NewsLetter
SurFace
Fall 2017
Surface imaging, analysis & metrology news from Digital Surf

In this issue

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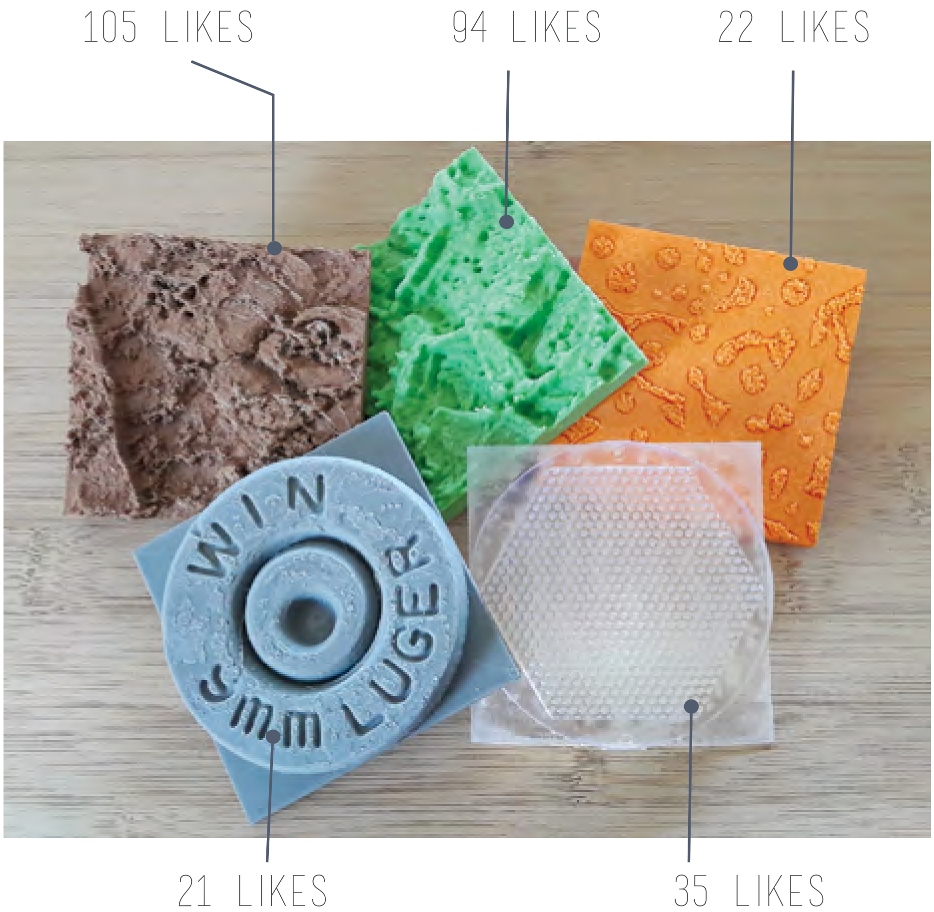
From screen to print

3D printing contest: the winning samples



Ever wondered what your surface data would look like printed in 3D? Five lucky Mountains® software users are about to find out!

These printed models are currently winging their way to the winners of our 3D printing contest.

Turn to page 2 to discover more.

EVENT

We look forward to seeing you at:

Booth #702

3D PRINTING CONTEST: THE WINNING SAMPLES CHOSEN BY YOU

When we launched our 3D printing contest back in September, we did not anticipate the sheer variety of examples that would be sent in by our users.

From biological samples to electronic components, it was great to see the full spectrum of what scientists, academics and industry members are studying with Mountains® software.

Here are the five winning examples chosen by visitors to the Digital Surf Facebook page. These have been 3D printed with a copy being sent to their lucky owners and another to be on show at the MRS Fall Exhibit in Boston. It was a tough decision as there were so many other worthy examples but we do hope to be able to present them all to our readers in future editions of *Surface Newsletter*.

1 HOT CHOCOLATE POWDER

and

2 ALOE PLANT

The two winning 3D views were generated from SEM images captured by fourth graders at the Victory World Christian School in Georgia, USA.

The school's science, technology, engineering and mathematics (STEM) coordinator Sophia Chin explained to *Surface Newsletter* that the presence of a SEM in the classroom helps "further develop practical applications with more advanced science equipment by exploring theoretical examinations. These examinations frame a working knowledge, which empowers deeper learning."

Great work kids, you are the scientists of tomorrow and almost certainly among the youngest ever Mountains® users!

3 MICROREPLICATED CERAMIC PAD CONDITIONER

This "forest of cones" is an array of precisely engineered 3D microreplicated ceramic structures coated with CVD diamond.

Known as a "pad conditioner", this component is used for Chemical Mechanical Polishing (CMP) in advanced node semiconductor manufacturing.

The micro-structures ensure consistent performance disk-to-disk and the metal-free cutting surface is ideal for advanced node processes sensitive to metallic contamination.

4 INDUSTRIAL POLYMER

This image comes from a recent study on industrial materials (applied in construction, pharmaceutics and other industries) where behavior of materials in different environments is of great importance.

Visualization of molecular structures and monitoring of conformational changes of polymers on different substrates opens novel possibilities for comprehensive molecular-scale studies.

5 9MM FIRED CARTRIDGE CASING

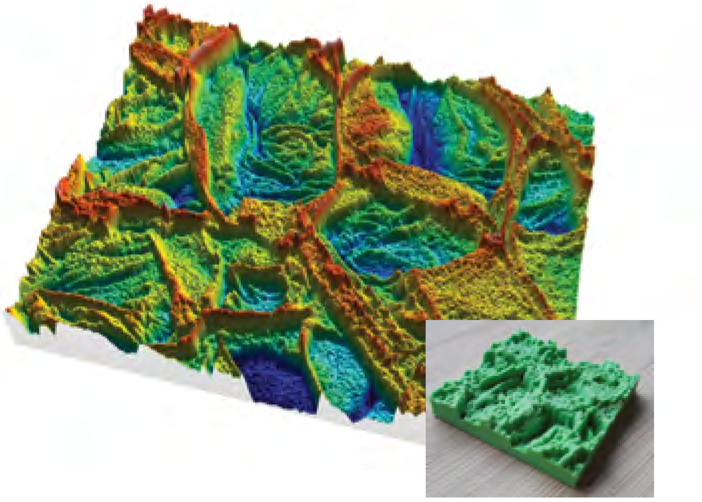
3D topography is now used in crime laboratories in measuring toolmarks and striations produced by firearms and imparted on crime scene evidence, such as fired bullets and cartridge cases. These individual marks are used by forensic examiners in helping to solve violent crimes.

The measurement depicted is of a 9 mm cartridge case. The full "head stamp" or back face of the cartridge is measured here. Examiners concentrate on three key areas of a casing: the breech face impression, firing pin and ejector mark.

HOT CHOCOLATE POWDER

Data obtained using scanning electron microscopy

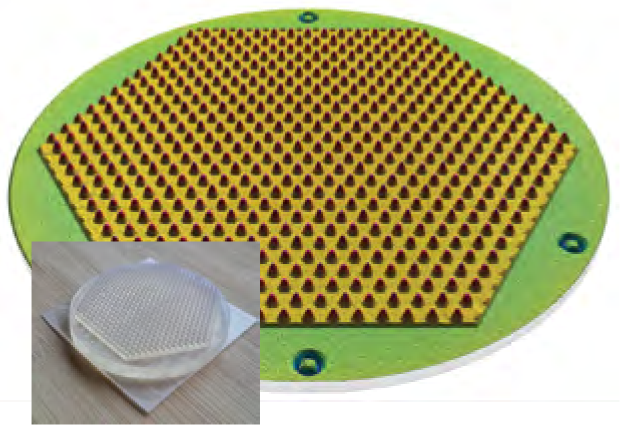
Entered by Sophia Chin, Victory World Christian School



ALOE PLANT

Data obtained using scanning electron microscopy

Entered by Sophia Chin, Victory World Christian School



MICROREPLICATED CERAMIC PAD CONDITIONER

Data obtained using a 3D measuring macroscope

Entered by Douglas Pysher, 3M Electronics Materials Solutions Division

INDUSTRIAL POLYMER

Data obtained using an atomic force microscope (AFM)

Entered by Mengmeng Zhang, Keysight Technologies

9MM FIRED CARTRIDGE CASING

Data obtained using focus variation microscopy

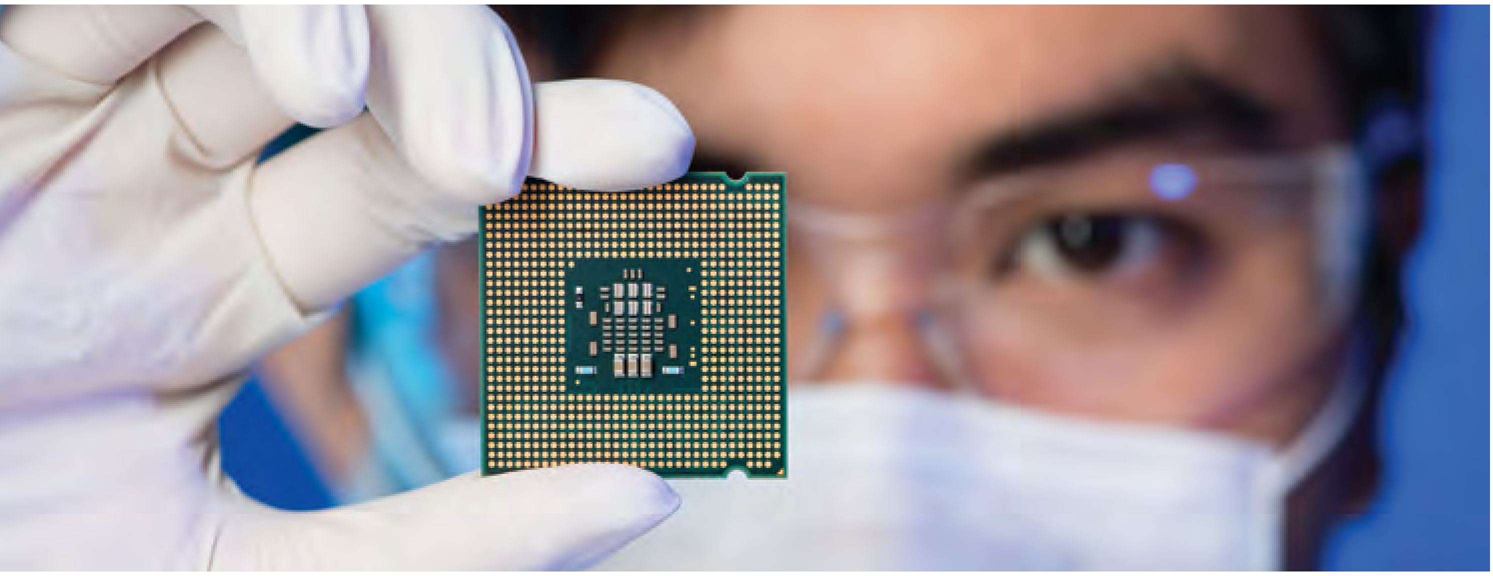
Entered by T. Brian Renegar, National Institute of Standards and Technology (NIST) - Nanometer-Scale Metrology Group

What about your sample?

Did you know that any Mountains® 3D view can be exported quickly and easily for 3D printing?

Find out more in our step-by-step guide: goo.gl/BXGTDt

SEMICONDUCTORS: CHARACTERIZING 3D STRUCTURES AT THE NANOSCALE



Nanolithography is a precise patterning technology used to fabricate functional nanostructures for applications in biosensors, advanced materials and extensively in the semiconductor sector for solar cells, printed electronics, LED, MEMS, etc.

The constant demand for lower process costs, easier implementation and higher throughput continues to push the development of nanolithography technology.

Besides traditional photolithography, various nanolithography technologies such as electron beam lithography, nano-imprint lithography and nano-sphere lithography have been developed[1][2][3].

After the pattern structure is generated, a precise characterization method is required to quantitatively check the quality of the structure. Since most lithographic patterns have a 3D structure, the characterization technique should offer the capability to measure in 3D.

AFM: the ideal tool for 3D nano-material charactacterization

The atomic force microscope (AFM), which utilizes a sharp probe to scan across the sample surface to record the surface morphology, provides not only high spatial resolution but also high vertical resolution at nanometer and sub-nanometer scale.

In this study, industrial researchers used the new AFM from Anton Paar, Tosca™ 400, equipped with Tosca™ analysis software based on Digital Surf's Mountains® surface analysis technology to characterize aluminum nanoparticles deposited on indium tin oxide (ITO) coated glass using lift-off based vapor deposition with electron beam lithography.

Two different aluminum nanoparticle patterns were deposited on ITO coated glass then imaged by using Tosca™ 400 in tapping mode:

- in the first case, a 400 x 200 nm pattern was used for nanoparticle deposition
- in the second, a 500 x 100 nm pattern was fabricated.

Surface geometry at the nano-scale

Using Tosca™ analysis software, surface morphology of the Al nanoparticle patterns was analyzed.

Two cross sectional (horizontal and vertical) profiles were extracted from the AFM topography image.

The lateral distance between nanoparticles was quantified by measuring the peak to peak distance. Pattern spacing was easily verified for both samples.

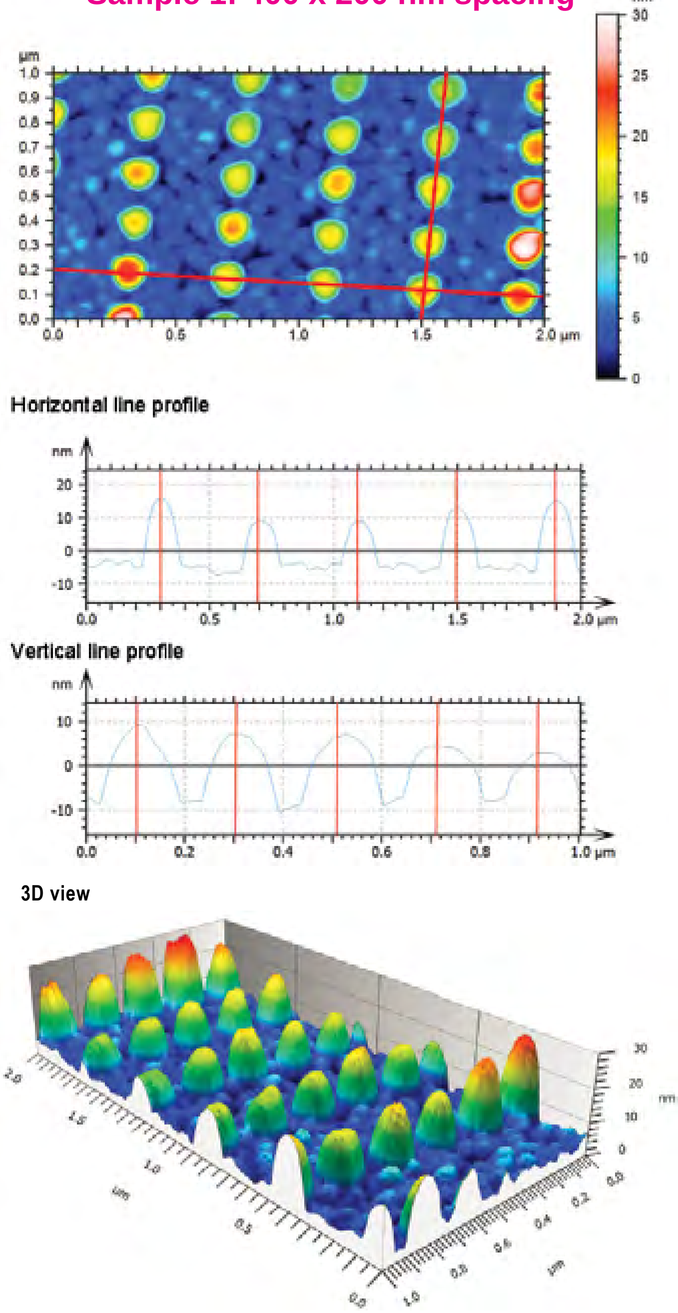
In the second sample, adjacent nanoparticles appeared to have already bonded to each other (or the gap between them was beyond the limit that the AFM tip could resolve). Despite this, spacing between nanoparticles could still be precisely measured. This suggests that 100 nm spacing is not sufficient to clearly separate the nanoparticles based on the deposition conditions.

Getting a better picture of surface structure

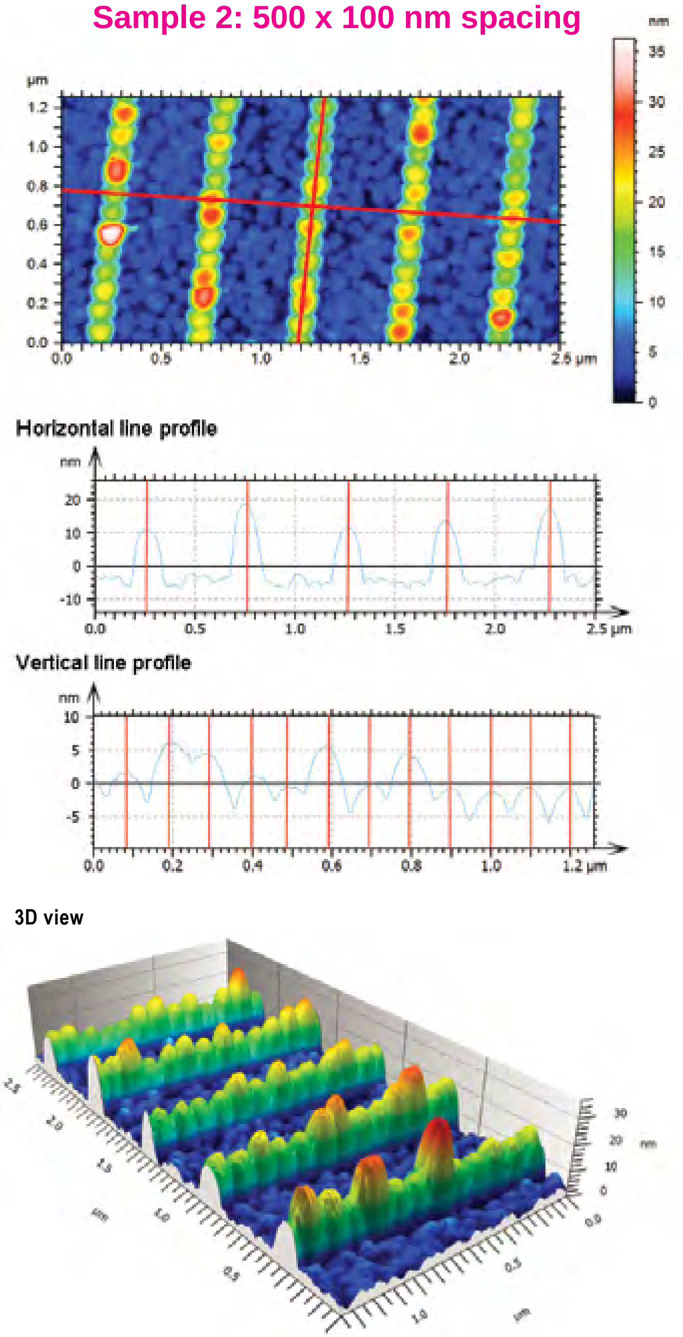
In order to see the structure more clearly, the data was displayed in three-dimensional view. Height amplification was applied to help the user see the 3D structures. Nanoparticles in the first sample had clear spacing while those in the second sample had already connected to each other, forming a line (or the gap between nanoparticles may be too small to be resolved).

The height of the nanoparticles in both cases varied from around 15 to 30 nm which suggests that the lift-off mask used in the lithography process may have varied in different locations, resulting in this non-uniform pattern.

Sample 1: 400 x 200 nm spacing



Sample 2: 500 x 100 nm spacing



References

[1] W. Rechberger, A. Hohenau, A. Leitner, J.R. Krenn, B. Lamprecht, F.R. Aussenegg, Opt. Commun. 2003, 220, 137.
[2] K.J. Byeon, H. Lee, Eur. Phys. J. Appl. Phys. 2012, 59, 10001.
[3] X.Zhang, E.M. Hicks, J.Zhao, G.C. Schatz, R.P.V. Duyne, Nano Lett. 2005, 5, 1503.

Measurements & initial text provided by Dr Ming Wu.
Samples courtesy of Ao.Univ.-Prof. Dr. Joachim Krenn (Nano-optics Group, University of Graz).

Contact: Anton Paar GmbH - support-nsp@anton-paar.com - Tel: +43 316 257 0 - www.anton-paar.com

ADD COLOR TO SEM IMAGES CONTAINING COMPLEX OBJECTS

If there's one thing we are committed to at Digital Surf HQ, it's replying to your questions and feedback! We are always eager to hear about your favorite Mountains® software features, as well as any issues you are having trouble with.

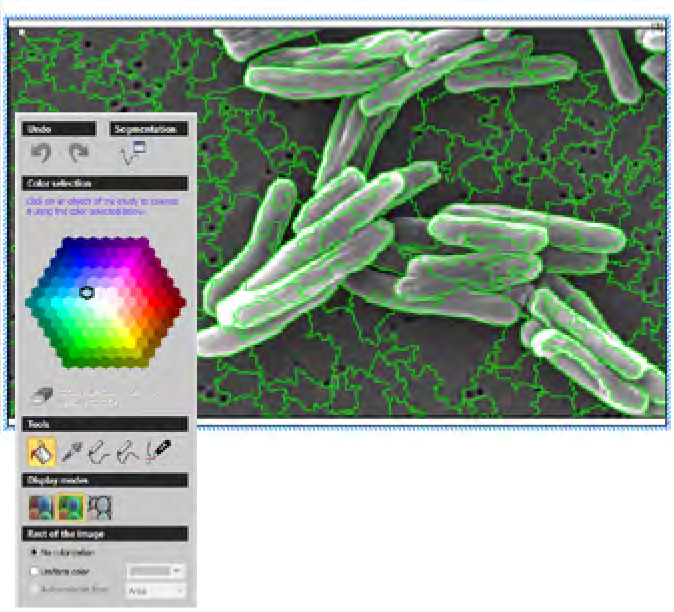
In this edition of *Surface Newsletter*, our direct sales manager Anne Berger shares her answer to a question she is asked frequently: how can I apply color to complex objects in scanning electron microscopy images?

Thanks to automatic object recognition, colorizing SEM images using Mountains® really is a straightforward exercise and will save you hours compared to performing the same operation with photo editing software.

Sometimes, however, objects in images are quite complex and you may not be getting the best results using the default segmentation settings.

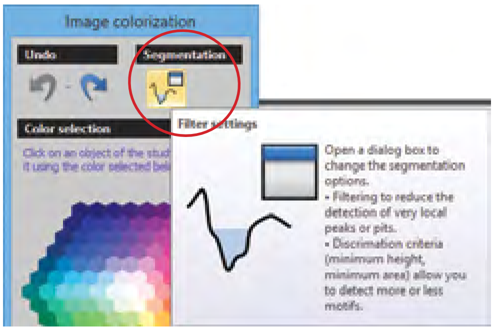
So, how do I get more selective granularity?

The image below of tuberculosis bacteria illustrates this problem.
The default settings applied by the Colorization tool produce too many "fragments".
Borders within the image must be redefined in order

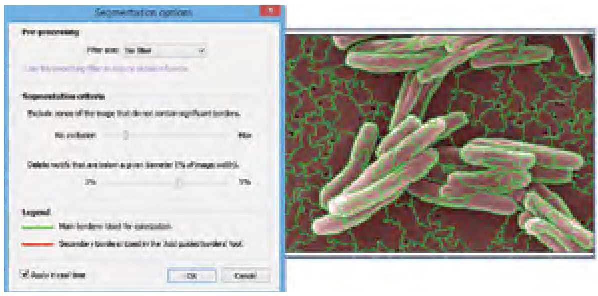


to isolate the main objects.
By applying the following steps, you will be able to easily deal with this.

1 In the Colorization Study, click on the Segmentation button

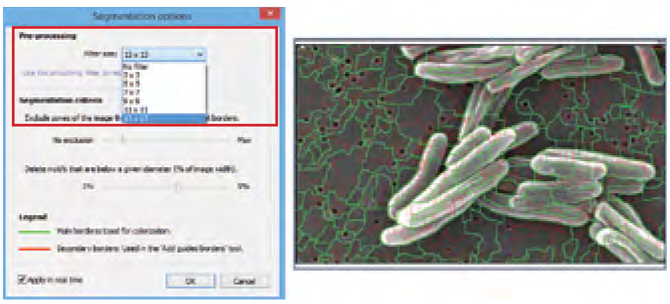


2 A dialog box appears and the main borders are shown

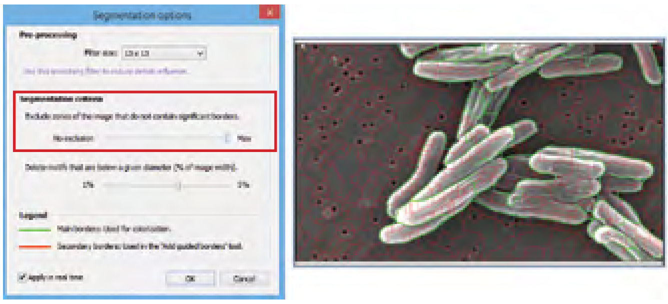


3 There are several different options to play with here

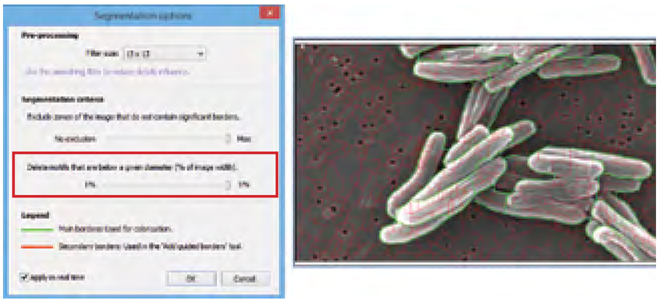
Filter size - this amends borders (a high value reduces the number of individual objects)



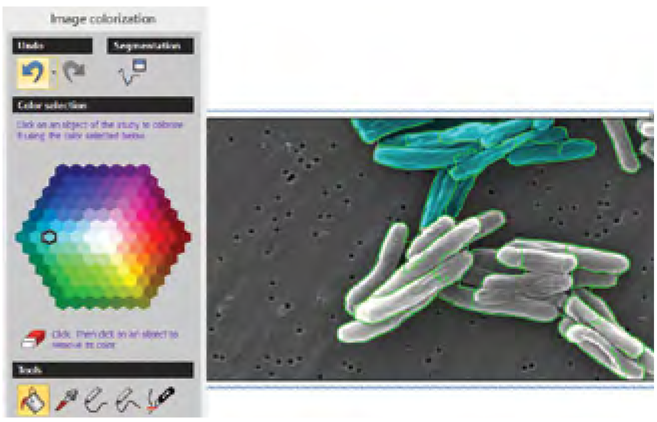
Exclusion - this excludes non-significant borders

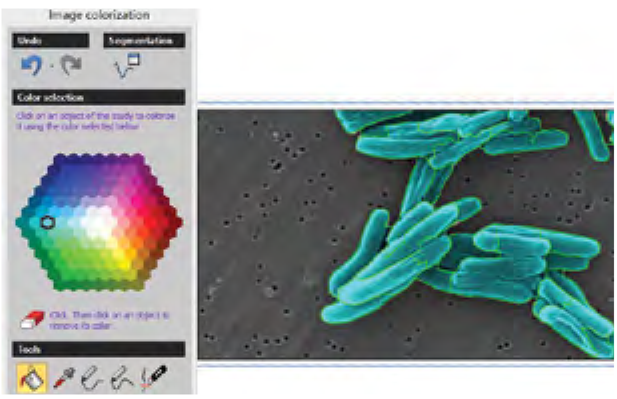


Motifs - this deletes smaller motifs

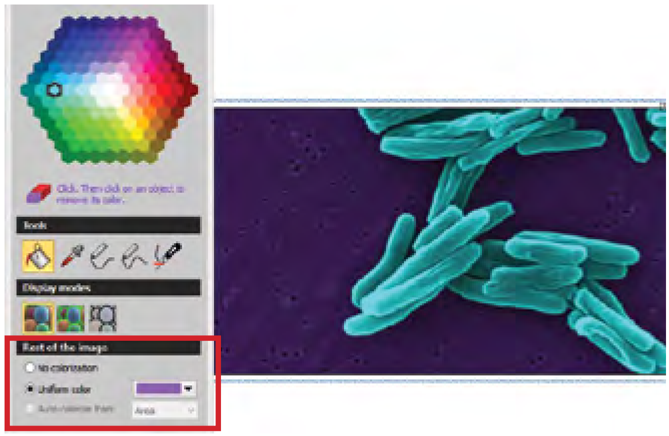


4 Then, you can begin to colorize each motif with the paint bucket tool. Because you now have fewer motifs, this should not take too long.
Feel free to zoom right in on motifs to add color. You may need to fine-tune some of the borders with the Add and Cut tools (Colorization window).





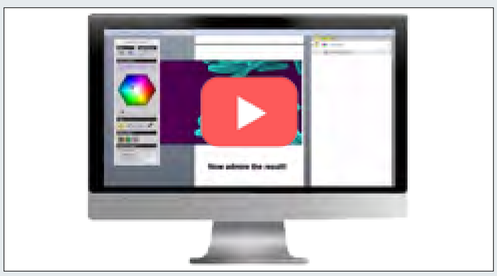
5 Finally, when this is done, choose the color you want for the background (rest of the image).



6 Now admire the result!
Make sure you select the Image only display mode to better visualize your image.

> See advanced SEM image colorization in action

Watch this video (and many more) on our YouTube channel:
https://youtu.be/_lJoNBoxr34



DOES IT MAKE SENSE TO COMPARE Ra AND Sa VALUES?

Are you measuring surface roughness over an area? Ever wondered whether it is OK (or not) to compare values calculated (Sa, Sq, Sz etc.) with profile surface texture specifications (Ra, Rq, Rz etc.)?

François Blateyron, Digital Surf's ISO surface metrology expert, sheds light on this issue which can easily cause confusion.

Optical profilers are very popular nowadays and frequently used to verify surface texture specifications on manufactured components. However, technical drawings are usually not made for such areal instruments and instead provide profile surface texture specifications. This can be confusing and may lead users to wonder how to compare profile and areal values.

The short answer is that they cannot be compared but in reality things are a little more complicated than that. The thing is that areal values only differ from profile values by a small margin. This could mean some users are comparing Sa values directly with Ra specifications, which is a mistake. The case of Ra/Sa is discussed here but the same reasoning can also applied to other parameters (Rk/Sk, Rq/Sq etc.)

A new tolerance value needs to be fixed for areal measurements and new specifications defined

Even though the equation of Sa is the areal extrapolation of the equation of Ra (see below), this does not mean that values should not be compared directly.

$$Ra = \frac{1}{l_r}\int_{l_r} |z(x)|dx \qquad Sa = \frac{1}{A}\iint_A |z(x,y)|dxdy$$

When a technical drawing contains a surface texture specification using Ra and a given tolerance limit, it is not possible to directly compare Sa values with the tolerance value given for Ra. A new tolerance value needs to be fixed for areal measurements and new specifications, adapted to Sa, need to be defined.

The first reason for this relates to the analysis bandwidth. Ra, by definition, is calculated on a roughness profile, based on a profile filter which filters spatial frequencies along the X axis (by default a Gaussian filter with a cut-off of 0.8 mm). Moreover, it is evaluated on several sampling lengths (as per ISO 4288) and averaged (except when calculating Ra according to ASME B46.1 where only one value is calculated over the sampling length).

On the other hand, Sa is calculated on a S-L or S-F surface based on a 3D filter. The areal filter takes into account wavelengths in all directions which means that it generates a different effect from the profile filter. The difference is especially visible when the surface has directional structures such as scratches or directional tool marks or possesses periodical patterns.

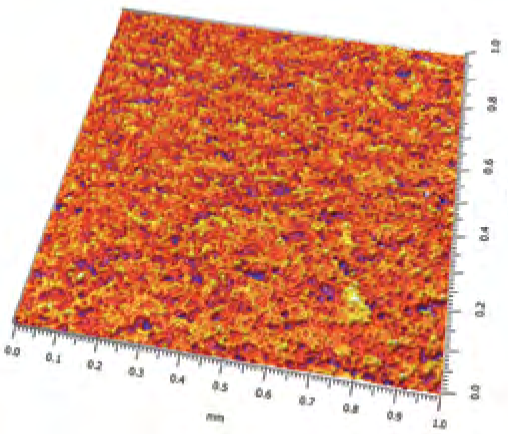
The second reason we need distinct specifications for Sa is to do with the size and resolution of the measured surface. When measuring a profile on a component, ISO 3274 defines the relationship between stylus tip, data spacing and evaluation length. A typical measurement is 5.6 mm long with a lateral resolution of 0.5 µm, which means 11,200 points.

An areal measurement made with an optical profiler is usually smaller in lateral size (commonly between 1 and 2 mm). Its lateral resolution may be of the same order (1 µm) depending on the instrument lens. Larger areas may be obtained using small magnification objectives (although these are less well adapted to surface texture) or by stitching many surfaces together. A lateral scanning instrument, such as a 3D stylus profilometer or a chromatic confocal probe, makes it possible to scan a larger area and generate a surface several millimeters in size, but users frequently select larger spacing in Y (between lines) than spacing in X (between points) in order to reduce the scanning time. These differences in lateral resolution and scan size lead to differences in parameter values.

The following examples show how results are different, yet close enough to create confusion. The comparison with profiles is obtained by extracting series of profiles along X or Y. A real profile measurement would usually be of a longer size and have better lateral resolution.

EXAMPLE 1:

Shot blasted aluminum, measured with a confocal microscope.



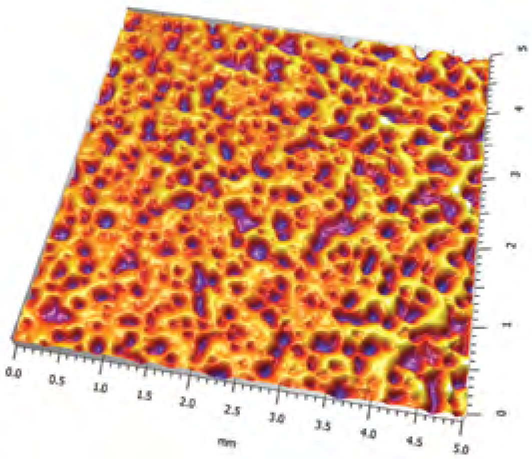
The surface is almost isotropic.

Sa = 3.283 µm
Ra(x) = 2.741 µm +/- 0.271 µm
Ra(y) = 2.974 µm +/- 0.243 µm

Gaussian filter with a cut-off of 0.25 mm.

EXAMPLE 2:

Grained plastic measured with a stylus profilometer.



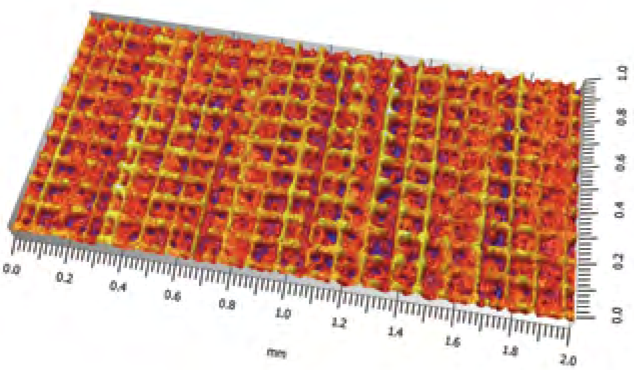
The surface has homogeneous texture cells.

Sa = 7.016 µm
Ra(x) = 5.422 µm +/- 0.928 µm
Ra(y) = 5.307 µm +/- 1.025 µm

Gaussian filter with a cut-off of 0.8 mm.

EXAMPLE 3:

Structures on an ultrasound transducer, measured with a chromatic confocal probe.



Sa = 1.247 µm
Ra(x) = 0.973 µm +/- 0.187 µm
Ra(y) = 0.876 µm +/- 0.331 µm

Gaussian filter with a cut-off of 0.25 mm

KEY TAKEAWAYS

- Areal parameters cannot be directly compared with specifications and tolerances of profile parameters.
- Distinct specifications need to be set for areal measurements and indicated as such on drawings.
- Recommended instrument technique may be indicated in order to avoid variations between specification and verification.

Resources

- Digital Surf Metrology Guide: www.digitalsurf.com/guide
- ISO 3274:1996 - GPS - Surface texture: Profile method - Nominal characteristics of contact (stylus) instruments
- ISO 25178-1:2016 – GPS – Surface texture: Areal - Indication of surface texture
- ISO 16610-1:2015 – GPS – Filtration: Overview and basic concepts
- Optical measurement of surface topography, R. Leach ed., Springer

EVENTS & PRODUCT HIGHLIGHTS

Microscopy & analysis in the Midwest

The Microscopy & Microanalysis (M&M) conference is the must-attend event in the US for users and manufacturers of many different microscopy techniques.

Anne, Cyrille and Nicolas were on hand at America's Center Convention Complex in Saint Louis, Missouri to provide visitors to the Digital Surf booth with answers to their surface imaging and analysis questions.

They also hosted tutorials on how to reconstruct a 3D model from scanning electron microscopy images as well as on quick and easy image colorization.

Thanks to all who stopped by our booth and see you in Baltimore, Maryland in 2018!

More info: www.microscopy.org/MandM/2018/

Big in Japan: JASIS 2017

For Digital Surf's third year at JASIS (Japan Analytical & Scientific instruments Show), Arnaud and Damien were pleased to welcome so many of our friends and new contacts to our booth.

The JASIS exhibition is on a simply massive scale and this year there were no less than 506 exhibitors, 1,478 booths and over 24,000 visitors in total.

More info: www.jasis.jp/en/

Product news

▶ Anton Paar launches Tosca™ Analysis for industrial AFM users

Following the recent launch of the Tosca™ 400 atomic force microscope, the leading scientific equipment manufacturing company Anton Paar announced the release of Tosca™ analysis software, based on Digital Surf's Mountains® surface analysis technology.

Specially designed for industrial users, the Tosca™ 400 comes with ToscaTM Control software for operating the AFM. Add to that new Tosca™ analysis software and users have a complete solution for complex nano-surface analysis in a variety of areas including characterization of semiconductor properties and investigation of polymer chains.

Read more: goo.gl/oSMWqD

WHAT'S HOT ON-LINE

Seen on LinkedIn
9/6/17: The ISO/TC 213 Working Group 16 meeting took place in Tokyo.
On the agenda: the continued development of the new ISO 21920 standard for profile surface texture, plus review of the ISO 25178-600 standard on the metrological characteristics of instruments and ISO 25178-700 on the calibration of these characteristics.
We also said thank you and goodbye to Masatoshi Arai of Tokyo Seimitsu, WG16 expert who is taking retirement this year. Many thanks to him for his contribution to ISO and as a long-time partner of Digital Surf!

Have you visited our YouTube channel recently?

Discover tips for getting started in Mountains®, tutorials for SEM image reconstruction & colorization and much more!

www.youtube.com/channel/UC5cyEQHs-9IWZdn0p-cJcJA

Popular on Facebook
10/13/17: The heat was on in Digital Surf's Besançon office as staff attended fire safety training.

Surface Newsletter

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Dive into our free online surface metrology guide and learn how to characterize surface texture in 2D and 3D

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