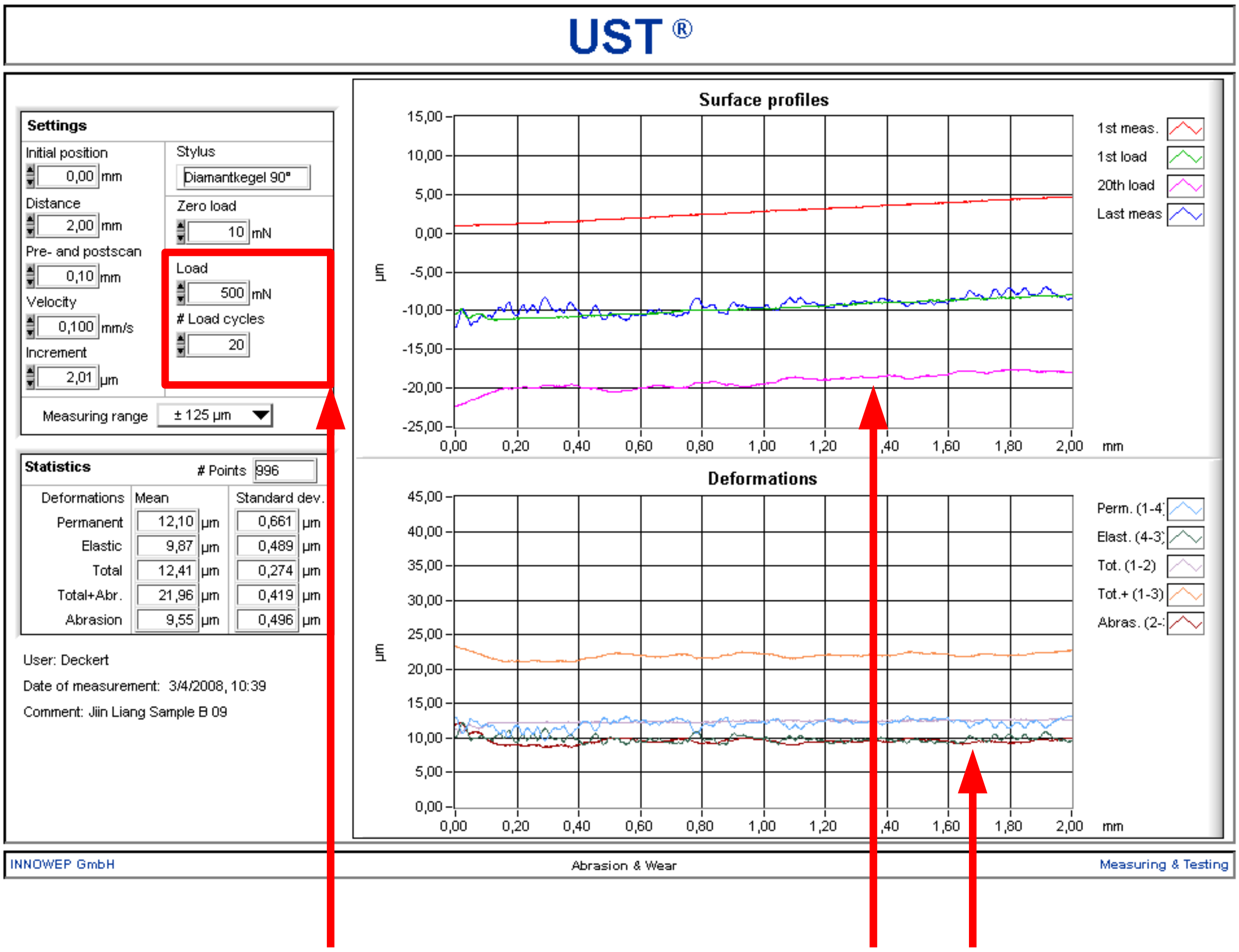
2.3 Abrasion

The abrasion module is based on the MISTAN® principle though the second step under load is repeated arbitrary times. So, besides the elastic and permanent deformations also the abrasion behavior under defined parameters can be investigated.



A change of the mistan-procedure allows a repetition of the second load step (constant load) as often as wanted. The so obtained identification of deformations and amount of abraded material yields a clearly understandable locally differentiated statement for the wear resistance. All areas of interest can be zoomed out for a deeper investigation.

Additional to the three surface and deformations profiles within the standard measurement, the UST® records the last load step of the abrasion test. The difference between the first and the last load cycle gives the local value of abrasion.

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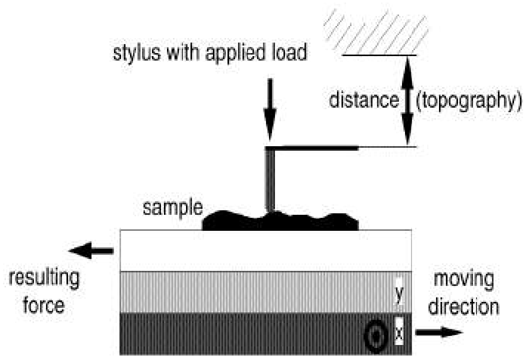
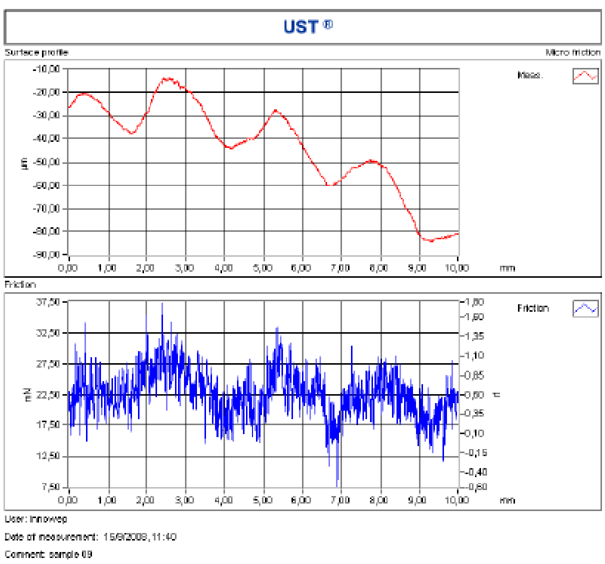
2.4 Micro friction

With the additional module "Micro friction" the analysis possibilities of the Universal Surface Tester are enhanced by the measured value of friction forces. It can be used as a standalone module or be combined with the standard measurement or scratch test. The measurement table (picture on the right) is mounted on the processing table, which is applied by the friction force. The counter-body on the sample, is detected by a highly sensitive piezo sensor, which is integrated into the measuring table. The measurement module can be used for haptical as well as microtribological investigations on flat and structured surfaces. In contrast to conventional force gauges the sensor has an extremely high frequency and stiffness and is therefore able to measure highly dynamic, without proper inertia, and with an extremely high local resolution. The module enables measurements in a large effective range with high force resolution in the sub-nm regime.

In the upper window of the micro friction software module the actual profile of the surface structure is displayed. In the lower window the friction forces during measurement are displayed. When the measurement is finished the averaged friction forces and friction coefficient μ are displayed in the statistics window.





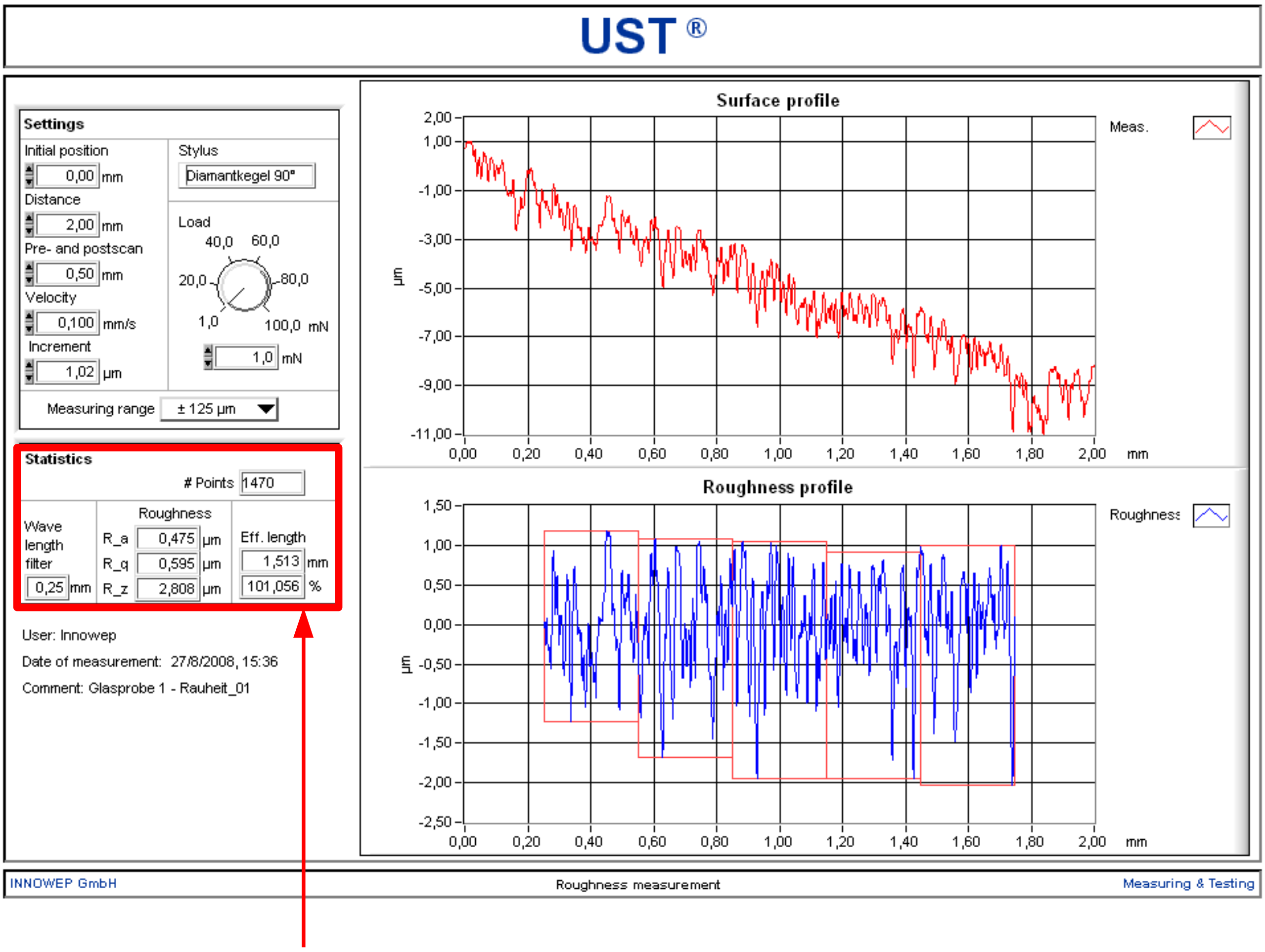
⇦ Surface structure

⇦ locally resolved, corresponding dynamic micro force signal

2.5 Roughness according to DIN EN ISO 4287

With the roughness module the roughness of a surface is evaluated according to DIN EN ISO 4287 bestimmt. The surface is scanned with a freely definable load. Afterwards the roughness values R_a, R_q and R_z are calculated automatically. With this module the roughness values can also be evaluated from previous standard, 3D standard, 3D topography, scratch or abrasion measurements.

In the upper window the surface profile is shown, in the lower window the roughness after subtraction of a linear offset and calculation with a selectable wavelength filter is displayed graphically. The statistic analysis is displayed in the lower left part of the measurement window.

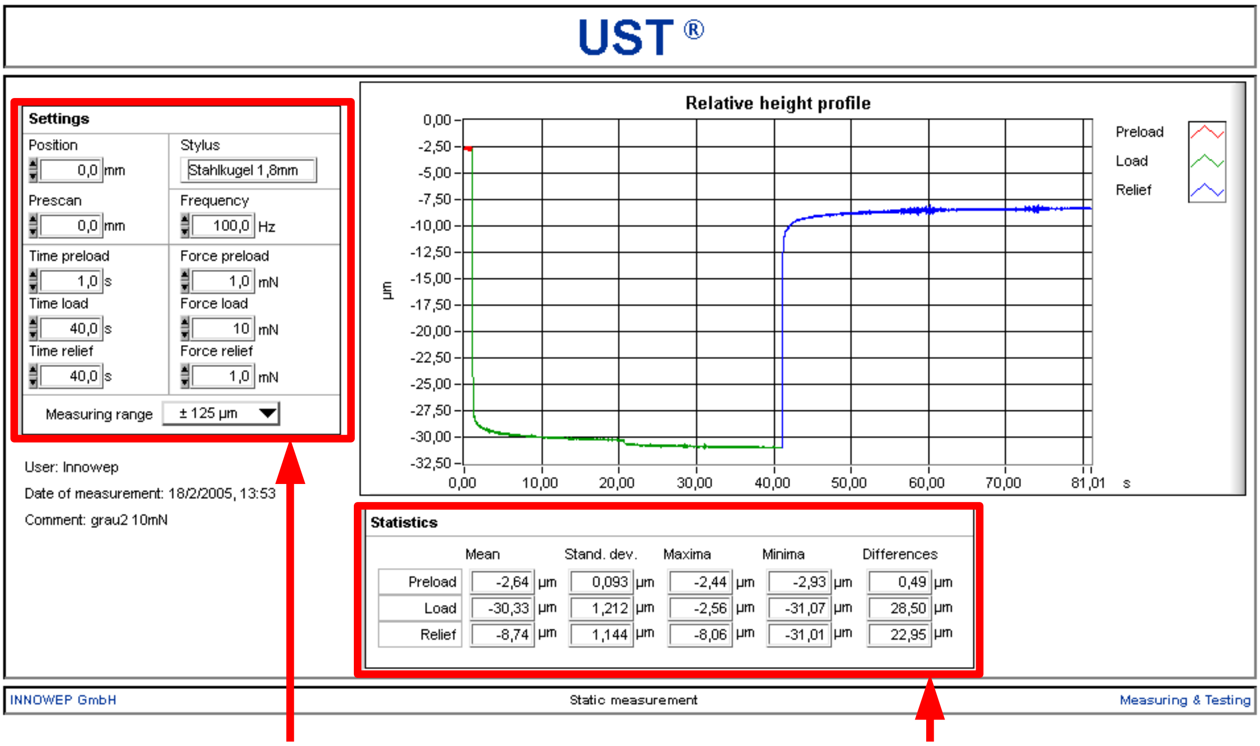


The wavelength filter is chosen automatically according to the international norm. To get additional information or to calculate the roughness of small surfaces the wavelength filter can also be chosen by hand.

Additionally to the roughness values R_a, R_q and R_z the system evaluates the effective length in mm and as percentage of the total measuring distance.

2.6 Viscoelasticity / Static measurement

For assessment of the viscoelastic material properties, a selective analysis is taken out and presented as a function of time. During the load duration, a characteristic material behavior can be observed: the material resistance under load (green line). During the relief stage a period of complete resetting of the elastically deformed part can be seen (blue line). The shape of the graph enables to understand the viscoelastic character of the material.



The graph is a function of time. Time and force of preload, load and relief can be set by the user.

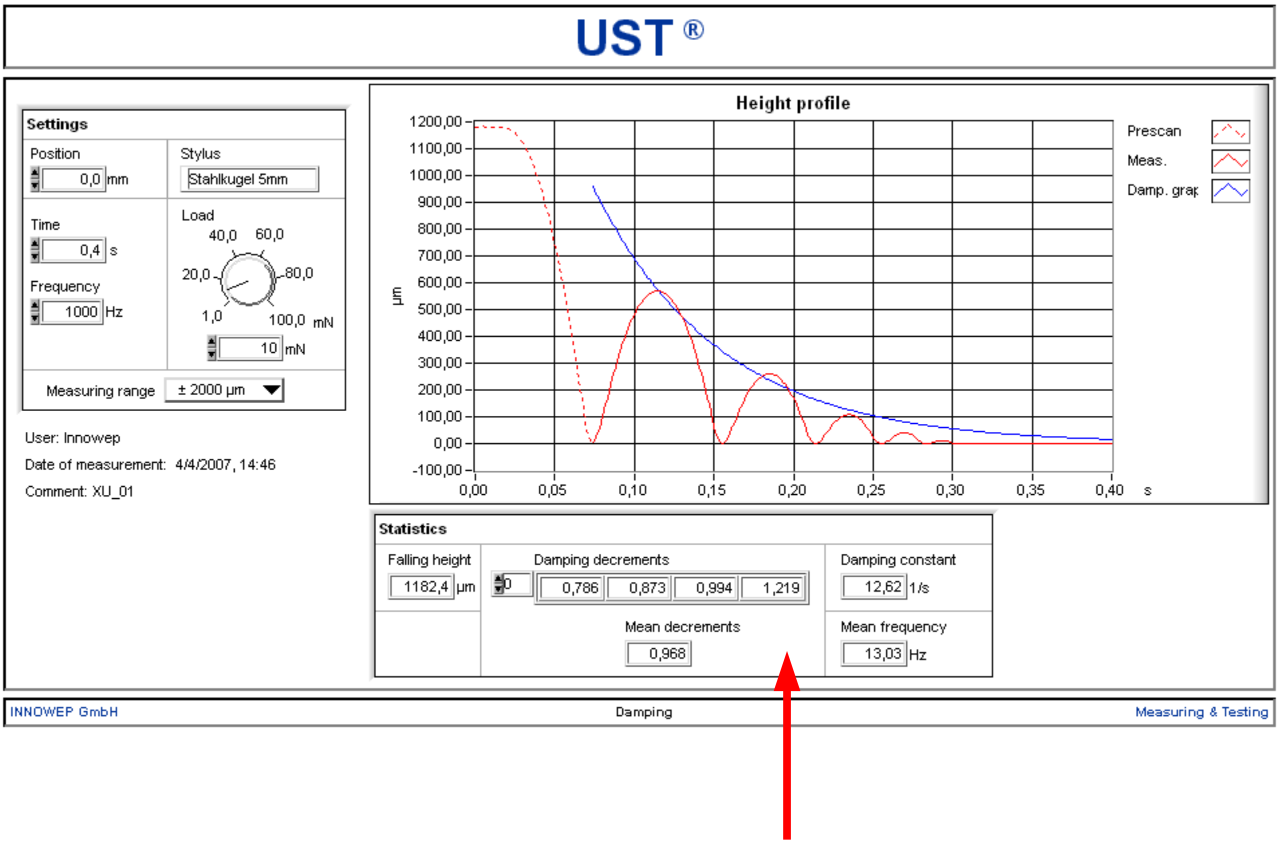
The differences in displacement under preload, load and relief are stated in the statistics box.

Based on this UST® module, many hardness and viscoelasticity measurements can be done according to international standards. Depending on the applied standard, a special tip geometry may be required.

2.7 Damping

The elastic properties of soft materials can be examined especially well with the damping module. The stylus is dropped from a defined height with a defined load onto the sample surface. The height signal is recorded during fall and bouncing.

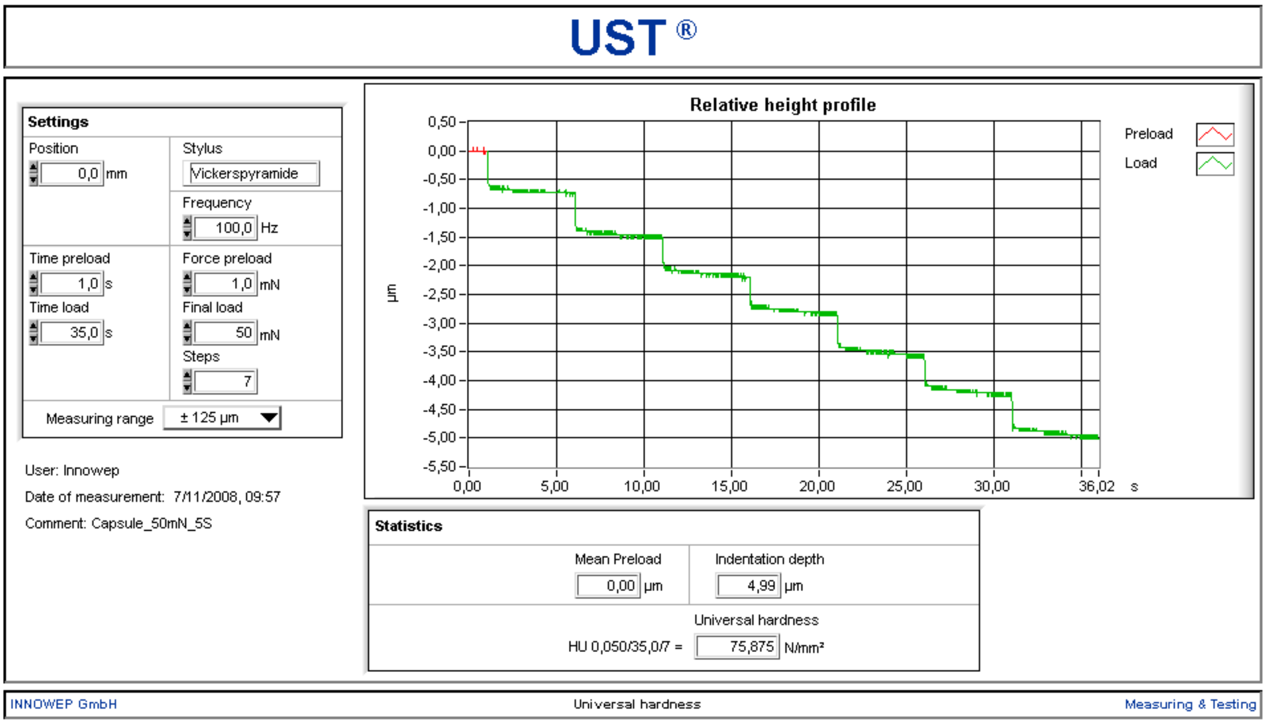
Depending on material, stylus and load the tip will bounce off the surface for a couple of times. The result is a damped oscillation, displayed in the graph window and evaluated for damping constant and mean frequency.



In the statistics windows below the graph window the falling height of the stylus, the first four damping decrements, their mean value, the damping constant and the mean frequency of oscillation are displayed.

2.8 Universal hardness

The measurement mode “Universal hardness” enables the evaluation of hardness values according to DIN EN ISO 14577-1. It consists of two steps: A predefined load will be applied to the stylus for a given time (preload). After that the load on the stylus will be increased stepwise over a predefined period. During the whole measuring time the signal of the stylus will be recorded. Finally the universal hardness is calculated from the total deformation that has been measured.



The universal hardness is given e.g. as HU 0.050/35.0/7 (see picture above) which means

HU: universal hardness measurement

0.050: final load in N (here 50 mN)

35.0: time of load in s (here 35 s)

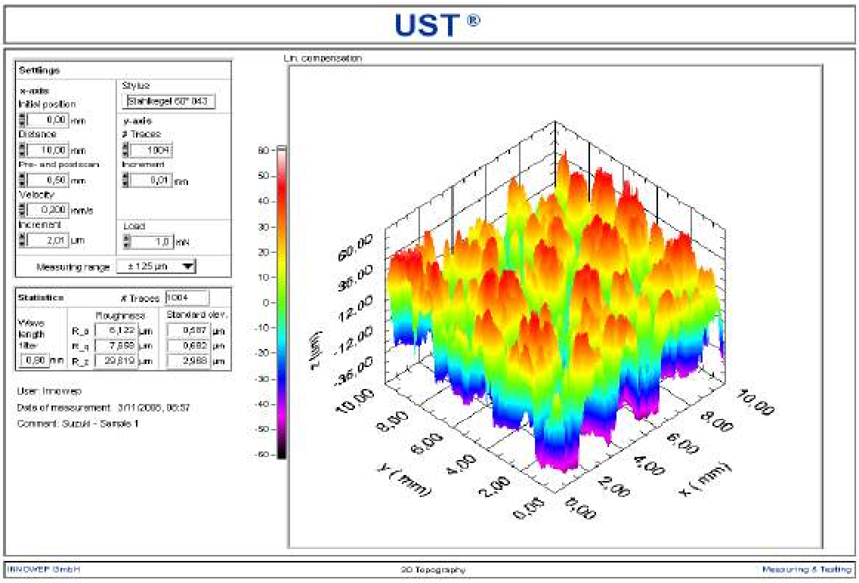
7: number of steps (here 7)

The unit of the universal hardness is [N/mm²].

2.9 3D topography

For the 3D topography measurement the height profile is scanned over several parallel lines. The distance in y-direction between these lines is freely adjustable. During measurement the height profile of each line is shown. Afterwards, the 3D topography is shown but can be switched to a 2D view of each line. In the lower left corner the statistics of the roughness values can be found.

In a special height cut mode it is possible to evaluate particles and porosity.



3. Samples

We received nine different paper samples which were labeled as follows:

Sample	Reel
AAA	12345-6
BBB	4567-8
CCC	9875-8
DDD	24563-2
EEE	12587-4
FFF	135748-6
GGG	136587-5
HHH	35896-7
III	1238579-4

We made five measurements on the coated side and two measurements on the uncoated side. Each area of a measurement was marked with a square, the measurement itself was done inside of it. Each square was numbered.

For these UST measurements we chose two samples, CCC and FFF, and did measurements on the coated side.

4. Results

4.1 Standard measurement with micro friction

The measurement with the module "Standard measurement with micro friction" was performed with the following parameters:

Module	Standard measurement with micro friction
Stylus	steel cone, 60°
Zero load [mN]	1
Load [mN]	50
Distance [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.1
Increment [µm]	1.98

Sample CCC

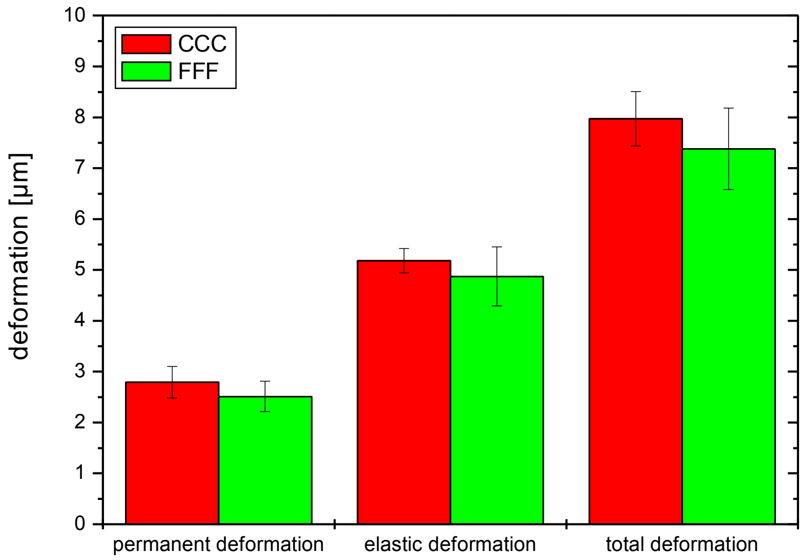
The measurement gave the following results, averaged over 2524 single points:

#	Deformations						Friction force	
	Permanent [µm]	σ [µm]	Elastic [µm]	σ [µm]	Total [µm]	σ [µm]	Force [mN]	σ [mN]
1	2.44	0.61	4.96	0.88	7.40	1.30	25.31	2.63
2	3.04	0.61	5.43	1.06	8.47	1.47	26.83	2.83
3	2.88	0.68	5.16	0.74	8.04	1.11	26.29	3.00
Average	2.79	0.31	5.18	0.24	7.97	0.54	26.14	0.77

Sample FFF

The measurement gave the following results, averaged over 2524 single points:

#	Deformations						Friction force	
	Permanent [µm]	σ [µm]	Elastic [µm]	σ [µm]	Total [µm]	σ [µm]	Force [mN]	σ [mN]
1	2.84	0.48	5.15	1.02	7.98	1.22	15.82	2.51
2	2.42	0.45	5.26	0.82	7.68	1.00	16.46	2.19
3	2.26	0.57	4.21	1.07	6.47	1.41	16.13	2.46
Average	2.51	0.30	4.87	0.58	7.38	0.80	16.14	0.32



Both deformations, elastic and permanent, are about 10 % higher on paper CCC. This could be due to the greater thickness of the paper. The standard deviation of paper FFF, especially of the elastic deformation, is significantly higher than of paper CCC. So, the material structure of paper FFF seems to be much more inhomogeneous.

The ratio between permanent and elastic deformation is about 1:2.

The difference in micro friction forces is much greater. The forces between paper and stylus on paper CCC are about 50 % higher than on paper FFF. So, the surface of paper CCC is more sticky, the surface of paper FFF is slicker.

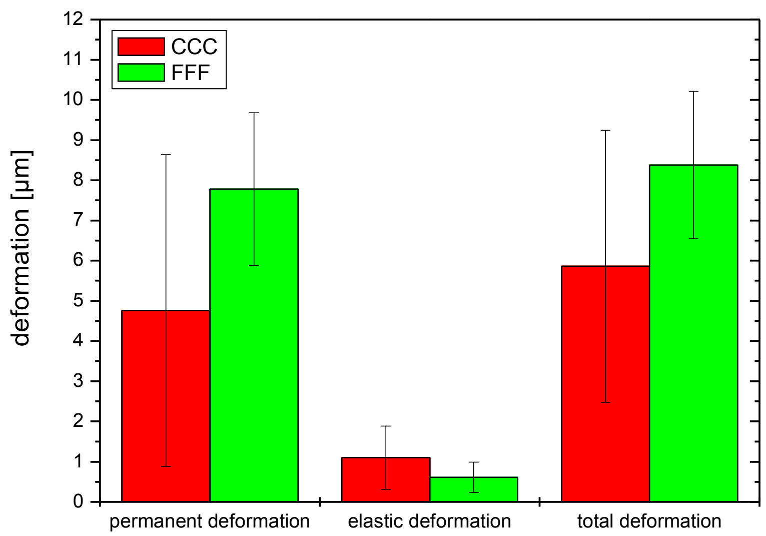
4.2 Scratch test with micro friction

The measurement with the module “Scratch test with micro friction” was performed with the following parameters:

Module	Scratch test with micro friction
Stylus	Scratch diamond
Zero load [mN]	1
Start load [mN]	1
End load [mN]	10
No. of load steps	10
Distance [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.1
Increment [µm]	1.98

In the following table the deformations of the highest load step at 10 mN are given. At this load step the result is averaged over 228 single points:

Sample	Deformations						Friction force	
	Permanent [µm]	σ [µm]	Elastic [µm]	σ [µm]	Total [µm]	σ [µm]	Force [mN]	σ [mN]
CCC	4.76	3.88	1.10	0.79	5.86	3.38	14.07	4.46
FFF	7.78	1.90	0.61	0.38	8.38	1.83	19.87	2.36



Although the load of 10 mN is much lower than in the “Standard measurement with micro friction” (50 mN) the permanent deformation and hence the damage of the coating is much greater. The ration between elastic and permanent deformation changed from 2:1 to 1:4 on paper CCC and 1:13 on paper FFF respectively. Although the coating on paper CCC seems to be much thicker the permanent deformation is not as great as on paper FFF. So, this coating is much more scratch resistant. But the large standard deviations, especially on paper CCC, are an indication that the dynamic process of scratching is in full motion.

The micro friction forces show a different behavior than in the “Standard measurement with micro friction”. Here, the forces on paper FFF are significantly higher. But this is due to the scratch process. The stylus is sinking deep into the coating thus the contact area between sample and stylus is much bigger resulting in higher friction forces.

4.3 Abrasion

The measurement with the module “Abrasion” was performed with the following parameters:

Module	Abrasion
Stylus	Steel cone 60°
Zero load [mN]	1
Load [mN]	50
Distance [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.1
Increment [µm]	2.01
No. of cycles under load	10

The measurement gave the following results, averaged over 2488 single points:

Sample	Deformations							
	Permanent [µm]	σ [µm]	Elastic [µm]	σ [µm]	Total [µm]	σ [µm]	Abrasion [µm]	σ [µm]
CCC	5.56	0.72	5.00	0.50	7.85	0.82	2.71	0.32
FFF	3.70	0.83	4.24	0.71	6.16	0.98	1.78	0.40

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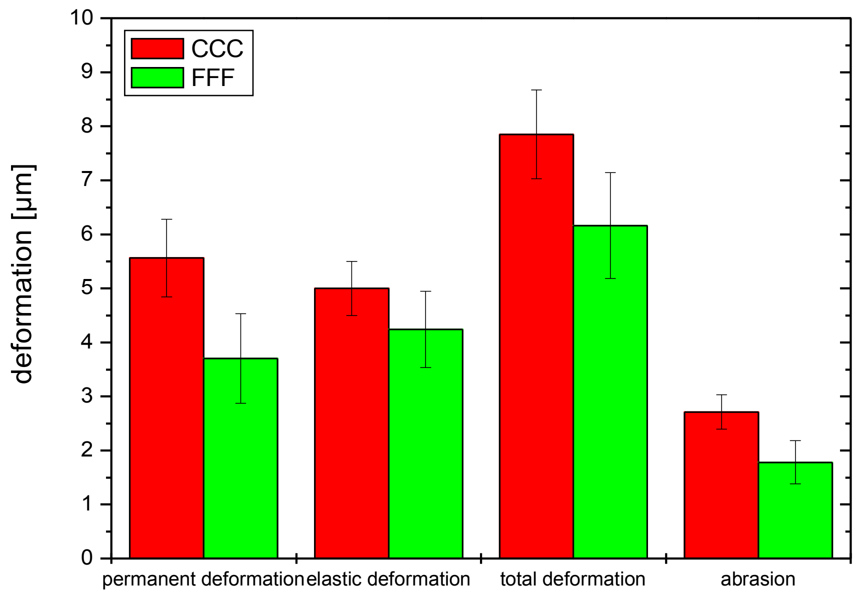


Just like in the “Standard measurement with micro friction” the deformations of paper CCC are greater than of paper FFF. The difference between the two papers are now greater due to the 10 times repeated load step. When using a steel cone stylus, no coating material has been abraded. The abrasion value is a measure for the degree of deformation during the 10 load steps. Paper CCC has a greater abrasion which is presumably due to the higher thickness of the coating.

4.4 Micro friction

The measurement with the module "Micro friction" was performed with the following parameters:

Module	Roughness
Stylus	Papillary stylus
Load [mN]	50
Distance [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.1
Increment [µm]	1.98

For this measurement a special haptics stylus was used. It is made of silicon rubber and has a special groove structure which simulates the human fingertip.

The measurement gave the following results, averaged over 2524 single points:

Sample CCC

#	Friction force [mN]	σ [mN]
1	52.73	1.22
2	54.11	1.53
3	55.89	1.52
Average	54.24	1.58

Sample FFF

#	Friction force [mN]	σ [mN]
1	49.40	1.76
2	47.46	0.91
3	49.33	1.07
Average	48.73	1.10

Paper CCC has significantly higher micro friction forces.

4.5 Roughness

The measurement with the module “Roughness” was performed with the following parameters:

Module	Roughness
Stylus	Steel cone 60°
Load [mN]	1
Distance [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.1
Increment [µm]	1.98

A wavelength filter of 0,80 mm was used. The measurement gave the following results, averaged over 1715 single points:

Sample CCC

#	Roughness values		
	R_a [µm]	R_q [µm]	R_z [µm]
1	0.717	0.907	3.580
2	0.918	1.257	4.470
3	0.850	1.064	4.183
Average	0.828	1.076	4.078

Sample FFF

#	Roughness values		
	R_a [µm]	R_q [µm]	R_z [µm]
1	0.563	0.691	2.977
2	0.447	0.562	2.421
3	0.618	0.790	3.552
Average	0.543	0.681	2.983

Paper CCC is significantly rougher than paper FFF.

4.6 Viscoelasticity / Static measurement

The measurement with the module “Static measurement” was performed with the following parameters:

Module	Static measurement
Stylus	Aluminum ball, ∅ 20 mm
Time preload [s]	300
Load preload [mN]	1
Time load [s]	3600
Load [mN]	100
Time relief [s]	1800
Load relief [mN]	1
Frequency [Hz]	100

The measurement gave the following results:

Sample	Viscoelasticity		
	Difference load [µm]	Difference relief [µm]	Ratio load / relief [%]
CCC	8.30	6.35	76.51
FFF	8.61	4.09	47.50

The creeping and recovery processes on paper FFF occur much faster and abrupt than on paper CCC. This could be due to the lower thickness of the paper and the coating. The absolute relief of paper CCC is 50 % higher than of paper FFF. This confirms the result of the “Scratch test with micro friction”. Here and there is the permanent deformation of paper CCC lower.

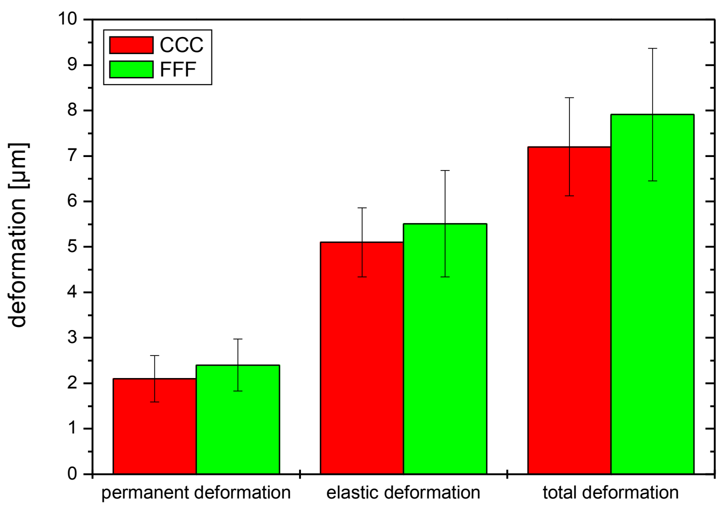
4.7 3D standard measurement

The measurement with the module "3D standard measurement" was performed with the following parameters:

Module	3D standard measurement
Stylus	Steel cone 60°
Zero load [mN]	1
Load [mN]	50
Distance x direction [mm]	5
Distance y direction [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.25
Increment x direction [µm]	2.01
Increment y direction [mm]	0.02

The measurement gave the following results, averaged over 624739 single points:

Sample	Deformations					
	Permanent [µm]	σ [µm]	Elastic [µm]	σ [µm]	Total [µm]	σ [µm]
CCC	2.10	0.51	5.10	0.76	7.20	1.08
FFF	2.40	0.57	5.51	1.17	7.91	1.46



These values not only confirm the results of the "Standard measurement with micro friction", they should also be more accurate because of the bigger data basis.

4.8 3D Topography

These measurements were done on the same spot as one of the TRACEiT® measurements for direct comparison. On paper CCC the test was performed in square 4 and on paper FFF in square 5.

The measurement with the module “3D topography” was performed with the following parameters:

Module	3D topography
Stylus	Steel cone 60°
Load [mN]	50
Distance x direction [mm]	5
Distance y direction [mm]	5
Pre- and post scan [mm]	0.5
Velocity [mm/s]	0.25
Increment x direction [µm]	2.01
Increment y direction [mm]	0.02

From the topographies, the roughness values R_a, R_q and R_z are calculated over 251 lines:

Sample	Roughness values					
	R_a [µm]	σ [µm]	R_q [µm]	σ [µm]	R_z [µm]	σ [µm]
CCC	0.86	0.12	1.08	0.15	4.16	0.55
FFF	0.56	0.06	0.70	0.08	2.97	0.33

These values not only confirm the results of the “Roughness measurement”, they should also be more accurate because of the bigger data basis.

5. Summary

One of the advantages of the UST® is the comparative measurement. Measuring different samples, the properties, advantages and disadvantages of the material structure can be clearly determined in situ and with high local resolution.

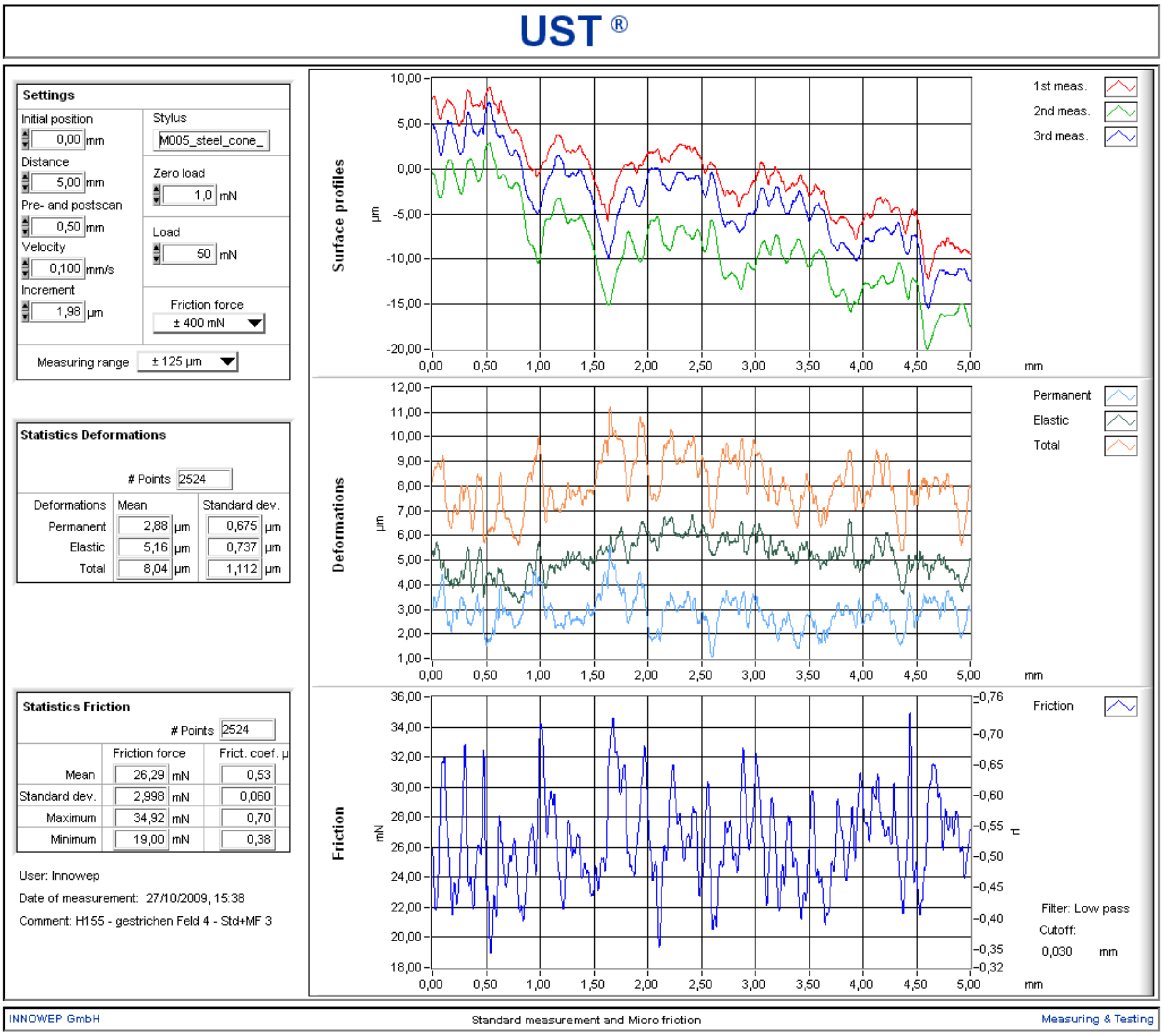
Die zur Verfügung stehende Probe wurde exemplarisch mit dem UST® hinsichtlich ihrer funktionalen Systemeigenschaften untersucht. Dafür wurden insgesamt sechs Module verwendet. Alle Module konnten problemlos durchgeführt werden und zeigten keine Messfehler.

For questions concerning the results, the UST® apparatus or further investigations you can ask us at any time.

6. Appendix

6.1 Measurement window “Standard test with micro friction”

Sample CCC (example)



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Sample FFF

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Settings

Initial position	0,00 mm
Distance	5,00 mm
Pre- and postscan	0,50 mm
Velocity	0,100 mm/s
Increment	1,98 µm
Stylus	M005_steel_cone_
Zero load	1,0 mN
Load	50 mN
Friction force	± 400 mN
Measuring range	± 125 µm

Statistics Deformations

Points 2524

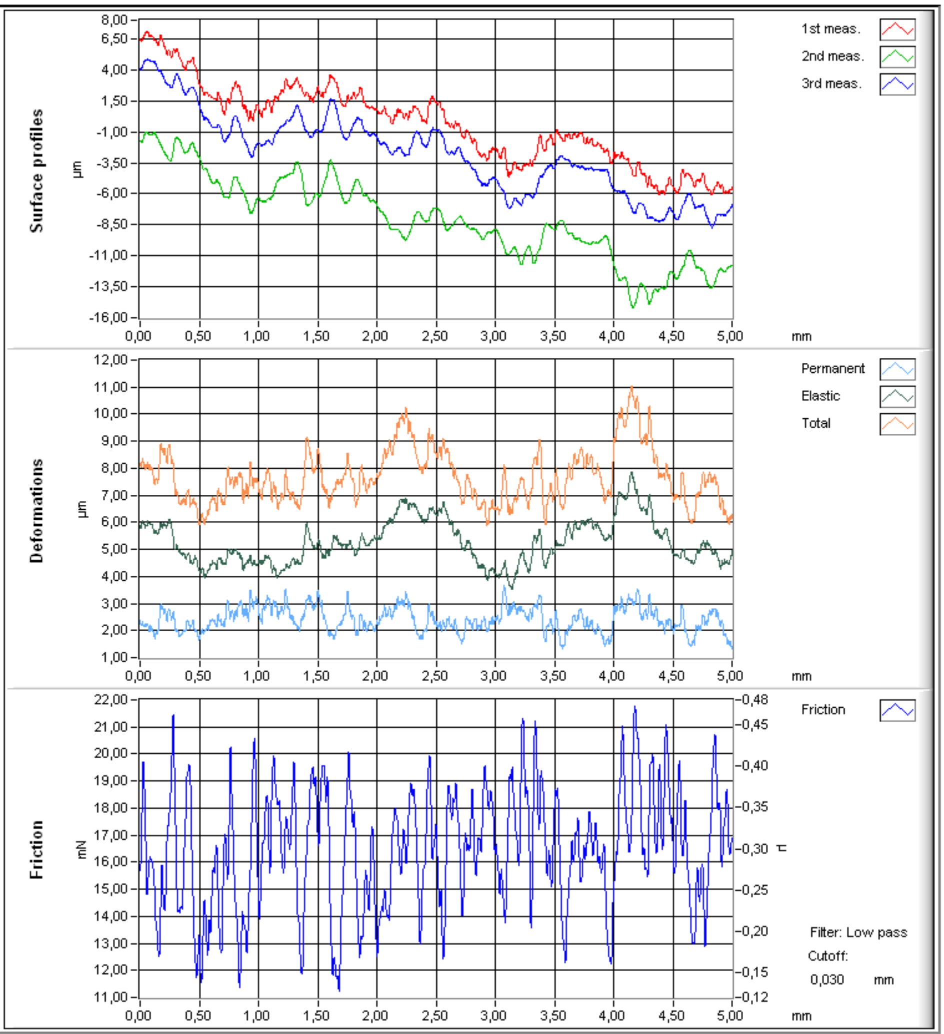
Deformations	Mean	Standard dev.
Permanent	2,42 µm	0,446 µm
Elastic	5,26 µm	0,821 µm
Total	7,68 µm	1,001 µm

Statistics Friction

Points 2524

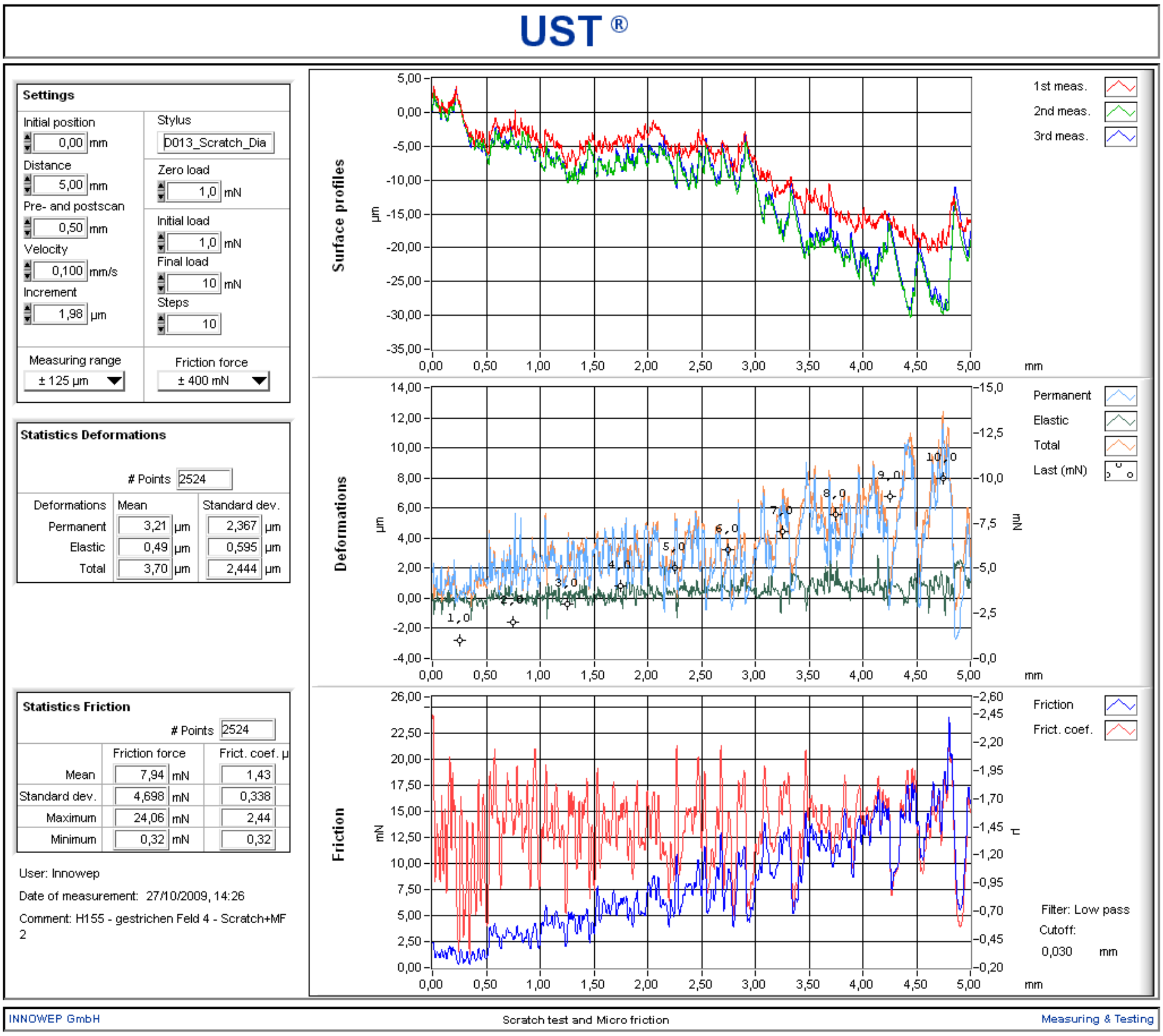
	Friction force	Frict. coef. µ
Mean	16,46 mN	0,33
Standard dev.	2,194 mN	0,044
Maximum	21,75 mN	0,43
Minimum	11,25 mN	0,22

User: Innowep
Date of measurement: 27/10/2009, 10:03
Comment: T7032 - gestrichen Feld 5 - Std+MF 2



6.2 Measurement window “Scratch test with micro friction”

Sample CCC



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Total Statistics UST Scratch Test and Micro friction

User:
Innowep

Date of measurement:
27/10/2009, 14:26

Comment:
H155 - gestrichen Feld 4 - Scratch+MF 2

50

Loads/mN	Number of data points	Permanent deformation Mean/µm	Permanent deformation Stand. dev./µm	Elastic deformation Mean/µm	Elastic deformation Stand. dev./µm	Total deformation Mean/µm	Total deformation Stand. dev./µm	Friction force Mean/mN	Friction force Stand. dev./mN	Frict. coef. µ Mean	Frict. coef. µ Standard dev.
1,00	253	0,88	0,593	-0,17	0,263	0,72	0,535	1,23	0,445	1,22	0,448
2,00	227	1,90	0,941	0,08	0,278	1,98	0,857	3,08	0,596	1,54	0,302
3,00	227	2,35	0,815	0,16	0,347	2,51	0,881	4,33	0,830	1,44	0,276
4,00	227	2,96	1,155	0,27	0,388	3,23	0,943	5,81	0,787	1,45	0,193
5,00	227	2,83	1,424	0,46	0,412	3,30	1,342	7,16	1,479	1,43	0,296
6,00	227	1,90	1,431	0,66	0,304	2,57	1,364	7,68	2,252	1,28	0,375
7,00	227	4,22	2,071	0,68	0,545	4,89	1,806	10,31	2,347	1,47	0,335
8,00	227	4,67	1,429	0,93	0,472	5,60	1,229	11,93	1,349	1,49	0,166
9,00	227	5,86	2,709	0,73	0,551	6,60	2,531	13,85	2,651	1,54	0,294
10,00	228	4,76	3,881	1,10	0,792	5,86	3,383	14,07	4,463	1,41	0,446
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
Total mean	2524	3,21	2,387	0,49	0,595	3,70	2,444	1,43	0,338	1,43	0,338

Filter: Low pass
Cutoff:
0,030 mm

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Sample FFF

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Settings

Initial position	0,00 mm
Distance	5,00 mm
Pre- and postscan	0,50 mm
Velocity	0,100 mm/s
Increment	1,98 µm
Stylus	D013_Scratch_Dia
Zero load	1,0 mN
Initial load	1,0 mN
Final load	10 mN
Steps	10
Measuring range	± 125 µm
Friction force	± 400 mN

Statistics Deformations

Points 2524

Deformations	Mean		Standard dev.	
Permanent	5,66	µm	2,579	µm
Elastic	-0,06	µm	0,488	µm
Total	5,60	µm	2,891	µm

Statistics Friction

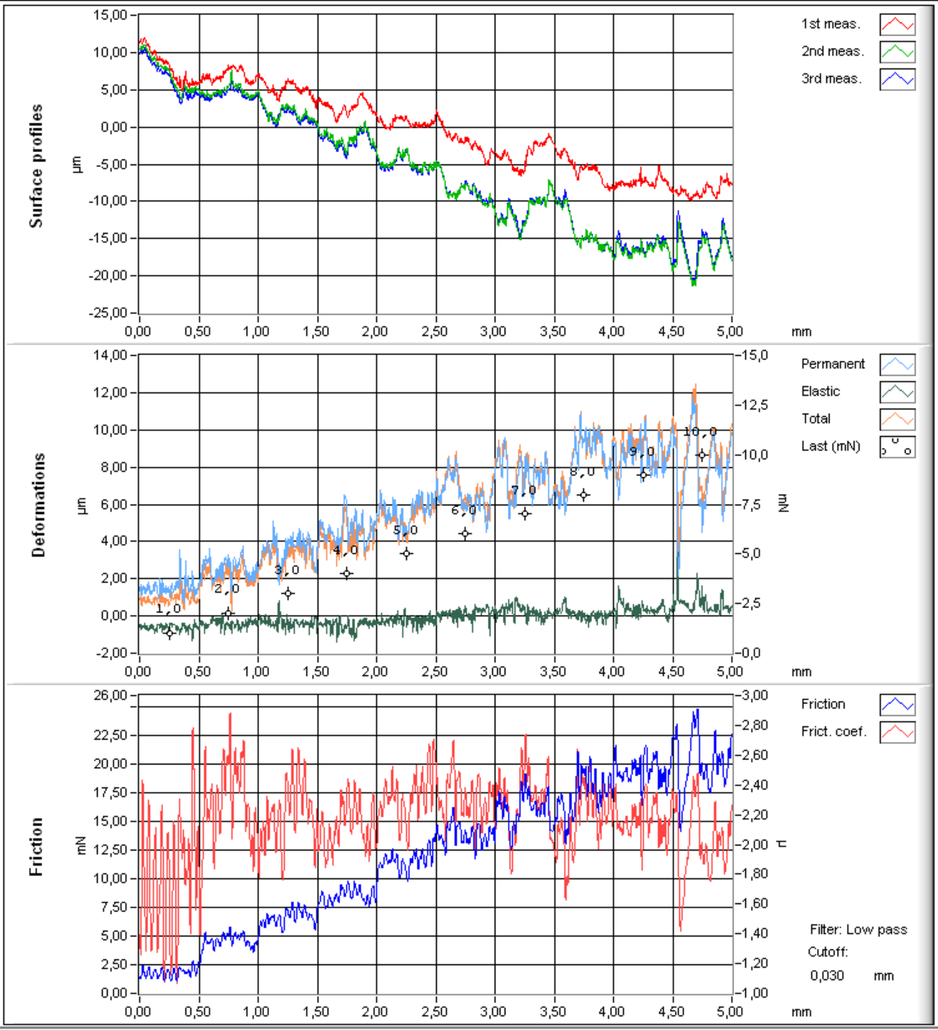
Points 2524

	Friction force		Frict. coef. µ
Mean	12,01	mN	2,17
Standard dev.	6,226	mN	0,269
Maximum	24,78	mN	2,88
Minimum	1,07	mN	1,07

User: Innowep

Date of measurement: 27/10/2009, 11:22

Comment: T7032 - gestrichen Feld 5 - Scratch+ MF 1



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Total Statistics UST Scratch Test and Micro friction

User:
Innowep

Date of measurement:
27/10/2009, 11:22

Comment:
T7032 - gestrichen Feld 5 - Scratch+MF 1

Filter: Low pass
Cutoff: 0,030 mm

		Permanent deformation		Elastic deformation		Total deformation		Friction force		Frict. coef. µ	
Loads/mN	Number of data points	Mean/µm	Stand. dev./µm	Mean/µm	Stand. dev./µm	Mean/µm	Stand. dev./µm	Mean/mN	Stand. dev./mN	Mean	Standard dev.
1,00	253	1,51	0,342	-0,61	0,147	0,90	0,287	1,80	0,389	1,79	0,378
2,00	227	2,57	0,482	-0,40	0,193	2,17	0,409	4,66	0,462	2,32	0,233
3,00	227	3,61	0,614	-0,37	0,237	3,25	0,545	6,68	0,604	2,23	0,200
4,00	227	4,63	0,666	-0,48	0,274	4,15	0,635	8,53	0,595	2,13	0,150
5,00	227	5,60	0,638	-0,23	0,222	5,37	0,595	11,69	0,637	2,33	0,162
6,00	227	6,54	0,886	0,15	0,266	6,69	0,886	13,85	0,672	2,31	0,147
7,00	227	7,28	0,978	0,23	0,313	7,52	0,956	16,02	1,400	2,28	0,202
8,00	227	8,53	1,256	0,09	0,272	8,63	1,132	17,62	1,717	2,20	0,214
9,00	227	8,72	0,740	0,36	0,254	9,08	0,749	19,45	1,029	2,16	0,113
10,00	228	7,78	1,898	0,61	0,377	8,38	1,827	19,87	2,359	1,99	0,236
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
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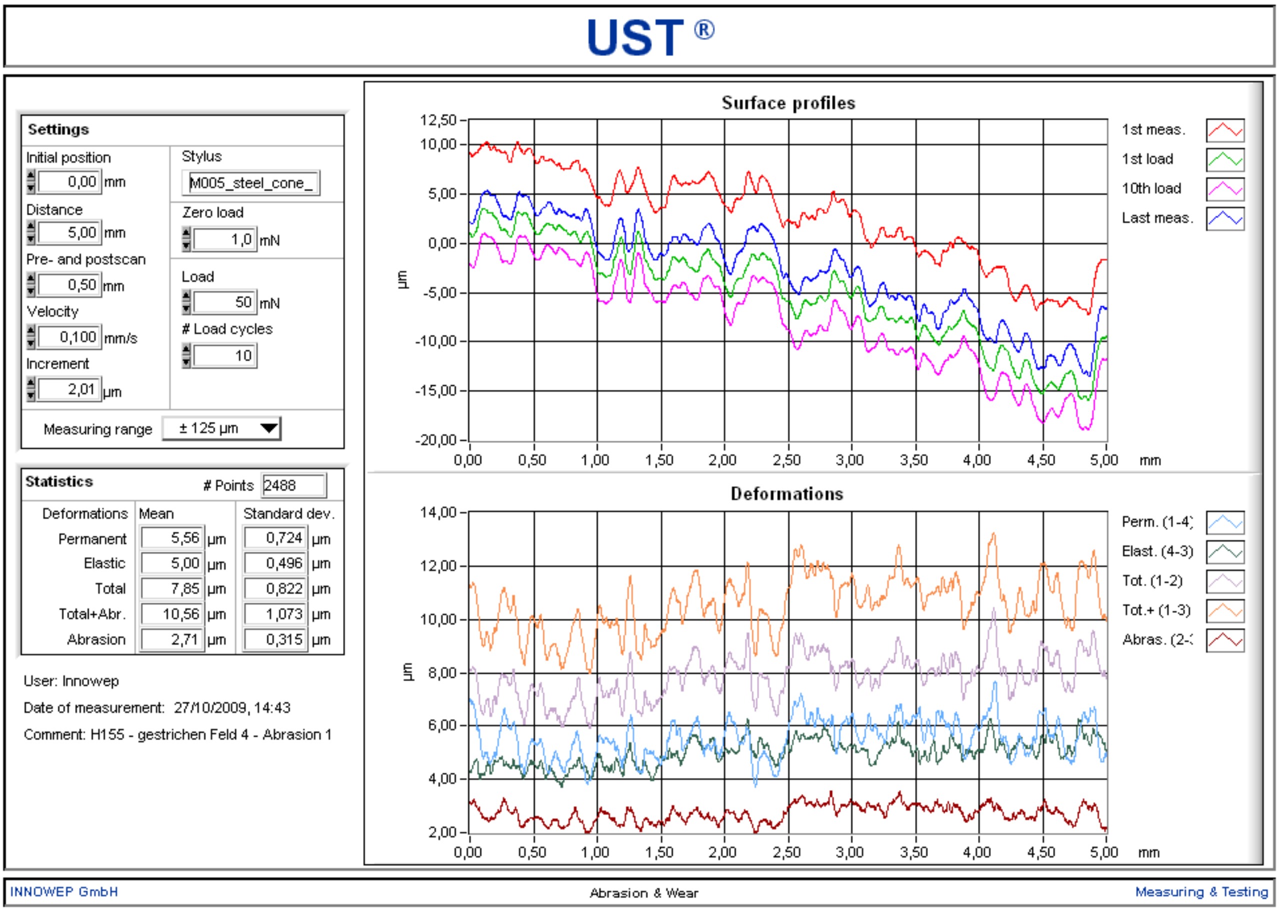
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
0,00	0	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000	0,00	0,000
Total mean	2524	5,66	2,579	-0,06	0,468	5,60	2,891	2,17	0,269	2,17	0,272

6.3 Measurement window "Abrasion"

Sample CCC



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Sample FFF

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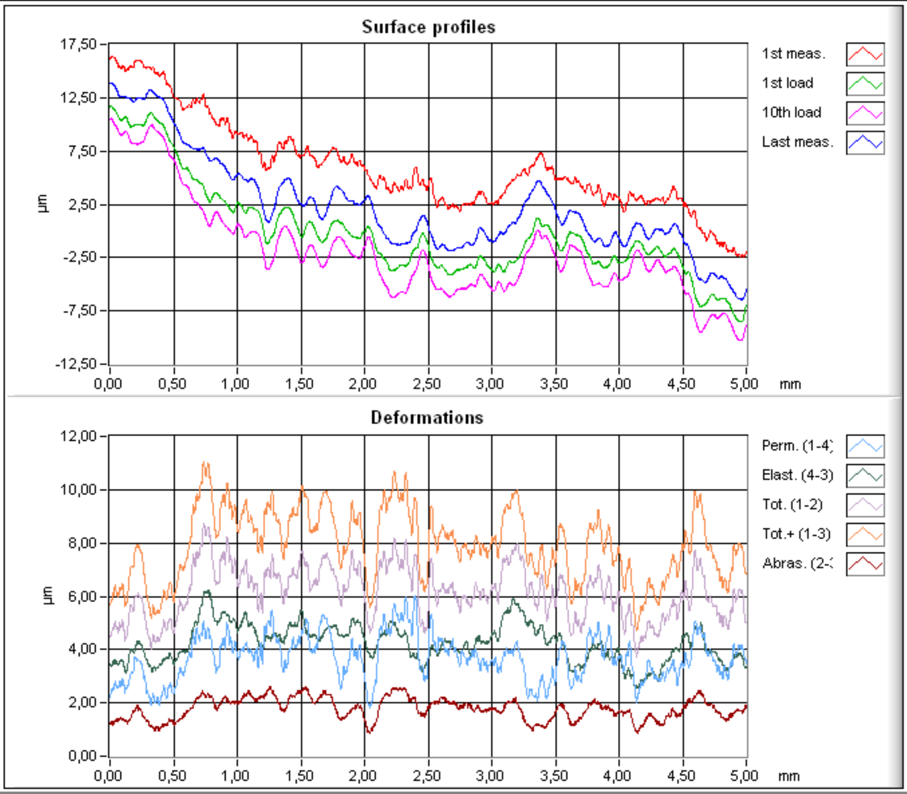
Settings

Initial position: 0,00 mm
Distance: 5,00 mm
Pre- and postscan: 0,50 mm
Velocity: 0,100 mm/s
Increment: 2,01 µm
Stylus: M005_steel_cone_
Zero load: 1,0 mN
Load: 50 mN
Load cycles: 10
Measuring range: ± 125 µm

Statistics — # Points: 2488

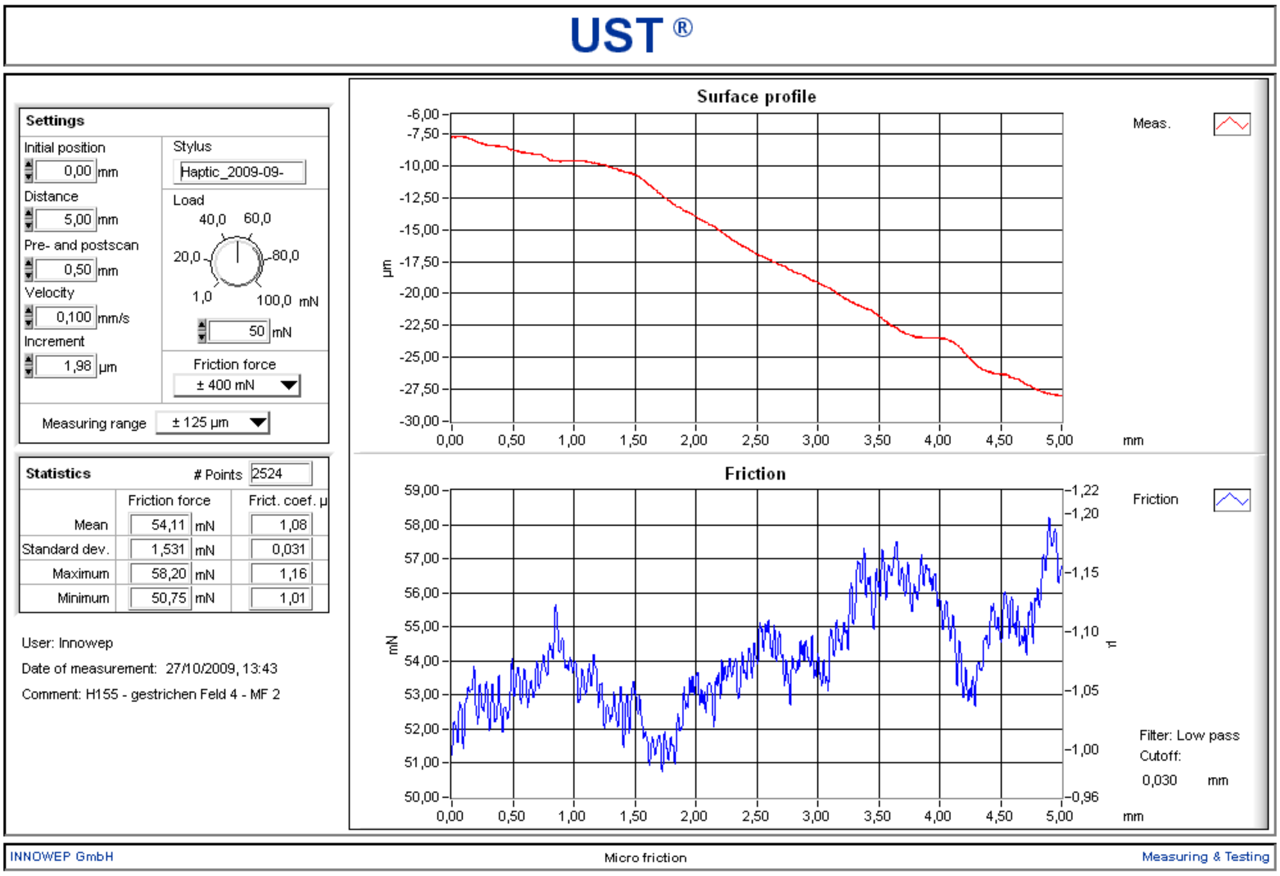
Deformations	Mean		Standard dev.	
Permanent	3,70	µm	0,833	µm
Elastic	4,24	µm	0,711	µm
Total	6,16	µm	0,984	µm
Total+Abr.	7,93	µm	1,324	µm
Abrasion	1,78	µm	0,404	µm

User: Innowep
Date of measurement: 27/10/2009, 10:40
Comment: T7032 - gestrichen Feld 5 - Abrasion 2



6.4 Measurement window “Micro friction”

Sample CCC (example)



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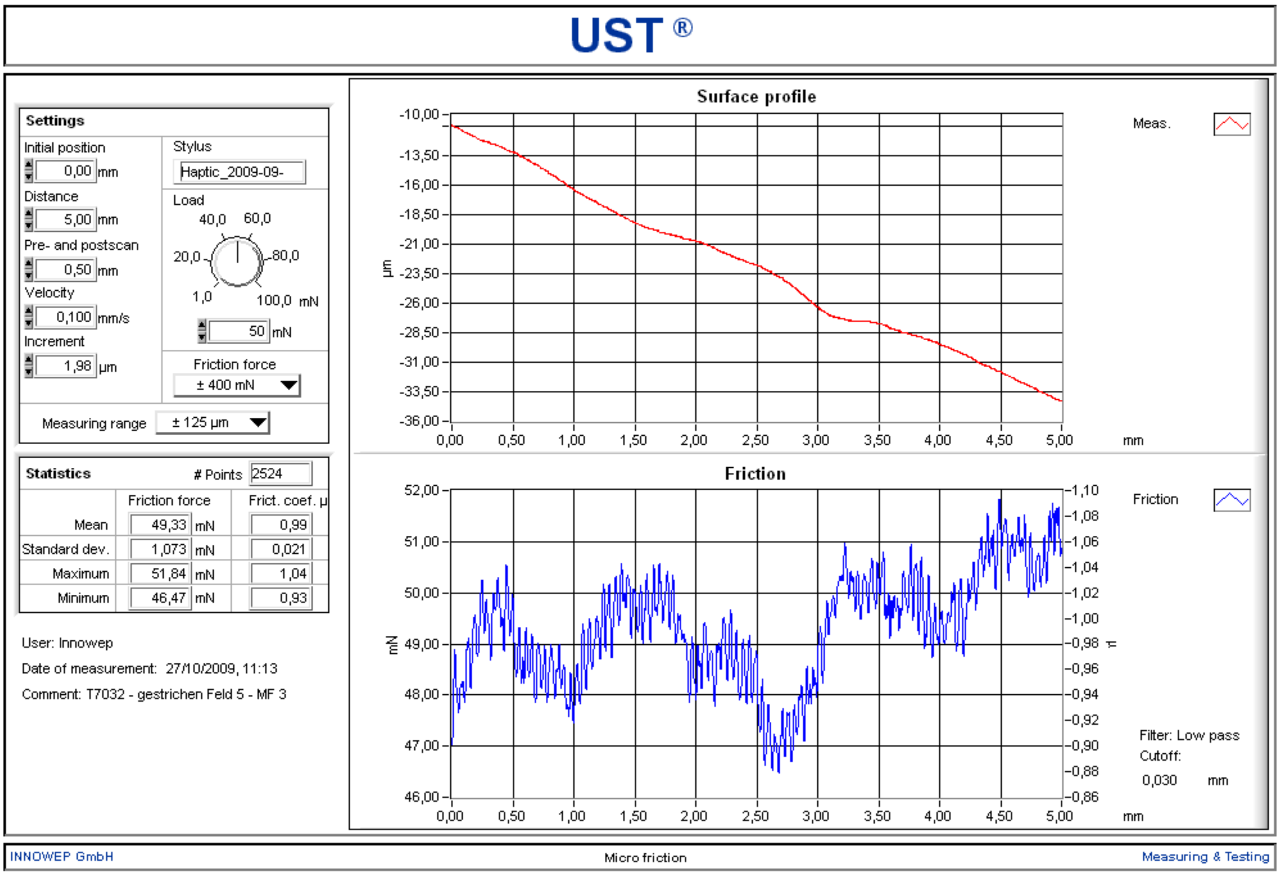
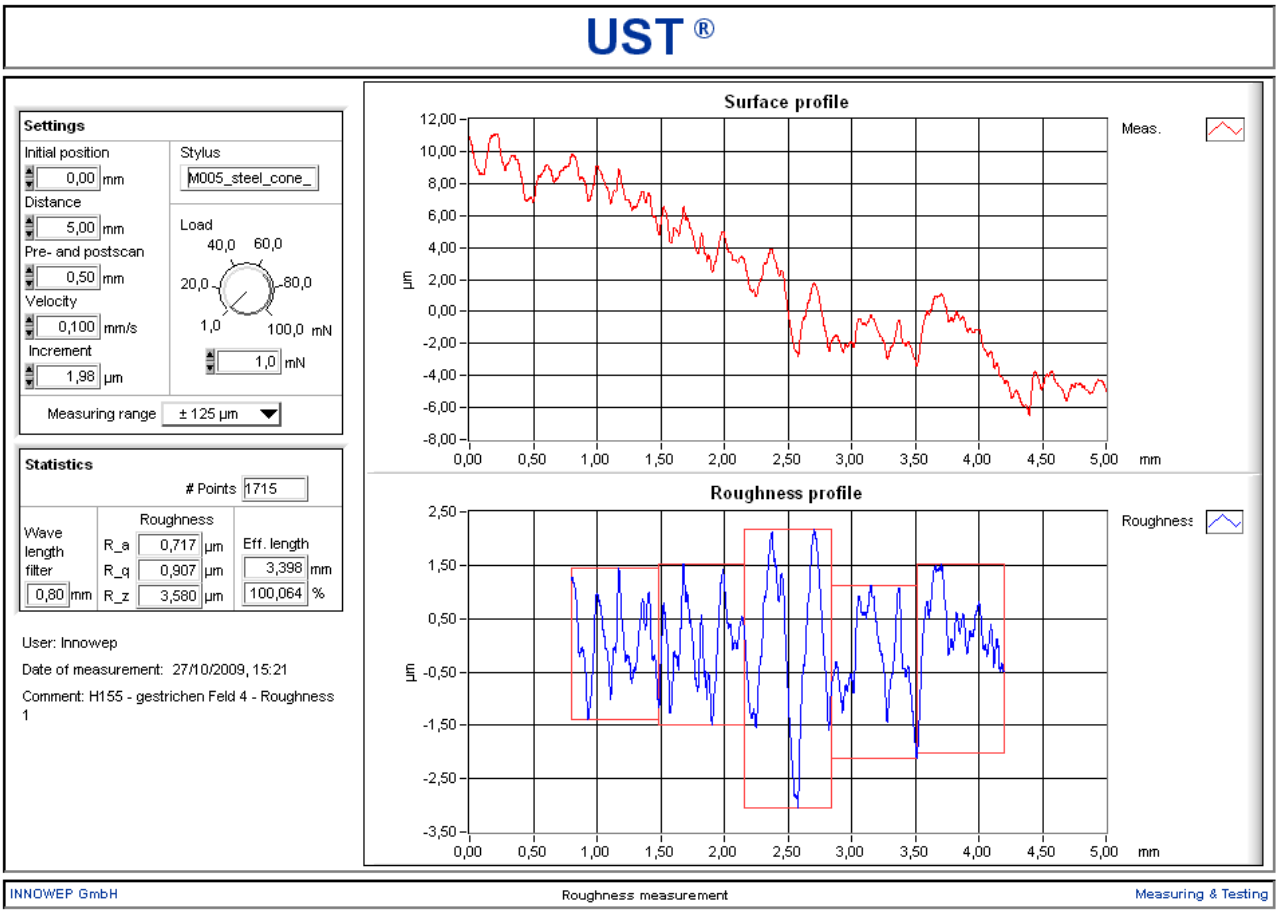
FFF (example)

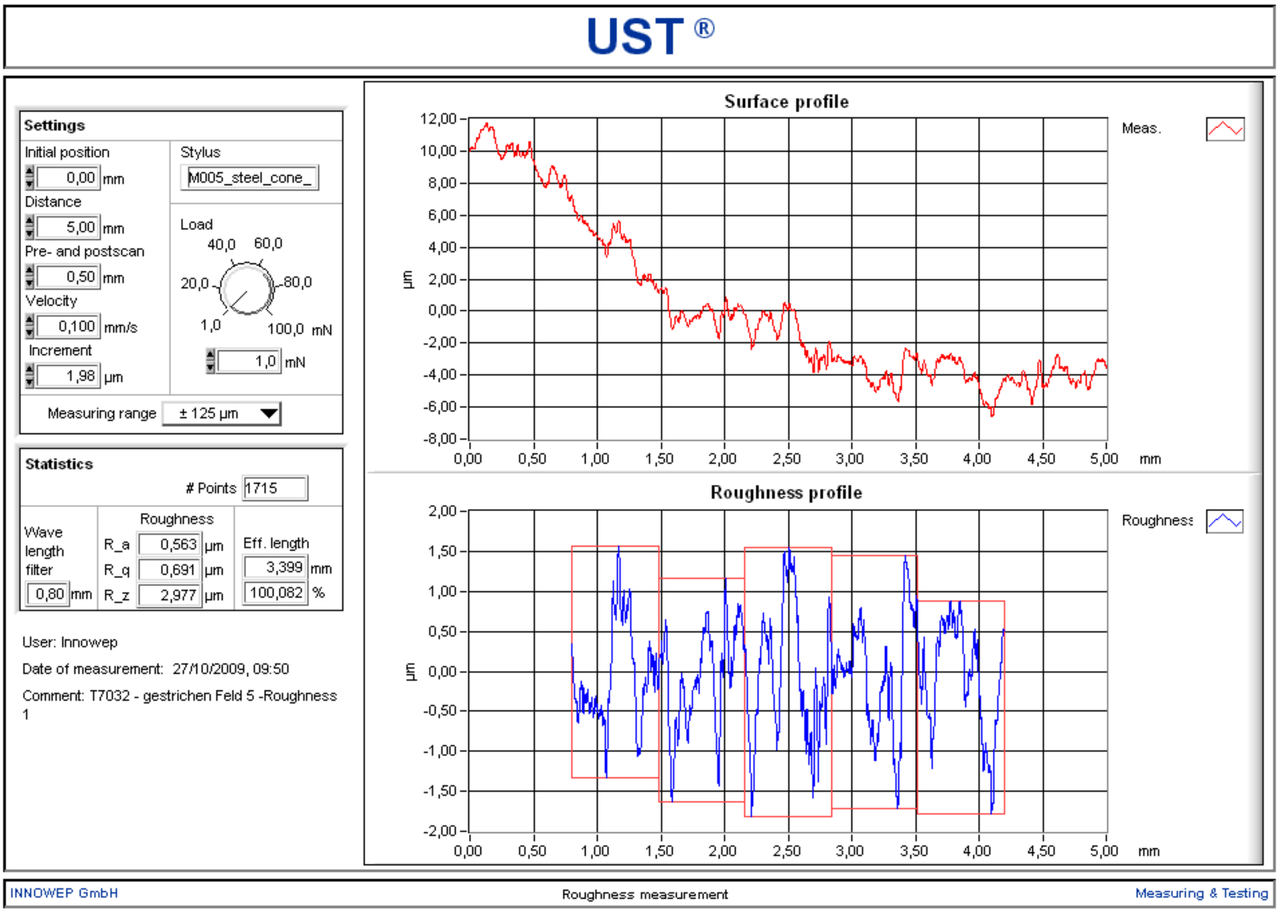


6.5 Measurement window “Roughness”

Sample CCC (example)

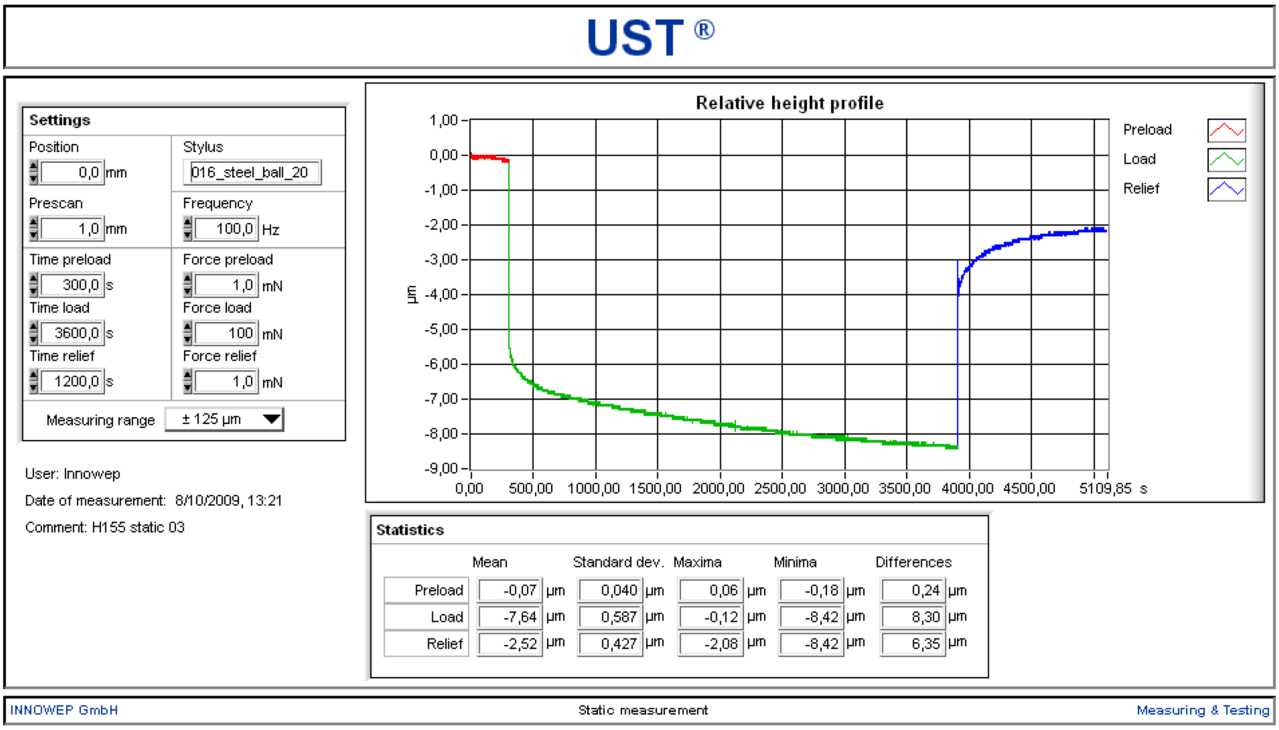


FFF (example)

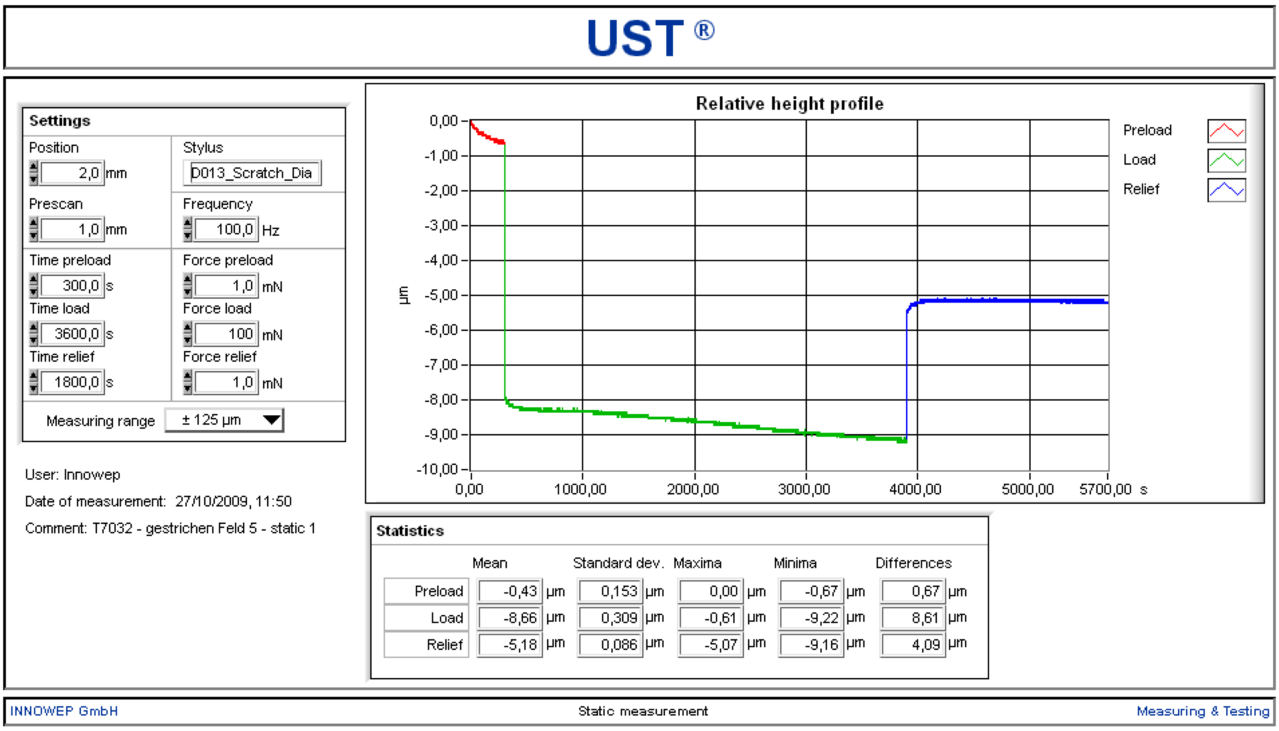

UST ®
Settings
Initial position 0,00 mm
Distance 5,00 mm
Pre- and postscan 0,50 mm
Velocity 0,100 mm/s
Increment 1,98 µm
Stylus M005_steel_cone_
Load
40,0 60,0
20,0 80,0
1,0 100,0 mN
1,0 mN
Measuring range ± 125 µm
Statistics
Points 1715
Roughness
Wave length filter 0,80 mm
R_a 0,563 µm
R_q 0,691 µm
R_z 2,977 µm
Eff. length 3,399 mm
100,082 %
User: Innowep
Date of measurement: 27/10/2009, 09:50
Comment: T7032 - gestrichen Feld 5 -Roughness 1
Surface profile
Meas.
µm
mm
Roughness profile
Roughness
INNOWEP GmbH
Roughness measurement
Measuring & Testing

6.6 Measurement window “Static measurement”

CCC

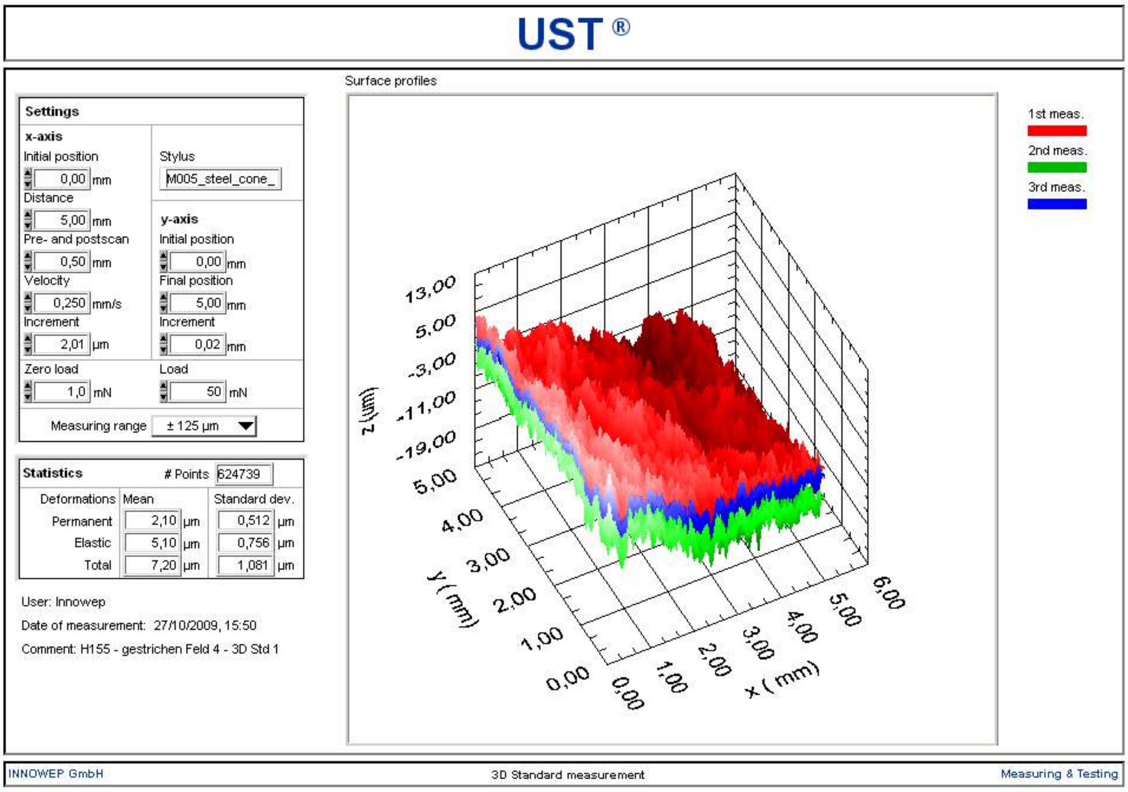


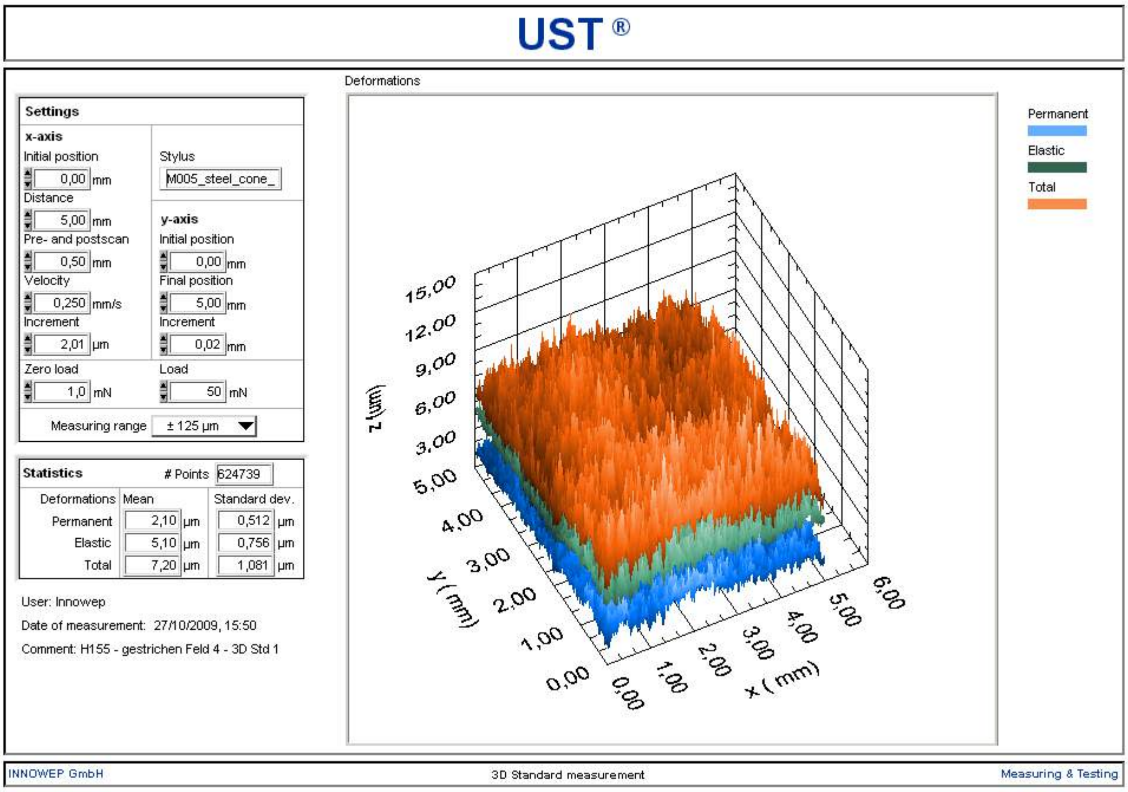
FFF



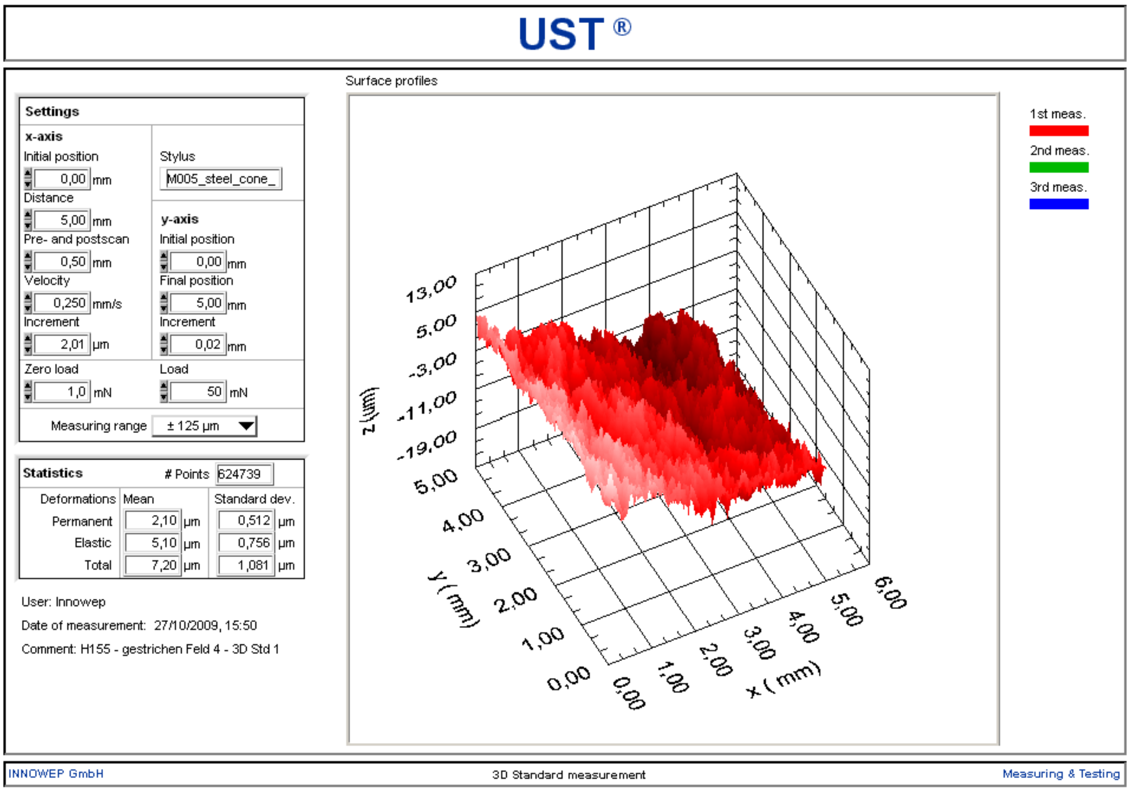
6.7 3D standard measurement

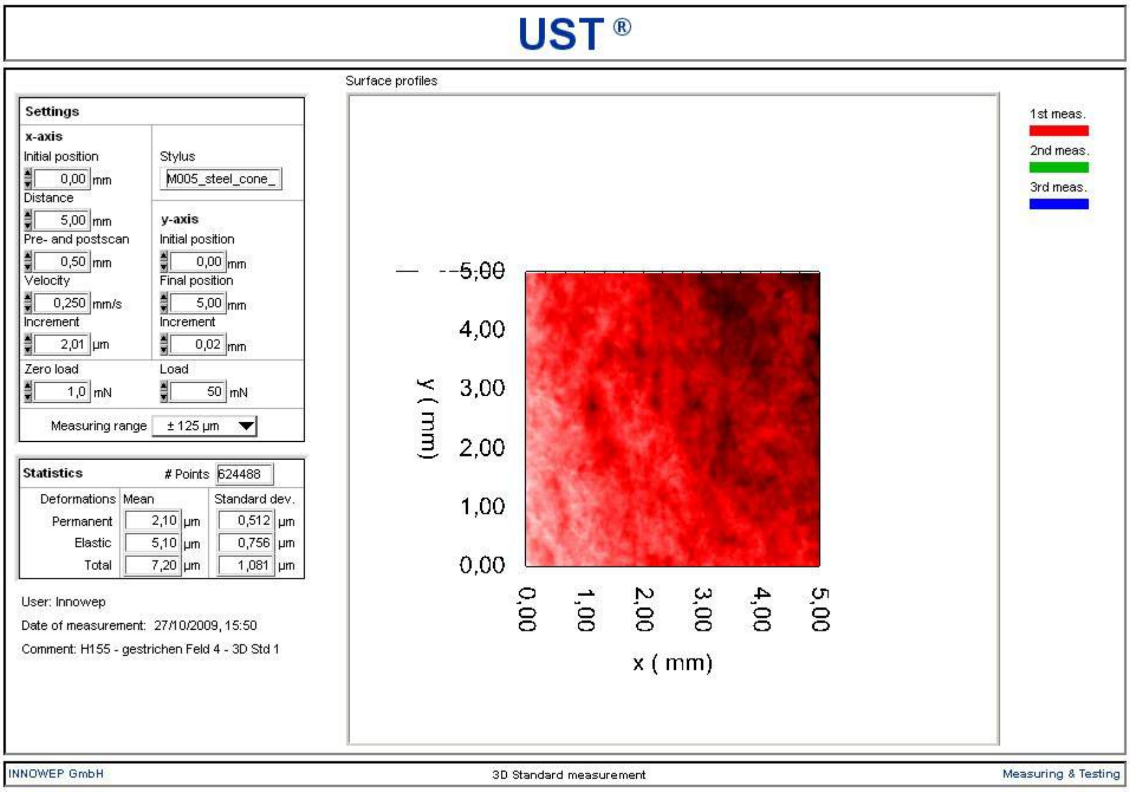
CCC, overview of surface profiles and deformations



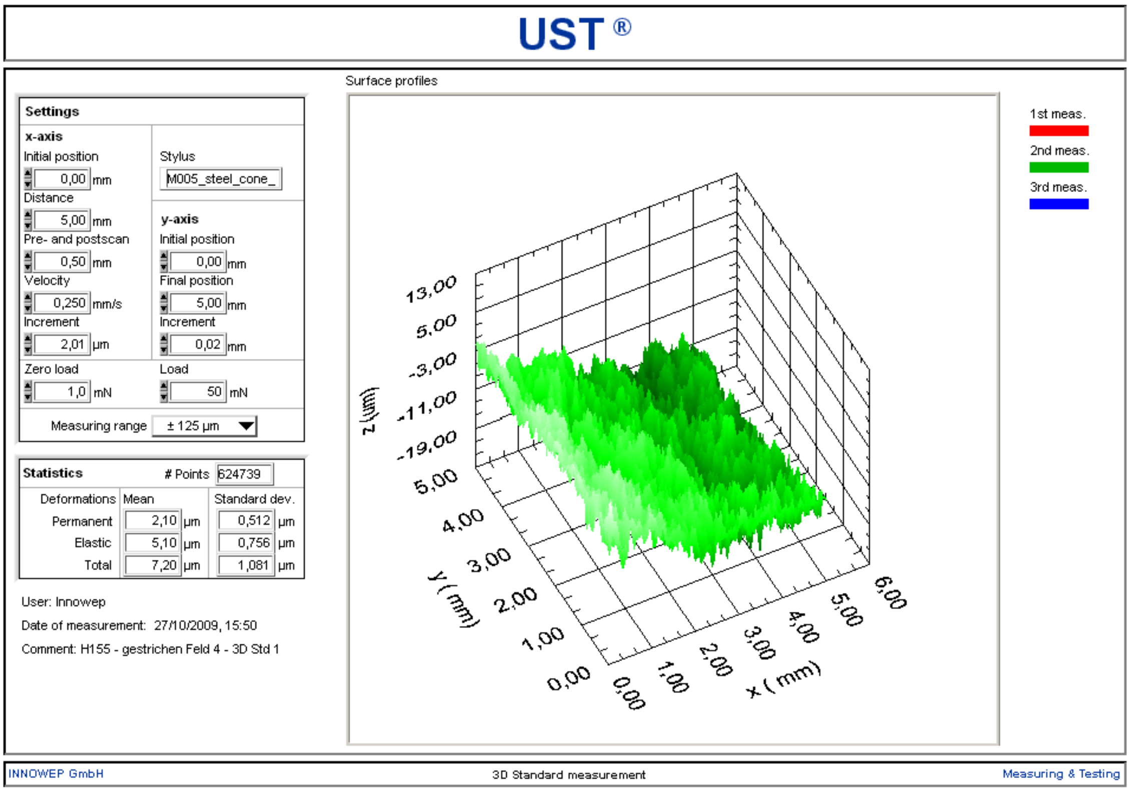


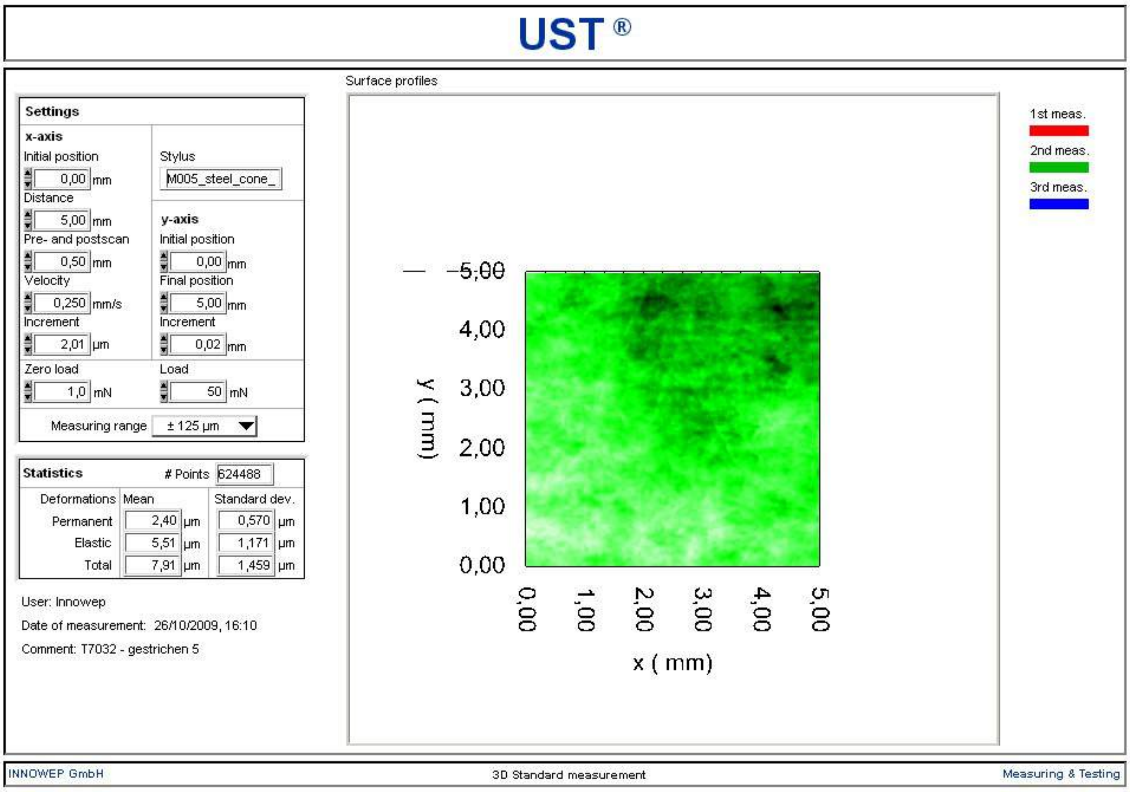
CCC, 1st measuring step



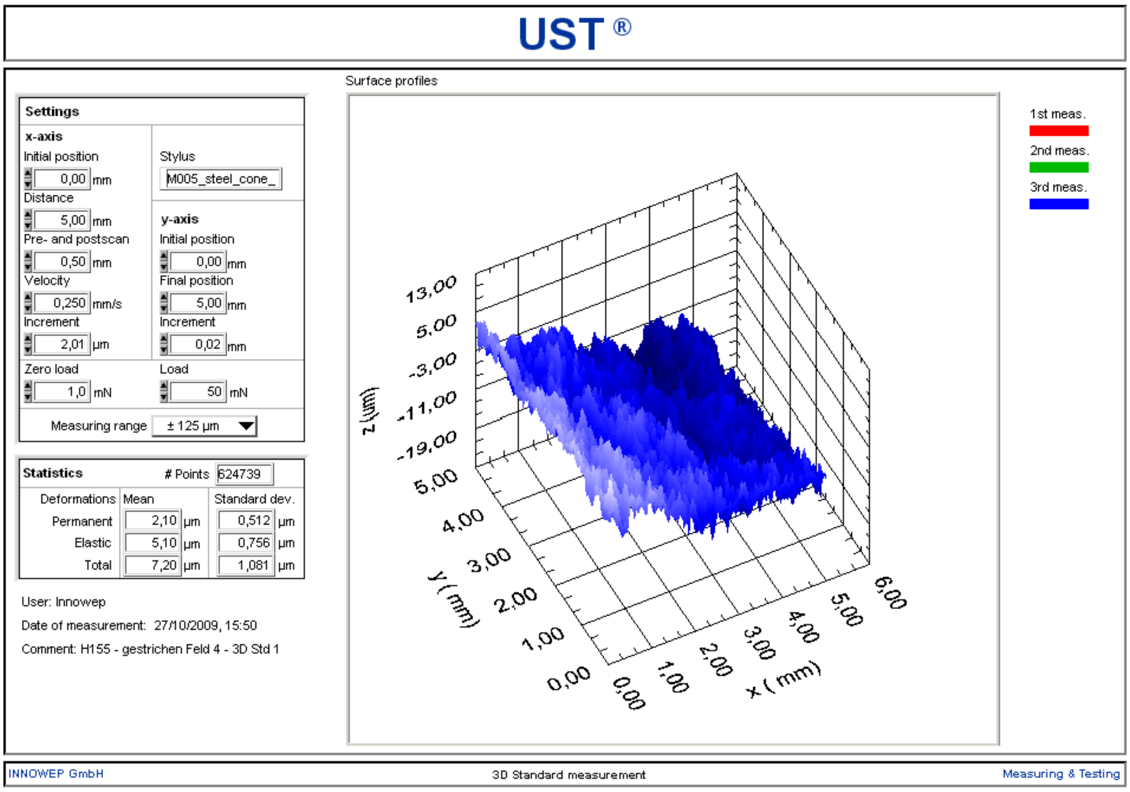


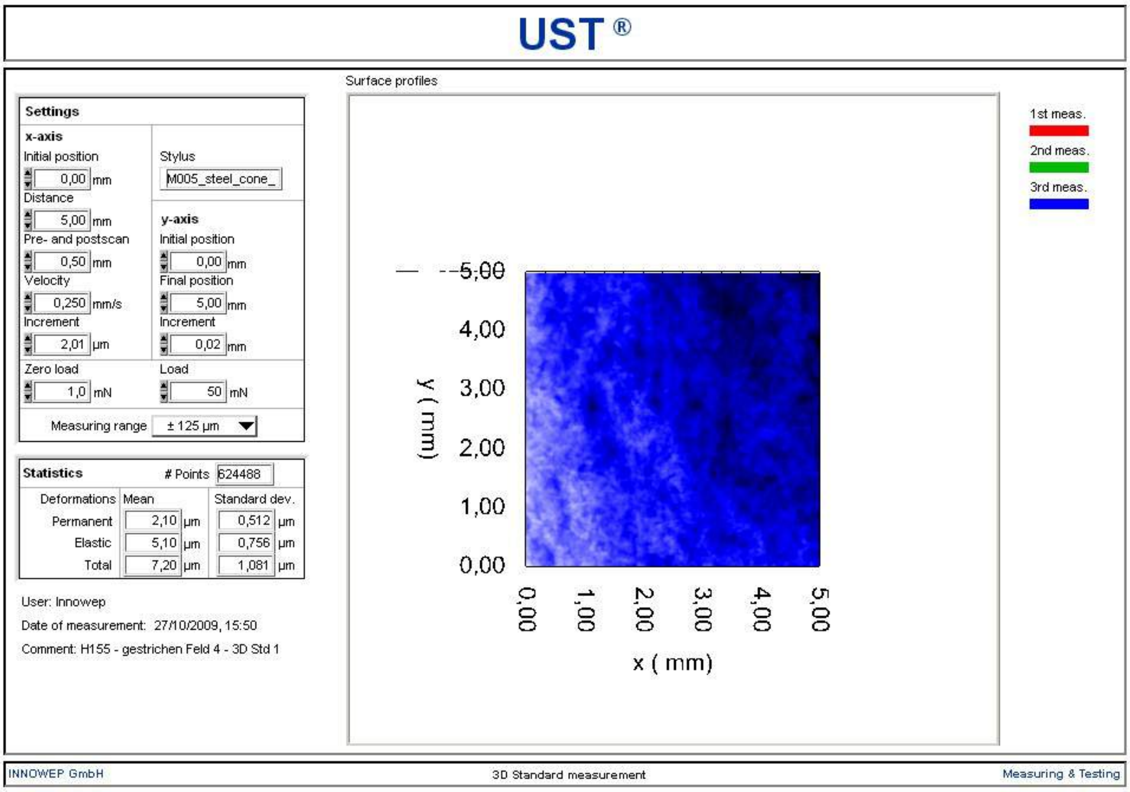
CCC, 2nd measuring step





CCC, 3rd measuring step





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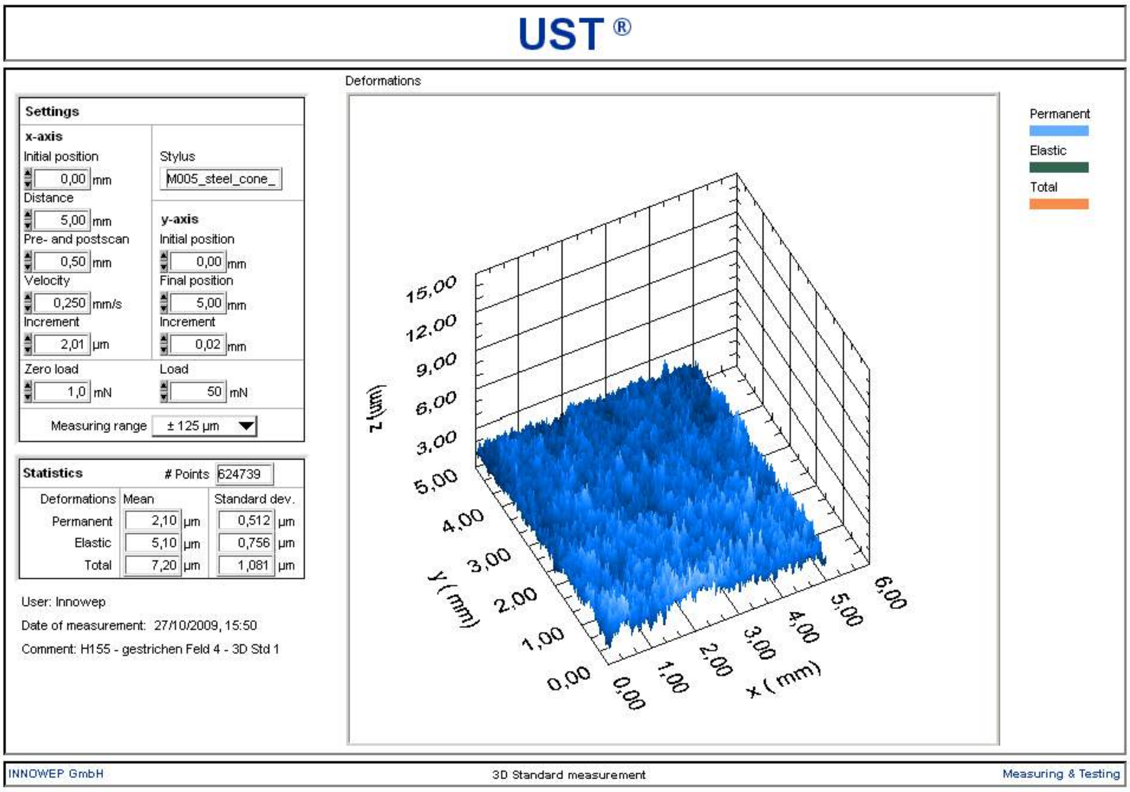
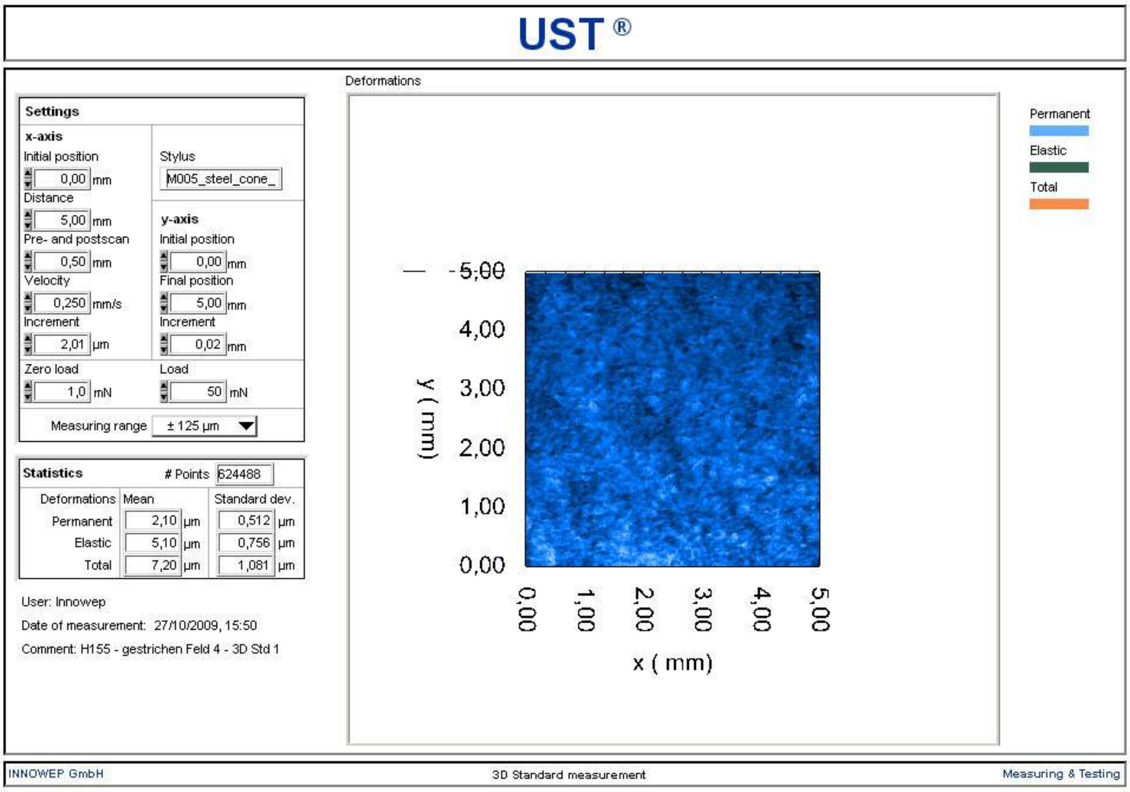
CCC, permanent deformation





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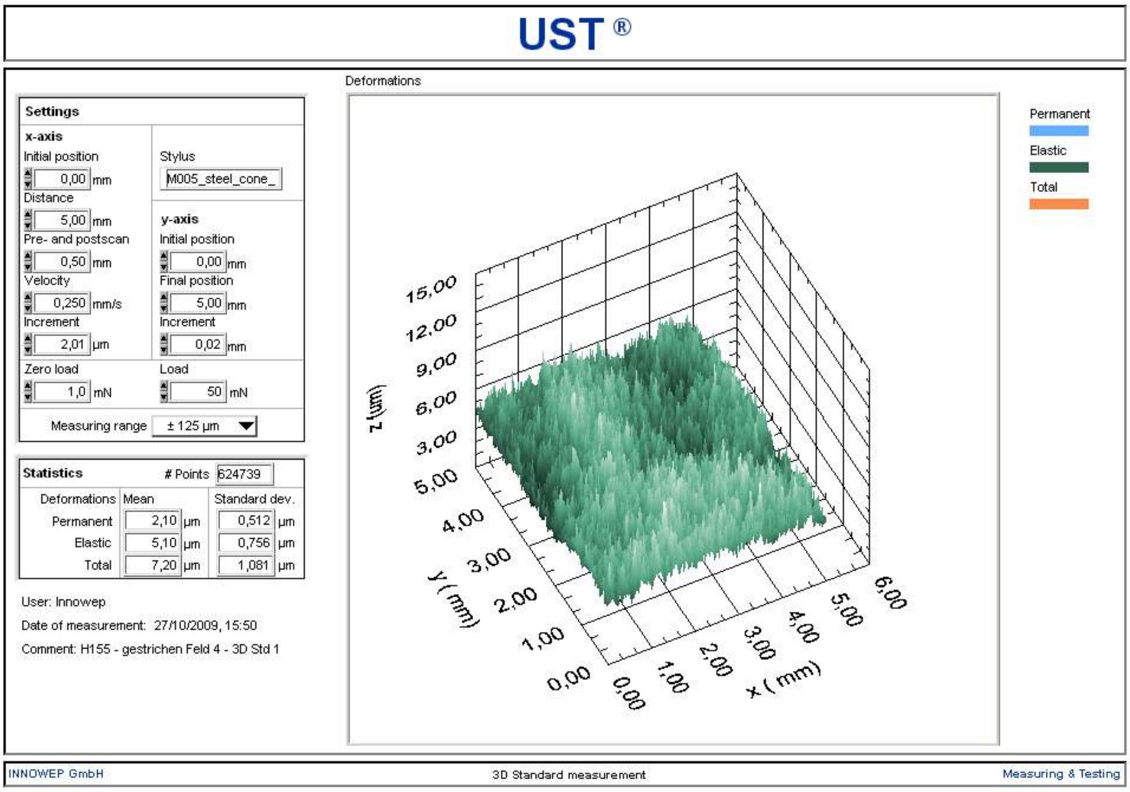
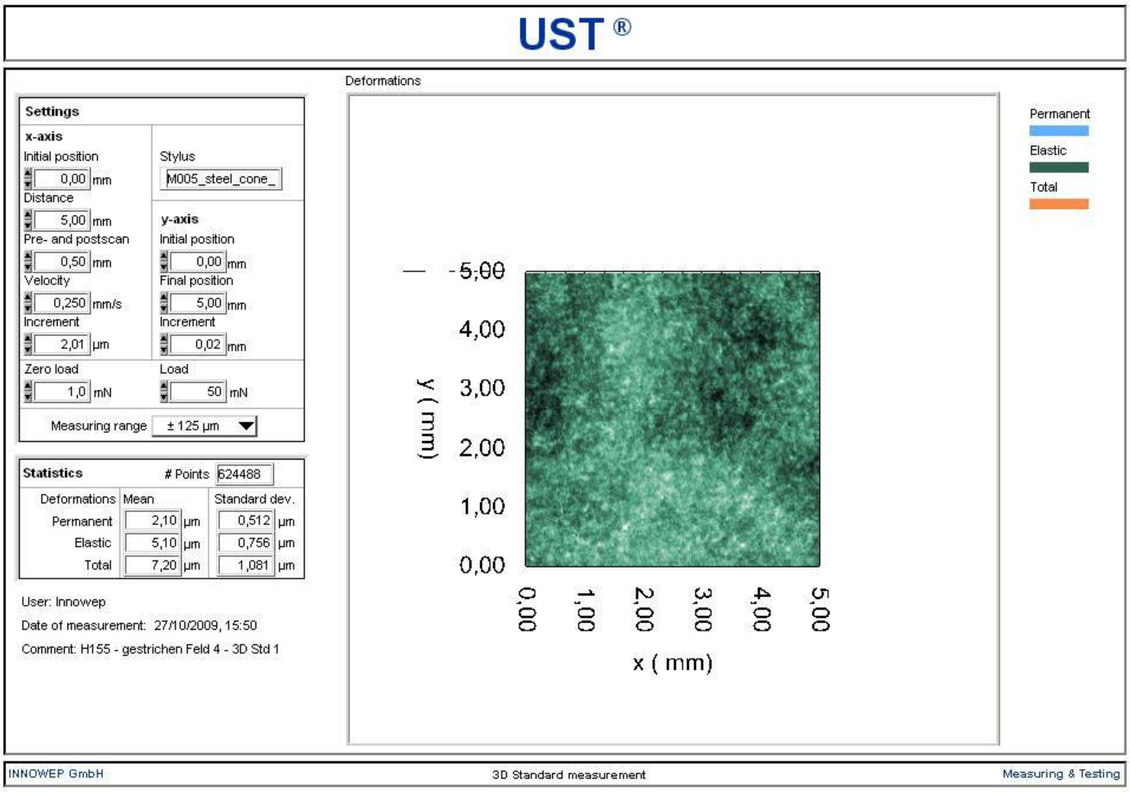
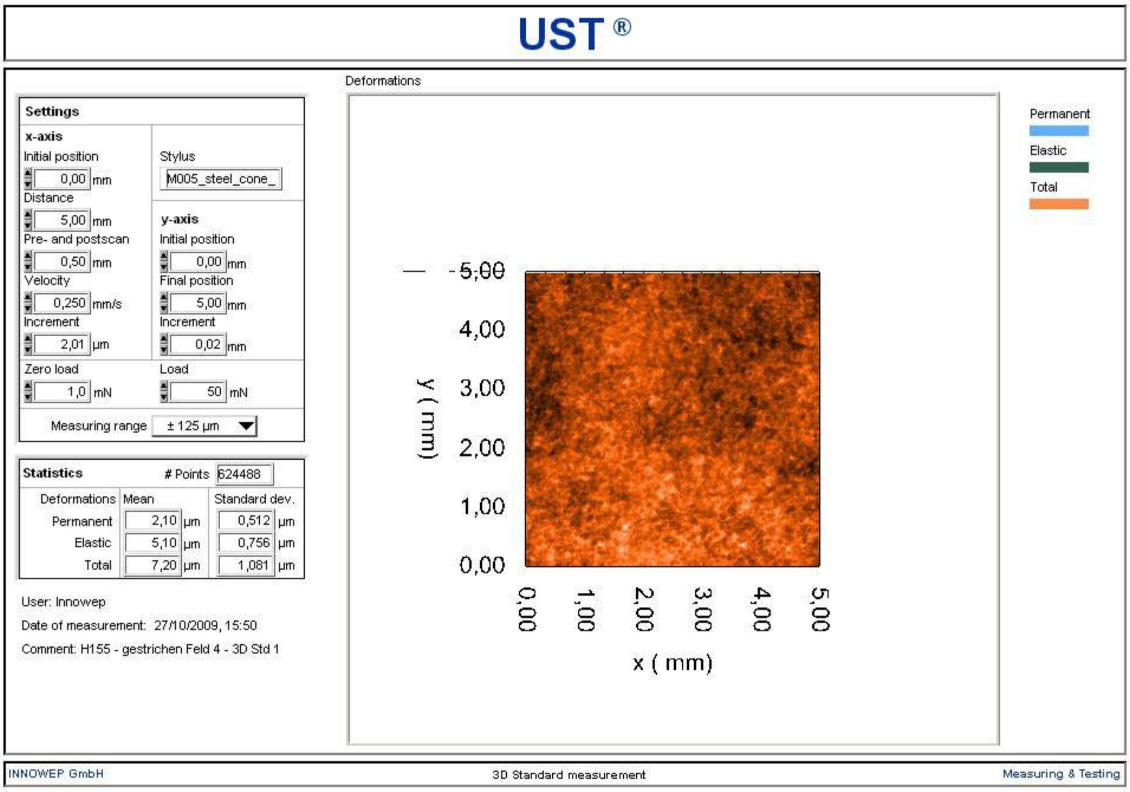
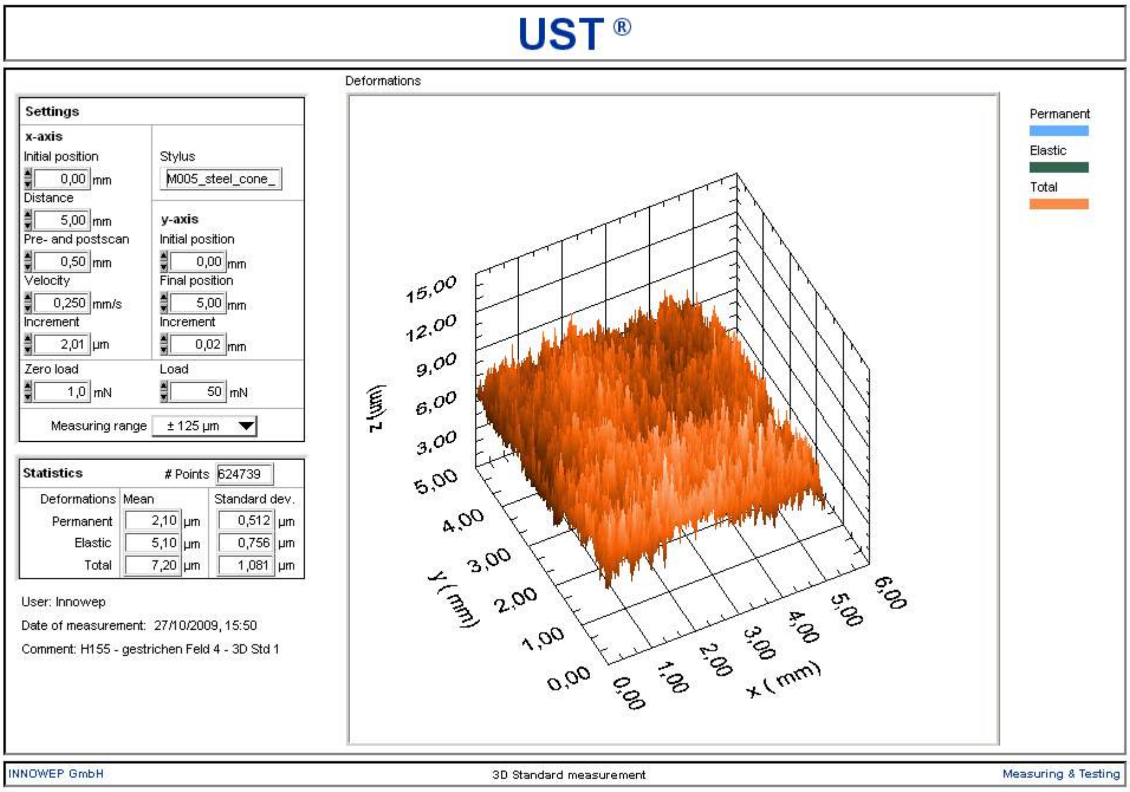
CCC, elastic deformation





CCC, total deformation





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FFF, overview of surface profiles and deformations

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Settings

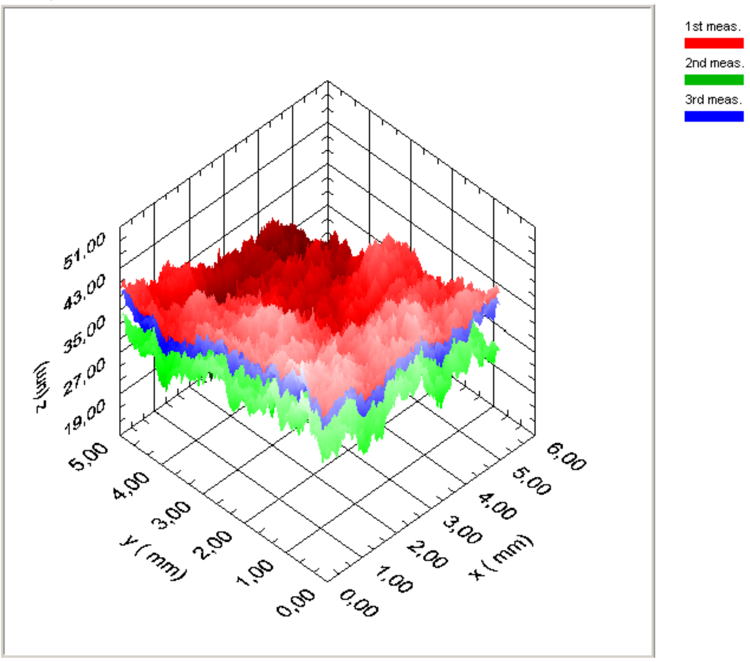
x-axis		y-axis	
Initial position	0,00 mm	Stylus	M005_steel_cone_
Distance	5,00 mm	Initial position	0,00 mm
Pre- and postscan	0,50 mm	Final position	5,00 mm
Velocity	0,250 mm/s	Increment	0,02 mm
Increment	2,01 µm		
Zero load	1,0 mN	Load	50 mN
Measuring range	± 125 µm		

Statistics # Points 624739

Deformations	Mean	Standard dev.
Permanent	2,40 µm	0,570 µm
Elastic	5,51 µm	1,171 µm
Total	7,91 µm	1,459 µm

User: Innowep
Date of measurement: 26/10/2009, 16:10
Comment: T7032 - gestrichen 5

Surface profiles



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Settings

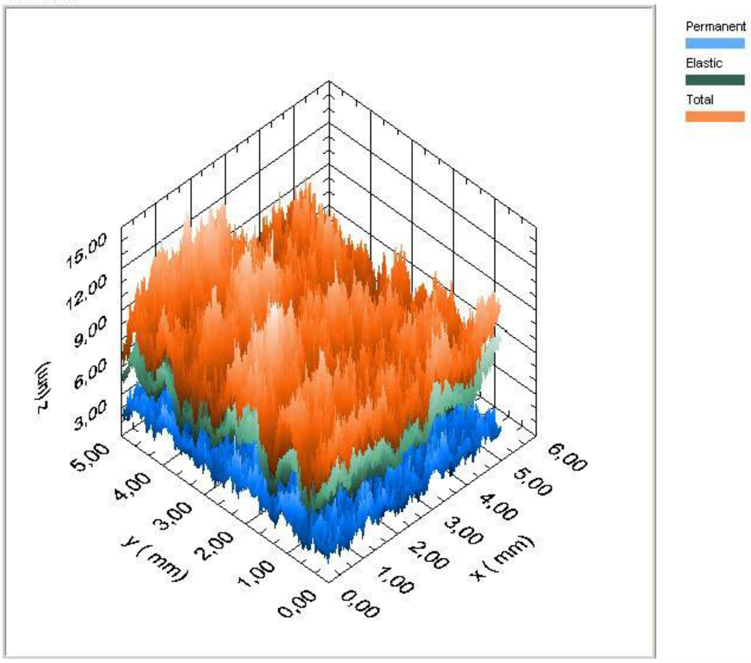
x-axis		y-axis	
Initial position	0,00 mm	Stylus	M005_steel_cone_
Distance	5,00 mm	Initial position	0,00 mm
Pre- and postscan	0,50 mm	Final position	5,00 mm
Velocity	0,250 mm/s	Increment	0,02 mm
Increment	2,01 µm		
Zero load	1,0 mN	Load	50 mN
Measuring range	± 125 µm		

Statistics # Points 624739

Deformations	Mean	Standard dev.
Permanent	2,40 µm	0,570 µm
Elastic	5,51 µm	1,171 µm
Total	7,91 µm	1,459 µm

User: Innowep
Date of measurement: 26/10/2009, 16:10
Comment: T7032 - gestrichen 5

Deformations



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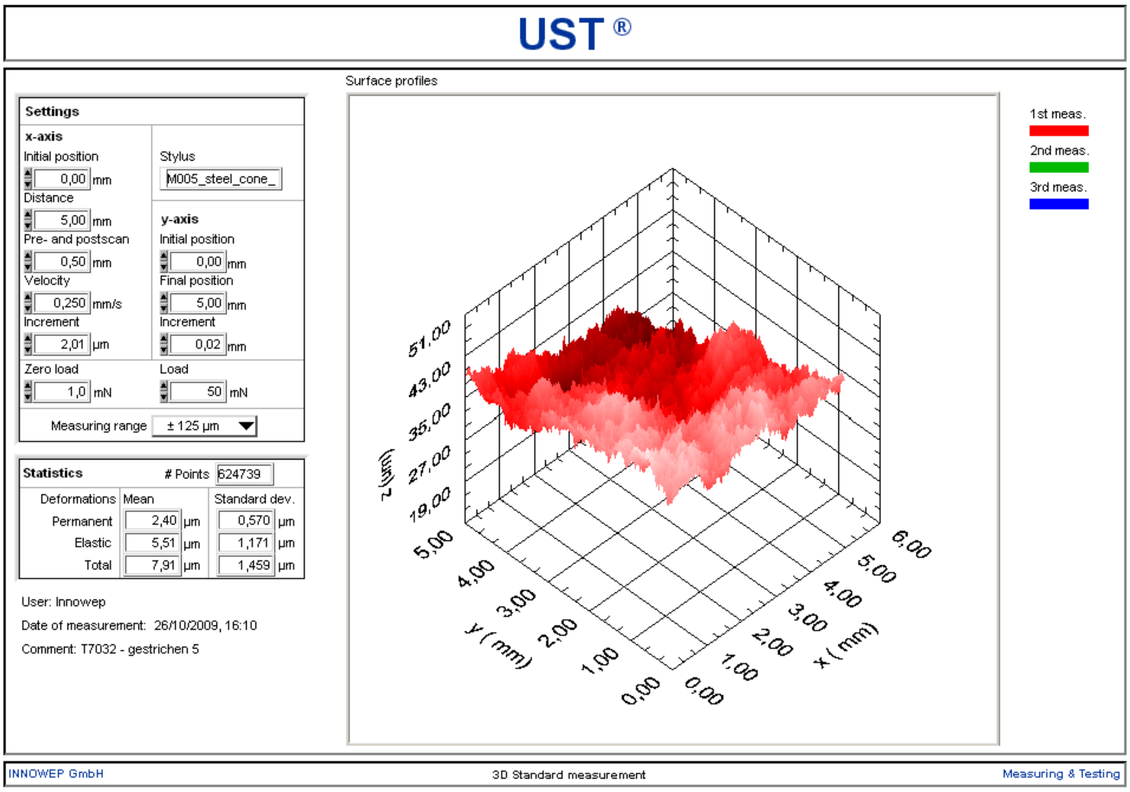
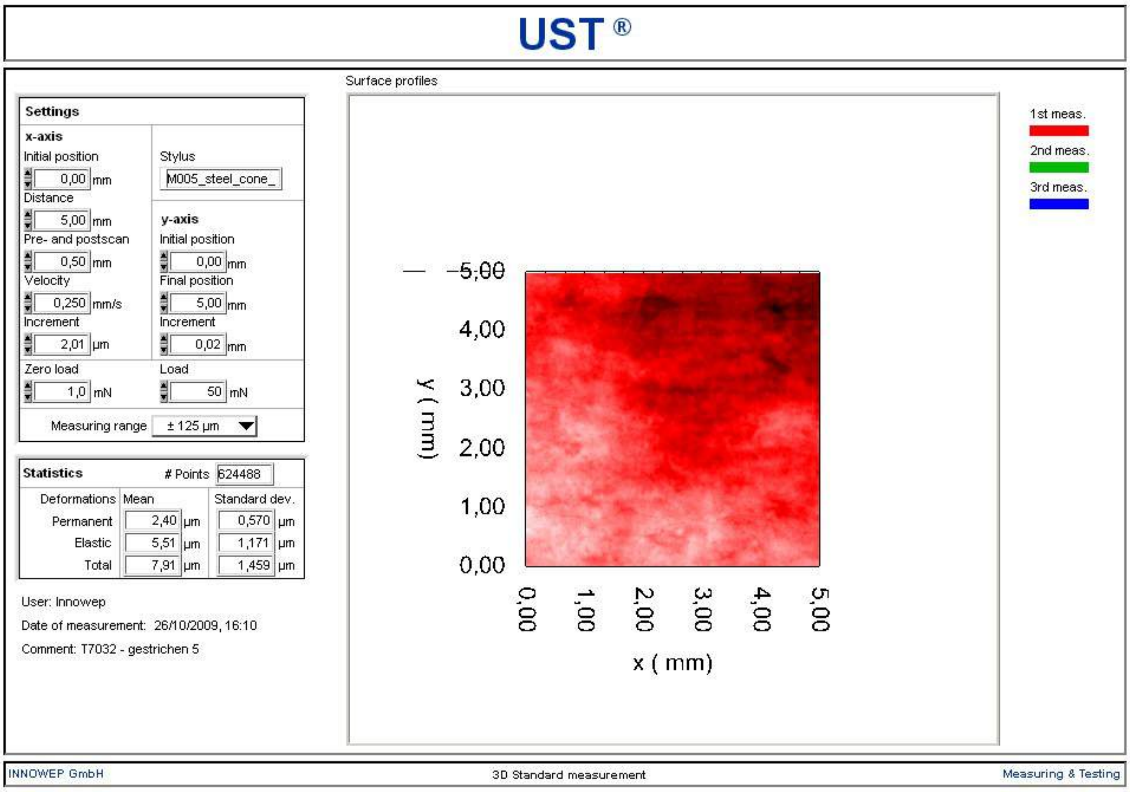
FFF, 1st measuring step





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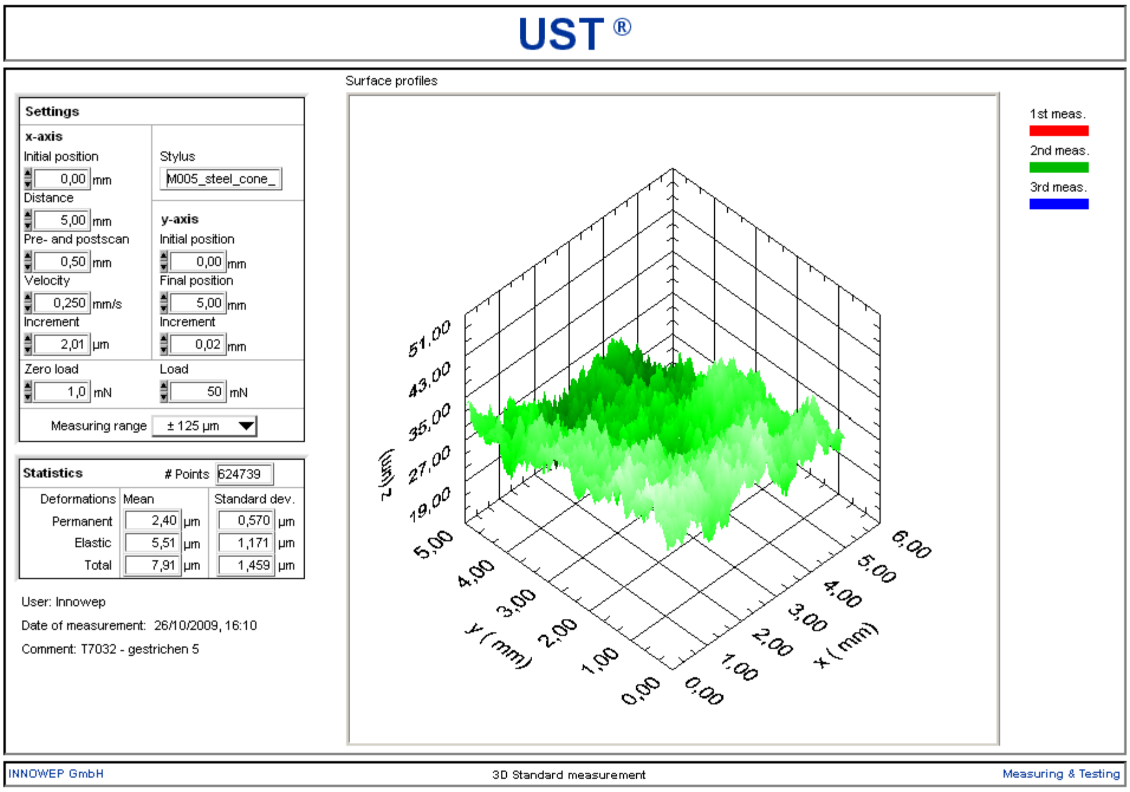
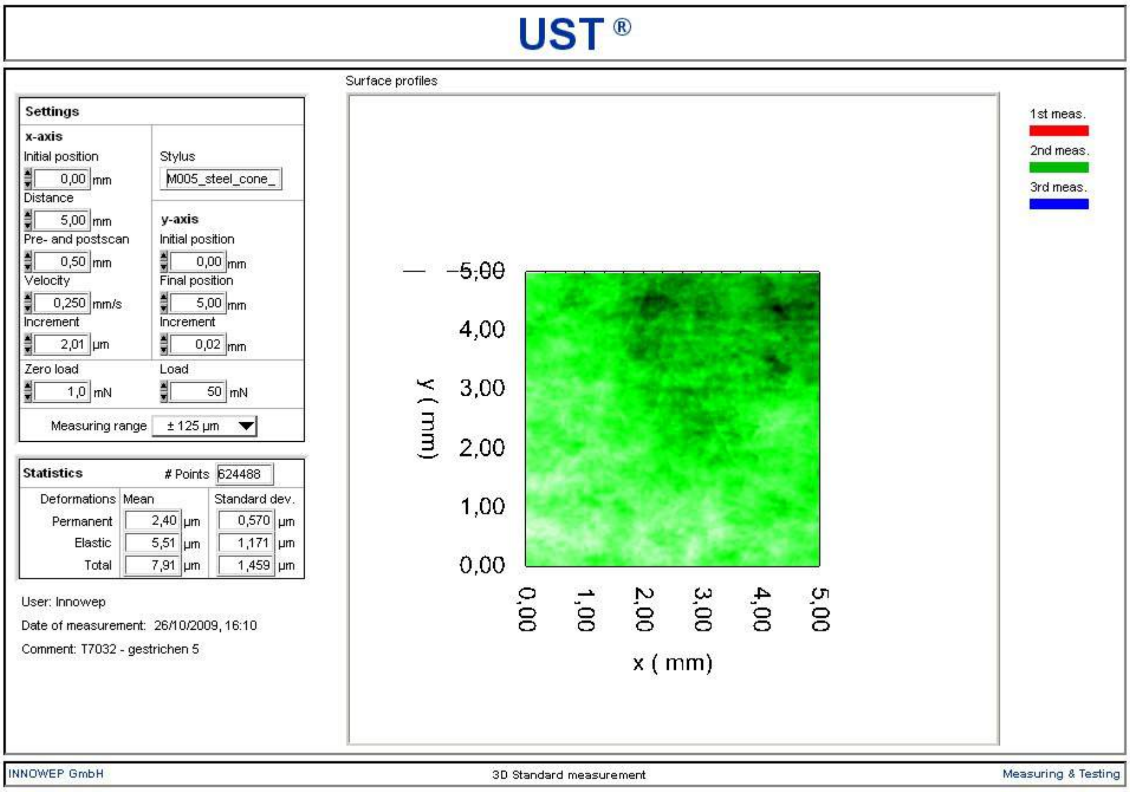
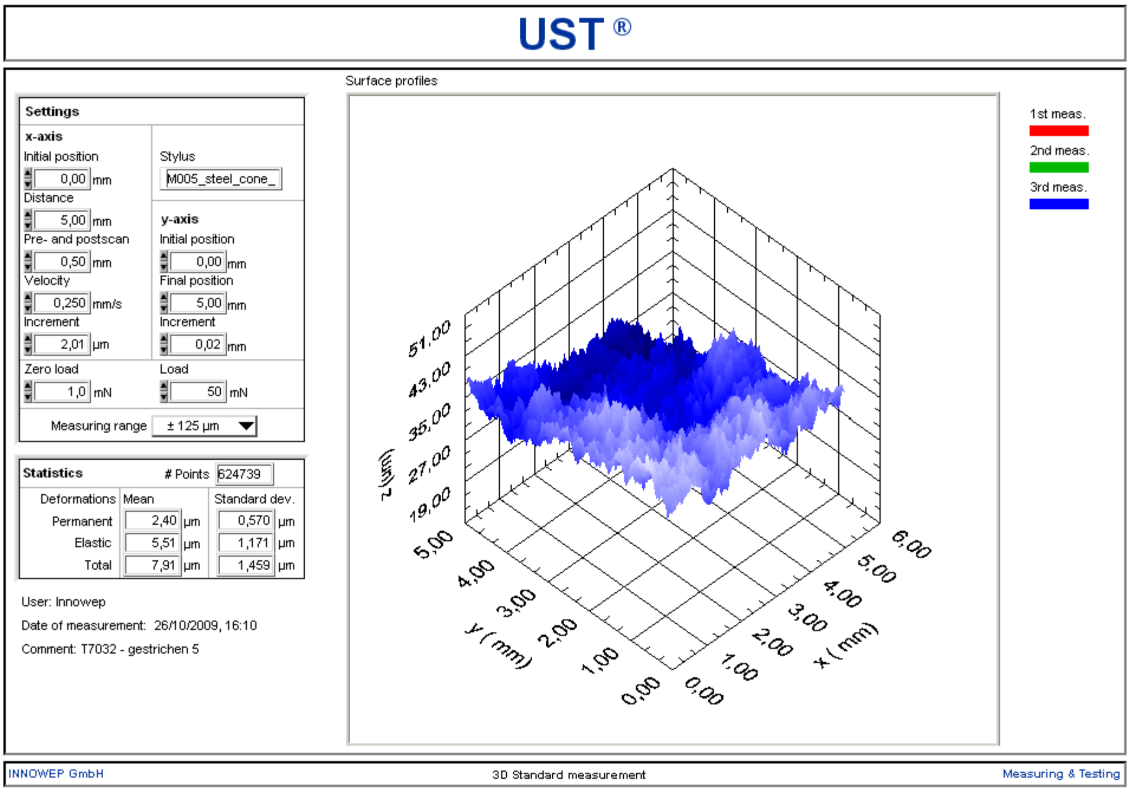
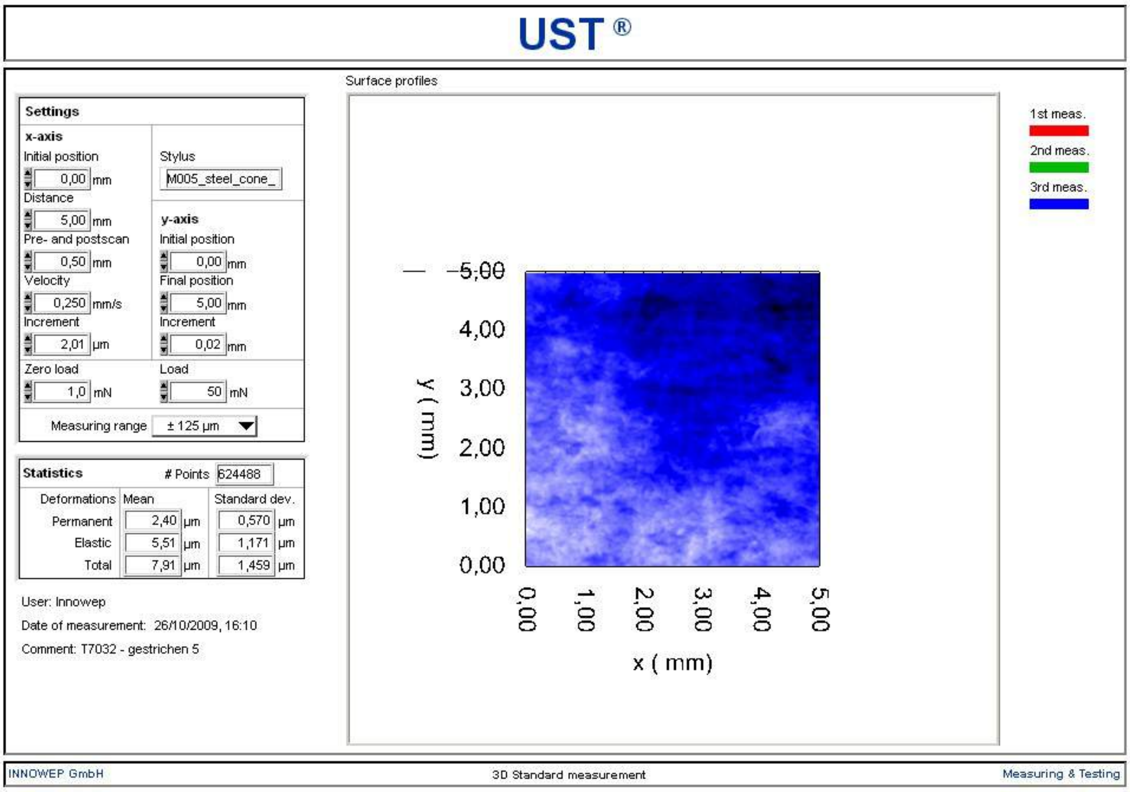
FFF, 2nd measuring step





FFF, 3rd measuring step





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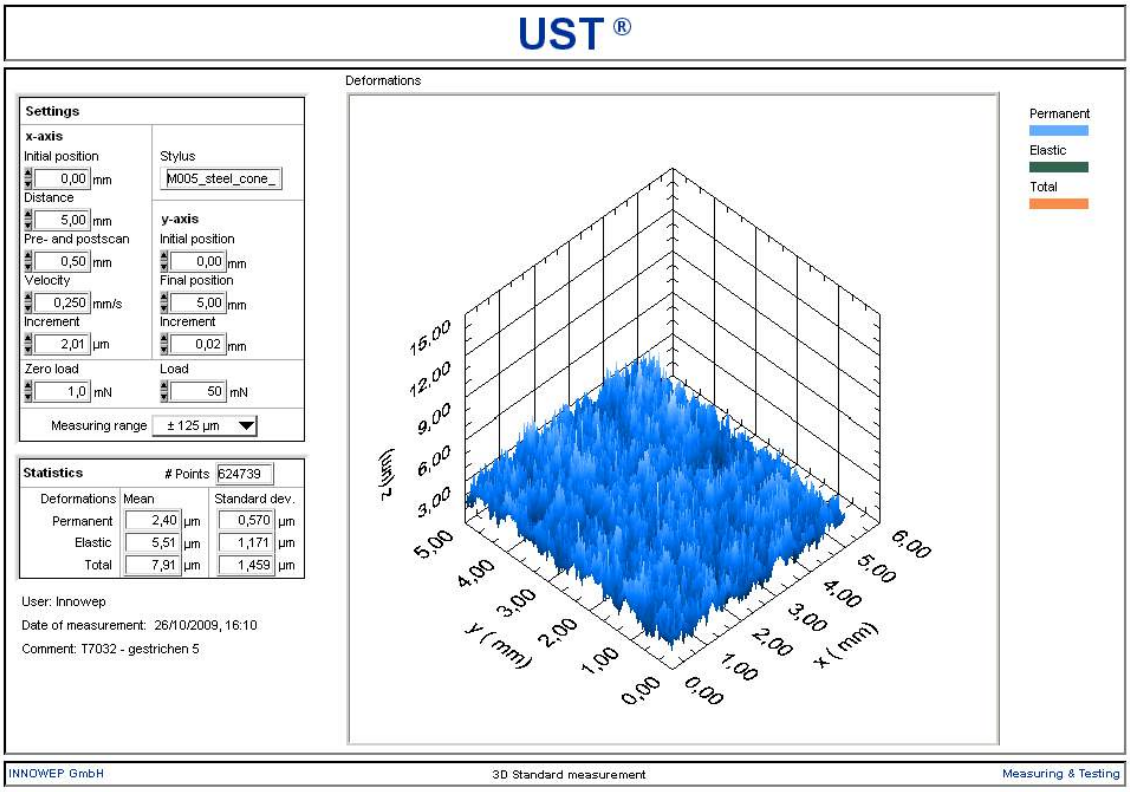
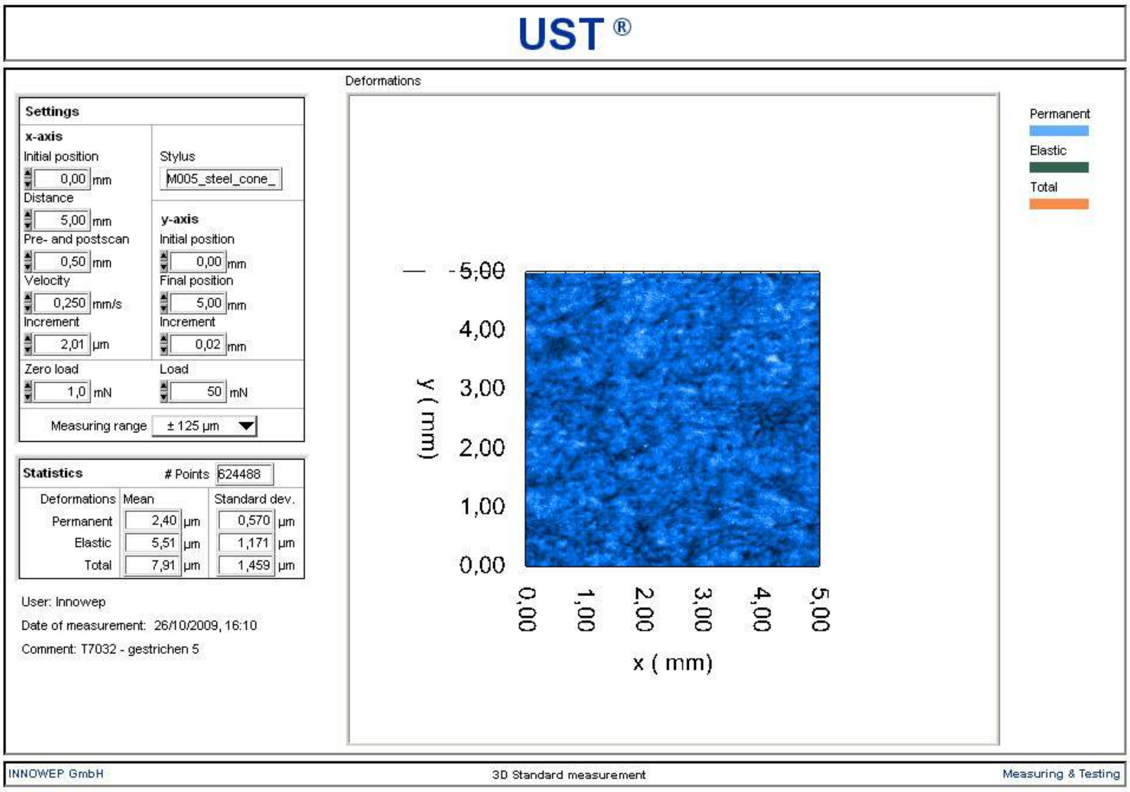
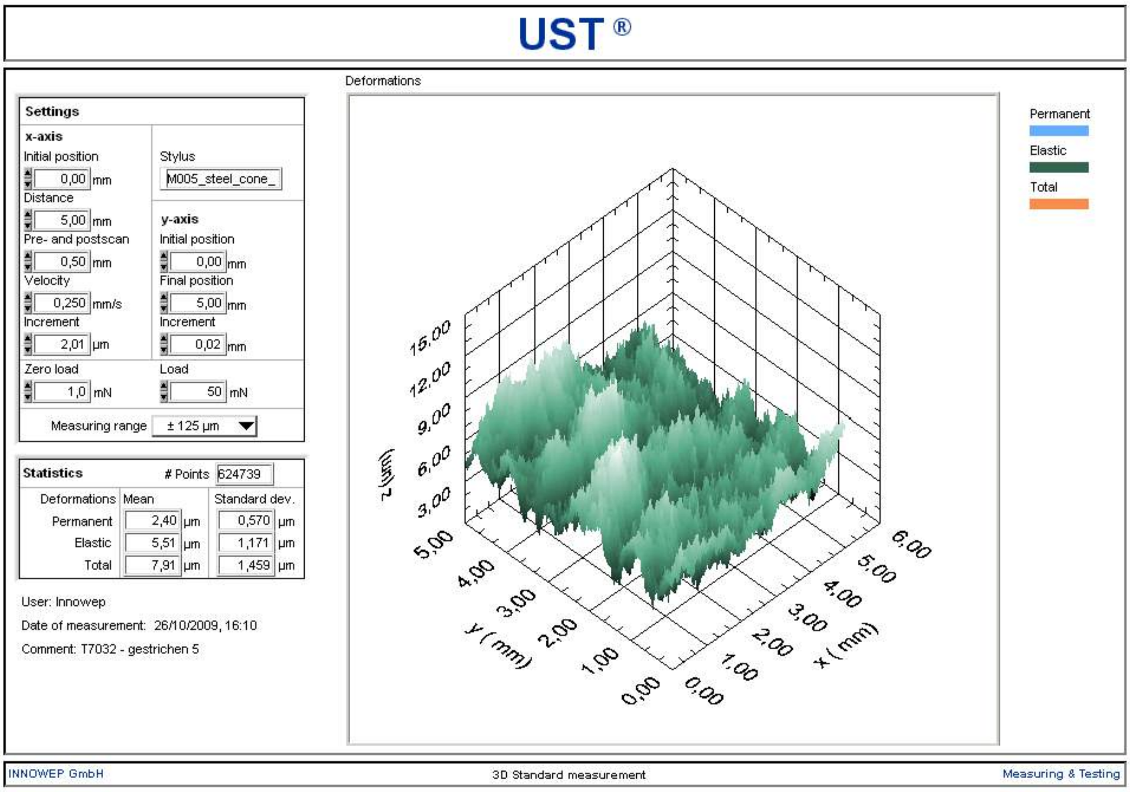
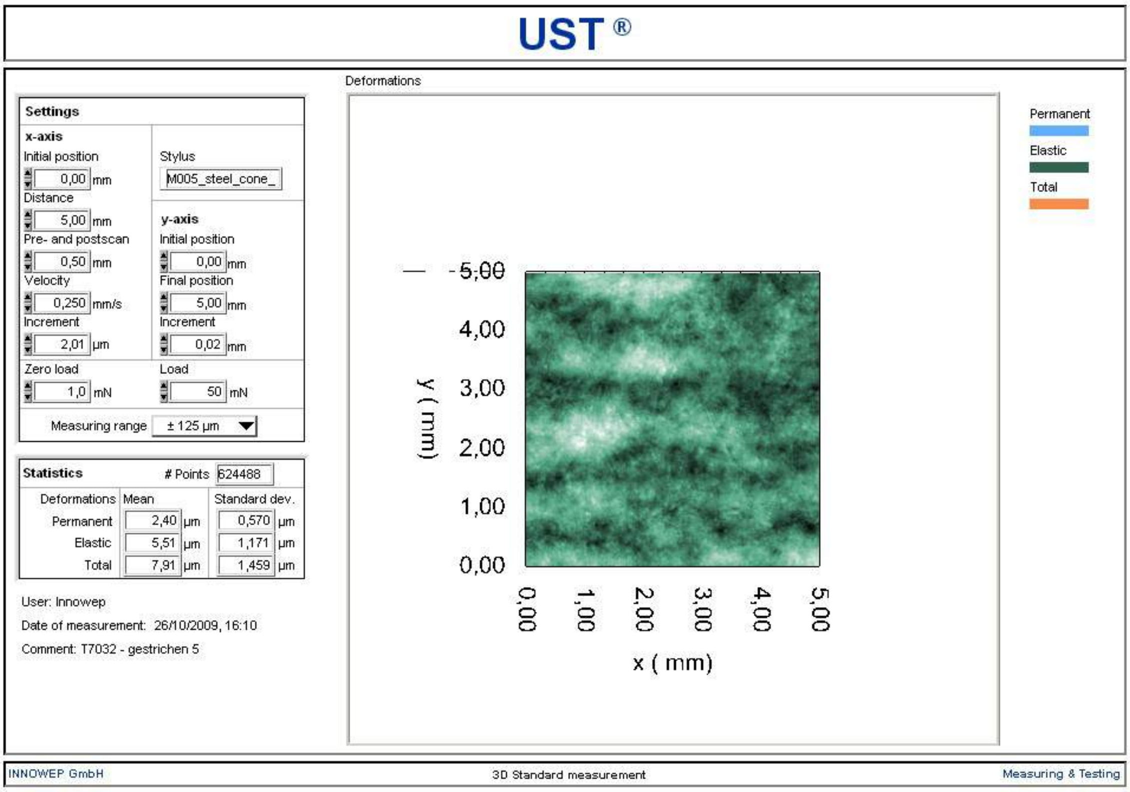
FFF, permanent deformation



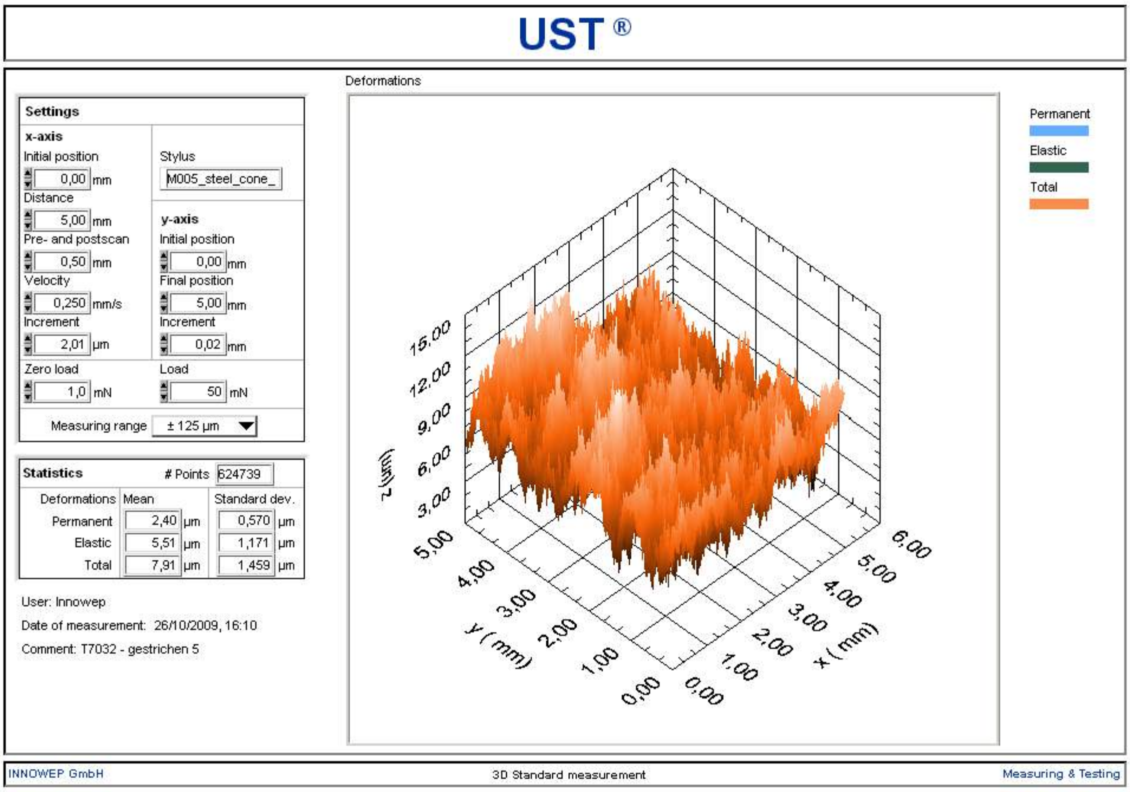


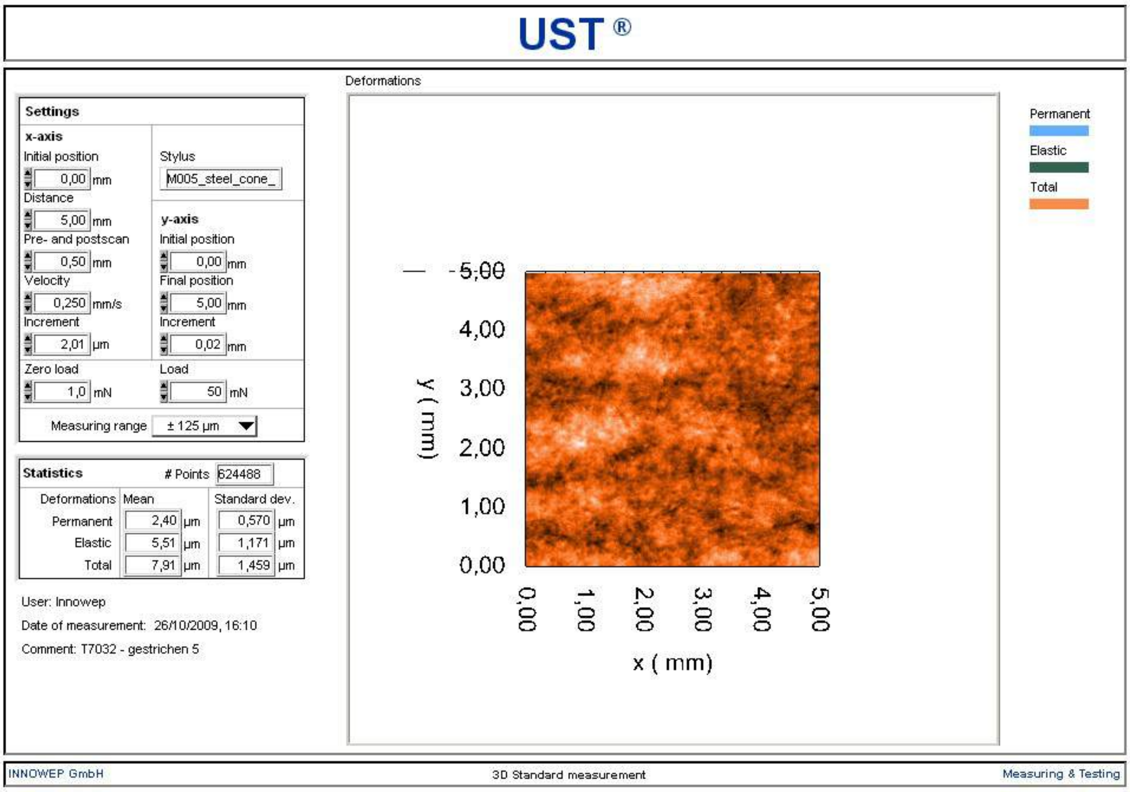
FFF, elastic deformation





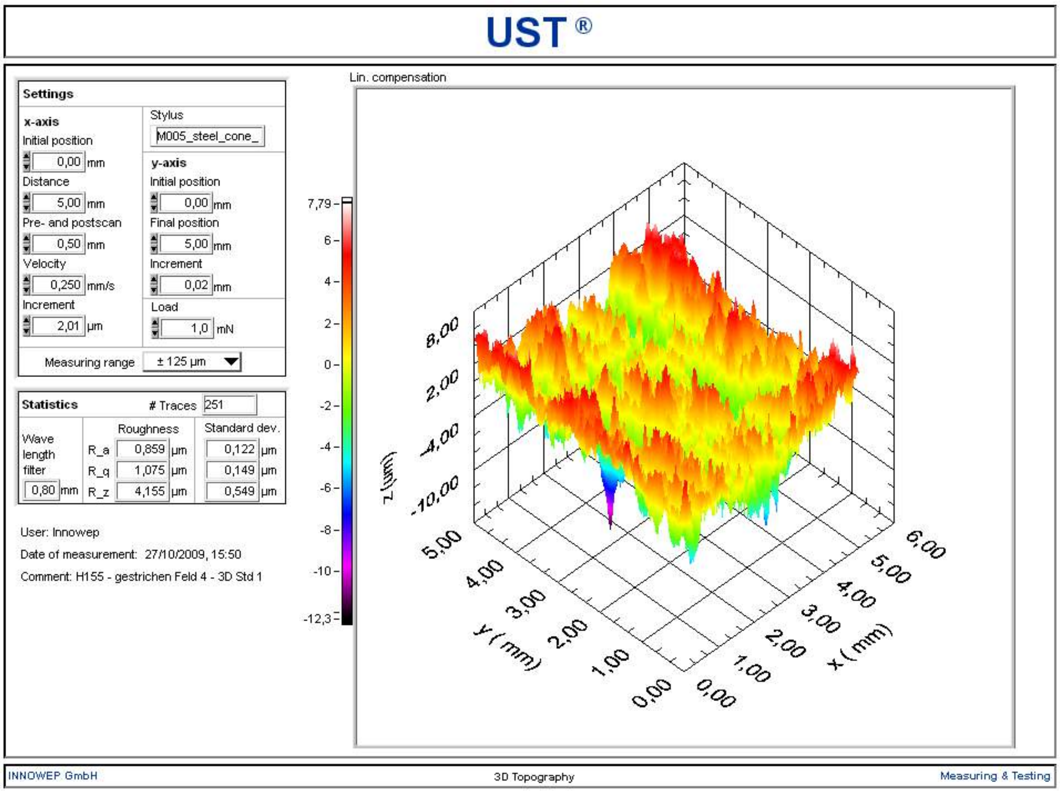
FFF, total deformation

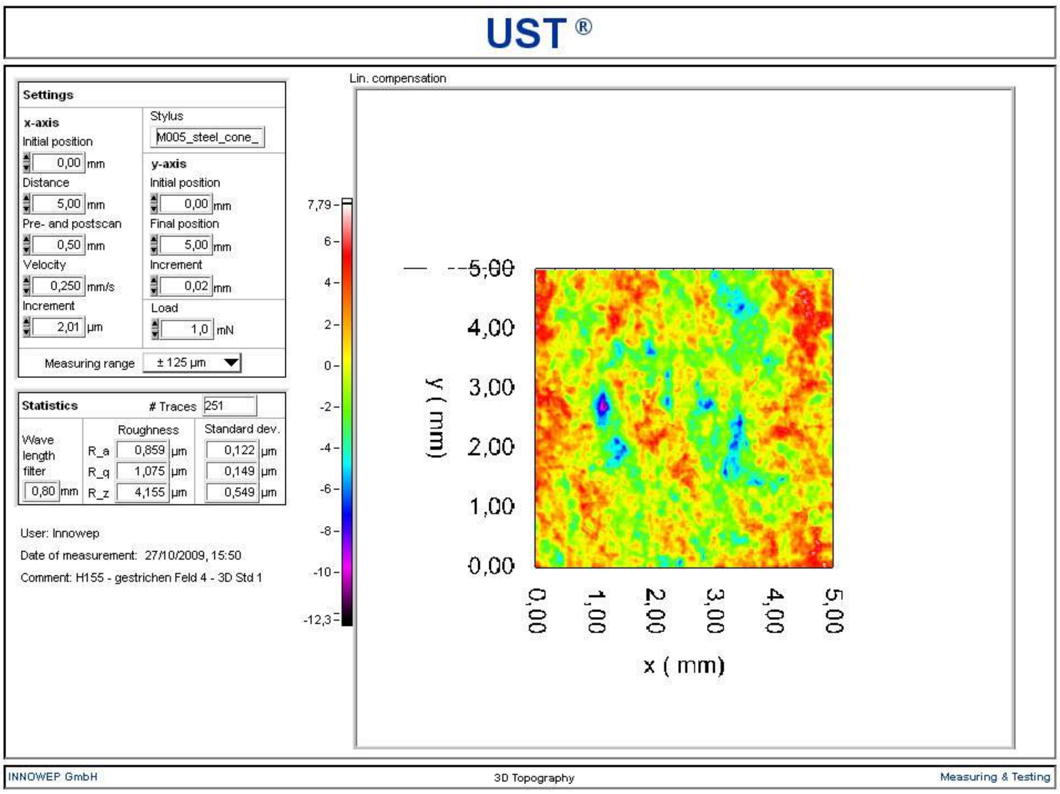




6.8 3D topography

CCC





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FFF