

# Digital Materials Analysis

## Part 1

Digital imaging methods and digital automation technology are the primary components of modern microscopy. Our series "Basics of Light Microscopy and Imaging" illustrated how closely microscopy and digital imaging have become entwined. The main contents of this series dealt with image generation, contrast, resolution, 3-D visualisation and fluorescence techniques. From this knowledge base, we now focus on the areas of materials science and metallography in our new series, "Digital Materials Analysis". The main emphases in these areas are inspection and analysis of samples from the widest variety of materials. Microscopy provides a magnified view of the sample, however, today's users in the materials sciences also expect image-processing capacity for acquiring, processing and evaluating images digitally. The ideal solution is to have software programmes that control the microscope's motorised components – such as the objective revolver (image magnification), the lamp voltage (image brightness) or the autofocus (image sharpness). In addition, these programmes control motorised microscope stages for exact sample positioning. All these requirements and possibilities combined together produce system solutions for modern quality and process control. In all applications of microscopy these system solutions simplify the acquisition and evaluation of image data in the lab and exploit the resulting innovative application potential.

### Digital Materials Analysis – a New Paradigm for Proven Methods?

To this day, the success of materials science analysis has been based on proven methods and the knowledge and the assessment skills of experts (figure 1). There are good reasons. These experts have mastered complex inspection methods and they established numerous strict internationally-applicable standards to regulate technical communication. By

the same token, the question is whether usage of digital technologies can reduce the tremendous effort required to handle and visually inspect samples. As the demands upon quality control rise continuously in terms of optimising processes and increasing profitability, are there new paths forward opening up? More specifically, is it possible to take conventional methods such as grain boundary or microstructural analysis and auto-

mate them? Is it possible to improve the reliability of experimental series results, increasing objectivity by making experimental steps reproducible? Can chart comparisons be conducted more ergonomically and more quickly? Can time-consuming workflows – in compliance with strict standards – be structured more efficiently via modern documentation and logging methods?

In this new series, we provide detailed answers to these questions, and below is a brief overview of the contents of the forthcoming series.

### Chapter 1: Fundamental Knowledge

Materialography, an essential segment of the materials sciences, is concerned with the structural composition and other structural characteristics of organic/inorganic materials, metals and their respective alloys. Technological processes for reclamation or postprocessing is examined in this context. Materialography provides valuable information on how materials technology (production, processing) and strain, on the one hand, are connected with materials structure and properties, on the other. After a series of various preparation steps – including embedding, grinding, polishing and etching – test pieces are produced (figure 2). An investigation of the surface with various microscopy techniques and digital image processing follows.

The interaction of light on material surfaces is subject to known physical laws and causes effects such as reflection, absorption, diffraction, polarisation and interference. Depending on the effect, there are various microscopical observation methods for ensuring optimal image contrast. These can be used to gather quantitative and qualitative data which describe the structure and homogeneity of the material.

The first chapter of the new series provides you with an accessible overview of the physical laws and basics relevant to basic microscopical methods.



Fig. 1: Visual inspection via microscopy and image-analysis methods are standard tools in many areas of the analytical and industrial materials sciences.

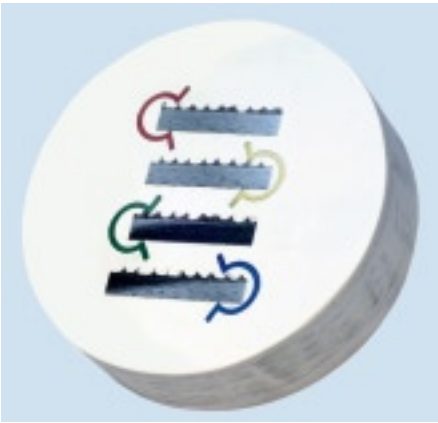


Fig. 2: Many metallography samples are embedded, ground and polished to be analysed. Depending on the application, other sample pre-processing steps such as surface etching may be necessary.



Fig. 3: One typical analytical metallography task is investigating graphite in cast iron. Using image-analysis methods for evaluation, each graphite particle is automatically detected and its shape and size evaluated. The size and shape distribution of all particles is displayed in tables and diagrams. Classifications according to national and international standards such as VDG, EN ISO, JIS or ASTM are integrated. In addition, the carbon-corrected ferrite/pearlite ratio can be determined.

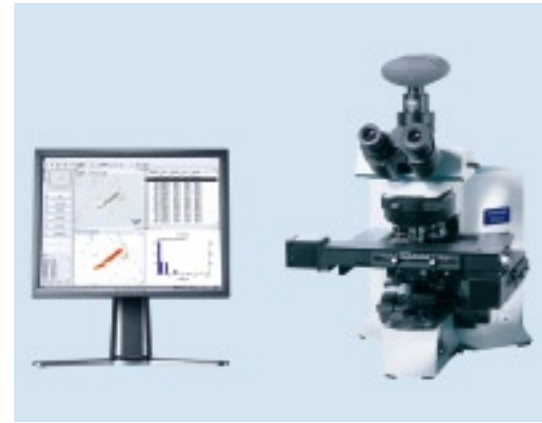


Fig. 4: Automatic system solutions are currently in great demand. These have finely-tuned hardware and software so that they offer high resolution and fast analysis, and guarantee measurement results that are standard-compliant and reproducible. The picture shows analySIS Filter-inspector, an Olympus system solution for fully automated optical analysis, classification and documentation of residues on circular filters. This system consists of a microscope, digital camera, motor stage with insert plate and special filter holder as well as PC – with a controller and the filter inspection software.

## Chapter 2: A New Flood of Data

The internationalisation of markets requires production companies and service companies to organise their workflows more efficiently and deploy their analysis systems more productively. In a modern “digital materials science lab” all orders or processes are managed and archived digitally. In the course of order processing, the user captures images of the sample at the microscope. Premium digital cameras are used to provide optimal image quality and further image analysis is done on the PC. Images, measurement and analysis results are in digital form and can be conveniently integrated with electronic documents of any kind, such as reports that are archived digitally or printed out. With the appropriate access authorization, everyone on a network has access to this data. Due to today’s legal requirements, data has to be stored for lengthy time periods which cause that river of data to turn into a flood – which grows day after day.

The entire data-handling process is in the crosshairs of the second chapter of our series. It deals with the new workflow concepts for documentation and archiving digital data. Without new data management concepts, the rising flood of data may lead to a short-term data crash.

## Chapter 3: Every Piece of Information Counts

Counting, measuring and evaluating – these are the core tasks in the materials sciences (fig. 3). Depending on the task,

the measurement might be e.g. a basic interactive measurement of distance; classification via particle analysis; or a standard analysis of non-metallic inclusions in steel materials. Each procedure requires high reproducibility and highly precise measurement. New technologies, such as digital microscopy and image processing, play an increasingly significant role by simplifying quality control and automating established testing methods. This makes test processes ergonomic and fast.

In chapter 3 of our series we introduce the primary measurement and analysis procedures of the materials sciences along with the most important standards. The special system solutions requirements for materials science analysis are easy to understand when viewed in this context.

## Chapter 4: Versatile Automation

Industrial producers of high-quality components and their customers make extremely high demands on product quality. These demands are defined by a steady flow of new, detailed and universally-valid directives, as well as internal company regulations. Fulfilling these requirements effectively and promptly requires automated system solutions (fig. 4). These systems are usually conceived to handle one particular task systematically and fully automatically. These com-

prehensive solutions integrate the optical performance of a premium light microscope, digital image acquisition technology, precise motor stages, computers and the corresponding software. Furthermore, there are new techniques and technologies to consider such as “frame independent image analysis”.

In chapter 4 we show you the situations best suited for using such systems. We go into some detail on the advantages that various system solutions offer you. We also cover things you should keep in mind with such systems, and how you can very possibly expand your own existing system to turn it into an automatic system.

## Chapter 5: Increasingly in Focus: The Third Dimension

The topographical investigation of material surfaces is based on image data acquisition in 3 dimensions. There are various techniques available to users for doing this, such as confocal laser scanning microscopy and nanotomography. Confocal laser-scanning microscopes provide high-resolution surface views and allow you to conduct extremely precise 3-D measurements – in real-time (fig. 5). This helps engineers, for example, to develop more efficient manufacturing processes and in developing prod-

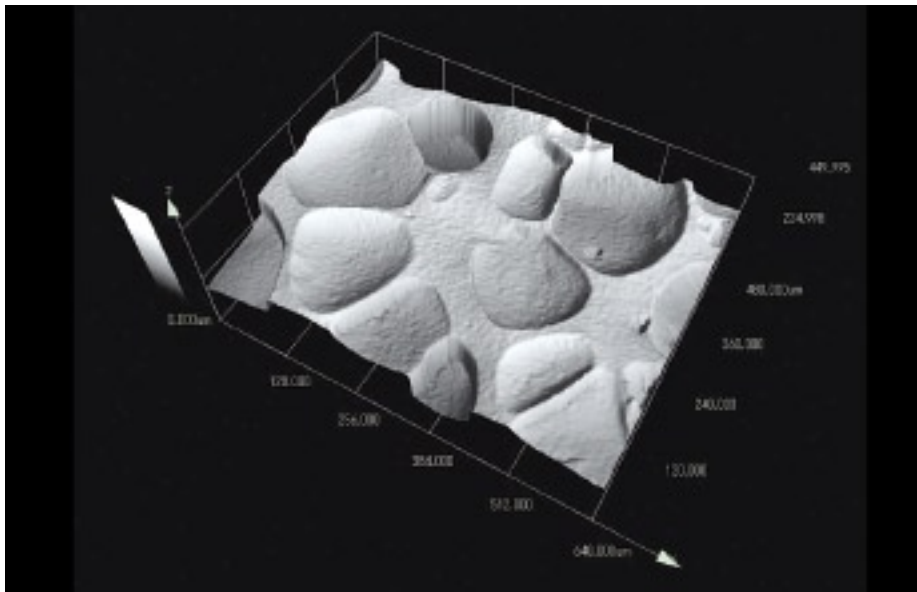


Fig. 5: Using confocal laser-scanning microscopes with a unique combination of high-resolving laser scanning and colour light microscopy, three-dimensional and true-colour image acquisitions are generated. When Differential Interference Contrast (DIC) is used as well, extremely fine differences on the sample surface can be identified. Scratches and tears are detectable via the dark-field contrast.

ucts with greater reliability. Optimising surface roughness is the key.

Nanotomography delivers 3-D images of the innermost areas of these materials and visualises structural condition in the nanometer range. The

structural information gained opens up new possibilities for the production of modern materials, by providing new insights into structural formation and the micromechanics of nanostructured materials.

These and other technologies for acquiring 3-D information are the foci of the final chapter of our series.

### Eyes on the Legend

Each separate chapter is divided up into segments which appear in multiple issues of *Imaging & Microscopy*. At the beginning of each article there is a legend which illustrates what segment of the chapter is in that respective issue. If you happen to miss a part of the series, any segments that have already appeared are available as pdf files on GIT's IMAGING & MICROSCOPY web site (<http://www.imaging-git.com>). In the next issue we'll kick off our new series. We hope we've tickled your curiosity!

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