NEWSLETTER
Summer 2016
SURFACE
Surface imaging, analysis & metrology news from Digital Surf

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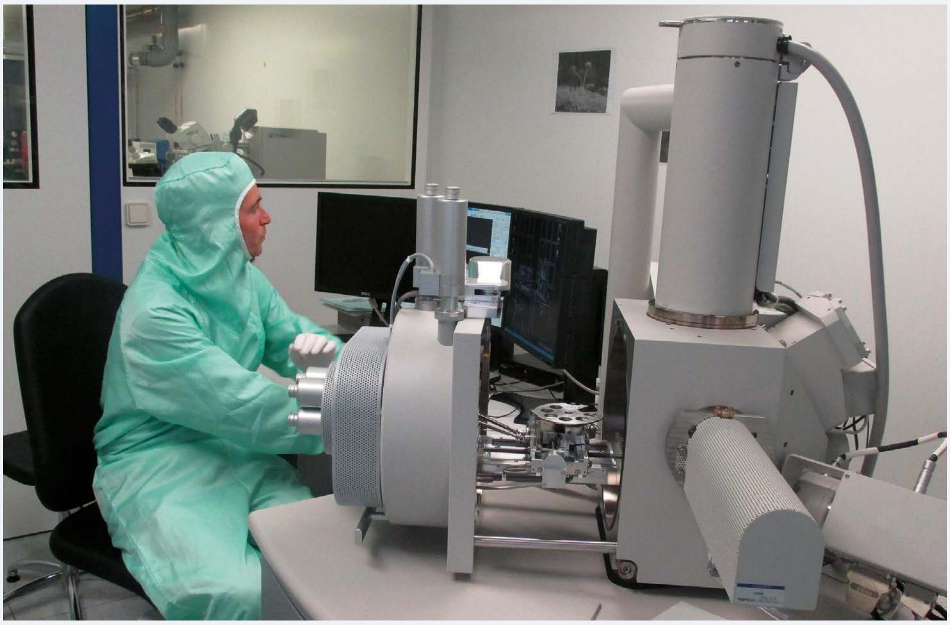
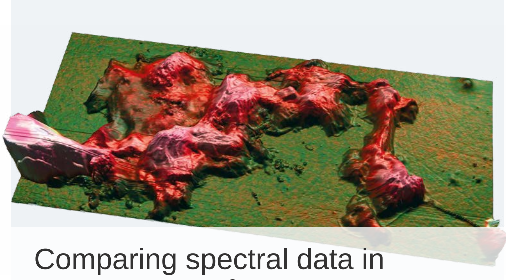
Working with data from scanning electron microscopy?



In this issue, we look at some of the tools available in Mountains® software for the processing and analysis of images and other data collected by SEM users.

Read more overleaf



Comparing spectral data in MountainsMap®

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PLUS

We look forward to seeing you over the summer at one of the following exhibits:

Microscopy & Microanalysis	European Microscopy Congress	Japan Analytical Scientific instruments Show
Columbus, Ohio	Lyon, France	Tokyo, Japan
July 24 - 28	August 28 - September 2	September 7 - 9
Booth 1223	**Booth 39**	**Booth 7A-401**

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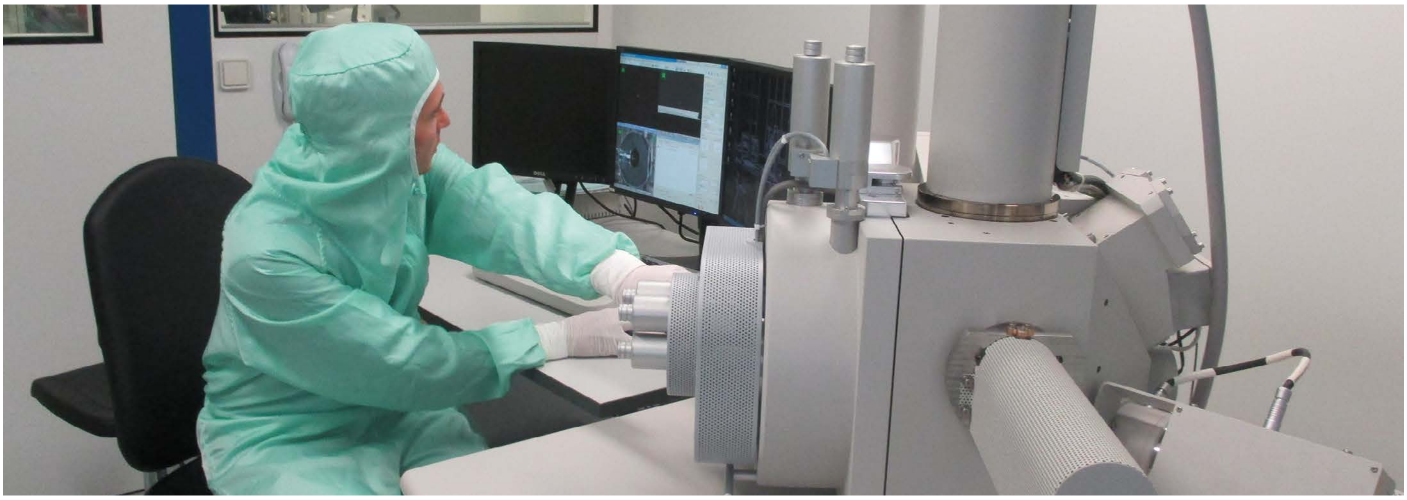
www.digitalsurf.com

4 WAYS TO GET MORE OUT OF YOUR ELECTRON MICROSCOPE DATA



Do you work with images from scanning electron microscopes?

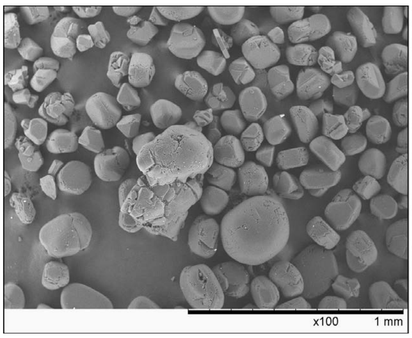
Whether you are based in industry or in research, in materials science or in life sciences, MountainsMap® SEM software, specifically engineered with the needs of SEM users in mind, offers a unique, comprehensive solution for processing your data.

Whilst 3D reconstruction and quick and easy colorization are two of the major innovations brought to MountainsMap® users (see right), there are a whole host of other advantages.

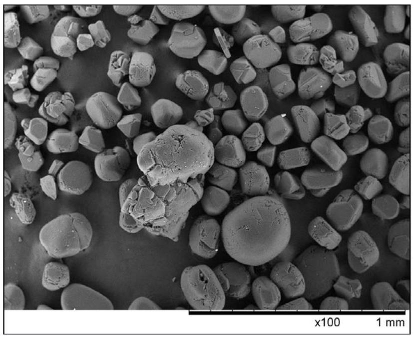
1. Correct image defects

A good quality SEM image is sharp and has optimum contrast and brightness. Contrast can of course be adjusted during image collection but what happens if it's not?

No problem! Help is at hand with the MountainsMap® Enhance tool.



This image of aggregated diamond nanorods shows too little contrast.

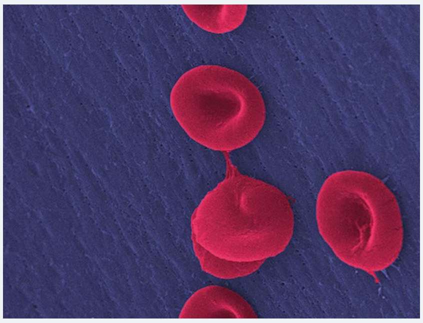


The image is corrected using MountainsMap®

Source: Ludvig14/CC A-SA 3.0

MountainsMap®, a 3D color upgrade for your scanning electron microscope

1 SEM image colorization made easy
Go from black and white to color effortlessly in just a few clicks.

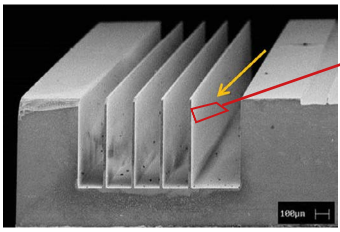


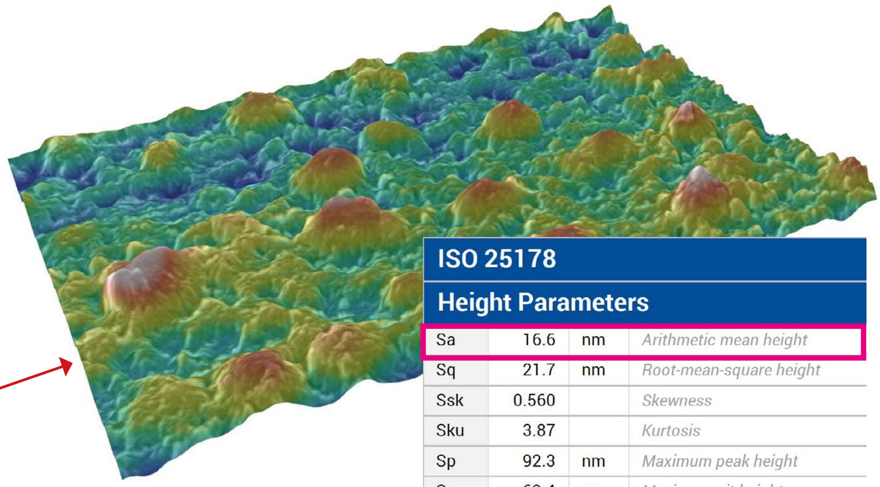
2 3D reconstruction of surface topography
From two successive SEM scans at different tilt angles or four SEM images obtained by a 4 quadrant detector

See: goo.gl/uzDzPx

2. Measure roughness

Quantifying surface roughness at a very small scale can often be tricky. Scanning electron microscopes can be used to access zones and scales other measurement instruments cannot see (as below).





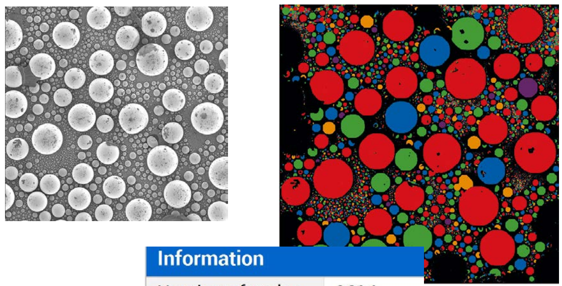
ISO 25178			
Height Parameters			
Sa	16.6	nm	Arithmetic mean height
Sq	21.7	nm	Root-mean-square height
Ssk	0.560		Skewness
Sku	3.87		Kurtosis
Sp	92.3	nm	Maximum peak height
Sv	63.4	nm	Maximum pit height
Sz	156	nm	Maximum height

3D reconstruction of ridge surface and parameters including roughness (Sa) generated using MountainsMap®
Data courtesy of Femto-ST

3. Perform grains & particles analysis

Grains & particles analysis is useful in a variety of fields of industry and science, from quality control to evaluation of nanostructural detail.

Scanning electron mcroscopy images in which object contours are clearly defined can be processed using MountainsMap®.



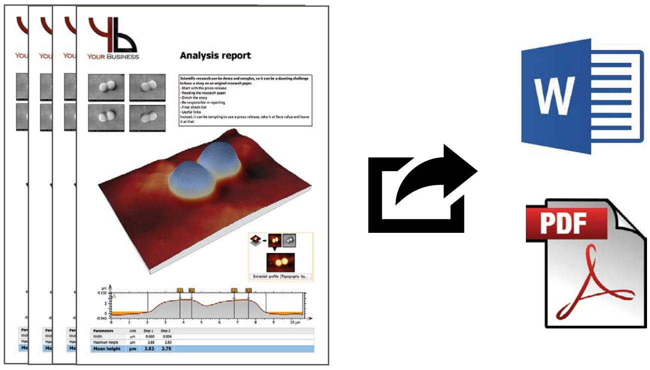
Information	
Number of grains	8614

Grain count on a SEM image of tin spheres

4. Create analysis reports

All across science and industry, reporting plays an essential role in getting ideas across and presenting new findings.

MountainsMap® users benefit from the software's unique tools for transforming data into visual analysis reports. Compile results, analytical studies, parameters, text and illustrations and export them in PDF or Word-compatible formats.



Compile reports on your image analysis data

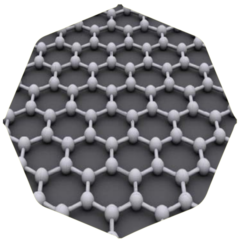
And also

- Filters, noise and artifact removal
- Image stitching
- Distance measurement and geometry (contour)
- Co-localization of SEM images with data from other measurement instruments
- Spectroscopy analysis (EDS, cathodoluminescence etc.)
- Series of FIB images
- And more…

Please note: features available depend on product type and level.

Visit the Mountains® SEM YouTube channel

SCIENTISTS CHARACTERIZE NEW WONDER MATERIAL SILICENE



MountainsMap® used for spectral analysis

Following in the footsteps of its famous cousin graphene — a carbon lattice just one atom thick — silicene, a two-dimensional material composed of silicon atoms, has fascinated researchers world-wide, in particular for its possible applications in the semiconductor industry.

Bruno Grandidier, researcher at the IEMN in Lille France, reports on his recent work, investigating the spectral composition of this new "wonder material".

"Two-dimensional atomic crystals present extraordinary electronic properties and high specific surface areas (SSA) that make them unique for investigating novel physical phenomena.

In addition, their two-dimensional geometry is directly compatible with established design and processing approaches already used in the semiconductor industry. Such an asset opens the way to numerous new applications in electronics, photonics, sensors, catalysis and energy storage.

Although graphene is the most well-known material of this type, other two-dimensional atomic crystals exist. One of the main focuses of research in this field currently is to investigate the unexplored physical properties of these materials in the hope of overcoming graphene's limitations and with the aim of paving the way to the conception of new innovative devices.

Silicene, the silicon (Si) analogue of graphene, consisting of a single sheet of sp^2-hybridized Si atoms, is at present emerging as a two-dimensional material with very attractive electronic properties.

Determining the atomic structure of Silicene

The IEMN research team recently revealed new specific physical properties of silicene.

In this study, a sample of silicene was grown on a silver surface by evaporating atomic Si onto a Ag(111) surface at a deposition rate of 0.02 monolayer/min^{-1}. The temperature of the silver surface was maintained at 230-250°C.

In order to gain insight into the true nature of the Si-Si bonds and the interplay between Si and Ag atoms, the silicene sample was studied using three different techniques, all combined in the same ultra-high vacuum system. These were:

- scanning tunneling microscopy (STM)
- low energy electron diffraction (LEED) and
- Raman spectroscopy.

For comparison, similar experiments were performed on the surface of a Si(111) crystal.

MountainsMap® software was used to visualize and analyze structure and composition of the silicene surface compared with the silicon crystal. The study confirmed differences in spectroscopic properties."

Author

Bruno Grandidier lectures on quantum mechanics, solid state physics, nanosciences and nanotechnologies at the Institut Supérieur de l'Électronique et du Numérique (ISEN) in Lille, France.

As part of the Institut d'Électronique, de Microélectronique et de Nanotechnologies (IEMN), also in Lille, France, his main areas of research are semiconductor nanomaterials and near-field microscopy.

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bruno.grandidier@isen.iemn.univ-lille1.fr

MountainsMap®: a multiphysics analysis tool

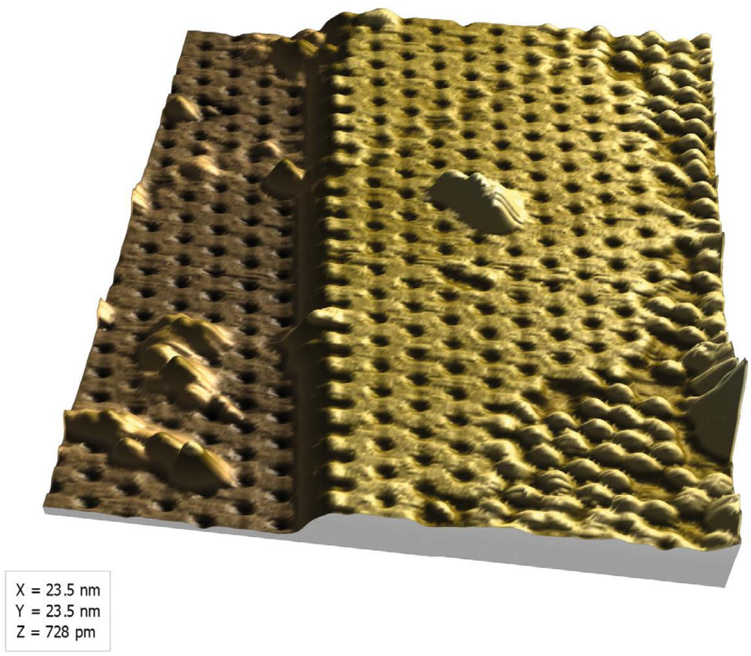
The atomic-scale **STM image** obtained after the deposition of one monolayer of Si atoms onto the Ag(111) surface shows the typical (4x4) atomic structure, that consists of a honeycomb lattice. Two terraces are visible and separated by an atomic step with a height of 2.4 angströms. Tunneling conditions: sample bias of -1.0V, tunneling current of 50 pA.

The structure is confirmed by the analysis of the **LEED pattern**, where the most intense diffraction one-four order spot (yellow) corresponds to the (4x4) structure, the other spots arising from the bare silver surface (red integer spot) and the partial formation of a second layer with the (√3x√3) structure (blue spot).

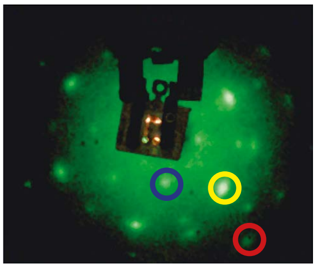
Although **Raman spectroscopy** was performed with the sample on the STM head in ultra-high vacuum, the measurement clearly shows a peak followed by a tail toward lower frequencies in the wavenumber range 450-550 cm^{-1}.

Based on the reference spectrum of silicon, the decomposition yields two contributions, the major one that is attributed to the TO mode of silicon, and a second one at lower frequencies that is caused by vibrational modes related to the particular hybridization of the Si orbitals with the Ag(111) surface.

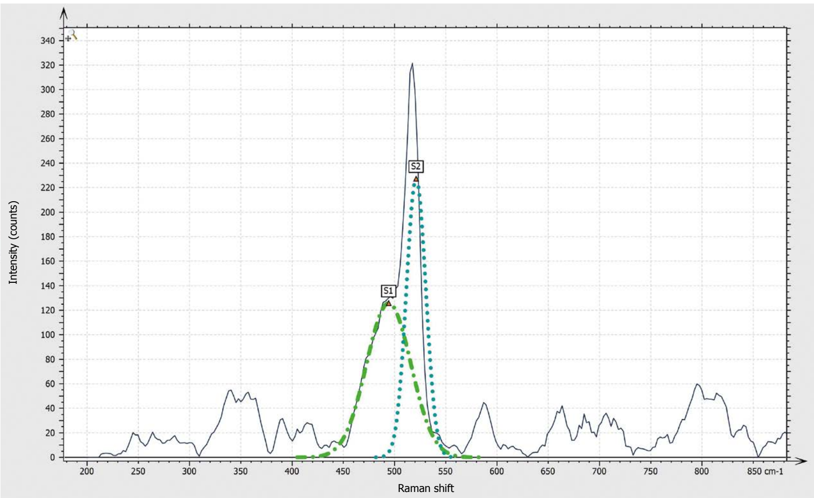
Read more: A. Diaz-Alvarez et al, Scanning tunneling spectroscopy and Raman spectroscopy of monolayer silicene on Ag(111), Surf. Sci. (2016), http://dx.doi.org/10.1016/j.susc.2016.06.005



Above. 3D view of the silicene surface generated in MountainsMap® showing an atomic step and typical "honeycomb" structure.



Right. LEED analysis



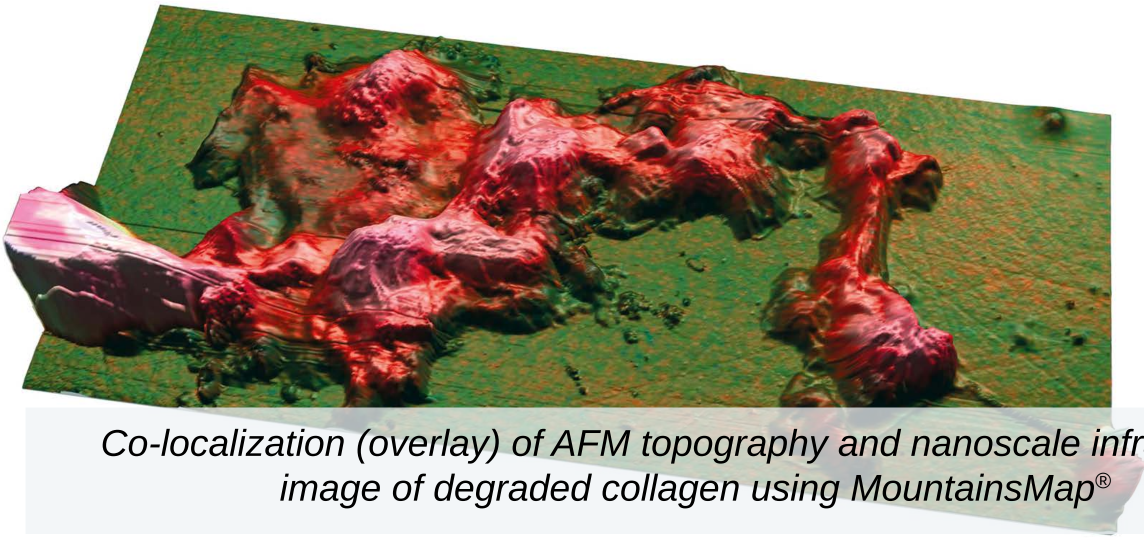
Parameters	Axis name	Unit	S1	S2
Wavenumber	Raman Shift	cm-1	494	521
Amplitude	Intensity		126	227
Half Maximum	Intensity		62.9	114
FWHM	Raman Shift	cm-1	51.0	22.3

Above. Spectrum analysis performed on the silicene surface shows two peaks including one at 494 cm^{-1}, specific to this material and not present in the spectral response of silicon.

Data obtained using the new Peak detection feature in MountainsMap®.

COLLAGEN DEGRADATION REVEALED BY CORRELATIVE IMAGING

Valuable insight for biomedical and heritage research



Co-localization (overlay) of AFM topography and nanoscale infrared (IR) image of degraded collagen using MountainsMap®

Collagen, the main structural protein found in animal connective tissue, has a wide variety of applications. In the form of gelatin it is used in the food, pharmaceutical and cosmetic industries to name but a few. It can also be found in articles used by ancient civilizations such as glue, bow strings or objects made from leather (clothes, scrolls etc.)

Researchers at the Université Paris-Sud (France)* recently presented the results of a ground-breaking project to map collagen denaturation using nonlinear optical microscopy (NLO) and nanoscale infrared (IR) spectroscopy.

Professor Alexandre Dazzi, one of the authors of this study, took time out of his busy schedule to tell *Surface newsletter* more.

"Our main aim in this study was to characterize gelatinization, the ultimate and irreversible alteration corresponding to collagen denaturation to gelatin. This process can be caused by UV radiation, or contact with water or heat for example. In our study, we analyzed its effects on a 17th century parchment but our findings could of course be applied to the study of other materials where collagen is present including biological tissues (skin for example).

Two complementary imaging techniques were used to probe alterations at various structural levels. Both these techniques have the advantage of being non-invasive and non-destructive, which means even fragile or precious objects may be studied, as was the case here."

1 First of all, **nonlinear optical microscopy (NLO)**, a renowned technique for quantifying collagen organization in tissues was used to obtain 3D multimodal imaging of scattering samples with micrometer-scale resolution.
Nevertheless this technique could not resolve nanometer structural features.

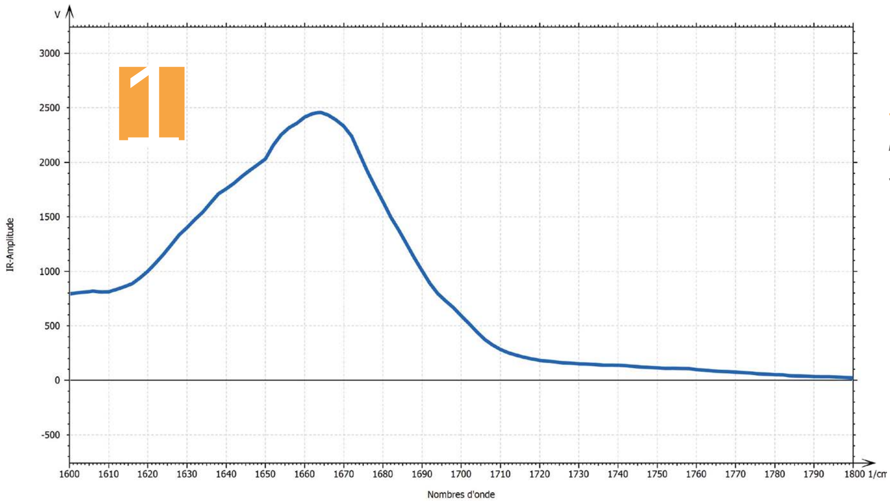
2 It was therefore combined with **infrared (IR) spectroscopy** in order to identify the chemical origin of morphological changes. Given the scale at which spectroscopic analysis must be carried out (~100nm), we used IR spectroscopy (nanoIR), a recent technique combining an Atomic Force Microscope (AFM) with an IR pulsed tunable laser (commercialized by Anasys Instruments).

3 This allowed us to acquire chemical mapping and local IR spectra and thus characterize images at the nanoscale.

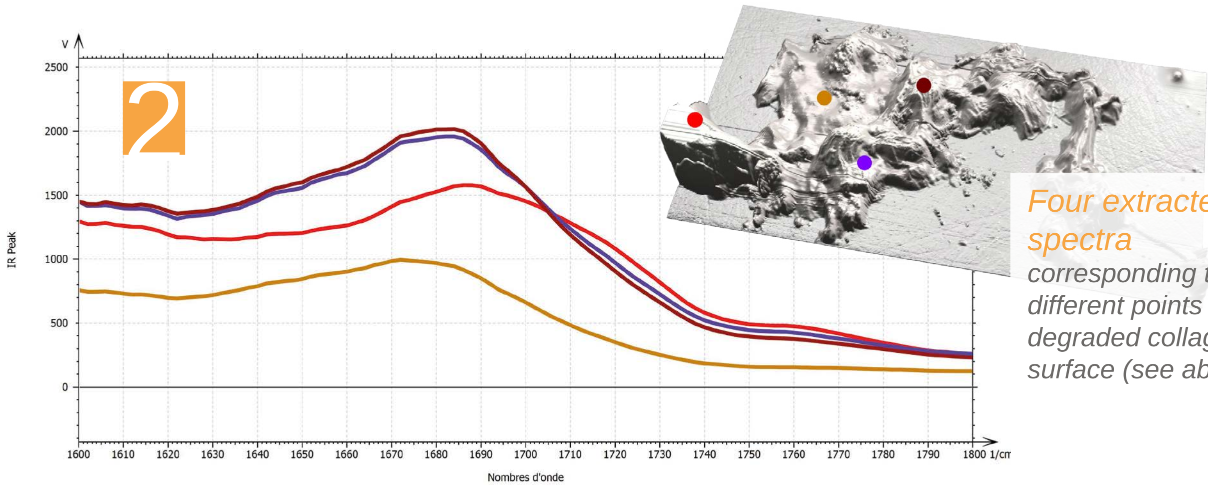
* Along with the French National Center for Scientific Research (CNRS), the Ministry of Culture and Communication, the École Polytechnique and the Université Pierre et Marie Curie.

Comparing spectral data in MountainsMap®

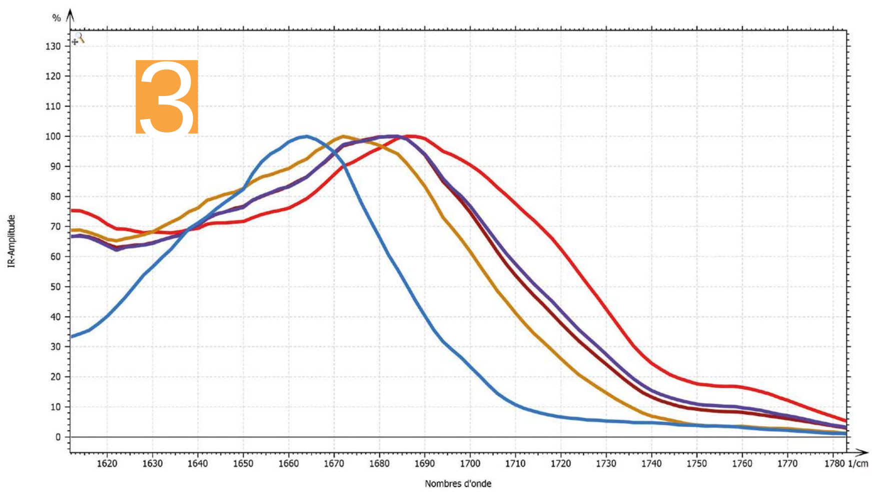
The spectroscopic signatures acquired were compared with data obtained from pure collagen reference samples. MountainsMap® tools for spectral analysis gave the following results:

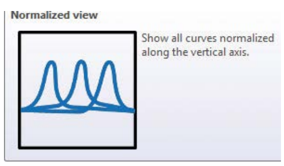


Spectral signature of collagen reference sample (filtered using the Smooth the spectra operator).



Four extracted spectra corresponding to four different points on the degraded collagen surface (see above).





Comparison of these four points with collagen reference spectra (blue), showing phase shift to the right. Data displayed in new Normalized view.

Author

Alexandre Dazzi teaches nanoscience at Université Paris-Sud, France, where he has a research program focused on nanoscale IR spectroscopy, which he invented.

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alexandre.dazzi@u-psud.fr

Read more:

Scientific Reports May 19, 2016, www.nature.com/articles/srep26344

WHERE SHOULD I READ UP ON SURFACE METROLOGY?

> Summer is coming, which for some means long, lazy hours spent reading on the beach or by the pool. But why not take a break from the latest bestseller to brush up on your surface metrology skills?

François Blateyron, Digital Surf's ISO surface metrology expert, has a few recommendations to make.

1 Start with the leading authorities on surface metrology

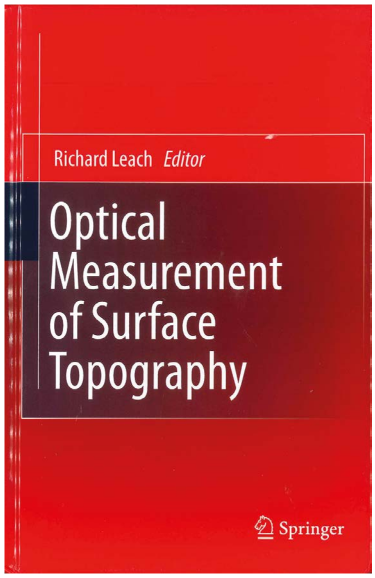
Should you be looking for technical information about instrument techniques and in particular optical surface texture instruments, **"Optical measurement of surface topography"** published by Springer is a book not to be missed.

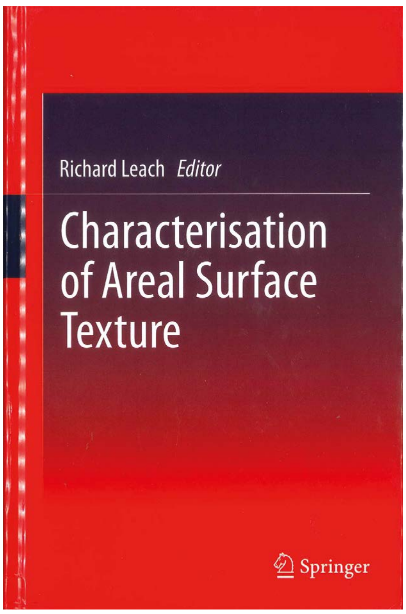
This collective work edited by Professor Richard Leach contains several chapters written by leading specialists of each technique.

Chapters cover the following techniques:

- Chromatic confocal microscopy
- Point autofocus instruments
- Focus variation instruments
- Phase-shifting interferometry
- Coherence scanning interferometry
- Digital holographic microscopy
- Imaging confocal microscopy
- Light scattering methods.

Most of these techniques are supported in the ISO 25178-60x series but this book provides more detailed information and describes a variety of case studies.





Another excellent reference book is **"Characterisation of areal surface texture"**, also published by Springer. This book describes post-processing and filtering methods in detail as well as surface texture parameters and also provides several practical applications.

Chapters cover the following topics:

- Areal field parameters
- Areal feature parameters
- Areal filtering methods
- Areal form removal
- Areal fractal methods
- Choosing appropriate parameters
- Characterization of individual features
- Multi-scale signature of a surface

It also describes a range of applications including solar cells, cylinder liners, laser structured cams and road surfaces.

See other book recommendations here: www.digitalsurf.com/en/guidepublications.html

2 Check out a few scientific publications

Application examples can also be found in scientific publications where authors explore material properties or process efficiency using surface texture tools.

A list of more than 700 publications is provided in Digital Surf's free online metrology guide: www.digitalsurf.com/en/guidemountainspublications.html.

The following excerpts highlight some interesting examples.

- **Metrological changes in the surface morphology of cereal grains in the mixing process (2016)**

  Study of the relationship between the moisture content of maize grains and 3D roughness parameters, in particular kurtosis and skewness parameters.

- **The Use of Focus-Variation Microscopy for the Assessment of Active Surfaces of a New Generation of Coated Abrasive Tools (2016)**

  This paper explores several surface texture parameters and analyses to characterize abrasive grains, using several instrument techniques.

- **Impact of GEM foil hole geometry on GEM detector gain (2015)**

  This paper exposes a characterization method of the geometry of gas electron multiplier holes using contour and step height analyses.

- **Influence of grinding conditions on the topographic characteristics of machined surfaces (2014)**

  Using frequency analysis, wavelets, fractal and motifs analysis, this paper demonstrates the differentiation of turning and grinding surfaces of same Sa value, depending on machining conditions.

- **Use of close range photogrammetry to assess the micro-texture of asphalt surfacing aggregates (2013)**

  Results obtained from 3D volume parameters for tracking wear on rock aggregates.

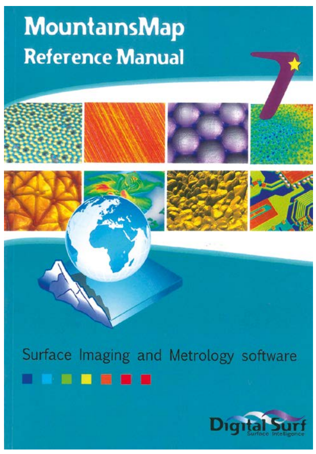
3 And don't forget the MountainsMap® Reference Guide

The MountainsMap® Reference Guide is the documentation installed with the software that can be displayed by pressing the F1 key anytime.

But it is not only a user help guide on how to use the software, it also contains valuable metrological information on standards, filters, as well as on mathematical algorithms used such as the Fourier transform or the autocorrelation function.

This online reference guide is available on paper as a reference manual, a 750-page book printed in color, in English, German and French.

It can be ordered by visiting: www.digitalsurf.com/usermanual



More information - Free online surface metrology guide:
www.digitalsurf.com/guide

EVENTS & PRODUCT HIGHLIGHTS

Another great year at the Control trade fair

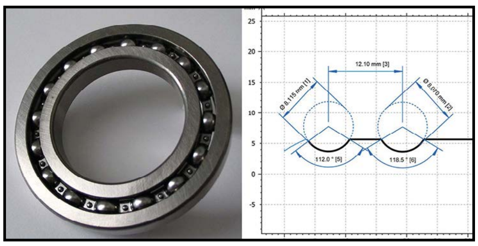
This year Control, the international trade fair for quality assurance, celebrated its 30th anniversary. International market leaders and innovative suppliers from the quality assurance industry converged in Stuttgart from April 26 to 29 to gather information about latest trends and developments.

We were pleased to unveil the redesigned Digital Surf stand in Hall 3 and welcome our partners and customers for a demonstration of all the latest capacities of MountainsMap® software.

It was also great to see so many of our partners software products based on Mountains® Technology also on show in the other halls. Many thanks to all who made Control 2016 a success!

Contour modules: new online ressources

Do you perform dimensional analysis on your data?
Contour and Advanced Contour Modules for Mountains® software enable you to calculate dimensions of measured profiles, compare them with CAD data and display form deviation.



Learn more:

> Contour module:
goo.gl/SmOsdO

> Advanced Contour module:
goo.gl/IXEJ2S

Product news

▶ April 2016

If you or one of your colleagues work with a Bruker microscope, we have good news for you!

Bruker and Digital Surf have teamed up to provide **Vision64 Map** data analysis and reporting software based on Mountains® Technology with Bruker's entire line of 3D optical microscopes. Applications range from performance assessment of automotive products to dimensional analysis of component geometry.

Find out more: www.bruker.com

▶ May 2016

Mountains® Technology is now also available with ISRA VISION 3D measurement systems.

New **ISRA Map** software gives users of ISRA VISION's KORAD3D optical measurement systems access to state-of-the-art surface imaging, analysis and metrology tools.

Please visit www.isravision.com

▶ June 2016

Finally, we are pleased to announce the release of **PM3D Map** imaging & metrology software for users of Advantest's Multi Vision Metrology Scanning Electron Microscope systems.

Applications include measuring the dimensions of nanoscale patterns on wafers, photomasks and other substrates.

Read more: www.advantest.com

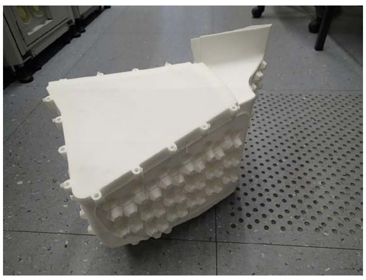
IMPROVING ENERGY EFFICIENCY OF CAR CLIMATE CONTROL

In Europe, cars are responsible for 12% of CO^2 emissions. As part of the effort to reduce our carbon footprint, a group of Swiss industrials and researchers recently presented an innovative project to cut back energy consumption of car air-conditioning by up to 50%.

Marc Vetterli, part of the research team, explains how MountainsMap® contributed to this study by revealing valuable information about component surface features.

"Our project was to develop a system designed to pre-process air before it is brought into the air-conditioning circuit of the car. The idea was to use the air inside the cabin of the car which has a comparatively lower (or higher, depending on the season) energy content than the air outside.

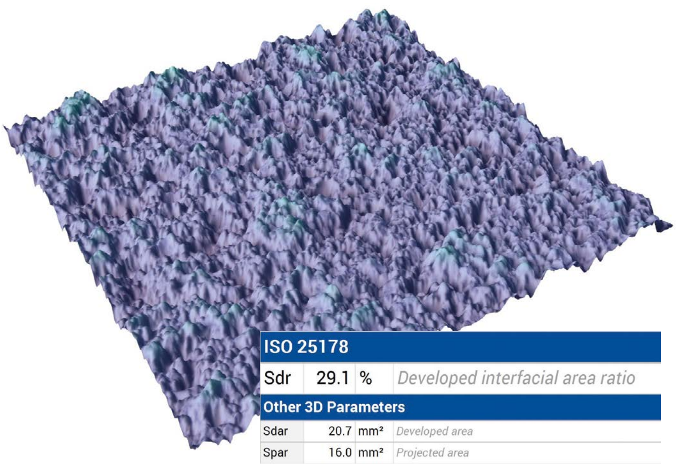
In summer, for example, the outside air is warm and the air in the cabin is cooler. By redirecting the cool air from the cabin through a box-unit (see photo) which also contains the hot air duct (air coming in from the outside), it is possible to create significant heat exchange between inbound and outbound air flows. Thus the hot air coming into the air-conditioning system of the car is "pre-cooled" and less energy is required to cool it further to the required level. In fact, the use of the air pre-conditioning system proved 50% more energy-efficient than a conventional air-conditioning system.



In further tests aiming make the system yet more efficient, we also discovered that the surface roughness of the material used to manufacture the walls of the box-unit also played an important part in increasing heat exchange between hot and cool air.

Thanks to the use of GelSight technologies (www.gelsight.com) and MountainsMap® surface analysis software, we were able to demonstrate that using materials with greater surface roughness values increased the area of the component in contact with air by 18 to 21% and so considerably improved the efficiency of heat exchange.

This novel air-conditioning system enables energy savings for cooling down cars in summer. Further studies show it can also be used to better heat-efficiency in winter conditions with the reuse of warm air from the passenger cabin. This feature is especially important for electric vehicles."



3D view of component surface and roughness values generated using MountainsMap®

Read more: goo.gl/I6Xugq

Contact: vetterli@inspire.ethz.ch, +41 71 2747329

Swiss Federal Project financed by the Commission for Technology & Innovation (KTI 14793.1 PFIW-IW), 2012-2014. Industrial partner: Weidplas AG. Recherche partners: EMPA, Group 504 Automotive Powertrain Technologies & Inspire AG.

USEFUL LINKS

FREE TRIAL

TRY MOUNTAINS MAP®

MountainsMap® Premium Software with all the options, free for 30 days!

CONTACT US FOR AN UPDATE

Contact us for information about updating MountainsMap® 6 or earlier software to the latest version of MountainsMap® 7

WATCH A MOUNTAINS® 7 TUTORIAL

Get the most out of Mountains® 7 by watching one of our tutorial videos

DOWNLOAD OUR BROCHURES

Learn more about Mountains® 7 software by downloading a brochure in English, French, German or Japanese

MEET DIGITAL SURF

- **Microscopy & Microanalysis** in Columbus, Ohio
  July 24 - 28, booth 1223
- **European Microscopy Congress (EMC)** in Lyon, France
  August 28 - September 2, booth 39
- **Japan Analytical Scientific instruments Show (JASIS)** in Tokyo, Japan, *September 7 - 9, booth 7A-401*

Digital Surf
Surface Intelligence

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