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Test Report TRACEiT®

Mobile optical surface structure analysis

Würzburg, 2012-04-17

Customer:

Samples: Paper

Report no.:

Test engineer:

Report by:

(sign)

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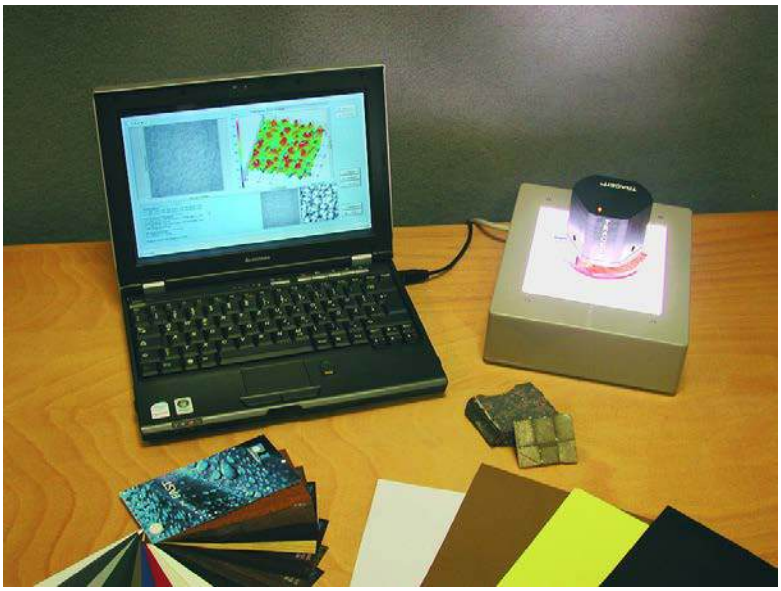
1. Principles of function TRACEiT®

The new, patented TRACEiT® system is a fully mobile, contact free surface documentation and analysis tool. It is the first instrument in the market to provide the reproducible visual impression as well as the 3D topography and the derived parameters like the roughness values R_a, R_q and R_z for the 3D topography or the „visual intensity“ for the visual impression. Hence with the TRACEiT® it is possible to document, analyze and evaluate the visual appearance and thus the visual impression to the human eye. The same applies to the 3D topography.

The evaluation of a surface by topographic and visual parameters happens at the same time and at the same place on the surface so it is possible to compare them for correlations or to take it into account for damage evaluation.

The measuring system consists of a sensing head connected to a special, modified notebook. All operations are processed via the interaction of measuring head and notebook. Storage, evaluation and analysis happen in the notebook. Data can be exported to other programs for further analysis. The system is independent of external power supply and other controls and allows measurements at almost any location.



TRACEiT® with transmitting light table

Optionally, there is a transmitting light table available to investigate transparent or translucent materials like e.g. glass, foils, fabrics or paper. So among other things the system is able to measure and evaluate the cloudiness, topography and visual impression of coated and uncoated materials as well as simultaneous measurement of multiple printed paper products.

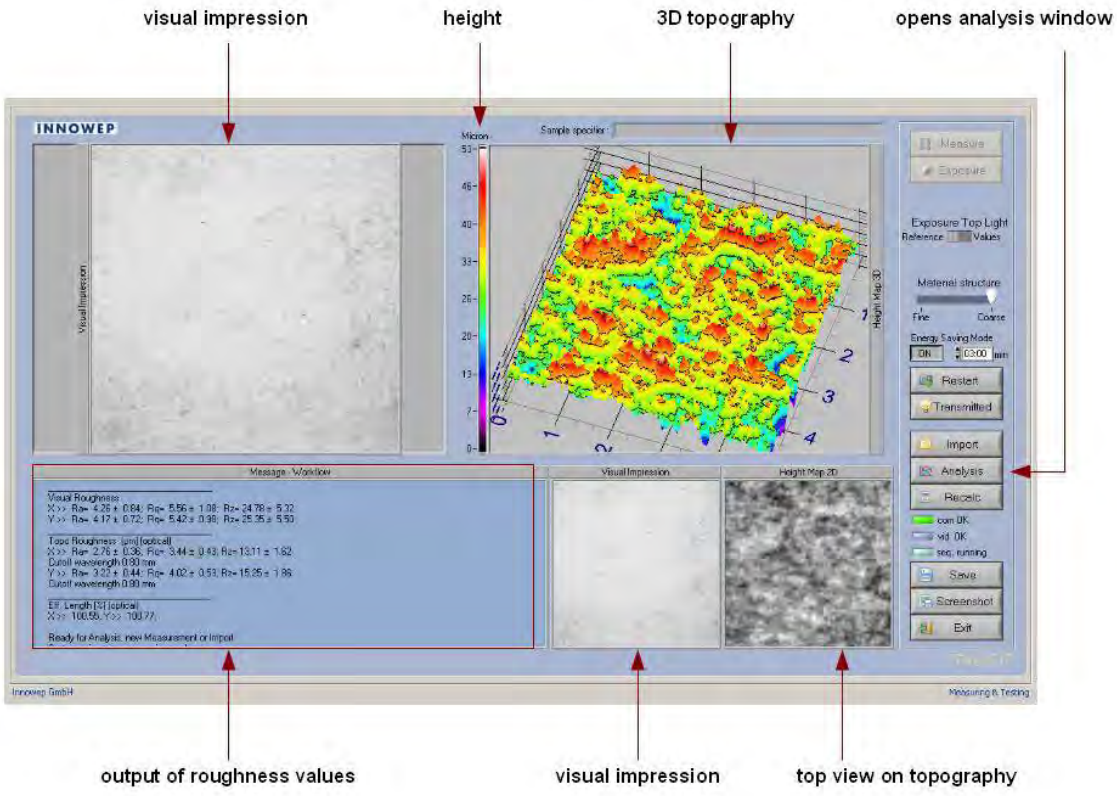
2. Documentation

The measured data is analyzed by a powerful software. In the following chapters the analysis windows are listed and explained in detail.

2.1 Total view

In the total view window the visual impression and the computed 3D topography together with the derived parameters are shown. The 3D topography is documented by the roughness parameters R_a, R_q and R_z and their standard deviations. The visual impression is documented by the „visual intensity“. The “Analysis” button opens the analysis window for the 3D topography and the visual impression. This is explained in chapter 2.2 and 2.3.

Overview main window



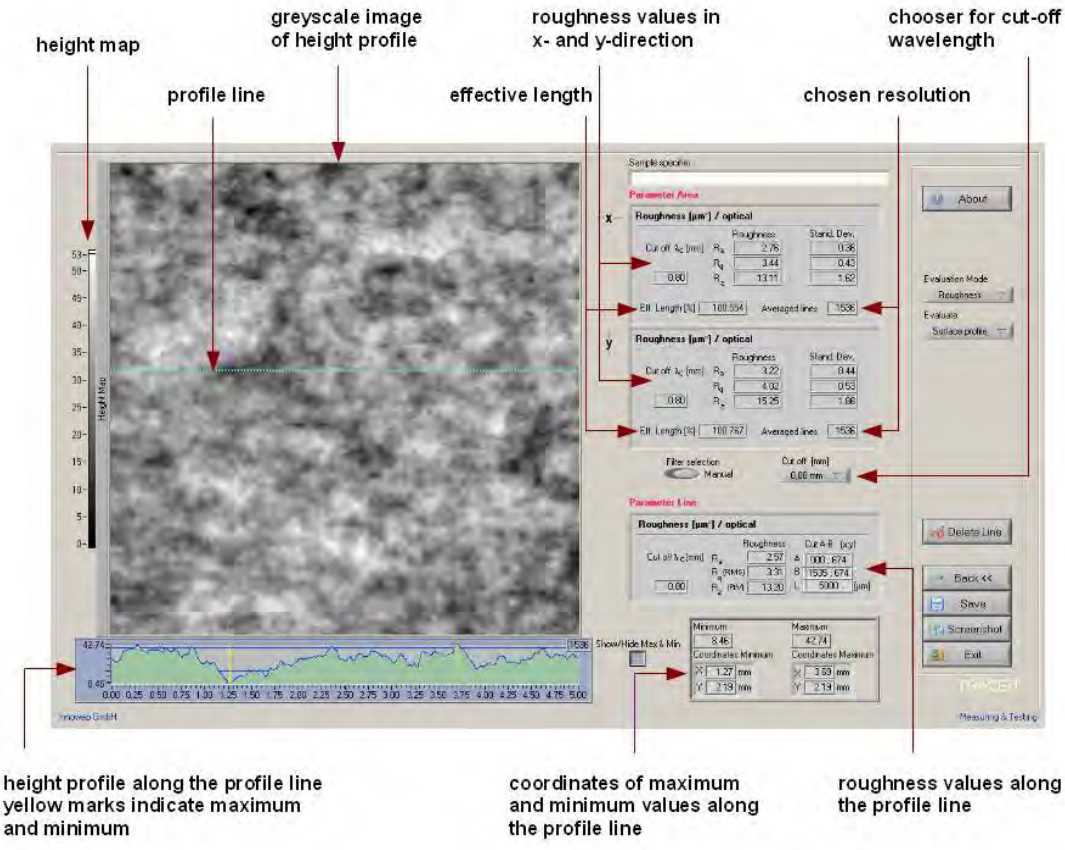
2.2 Documentation of topographic roughness

The topographic roughness can be examined in the analysis window. It contains the calculated height profile as a gray scale image map with the corresponding heights in µm. It displays the roughness parameters R_a, R_q and R_z and their standard deviations. In addition the effective length, i.e. the total length of the “straightened” roughness profile, is calculated as a mm- and %-value.

The evaluation of the topography happens with a maximum resolution of 1536 lines in x and y direction. With every line being 5 mm in length this summarizes to 7.50 m each in x and y direction (just for comparison: the evaluation length of standard roughness measuring tools amounts to 4 mm). The lateral resolution of the system amounts to 1.2 µm. The evaluation in x and y direction happen independently so that possible anisotropies can be detected and evaluated separately.

Additionally it is possible make line cuts in horizontal or vertical direction or along a freely drawn line. The roughness parameters are displayed while moving the mouse in the map. Below the image map the height profile of the actual cut is displayed together with the minimum and maximum values.

Overview analysis window for topographic roughness



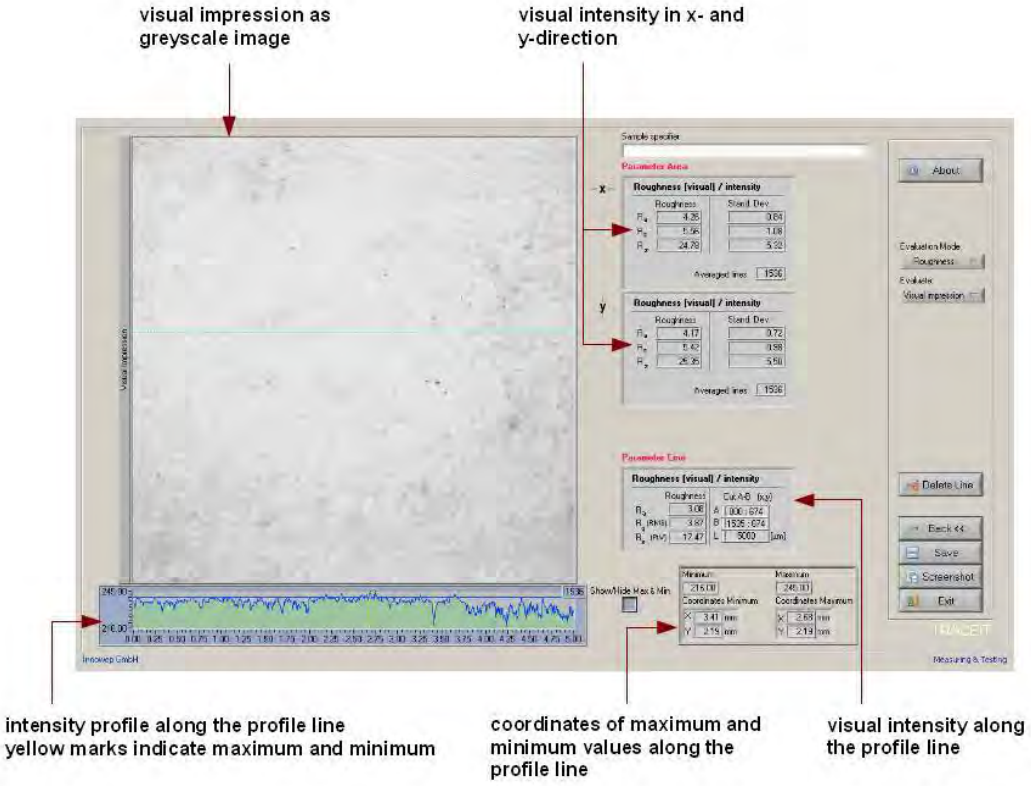
2.3 Documentation of the visual impression

The visual impression documents the appearance of a surface to the human eye. The analysis window contains an image of the measured surface in light intensities which presents the intensity stimuli to the human eye. The evaluation is done accordingly to the topographic roughness measurement but applied to the light intensity values.

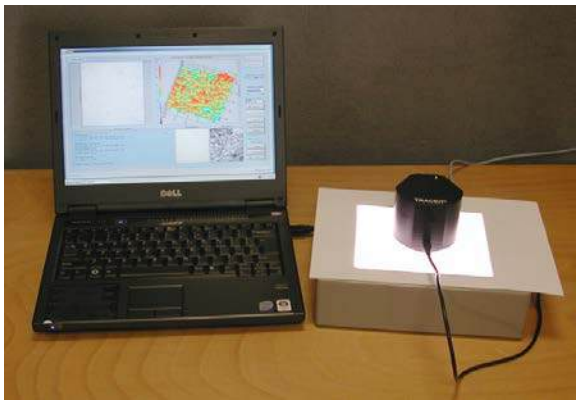
in the style of the topography but in gray tone units. Therefore the visual roughness parameters have no defined unit. The visual roughness parameters $R_{a\ opt}$, $R_{q\ opt}$ and $R_{z\ opt}$ document the bright/dark contrast of the sample.

Both, visual impression and topography measurement happen with the same resolution at the same time and the same place. Thus a direct comparison of topographic roughness and visual intensity is possible.

Overview analysis window of the visual impression



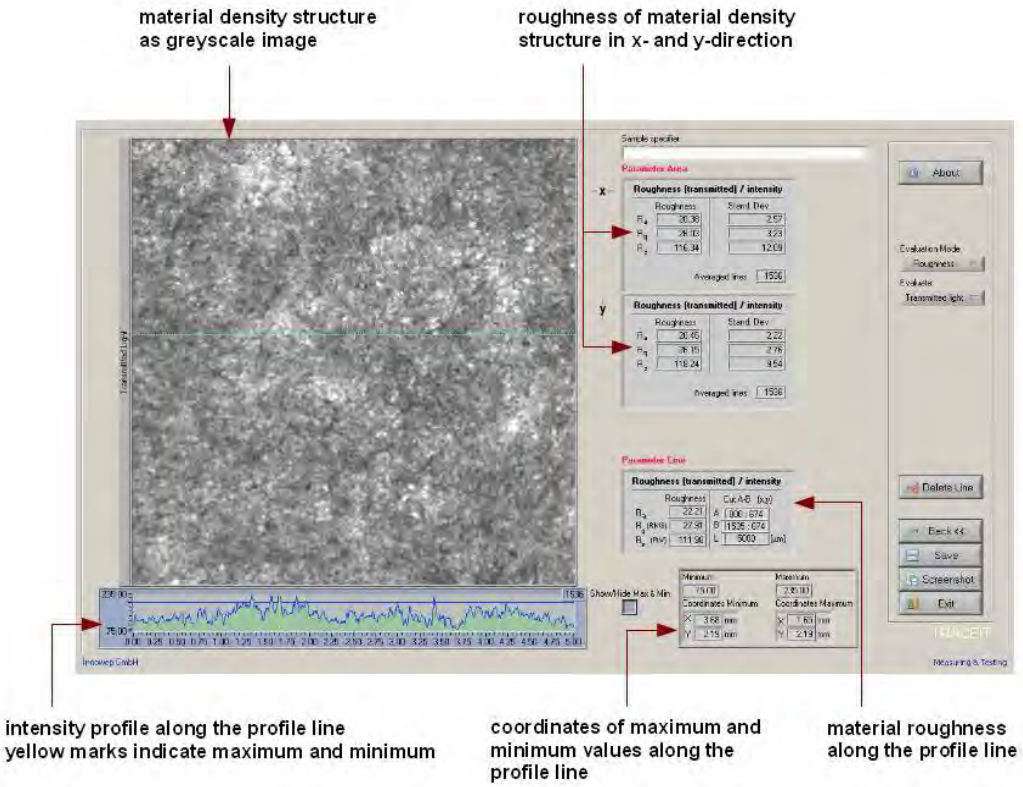
2.4 Documentation of the transmitted light mode



In order to examine material structures of transparent or translucent materials like paper, glass, foils or fabrics, the optional transmitted light unit can be used. This enables the TRACEiT® system to measure e.g. the cloudiness of paper.

Therefore, a transmitted light table is needed which illuminates the sample from the back. The transmitted light measurement is performed on the same place and with the same resolution as the topography and visual impression measurements so they can be compared directly.

Overview analysis window of the transmitted light image

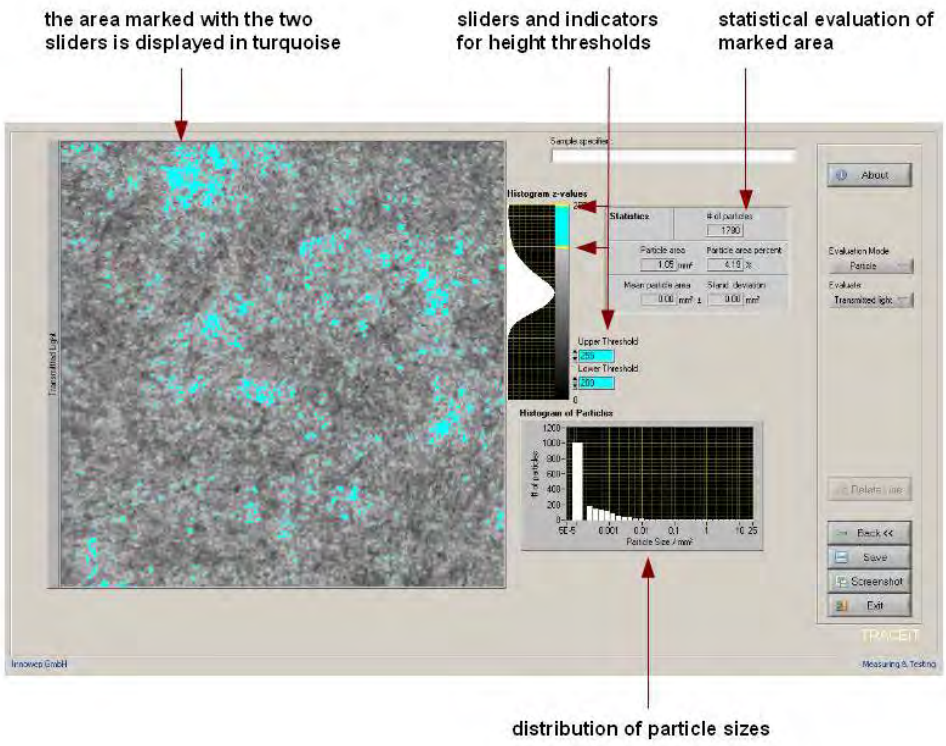


2.5 Particle mode

Besides evaluation of the surface based on roughnesses, visual impression and material density structure a particle mode is available. Here, the topographies can be examined regarding particle or pore distribution, effective contact area or structure by vertical sections. This is of particular interest if the contact area with other materials or the human hand shall be determined. In the statistics block the system displays the total area of the particles as absolute value and as portion of the total area as well as the average particle size.

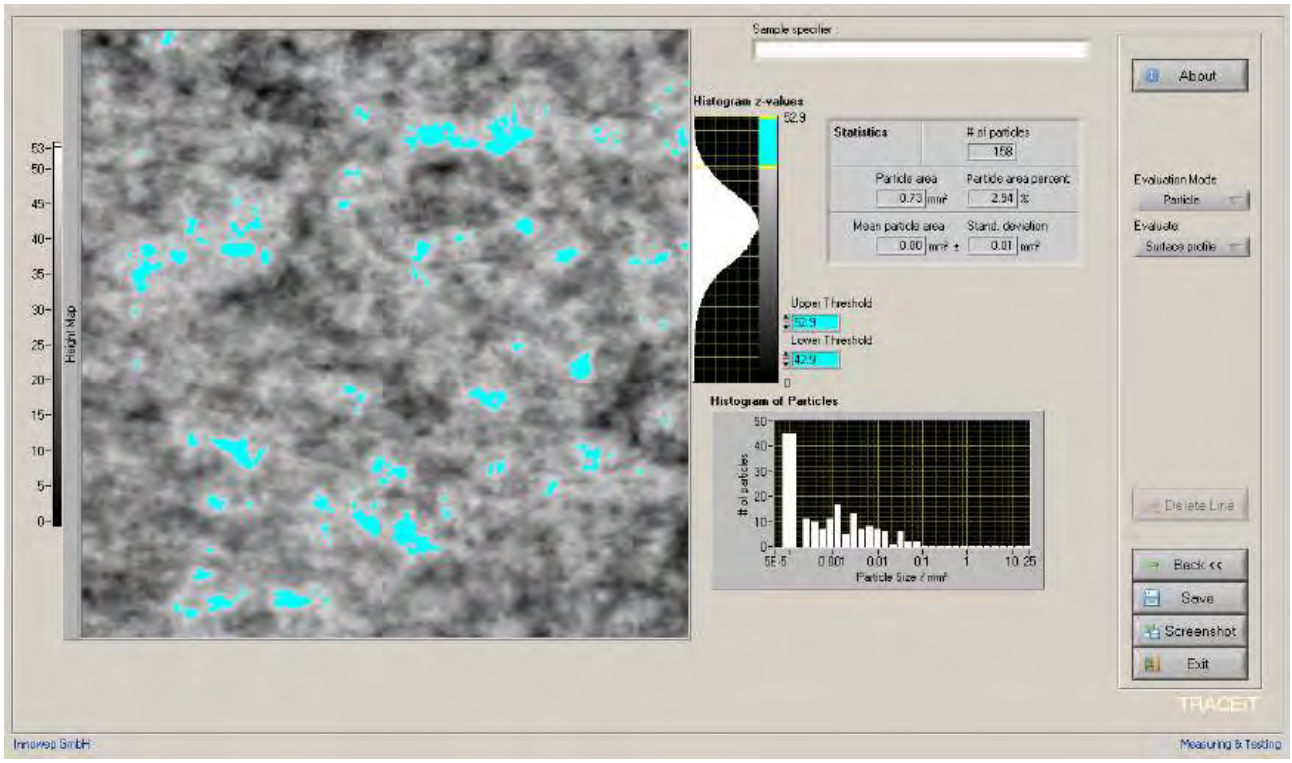
The particle mode can not only be applied to the topography but also to the visual impression and transmitted light image. This enables to evaluate e.g. the color tone (as a gray tone) of the sample or the material density through the light absorption.

Overview particle mode window



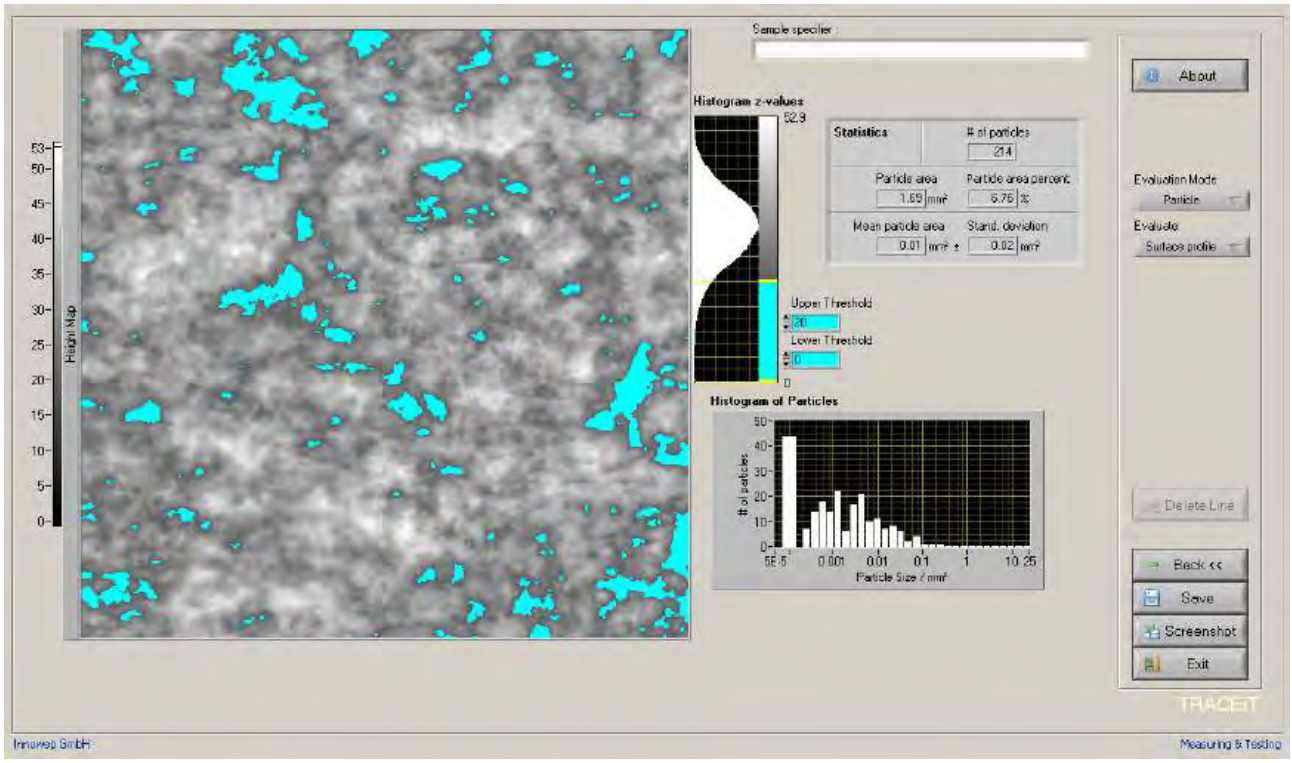
In this example the particle mode was applied to the transmitted light image. The two threshold indicators were set to 200 and 255 so the brightest areas are marked. These are the spots were the light from the transmitting light table shines through the paper sample the most indicating that here the material density is the lowest.

Effective contact area



The effective contact area is the highest part of the surface, the part to which e.g. rollers have direct contact with. In this example the highest 10 µm of the topographic surface are marked.

Porosity

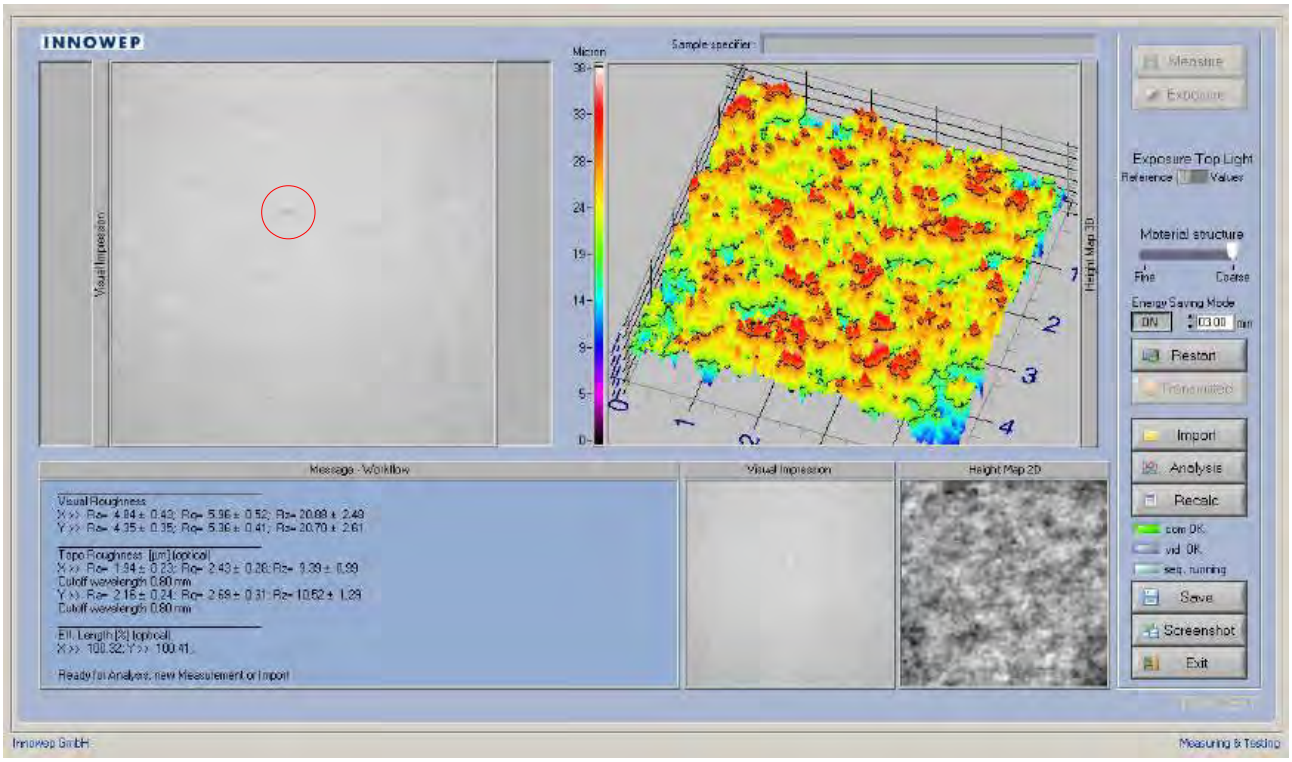


The part of the surface that is lying below the average surface level and that is building holes and valleys can be evaluated when the lowest parts in the histogram are marked. In this example the lowest 20 µm are marked.

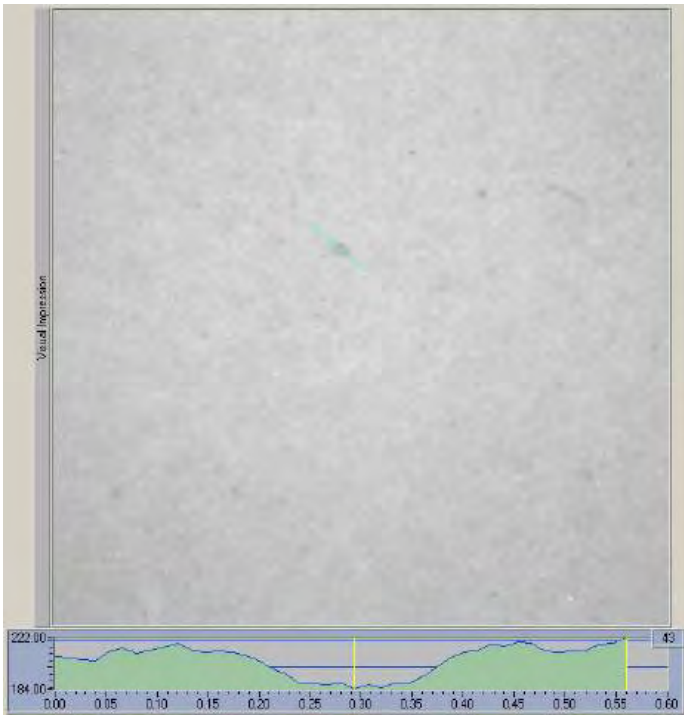
2.6 How the surface profile, visual impression and transmitted light modes can work together

Here is an example, how the three roughness evaluation modes for surface profile, visual impression and transmitted light can work together to characterize an imperfection on a coated paper surface.

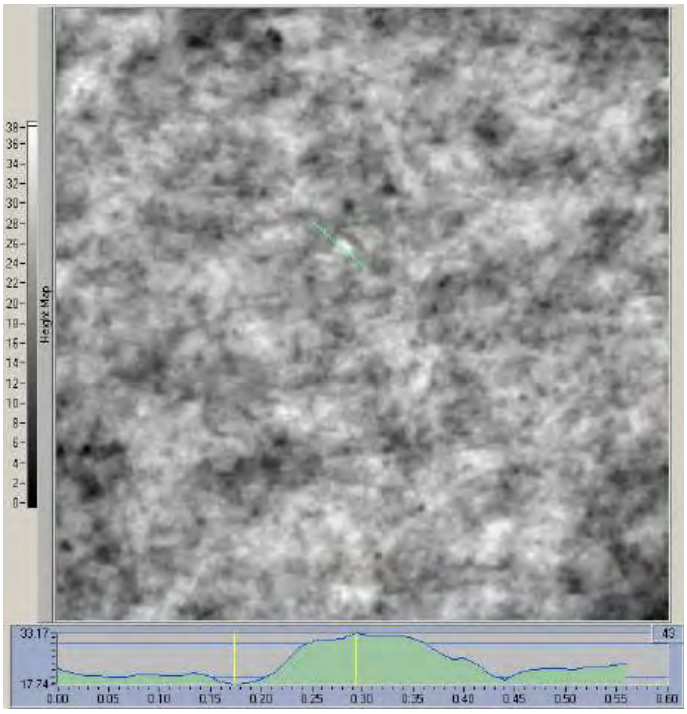
Firstly, the imperfection is spotted as a dark mark on the paper surface. This can be seen best in the visual impression mode of the software (in the red circle in the next picture).



Once the particle is recognized it can be analyzed with the various analysis tools of the TRACEiT® software.

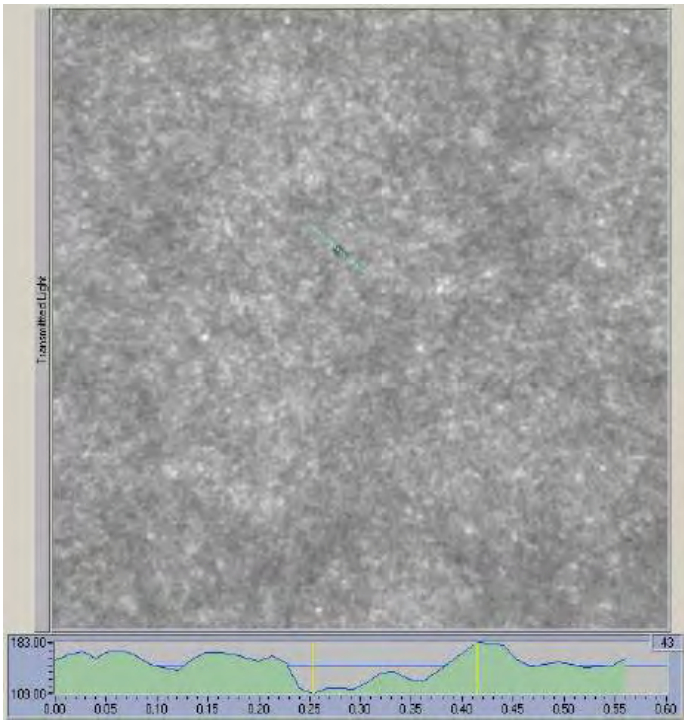


In the visual impression mode the contrast between light and dark is evaluated. The particle is much darker than the surrounding paper. This is a disturbance for the impression the human eye gets from the surface.



While switching between the analysis tools the marked line will stay at the same place so a direct comparison is guaranteed.

In the surface profile mode the size and the shape of the particle can be evaluated. In this example the particle has a height of 16 µm and a diameter of roughly 250 µm.



In the transmitted light mode the particle is analyzed regarding its transparency. The particle is much more solid than the surrounding paper which can be seen from the reduced transmittance.

When the three evaluation modes of the TRACEiT® software intertwine with each other the most information can be retrieved from the data.

2.7 Definition of roughness parameters

Roughness is a measure of the texture of a surface. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small the surface is smooth. Roughness is typically considered to be the high frequency, short wavelength component of a measured surface.

Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces. Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion.

In everyday's work three roughness definitions have been established:

1. Mean Roughness (*Roughness average* R_a): R_a is the arithmetic average of the absolute values of the roughness profile ordinates. R_a is one of the most effective surface roughness measures commonly adopted in general engineering practice. It gives a good general description of the height variations in the surface.

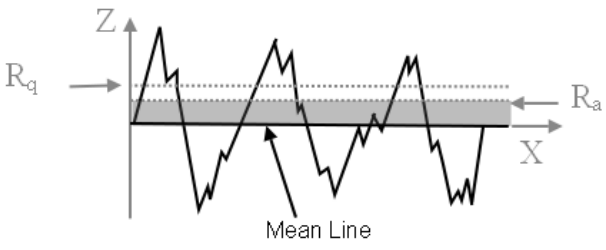
   $$R_a = \frac{1}{n}\sum_{i=1}^{n} |y_i|$$

2. The Root Mean Square (RMS) roughness (R_q): R_q is the root mean square average of the roughness profile ordinates.

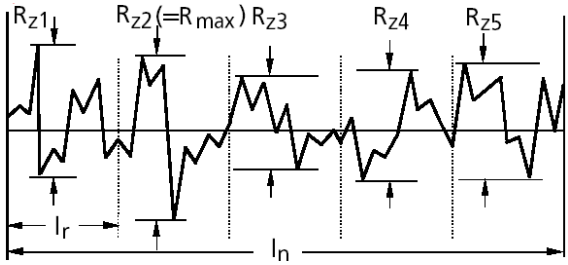
   $$R_q = \sqrt{\frac{1}{n}\sum_{i=1}^{n} y_i^2}$$

3. Mean Roughness Depth (R_z): R_z is the arithmetic mean value of the single roughness depths (the vertical distance between the highest peak and the deepest valley within a sampling length) of five consecutive sampling lengths.

   $$R_z = \frac{1}{n}(R_{z1} + R_{z2} + R_{z3} + R_{z4} + R_{z5})$$



definition of R_a and R_q

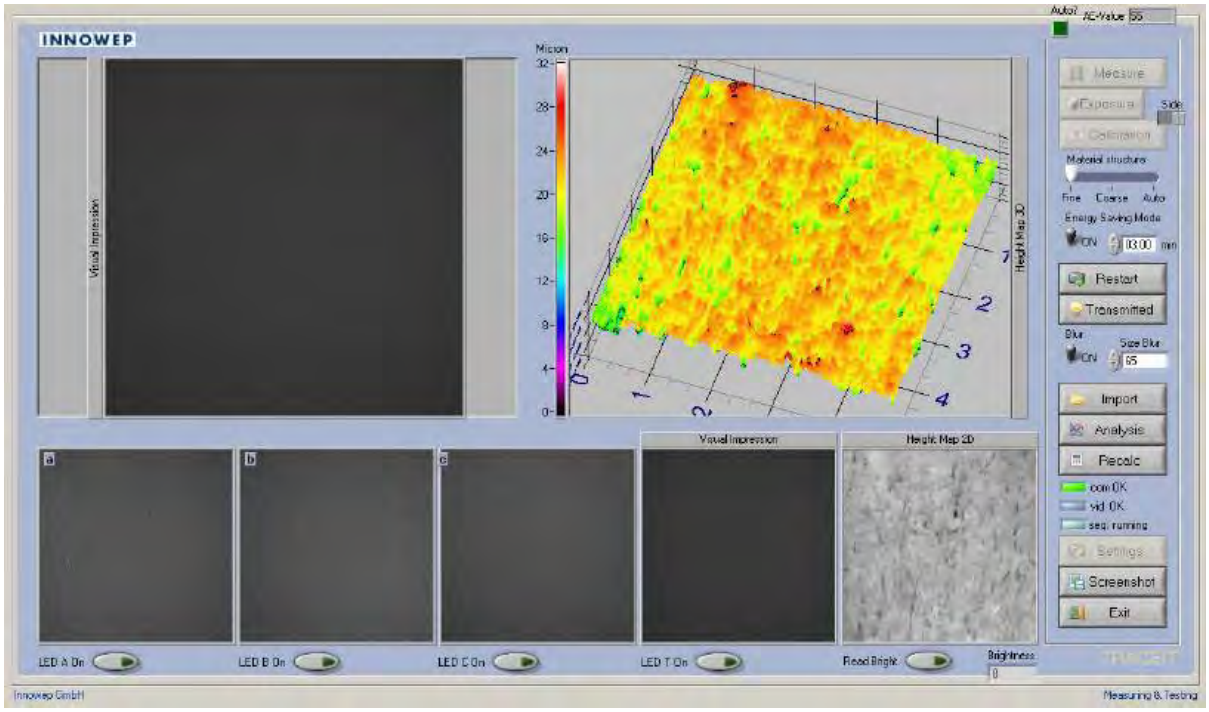


definition of R_z

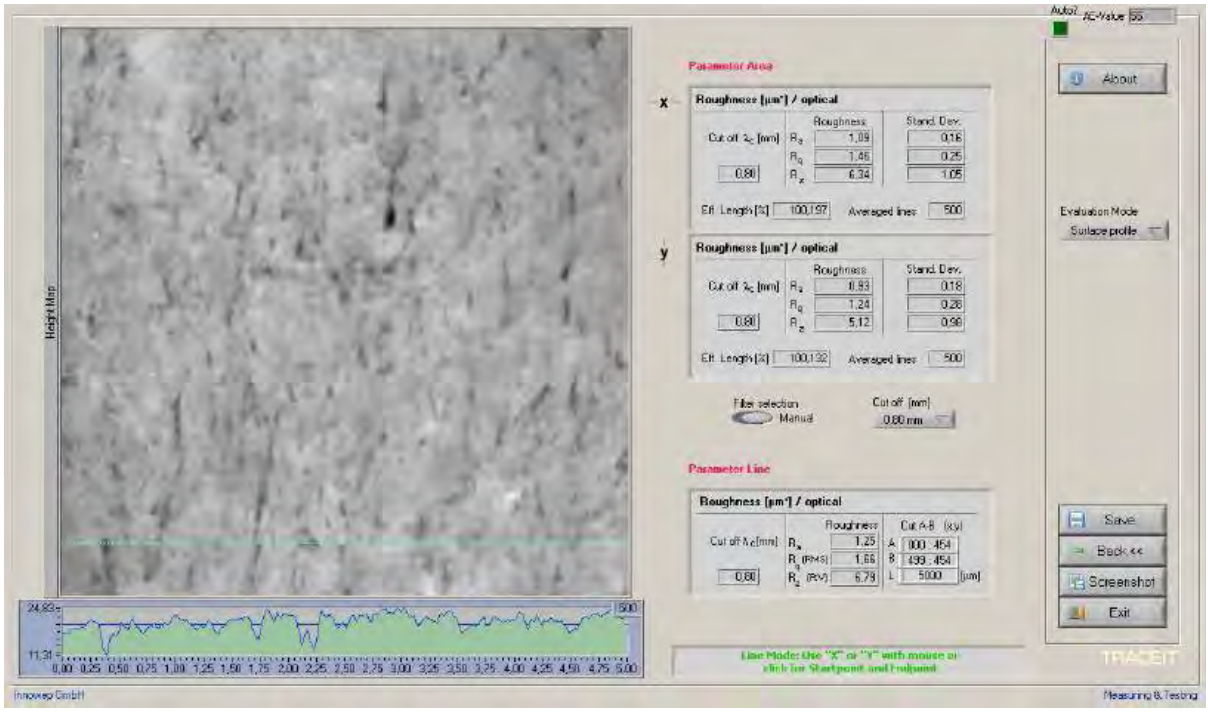
In highest resolution mode the TRACEiT evaluates the roughness parameters over 1500 lines, each 5 mm in length. This summarizes to 7.50 m independently in x as well as y direction!

3. Appendix

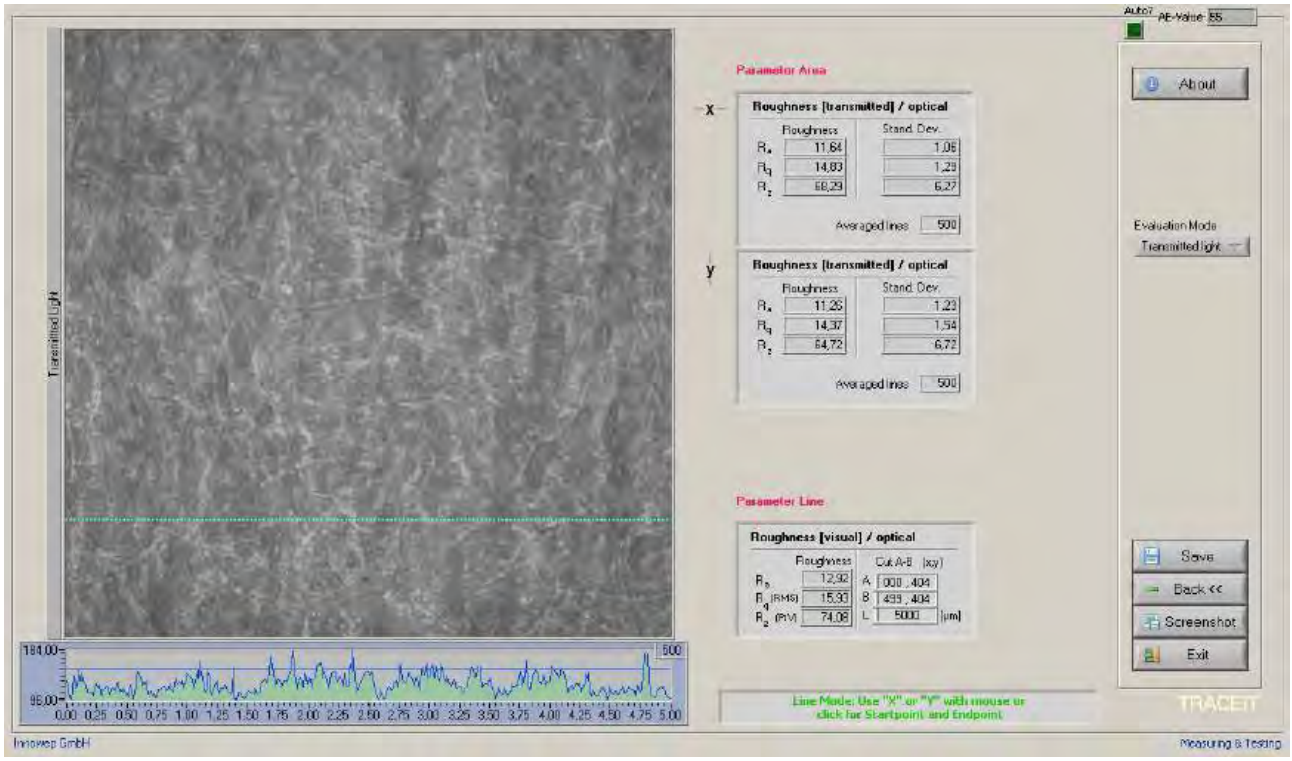
Single coated paper



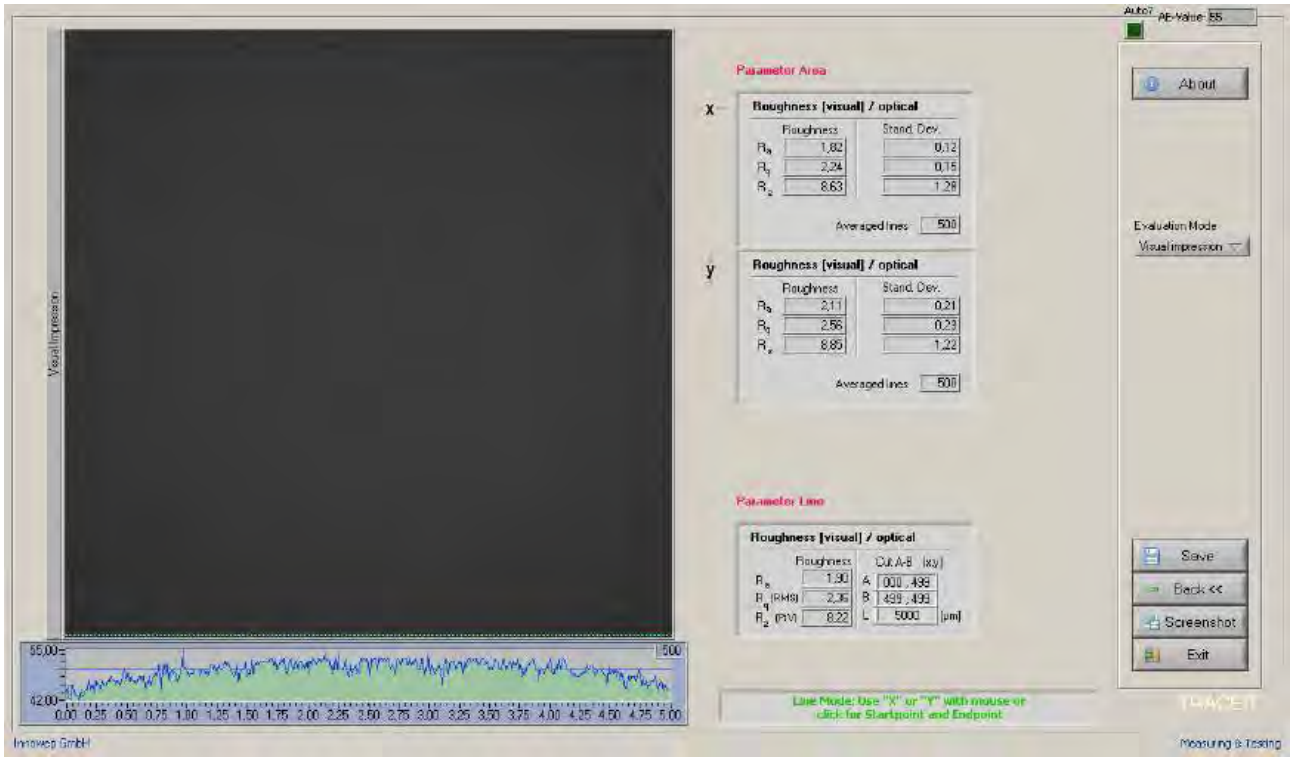
Single coated paper, surface profile



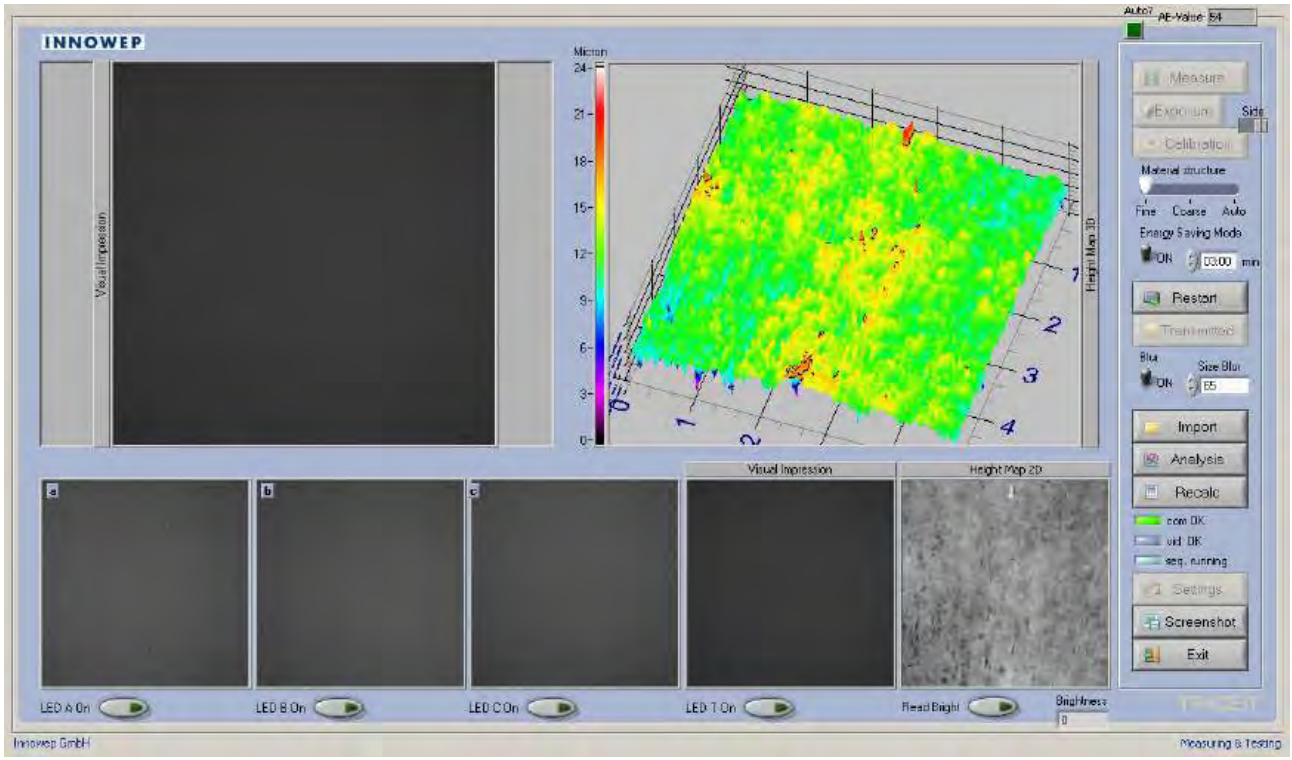
Single coated paper, transmitted light



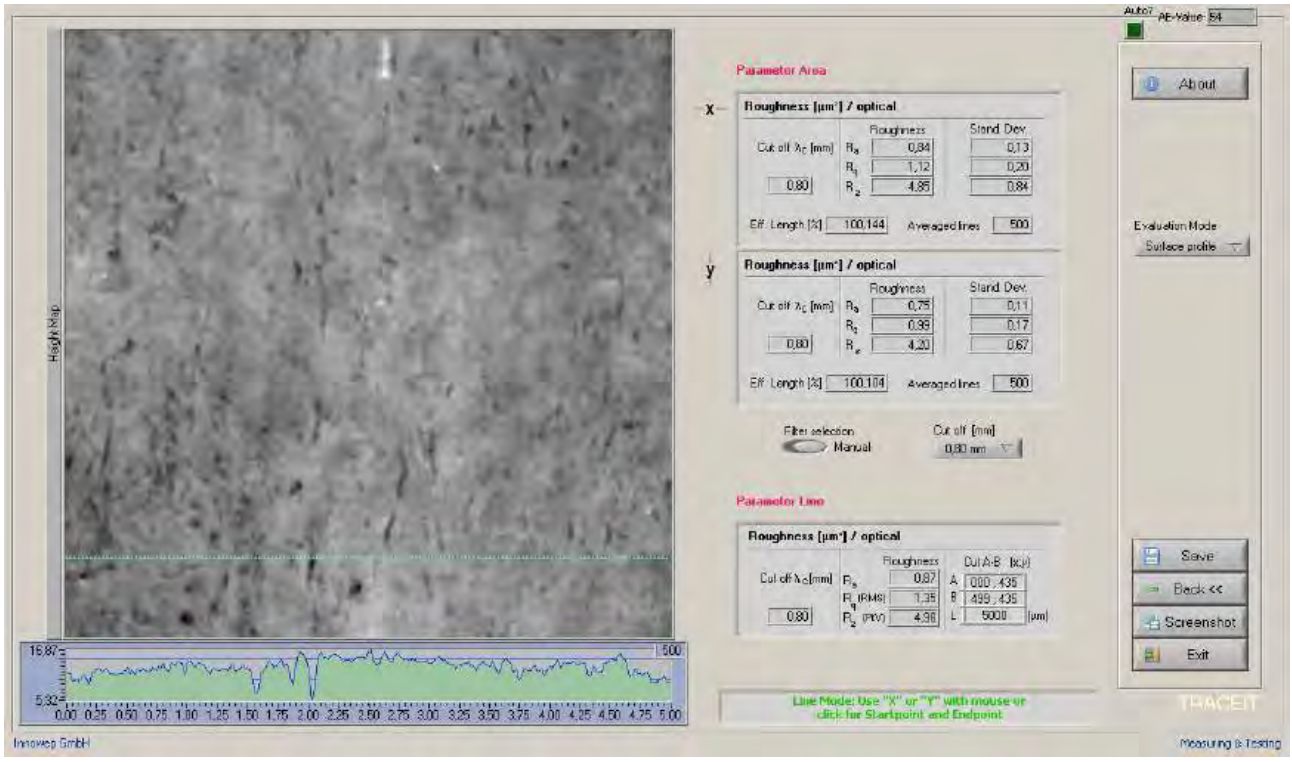
Single coated paper, visual impression



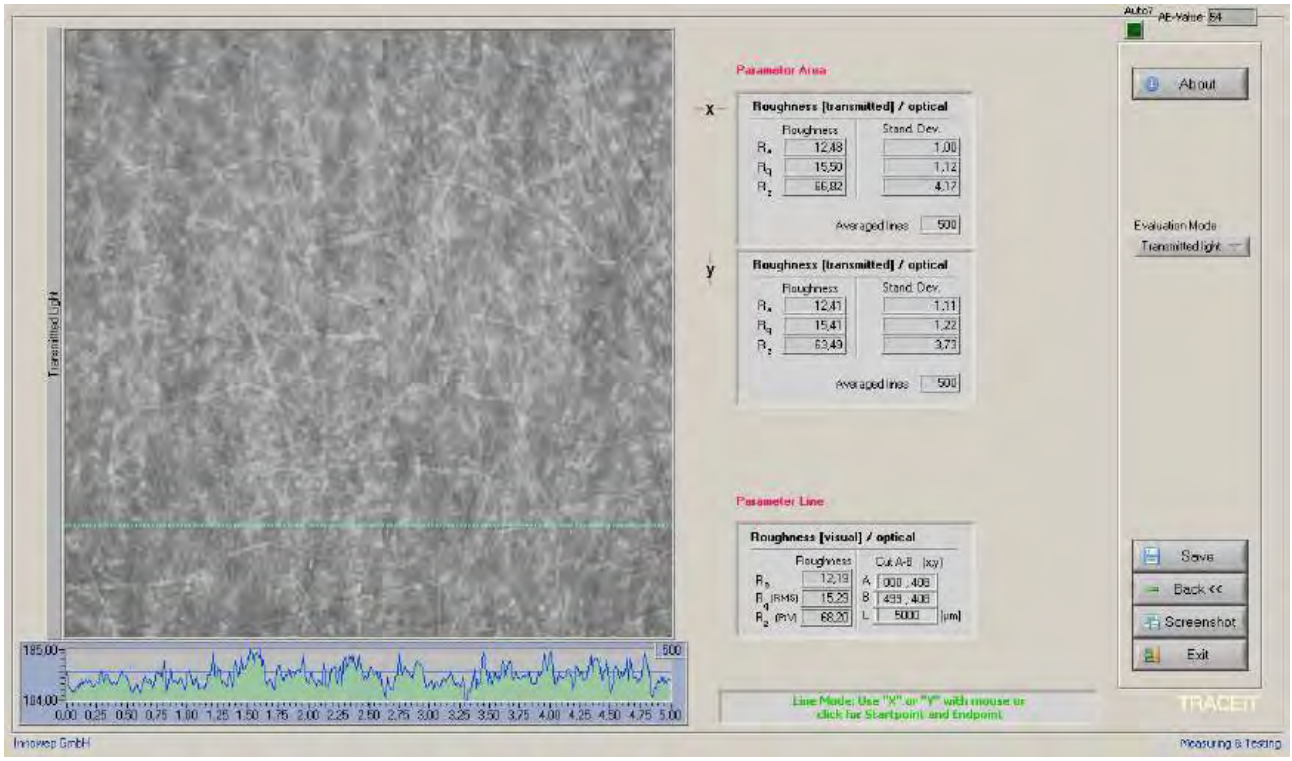
Double coated paper



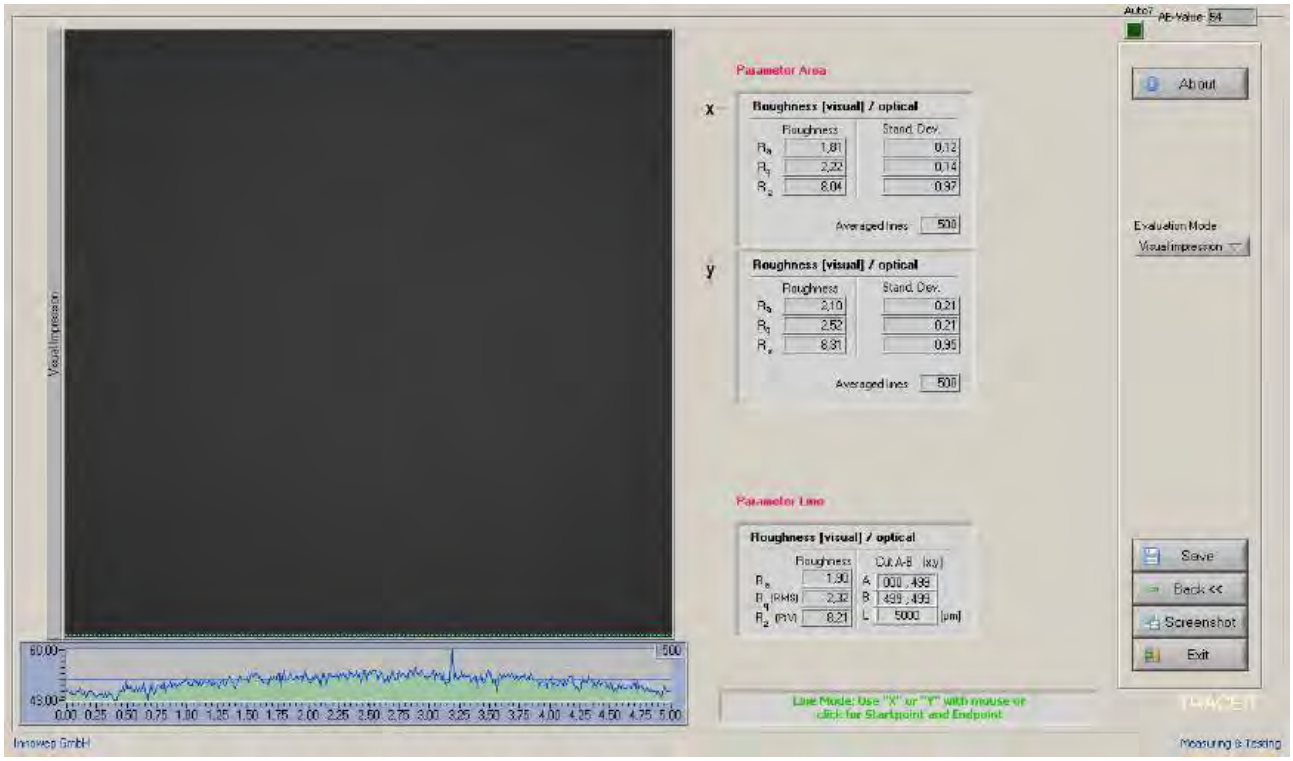
Double coated paper, surface profile



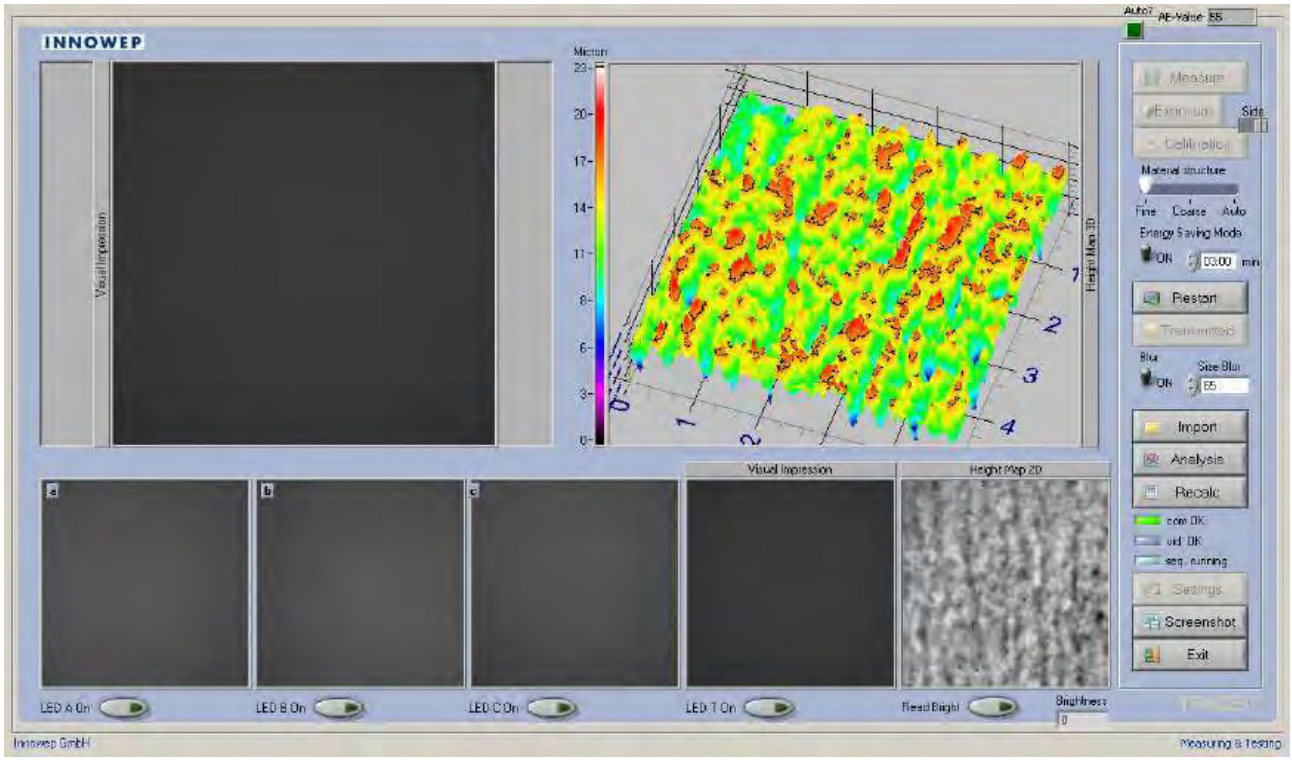
Double coated paper, transmitted light



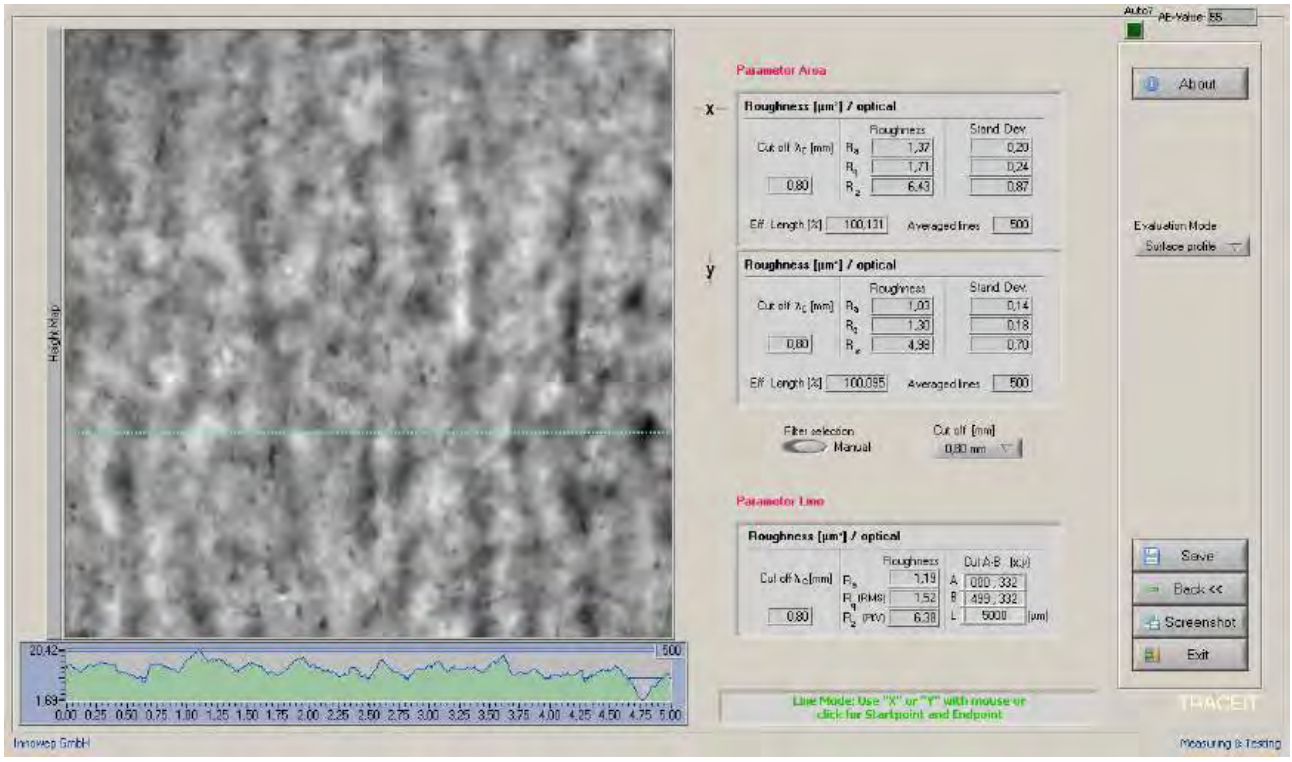
Double coated paper, visual impression



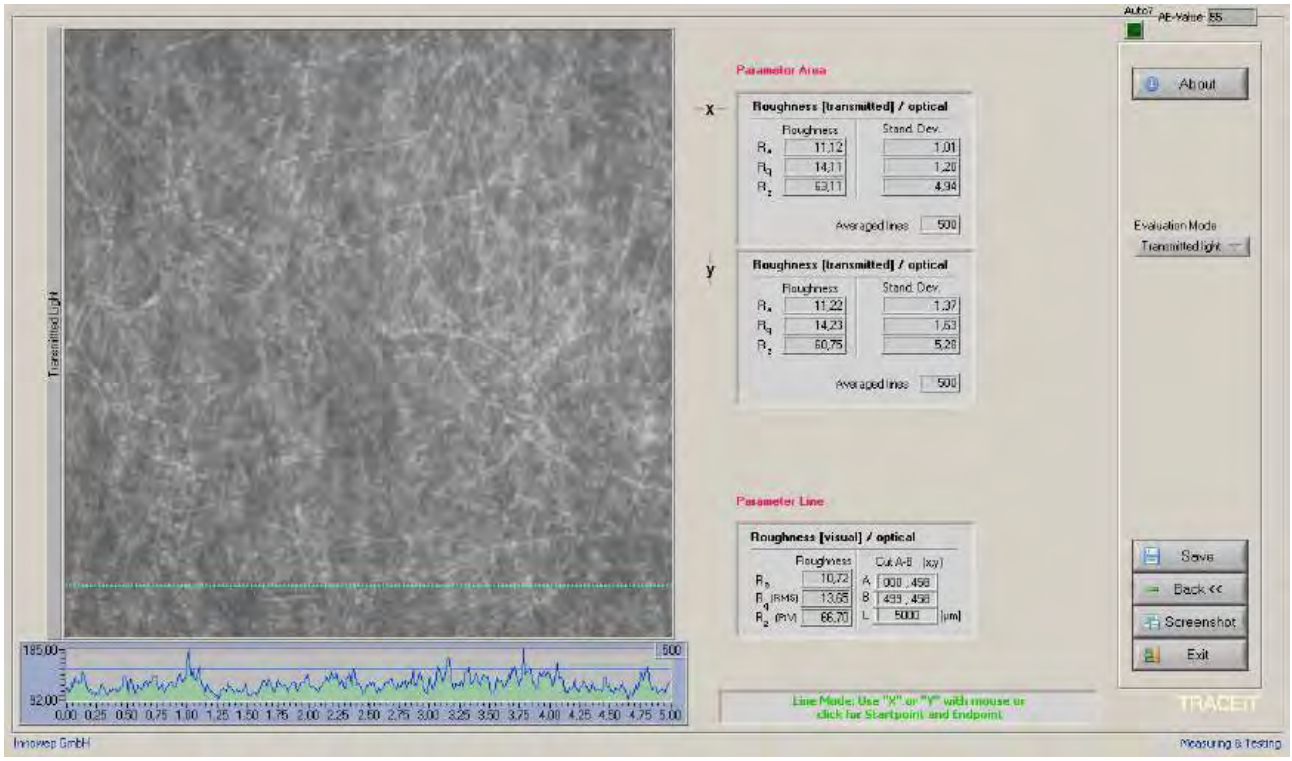
Single coated and calendered paper



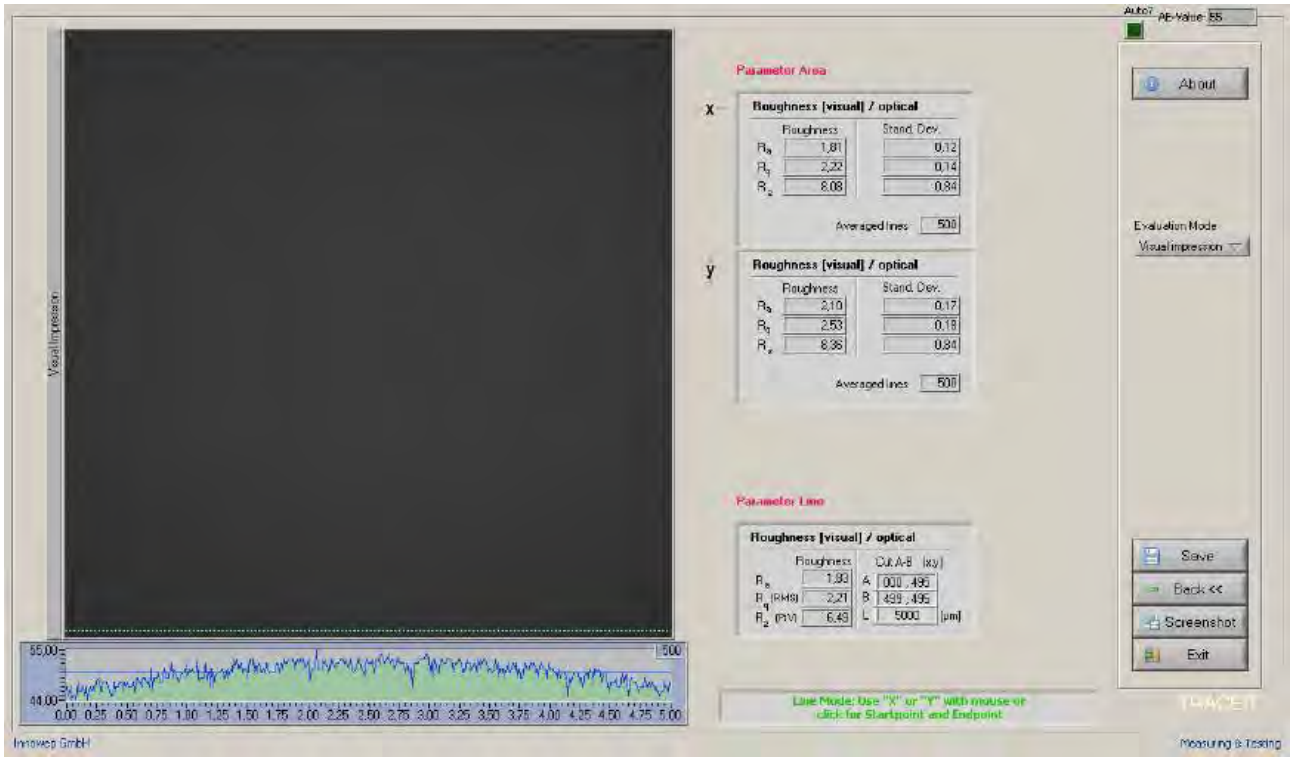
Single coated and calendered paper, surface structure



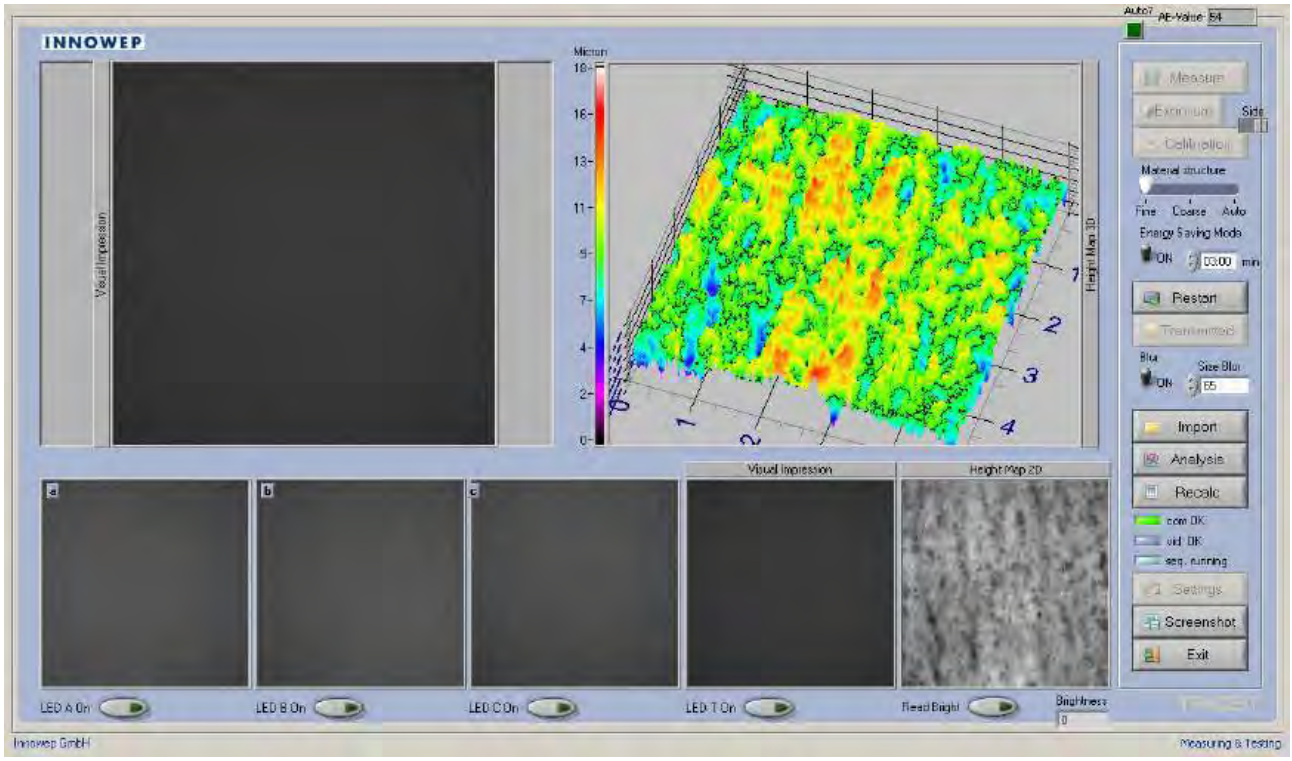
Single coated and calendered paper, transmitted light



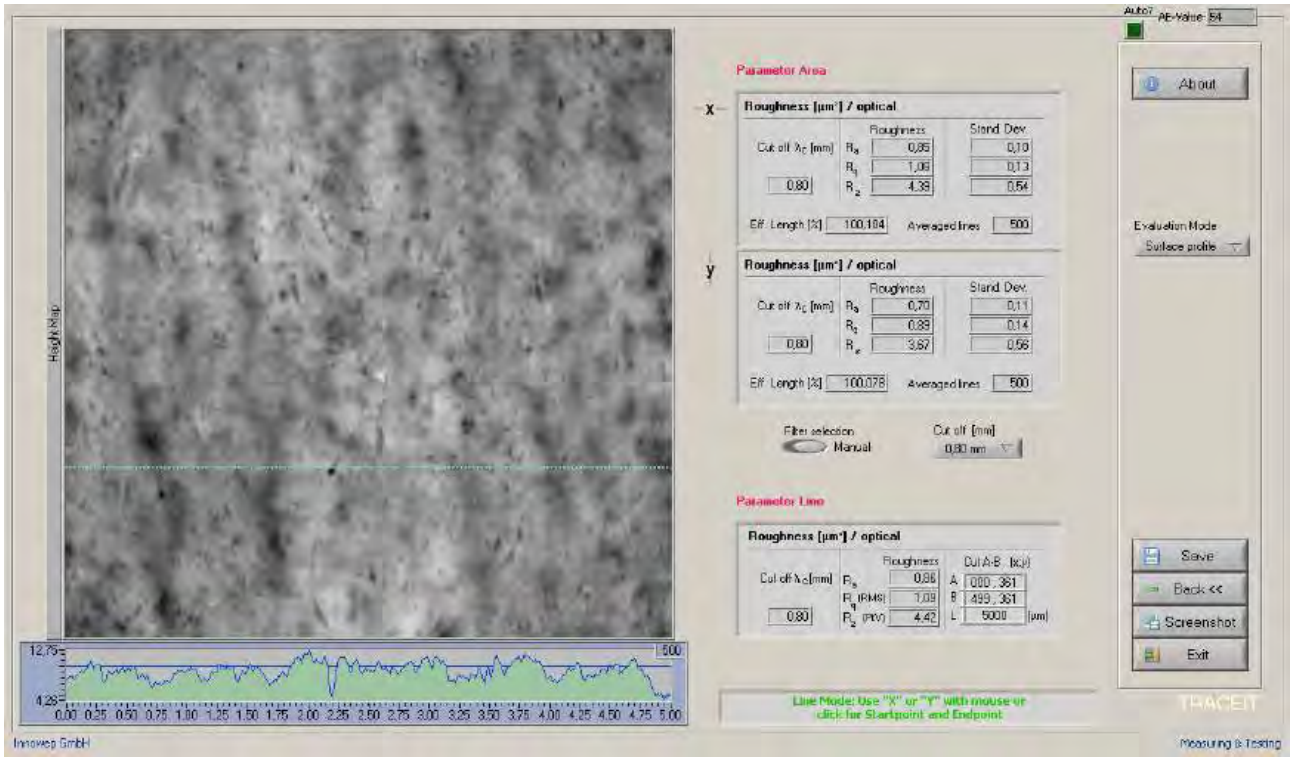
Single coated and calendered paper, visual impression



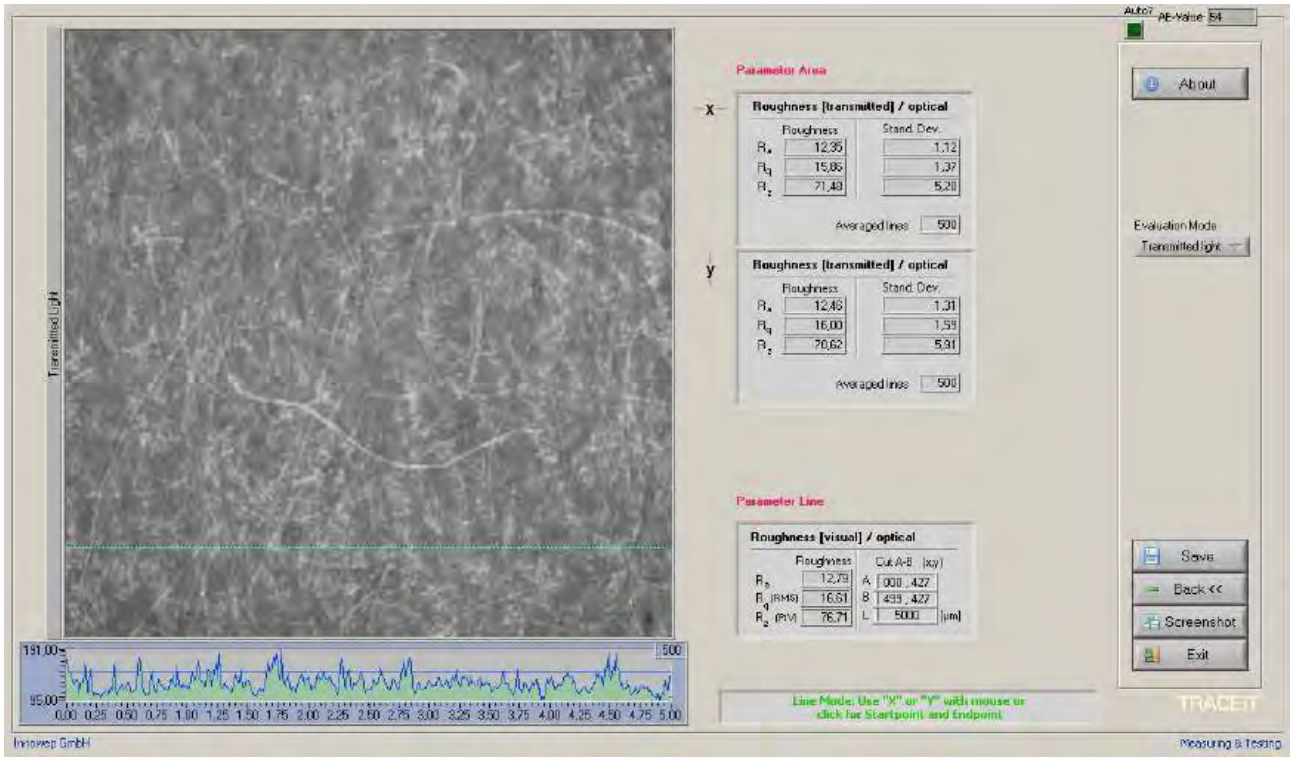
Double coated and calendered paper



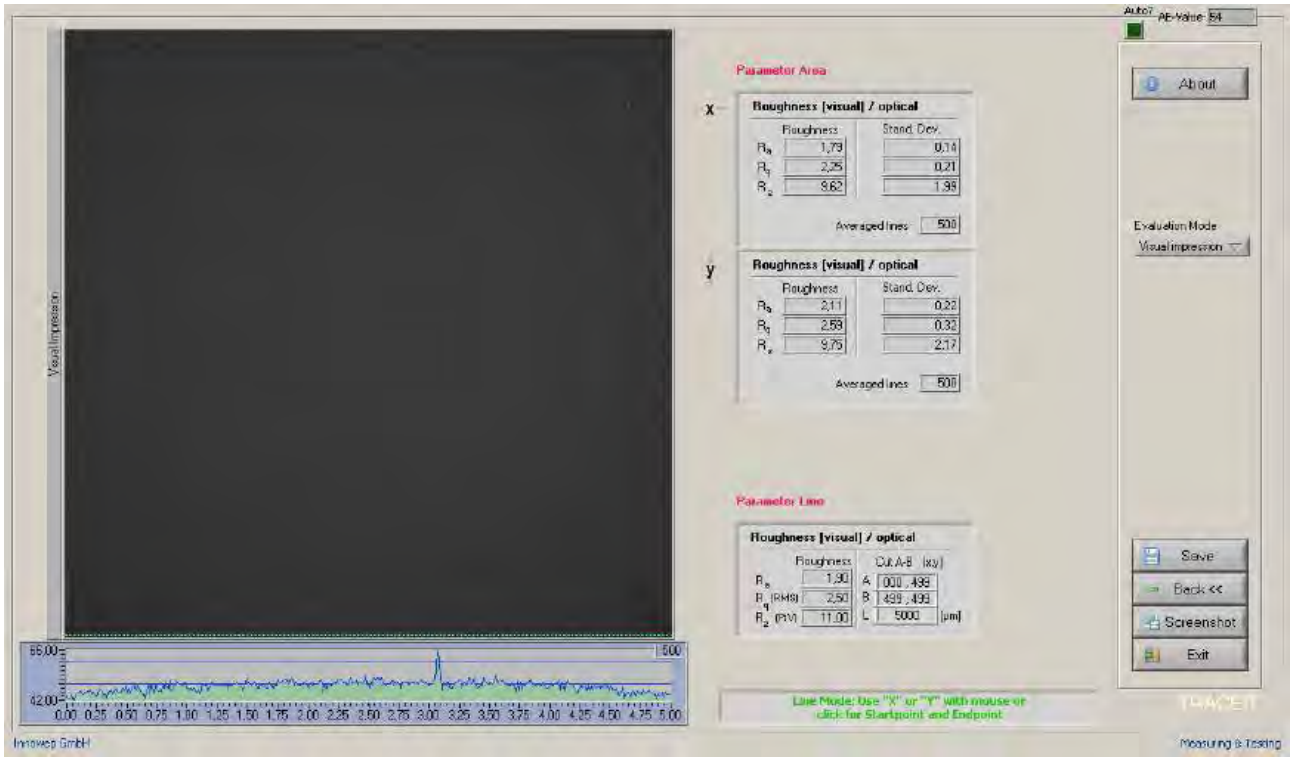
Double coated and calendered paper, surface profile



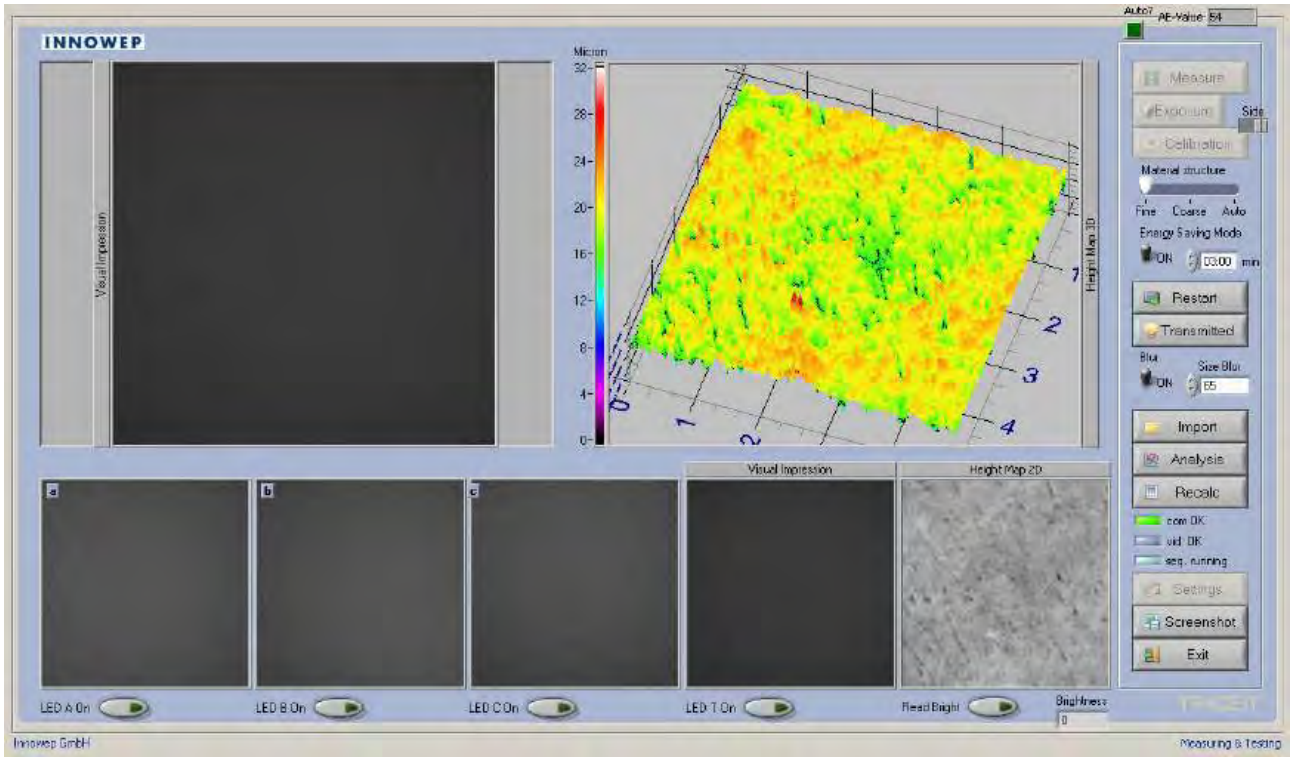
Double coated and calendered paper, transmitted light



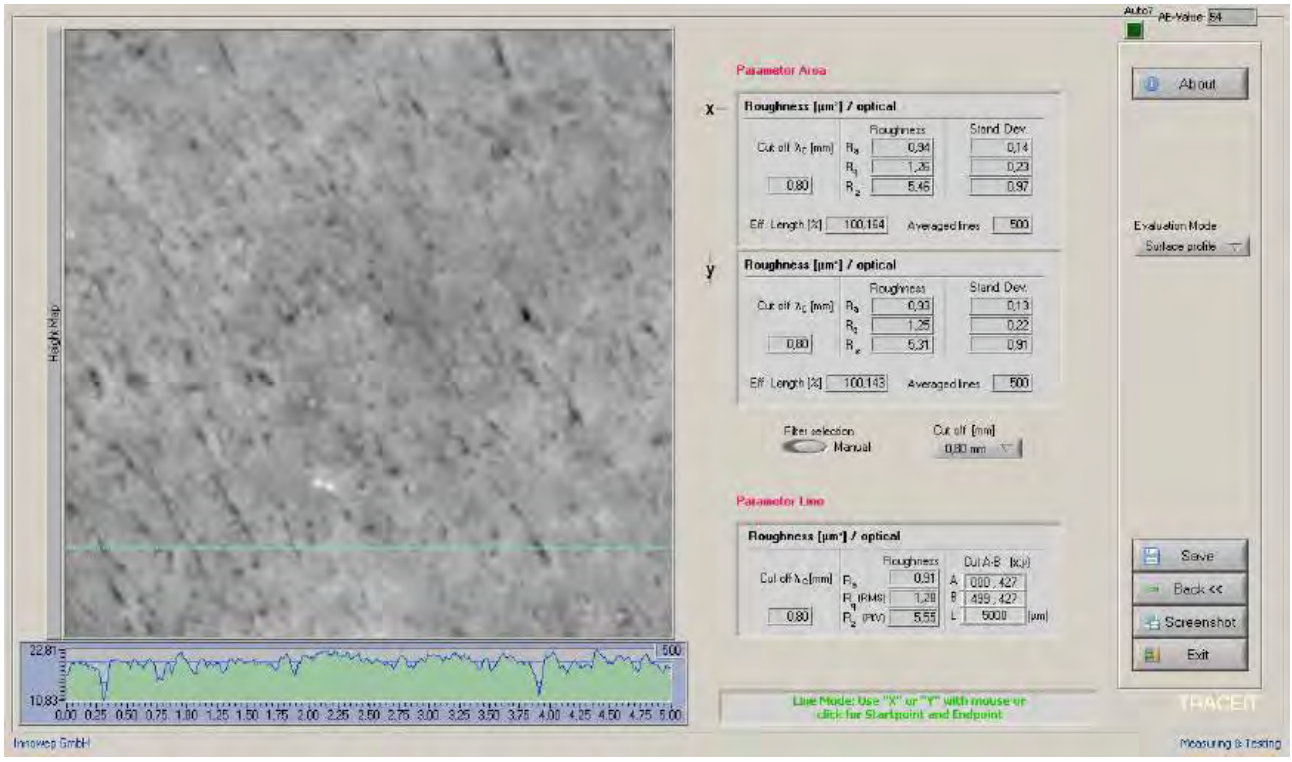
Double coated and calendered paper, visual impression



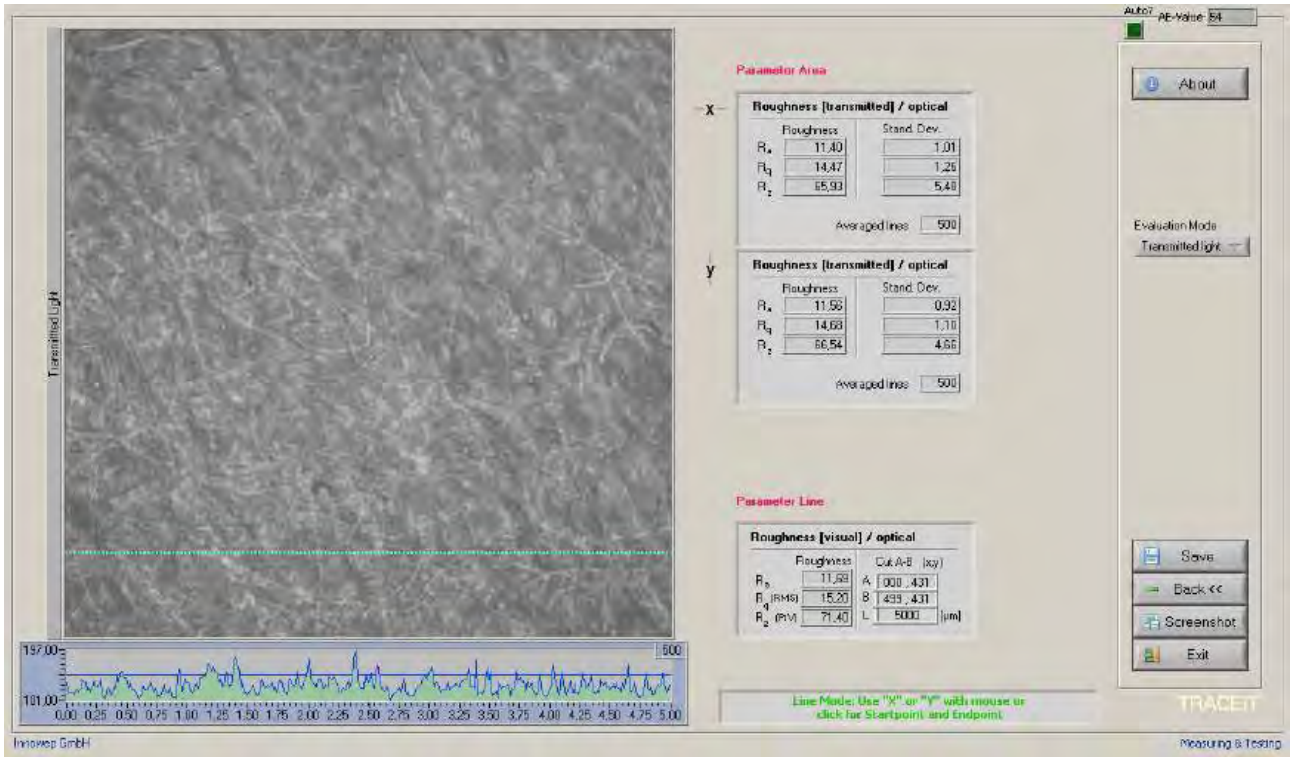
Raw paper



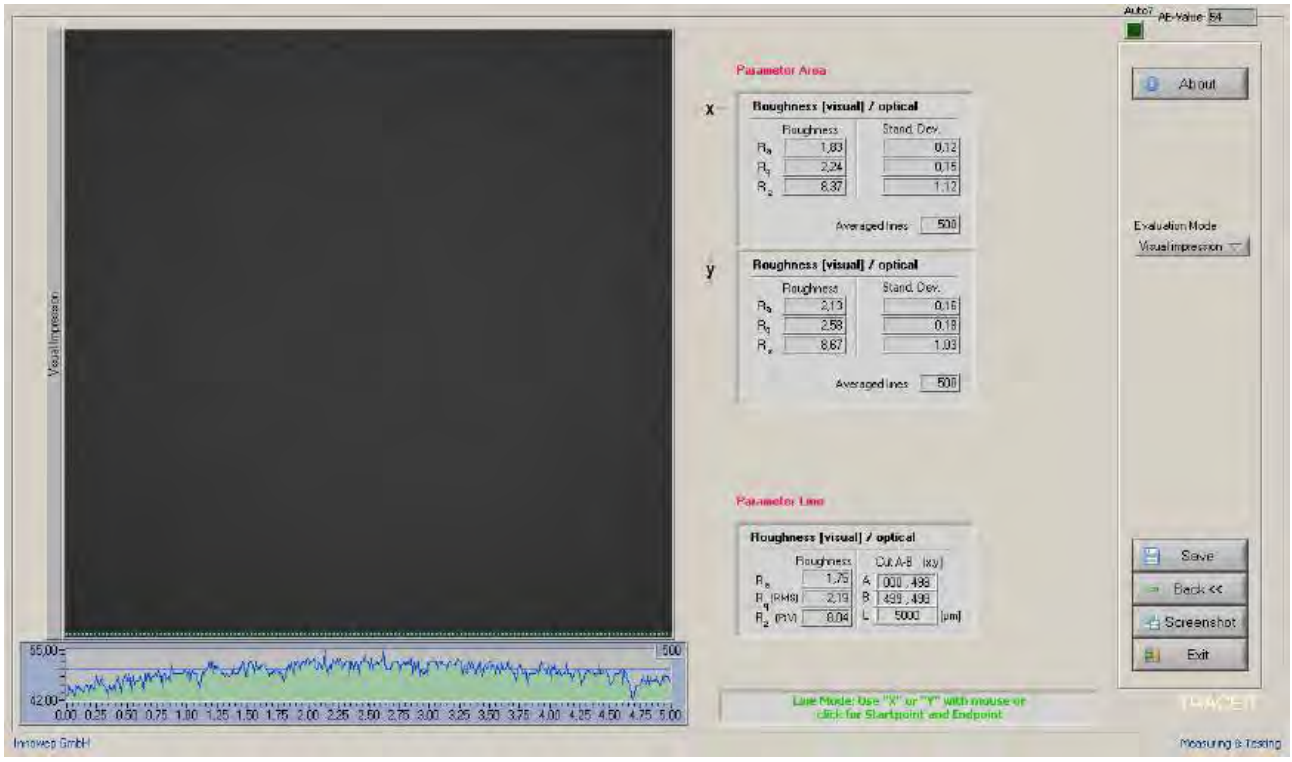
Raw paper, surface structure



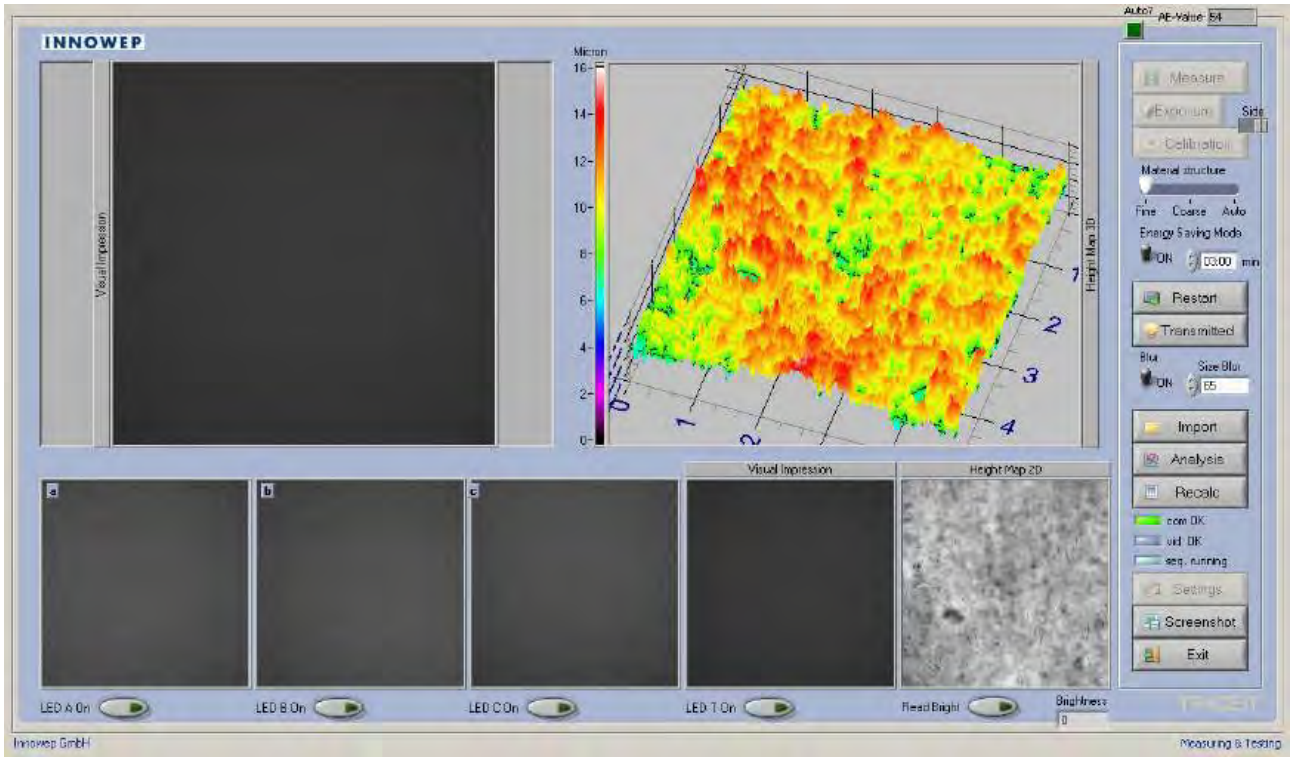
Raw paper, transmitted light



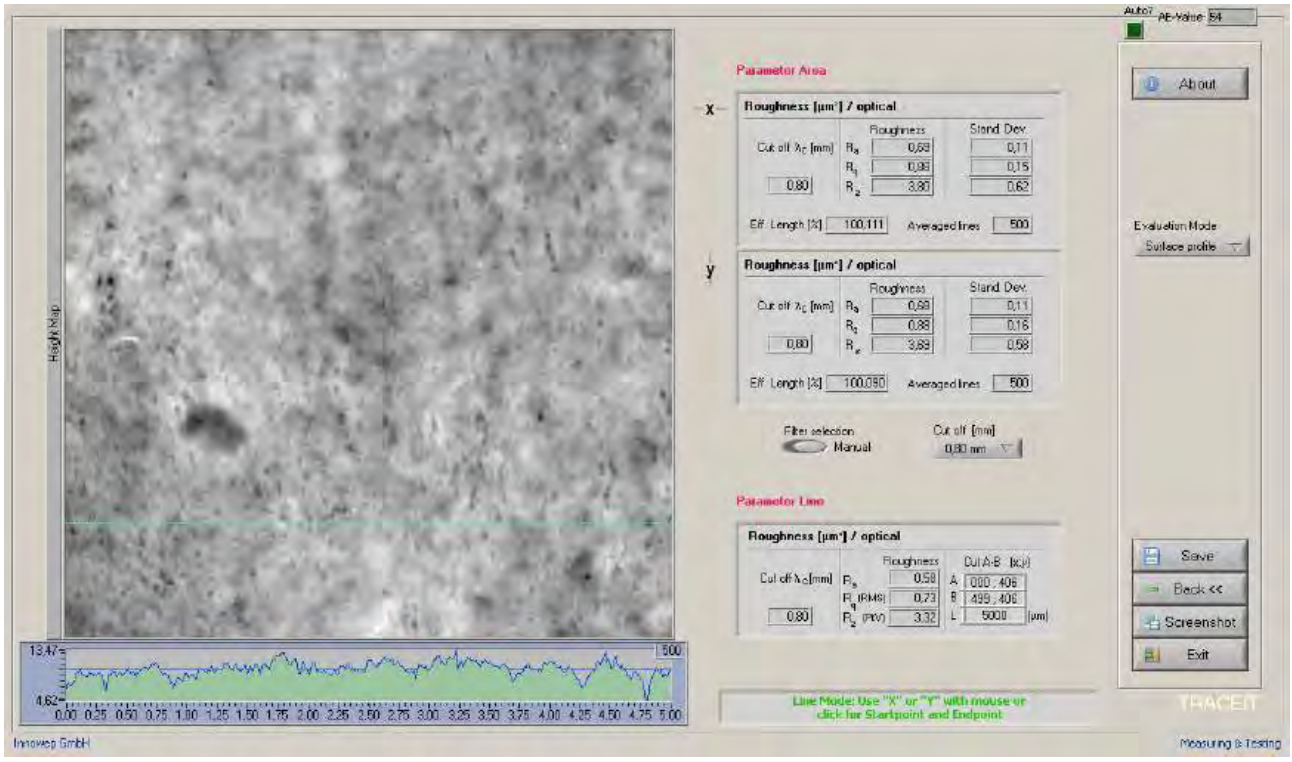
Raw paper, visual impression



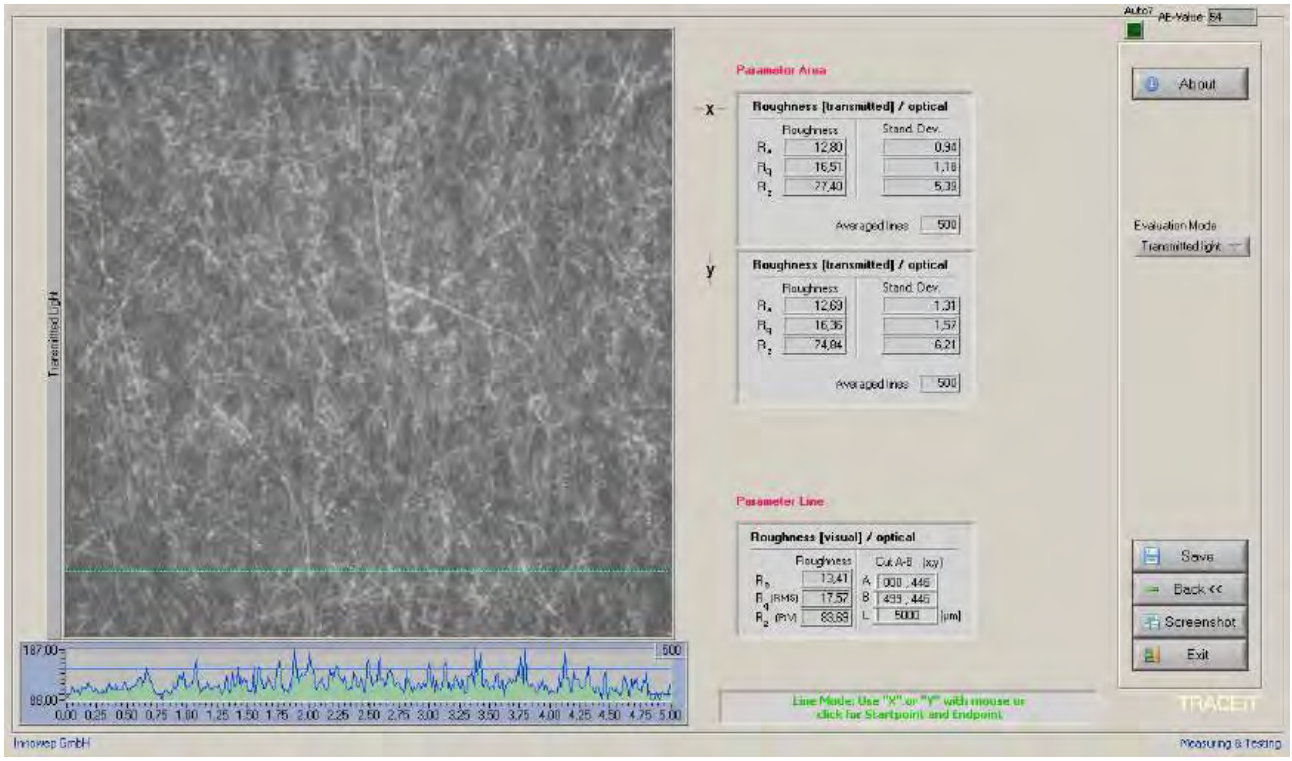
Raw paper, calendered



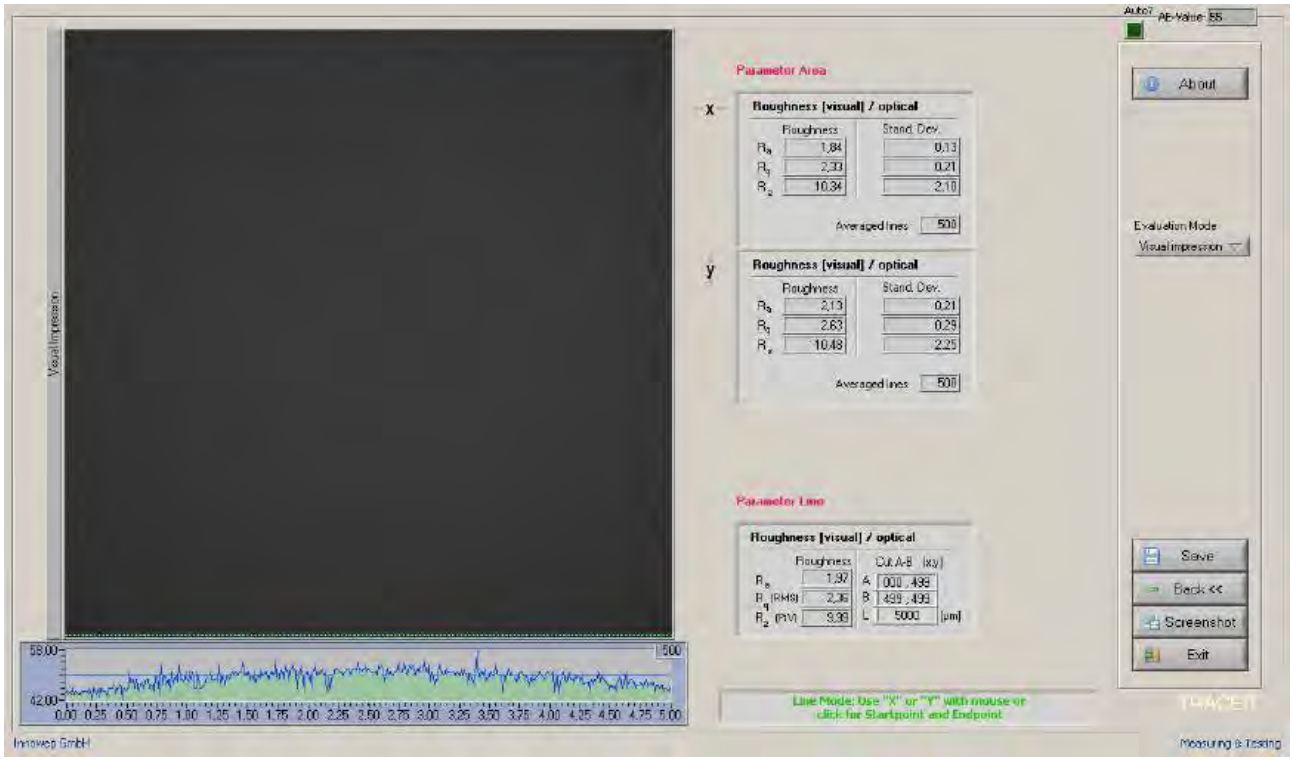
Raw paper, calendered, surface structure



Raw paper, calendered, transmitted light



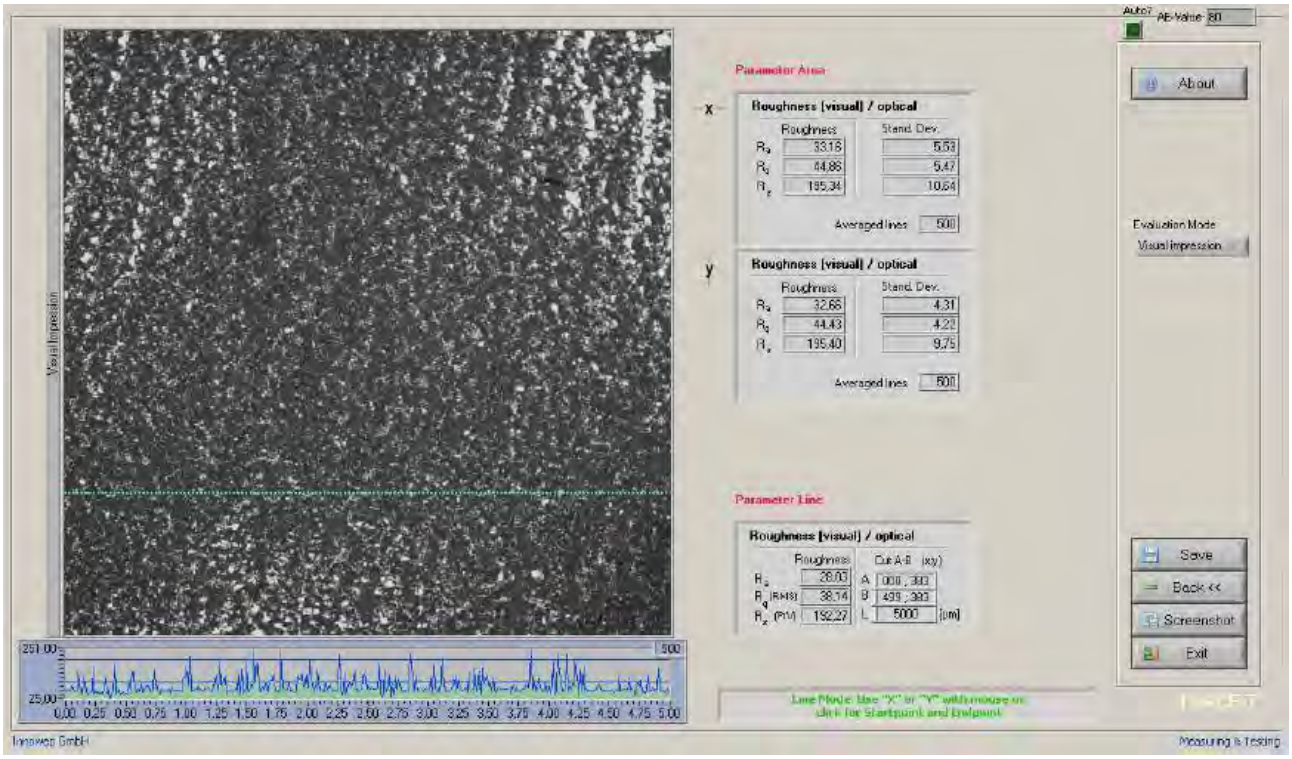
Raw paper, calendered, visual impression



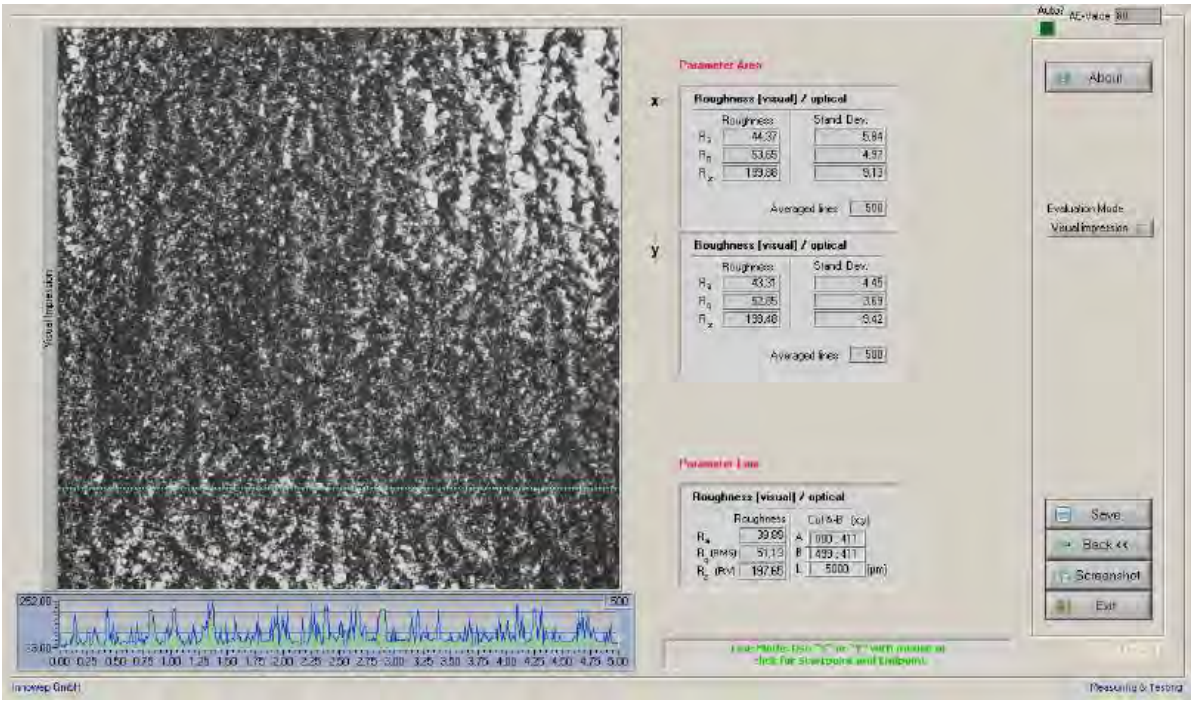
Printed paper

Due to the high reflectivity of the printed papers only on one sample the visual impression was measured exemplarily:

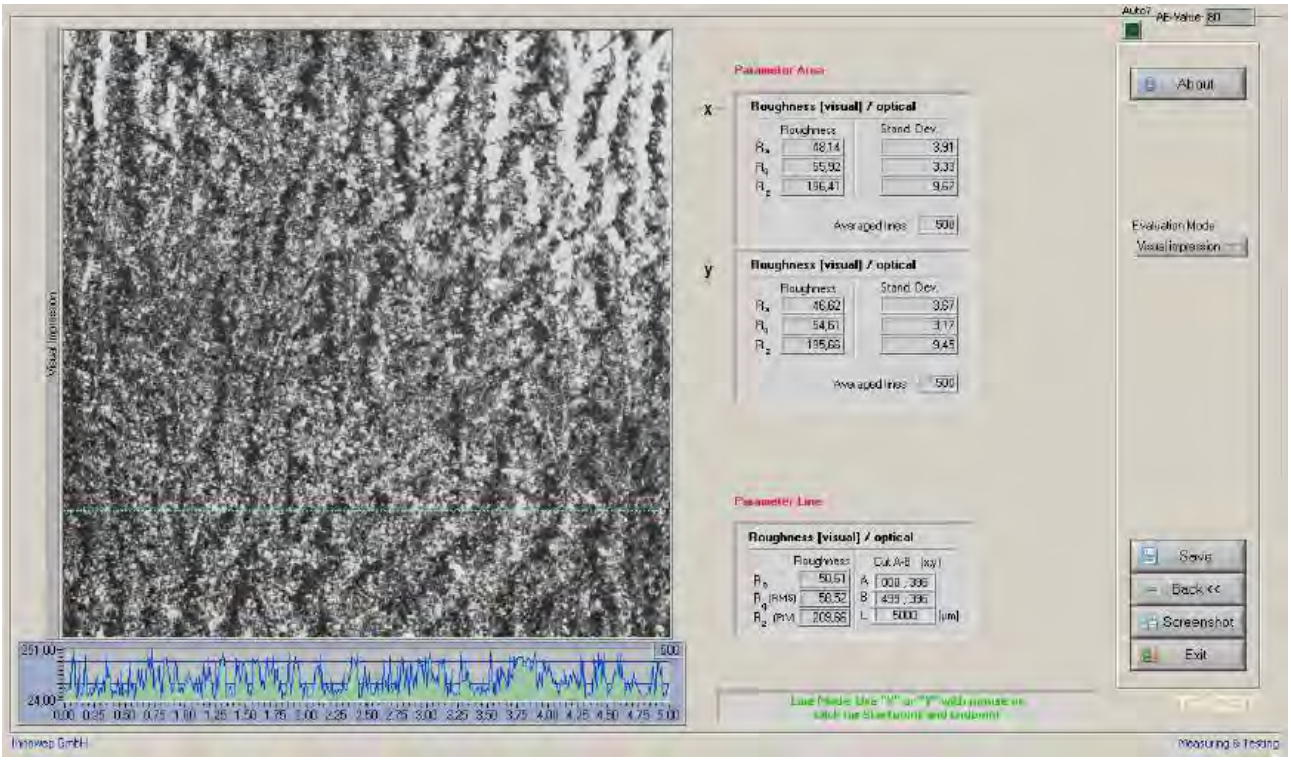
60/80



80/80


About
Roughness [visual] / optical
Roughness
Stand. Dev.
Averaged lines
500
Roughness [visual] / optical
Roughness
Stand. Dev.
Averaged lines
500
Roughness [visual] / optical
Roughness
Cut-A-B (xy)
Evaluation Mode
Visual Impression
Save
Back <<
Screenshot
Exit

100/80



The more “golden” the paper is printed, the higher is the reflectivity.