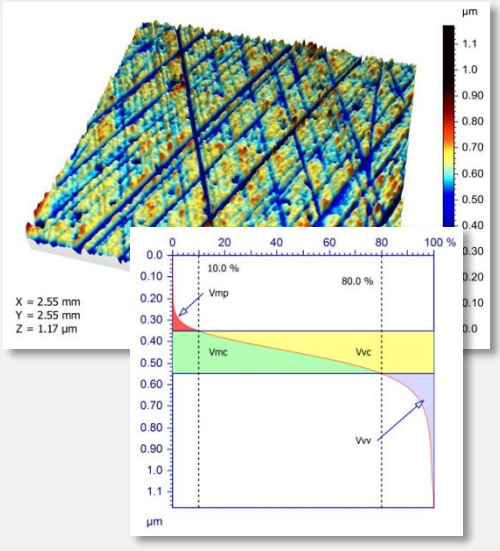
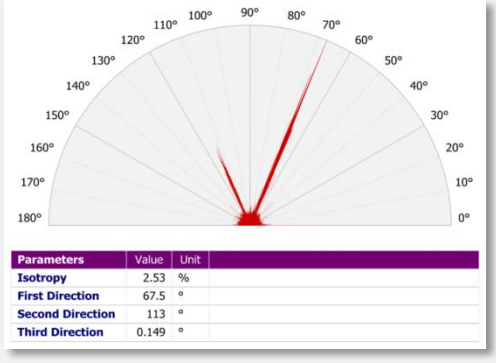
3D Advanced Surface Texture Module for MountainsMap®

Advanced studies, parameters and filters for 3D analysis

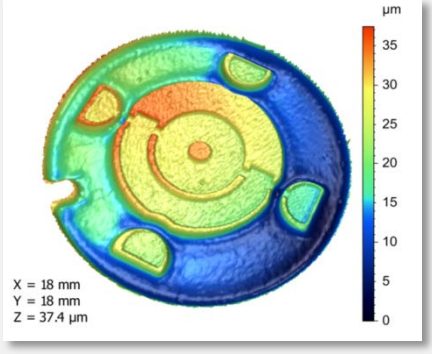
- Extended compatibility with 3D surface profilometers and optical microscopes
- Advanced surface texture (ISO 25178) and flatness (ISO 12781) parameter sets
- Visualization and analysis of friction, core and lubrication zones (tribology)
- Sub-surface extraction, leveling and analysis (just like a full surface)
- Characterization of surface isotropy, periodicity and directionality
- Extended analysis: furrows, fractals, peak/grains count and density
- MATLAB™ compatibility, advanced filtering techniques and more

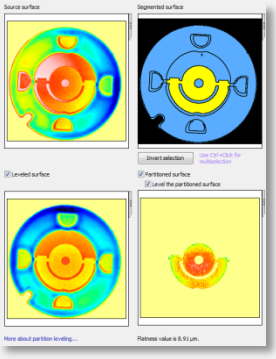


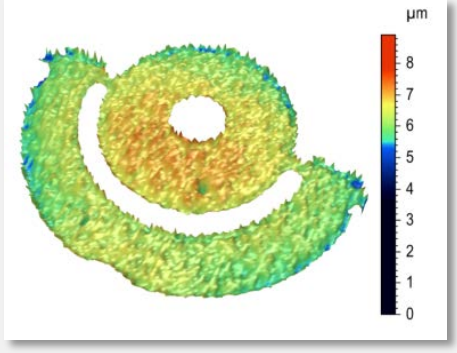
ISO 25178		
Functional Parameters (Volume)		
Vm	3.9e-006	mm³/mm²
Vv	0.000129	mm³/mm²
Vmp	3.9e-006	mm³/mm²
Vmc	9.07e-005	mm³/mm²
Vvc	0.000107	mm³/mm²
Vvv	2.13e-005	mm³/mm²
Spatial Parameters		
Sal	0.0242	mm
Str	0.0253	
Std	67.5	°
Hybrid Parameters		
Sdq	0.00964	
Sdr	0.00465	%



Parameters	Value	Unit
Isotropy	2.53	%
First Direction	67.5	°
Second Direction	113	°
Third Direction	0.149	°





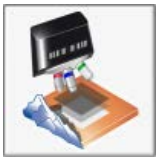


ISO 12781		
Flatness Parameters		
FLTt	5.15	µm
FLTp	2.41	µm
FLTv	2.74	µm
FLTq	0.932	µm

MountainsTM

Digital Surf

Extended instrument compatibility



The 3D Advanced Surface Texture Module for MountainsMap® includes compatibility with all supported

- 3D contact and non-contact surface profilometers
- 3D confocal and interferometric microscopes, and
- other 3D optical microscopes and profilers.

Advanced ISO 25178 surface texture parameters

Advanced ISO 25178 functional volume, spatial and hybrid parameters are included in the 3D Advanced Surface Texture Module for MountainsMap®.

ISO 25178				
Functional Parameters (Volume)				
Vm	3.9e-006	mm³/mm²	*p = 10%*	*Material volume*
Vv	0.000129	mm³/mm²	*p = 10%*	*Void volume*
Vmp	3.9e-006	mm³/mm²	*p = 10%*	*Peak material volume*
Vmc	9.07e-005	mm³/mm²	*p = 10%, q = 80%*	*Core material volume*
Vvc	0.000107	mm³/mm²	*p = 10%, q = 80%*	*Core void volume*
Vvv	2.13e-005	mm³/mm²	*p = 80%*	*Pit void volume*
Spatial Parameters				
Sal	0.0242	mm	*s = 0.2*	*Auto-correlation length*
Str	0.0253		*s = 0.2*	*Texture-aspect ratio*
Std	67.5	°	*Reference angle = 0°*	*Texture direction*
Hybrid Parameters				
Sdq	0.00964			*Root mean square gradient*
Sdr	0.00465	%		*Developed interfacial area ratio*

Functional volume parameters:

- Material volume, **Vm**
- Void volume, **Vv**
- Peak material volume, **Vmp**
- Core material volume, **Vmc**
- Core void volume, **Vvc**
- Pit void volume, **Vvv**.

Spatial parameters:

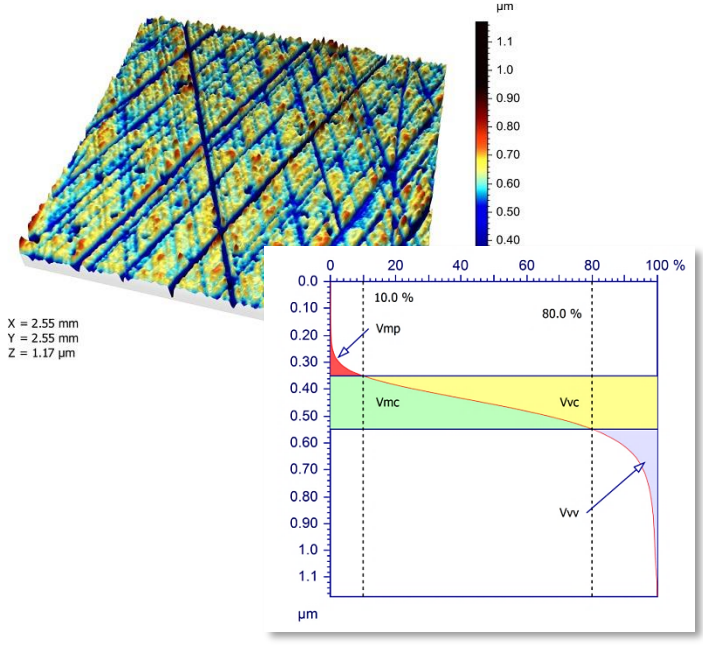
- Auto-correlation length, **Sal**
- Texture aspect ratio, **Str**
- Texture direction, **Std**.

Hybrid parameters:

- Root mean square gradient, **Sdq**
- Developed interfacial area ratio, **Sdr**.

Recommended reading: for a detailed description of these parameters, see F. Blateyron “The Areal Field Parameters” in R. Leach (ed.) *Characterisation of Areal Surface Texture*, Springer-Verlag 2013.

Visualization and analysis of friction, core and lubrication zones



Plot generated by the Graphical Study of Volume Parameters study for a honed motor cylinder head

The **Graphical Study of Volume Parameters** shows the Abbott-Firestone bearing ratio curve and the ISO 25178 functional volume parameters that are calculated with respect to it.

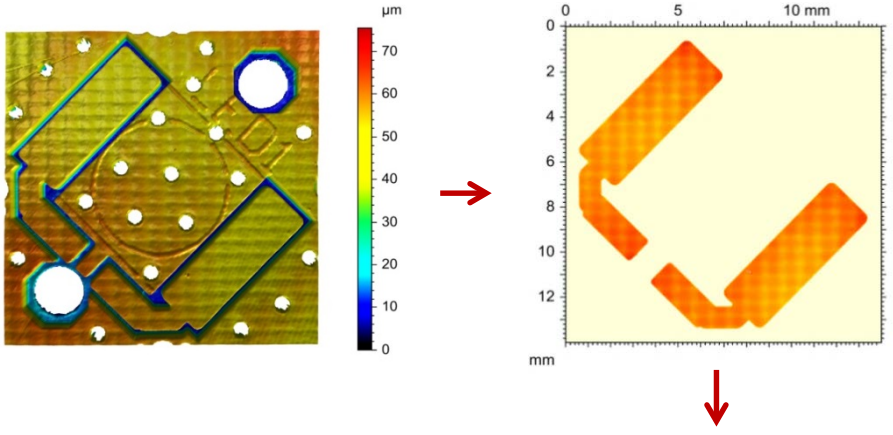
- The **Vmp** (peak material volume) parameter is shown in red.
- The **Vmc** (core material volume) parameter is shown in green.
- The **Vvc** (core void volume) parameter is shown in pale yellow.
- The **Vvv** (valley void volume) parameter is shown in blue.

The **Vmp**, **Vmc**, and Vvv zones are sometimes called the friction, core and lubrication (or entrapment) zones, respectively.

The **Graphical Study of Sk Parameters** shows the **Sk** parameters in a similar way.

ISO 12781 flatness parameters

- Peak-to-valley flatness deviation of the surface, **FLTt**
- Peak-to-reference flatness deviation, **FLTp**
- Reference-to-valley flatness deviation, **FLTv**
- Root mean square flatness deviation, **FLTq**.



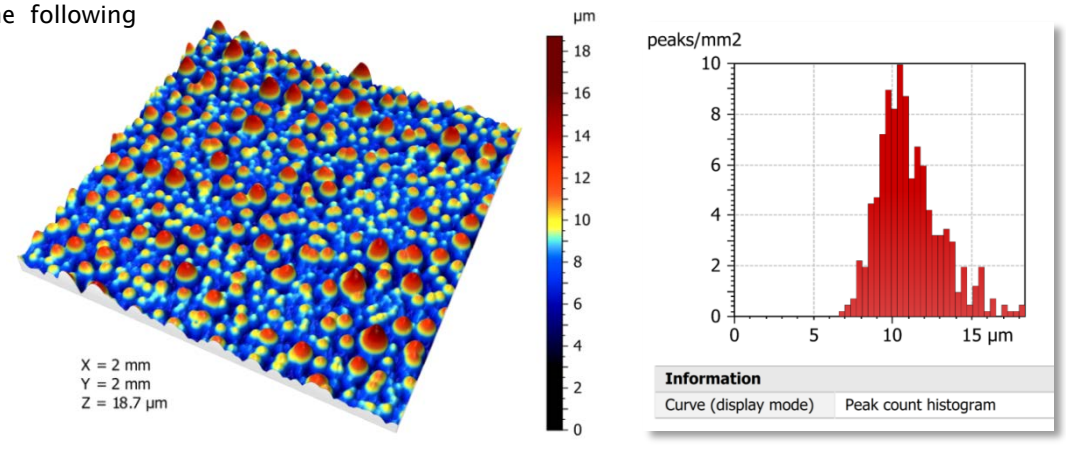
ISO 12781		
Flatness Parameters		
FLTt	10.8 µm	*Peak-to-valley flatness deviation of the surface*
FLTp	3.56 µm	*Peak-to-reference flatness deviation*
FLTv	7.23 µm	*Reference-to-valley flatness deviation*
FLTq	1.55 µm	*Root mean square flatness deviation*

Flatness parameters for an LED landing zone on a printed circuit board.

Peaks – count, density and area

The **Peak Count** study includes the following charts and graphs:

- Peak count histogram.
- Peak density histogram.
- Area and log curve.



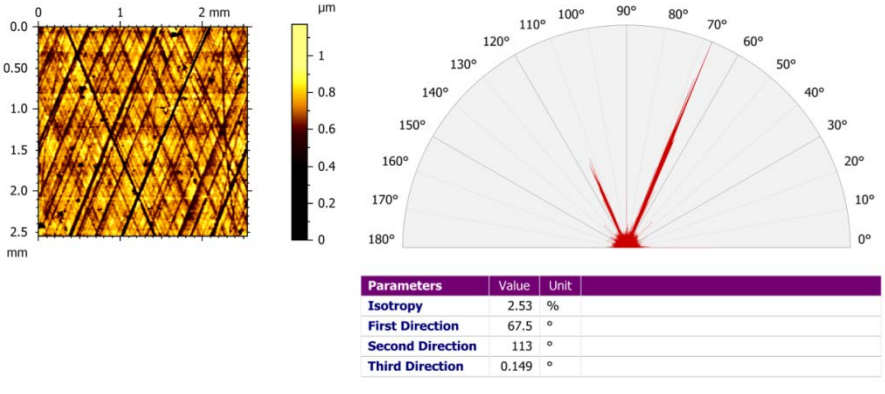
Peak count histogram: peaks/mm²

Texture direction

The **Texture Direction** study analyzes the surface using the Fourier transform and shows dominant surface directions on a polar or Cartesian plot. It calculates the following parameters:

- Isotropy (the higher the percentage value the more the surface resembles itself in every direction).
- The three most dominant lay directions of a surface (in degree units).

Note: shorter wavelengths (microroughness) and longer wavelengths can be excluded by percentage thresholding.



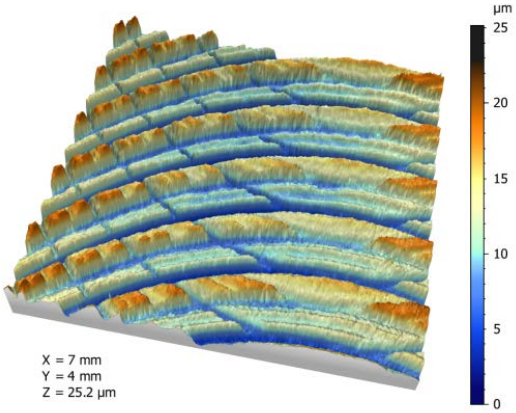
Parameters	Value	Unit
Isotropy	2.53	%
First Direction	67.5	°
Second Direction	113	°
Third Direction	0.149	°

Texture Direction study of honed motor cylinder: direction rose and parameters.

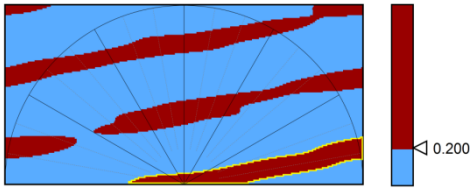
Texture isotropy & periodicity

The **Texture Isotropy** study calculates the following parameters with respect to a user-definable threshold:

- Isotropy (%)
- Periodicity (%)
- Period (length)
- Direction of the period (degrees)



Texture Isotropy study of roughness standard: isotropy and periodicity parameters.



Parameters	Value	Unit
Isotropy	5.36	%
Periodicity	66.5	%
Period	0.784	mm
Direction of period	90.0	°

Fractal Analysis

study the fractal dimension of a surface using two standard methods

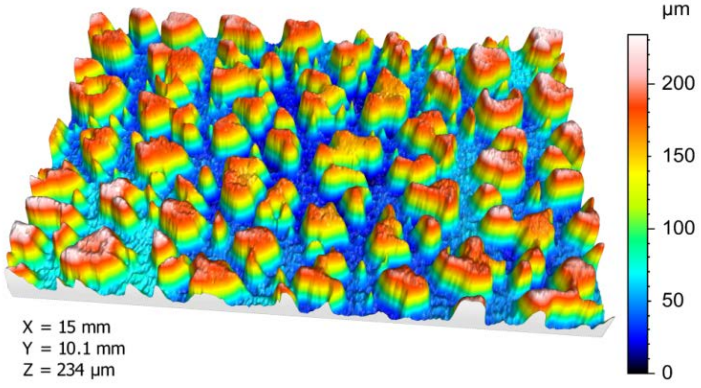
The **Fractal Analysis** study calculates a number of parameters for profiles and surfaces using two methods:

- the enclosing boxes method and
- the morphological envelopes method.

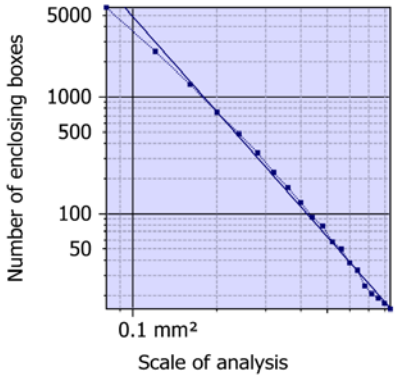
The number of enclosing boxes or the enclosed area (profiles) / volume (surfaces) is shown as a function of scale (the size of the boxes or structuring elements).

The following parameters are calculated:

- Fractal dimension (between 1 and 2 for a profile and between 2 and 3 for a surface).
- Slope and correlation coefficient (R^2) of regression line(s).



Fractal analysis of PVC surface:
enclosing boxes method gives fractal dimension 2.7



Information	
Method	Enclosing boxes

Parameters	Value
Fractal dimension	2.70
Slope(1)	-2.7
R^2(1)	0.997
Slope(2)	-2.7
R^2(2)	0.997

Sub-surface analysis

extract and analyze a sub-surface in exactly the same way as a full surface

Sub-surfaces can be extracted - from electronic components, mechanical components, MEMS and any other geometric surface – using the **Partition & Level** operator.

Geometric sub-surfaces are partitioned into motifs (zones) using the segmentation by watersheds algorithm defined in ISO 25178.

A sub-surface is analyzed in exactly the same way as a full surface.

Sub-surface selection, leveling and flatness

Before extraction a sub-surface

- is defined by interactively selecting one or more zones (which may or may not be contiguous), and
- can be leveled automatically.

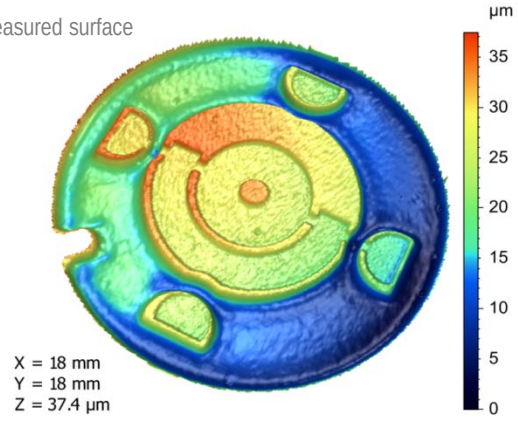
The flatness value of the sub-surface is calculated and displayed before extraction.

Fine tuning the partitioning

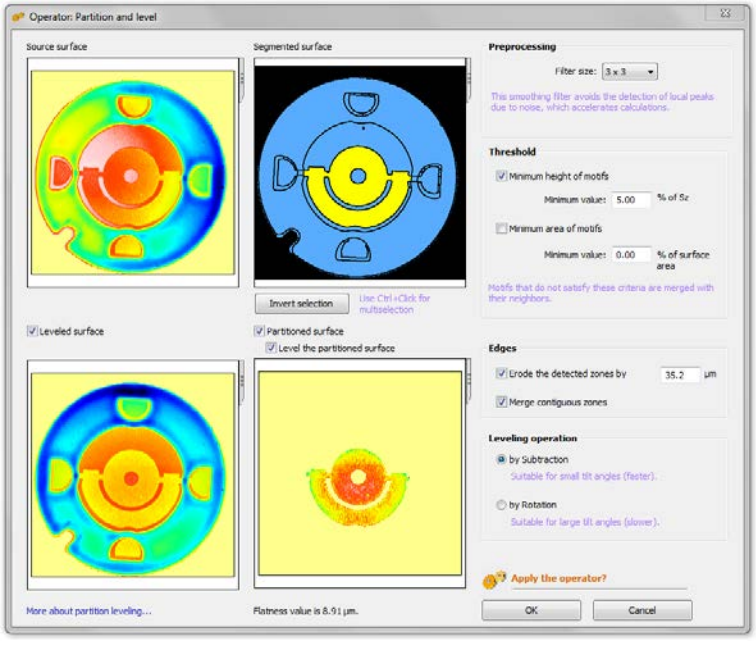
Partitioning can be fine tuned by Wolf pruning with respect to:

- the minimum height of zones to a percentage of the Sz (maximum height of the surface) parameter,
- the minimum area of zones as a percentage of surface area.

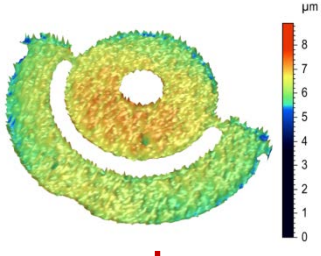
MEMS – measured surface



Partition and level dialog



Extracted surface (leveled)



Parameters for extracted surface only

ISO 12781 Flatness Parameters		
FLTt	5.15	µm
FLTp	2.41	µm
FLTv	2.74	µm
FLTq	0.932	µm

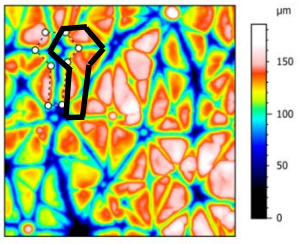
Furrows Analysis

visualize furrows and generate parameters

Depth of a single furrow/valley

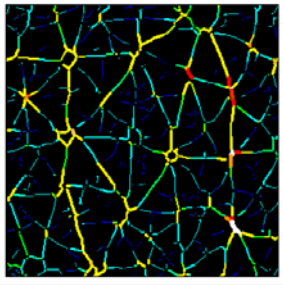
In the **Valley Depth** study a single furrow is identified interactively and the following parameters are calculated:

- Horizontal area.
- Valley area.
- Complexity (%).
- Depth.
- Volume.
- Perimeter.



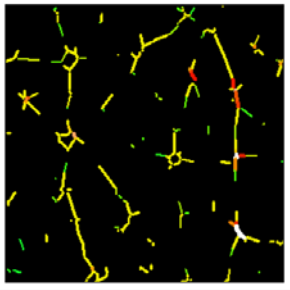
Parameters	Value	Unit
Horizontal Area	0.203	mm²
Valley Area	0.254	mm²
Complexity	25.2	%
Depth	80.1	µm
Volume	0.00458	mm³
Perimeter	2.19	mm

Skin - calculation of parameters on single furrows or valleys that are identified interactively.



All furrows are displayed.

Parameters	Value	Unit
Maximum depth of furrows	114	µm
Mean depth of furrows	36.5	µm
Mean density of furrows	71.5	cm/cm2



Only furrows deeper than the threshold are displayed.

Parameters	Value	Unit
Maximum depth of furrows	114	µm
Mean depth of furrows	67.3	µm
Mean density of furrows	17.1	cm/cm2

Display of all furrows (above left), furrows below a specified threshold (above right) and furrows parameters.

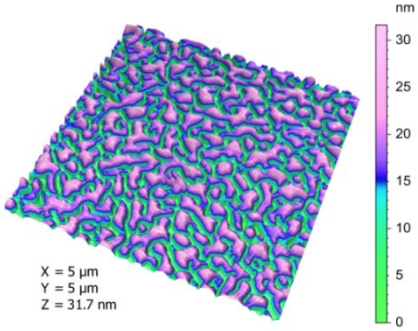
Detection and characterization of furrows

The **Furrows** study detects and displays

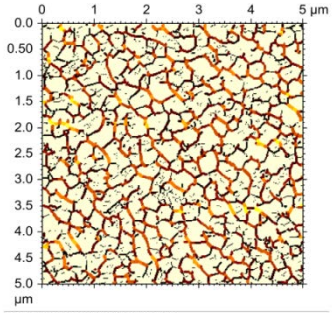
- All furrows
- Furrows below a specified threshold height or
- Furrows above a threshold height.

The following parameters are calculated:

- Maximum furrow depth.
- Mean furrow depth.
- Mean density of furrows.



AFM measurement of a polymer:



Only furrows above threshold are displayed.

Parameters	Value	Unit
Maximum depth of furrows	20.6	nm
Mean depth of furrows	9.55	nm
Mean density of furrows	61989	cm/cm2

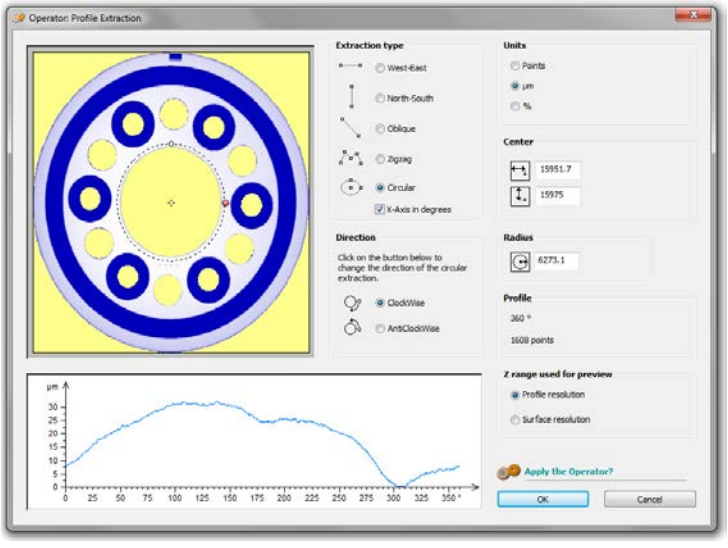
Display of all furrows above a specified threshold and parameters.

Extended profile analysis

Analyze multi-point and circular profiles

Multi-point profiles can be extracted for analysis.

Circular profiles can also be extracted from a surface and the X axis of the profile can be displayed in length or degree units.



Morphological filtering, custom spatial filters and more

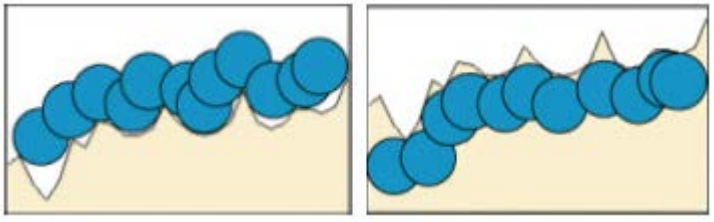
denoise surfaces and reveal hidden features

The **Morphological filtering** operator (ISO 16610-41 and ISO 16610-81) uses a horizontal plane or a sphere with a user-definable length or diameter as a structuring element to carry out dilation of the top side of a surface and erosion of the bottom side. In addition to dilation and erosion operations, the following filters are available:

- Closing filter – closes thin valleys, leaves peaks unchanged.
- Opening filter – reduces peaks and opens valleys.
- Alternating sequence filters – used to denoise a surface.

The **Spatial Filtering** operator can be used to define custom spatial filters.

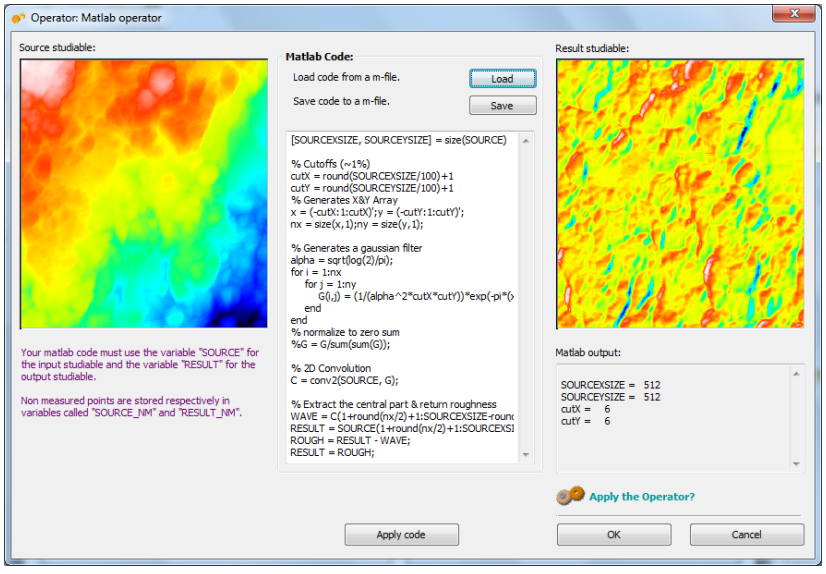
The **Form Removal** operator includes the ability to select one or more user-defined areas on the surface for inclusion in the form removal calculation or to exclude user-defined areas so that they are not taken into account.



Morphological filtering: dilation (left) and erosion (right) using a sphere as the structuring element

MATLAB™ compatibility

Design your own custom filters and use them in MountainsMap®



Use the MATLAB operator to execute your own m scripts

MATLAB™ scripts can be executed by loading an m file or writing your own script. This makes it possible for users to develop and apply their own operators to studiables (measurement data sets).

Note: MountainsMap® and MATLAB™ must be installed on the same computer.

3D Advanced Surface Texture Module for MountainsMap®

Selected features

3D Advanced Surface Texture Module for MountainsMap®	
Extended instrument compatibility	• All supported 3D contact and non-contact profilometers, confocal microscopes, interferometric microscopes, other 3D optical microscopes and profilers.
3D parameters	• ISO 25178 spatial, hybrid and functional volume parameters. • ISO 12781 flatness parameters. • EUR 15178 functional volume, spatial and hybrid parameters and functional indices.
Graphical studies of functional volume and *Sk* parameters	• Graphical study of ISO 25178 functional volume parameters. • Graphical study of *Sk* parameters.
Peak/grain/particle distribution	• Peak/grain/particle count and density plots. • Grain/particle area and log curves.
Isotropy, directionality and periodicity	• Polar and Cartesian plots of dominant directions of surface lay. • Calculation of three most dominant directions, isotropy, periodicity, period and direction of period.
Sub-surface extraction and analysis	• Partition surfaces into motifs (zones) in accordance with ISO 25178 segmentation by watersheds algorithm. • Fine tune partitioning with respect to minimum zone height and/or minimum zone area. • Merge contiguous zones automatically. • Select one or more zones for sub-surface extraction. • Automatic leveling of sub-surface and calculation of flatness. • Sub-surface extraction. • Subsequent sub-surface analysis exactly as full surface analysis.
Fractal analysis	• Carry out fractal analysis using the enclosing boxes method or the morphological envelopes method. • Calculate fractal dimension, slope and correlation coefficient (R^2) of regression line(s).
Extended profile analysis	• Extract multipoint and circular profiles from surfaces. • Display X axis of circular profiles in length or degree units.
Furrow analysis	• Identify a single furrow/valley interactively and calculate the following parameters: horizontal area, developed area, complexity (%), depth, volume, perimeter. • Vectorize a furrows/micro-valleys network to detect and display all furrows, furrows below a specified threshold height or furrows above a threshold. • Calculate the following parameters: maximum furrow depth, mean furrow depth, mean density of furrows.
Advanced filtering	• Morphological filtering of a surface using a horizontal plane or a sphere as a structuring element: dilation, erosion, closing filter, opening filter, alternating filters. • Definition of custom spatial filters with an XY matrix up to 15 x 15 • Select areas to be taken into account or ignored during form removal.
MATLAB™ compatibility	• Execute MATLAB™ scripts by loading an m file or writing your own script. • Develop and apply custom operators (MATLAB™ and MountainsMap® must be installed on the same computer).

3D Advanced Surface Texture Module for MountainsMap®: Version 7.0
Doc Revision: 20160627

Digital Surf Head Office & R&D Center
Digital Surf SARL, 16 rue Lavoisier,
25000 Besançon, France
Tel +33 3 81 50 48 00
contact@digitalsurf.com
www.digitalsurf.com

Digital Surf
Surface Intelligence