Quantitative Structural Analysis of CFRP Components Using ZEISS ZEN 2 core

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Lightweight construction materials, in particular carbon fiber reinforced plastics (CFRP), have increased in importance over the last few years. The structural constitution of the material is crucial for its quality and with the help of light microscopy and ZEN 2 core software, major micro-structural features can be determined quantitatively. The example of CFRP cross-sections shows the advantages of using ZEN 2 core software for such investigations.

Introduction

ZEN 2 core can be used for both light microscopic tasks and the efficient quantitative structural analysis of micrographs, as shown by the example of a CFRP cross-section using ZEN 2 core in combination with the ZEISS Axio Zoom.V16 light microscope. CFRP components are often edited by machining and at this point, the structural constitution significantly influences their quality. Structural features that are important for their ease of machining are, amongst others, the thickness of the individual layers and the porosity, which both can be determined using ZEN 2 core. The results of the analyses can be reported in previously layered out templates. Furthermore, ZEN 2 core allows the user to save the investigation as a so called 'job template' for recurring analyses, which saves time and enables the user to carry out the investigations with reproducible output data.

Generating tile overview image

A micrograph of the CFRP component with a magnification of 100 times is taken as a tile image. With the help of the tool 'tiles interactive' the user sets up the tile image. In doing so, he or she must choose the magnification and determine its corners (Figure 1a). The tile pattern is defined automatically by the ZEN 2 core software (Figure 1b). Figure 1c shows the generated and stitched output micrograph that can be used for further investigations.
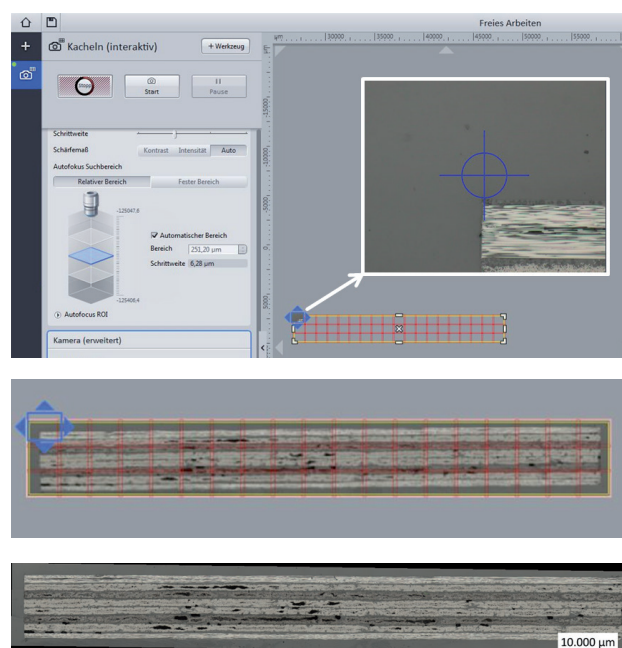

Figure 1: *a) Setup of the tile image using the tool 'tiles interactive', definition of the corners; b) Tile pattern; c) Stitched overview tile image of the CFRP cross-section, 100×, coaxial light*

Determination of component measures and individual layer thicknesses

The individual layer thicknesses of the CFRP (Figure 2a), as well as its dimensions in cross-section, (Figure 2b) can be quantified using the tile image. The measurement of the individual layer thicknesses is carried out at magnified sectors of the tile micrograph. With help of the tool

'interactive measurement', lengths and distances can be metered. In order to get the correct results, the starting points must be adapted. The results are then saved in a measurement table.
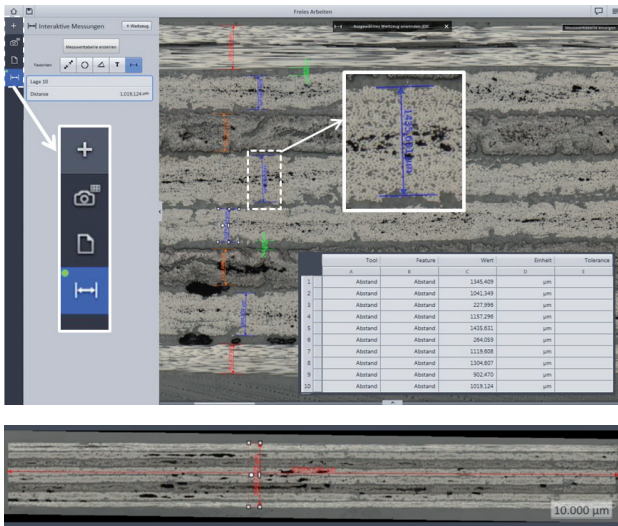

Figure 2: *Measurement of (a) the individual layer thicknesses, as well as (b) the component length and height, using the 'interactive measurement' tool. The results are listed in a table (a). The magnified workbench in (a) registers the tools used, the active tool is shown in blue.*

Measurement of porosity using the 'image analysis wizard'

The porosity is measured with quantitative structural analysis using the tile micrograph of the CFRP cross-section. The threshold analysis used to segment the pores is setup with the help of the 'image analysis wizard', one of the automatic measurement tools (Figure 3a). Object and individual classes are defined, the favored measurement features selected and the threshold adapted (Figure 3b). The output image shows the segmented porosity (red, Figure 3b, c). Measurement tables with the selected features can be saved.
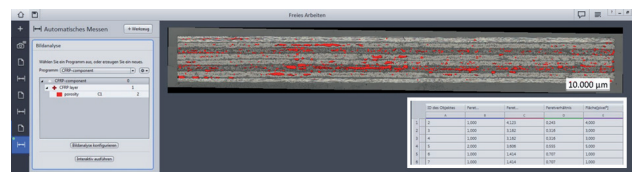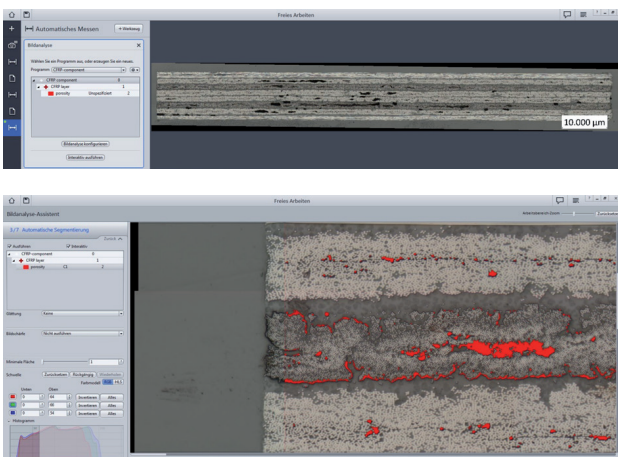

Figure 3: *Measurement of CFRP porosity. a) Setup of image analysis wizard; b) Adapting the threshold value; c) Output image showing the segmented porosity (red) and output data table.*

Reporting the results

The ZEN 2 core software's reporting tool allows the results of the investigation to be documented efficiently, in a prescribed manner. The results (micrographs, tables etc.) can be saved in previously established templates using MS Word. Figure 4 a shows the options of possible templates which may be chosen. The individual place holders for micrographs, tables etc. within the selected template can be filled with the results via clicking (cf. Figure 4 b).
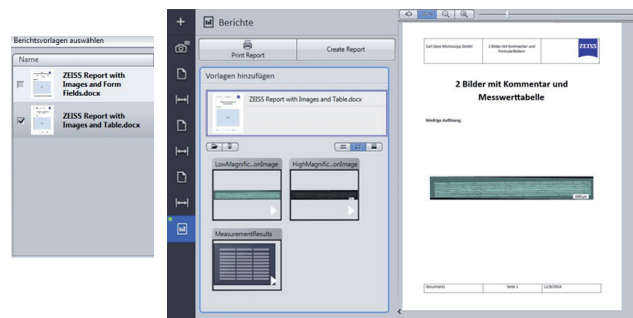

Figure 4: *ZEN 2 core reporting tool. a) Selection of favored template; b) Load up of investigation results (e.g. micrographs, tables).*

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