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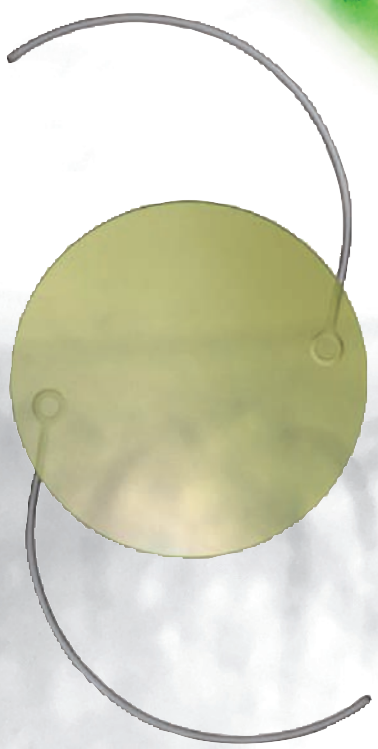


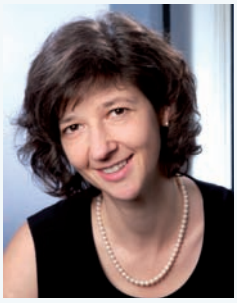
Precision That Saves Eyesight

Stereomicroscopes in the Production of Surgical Instruments

Steel – the All-Rounder That Has to Pass Many Tests

Quality Control for Special Steel

EDITORIAL



Dear Readers,

Our eyes are our most important sensory organ. Sometimes, however, the complex interplay of refraction and focusing via the lens and transformation of the optical signals into electric nerve impulses via the retina stops functioning properly. Although medical technology is not yet able to replace the human eye, the possibilities of eye surgery are fascinating. Two articles in this issue of reSOLUTION describe the precision instruments and high-tech lenses – produced and inspected with the aid of stereomicroscopes – that help surgeons save our eyesight.

The world of steel deals with rather different dimensions. Yet top precision and microscopic analysis are just as essential in the production process. Today, many safety-relevant structural components are made of steel and the microstructure of the metal alloy used plays a major role for the properties of the finished product. We interviewed an expert on the subject of elaborate quality control in steel production.

There's hardly a technology magazine that doesn't report on nanotechnology – and reSOLUTION is no exception. Our feature, however, is not so much about the latest technological developments as the contribution made by a high-tech microscope to show young people exciting pictures from the nano world and fire their enthusiasm for this promising branch of industry.

Have fun reading!

Anja Schué
Communications & Corporate Identity

Carola Troll
European Marketing Manager Industry

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Stereomicroscopes in the Production of Surgical Instruments

Precision That Saves Eyesight

Anja Schué, Leica Microsystems

Retina surgery demands experienced surgeons and precision technology. In vitreoretinal surgery, the surgeon operates with microscissors and forceps that are less than a millimeter thick. The Swiss company Alcon Grieshaber is one of the world's leading specialists in handheld instruments for minimally invasive eye surgery. Stereomicroscopes from Leica Microsystems support the manufacturing of these instruments from their development to the final inspection. Alcon Grieshaber chose these microscopes not only for their optical quality, but also for their ergonomics.

The retina has 130 million sensory cells for capturing an image of the world around us. If they are damaged and die, our eyes lose their vision. Losing our eyesight is a terrible thought, but for most of us it is just as frightening to imagine an operation on our eyes. There are many causes for retinal damage or detachment or yellow spot (macula), and without an operation there is great danger of going blind. Statistically speaking, one in 10,000 people is affected. Thanks to modern eye surgery, however, the chances of fully restoring the patient's eyesight are excellent if the problem is diagnosed early enough.

Scissors or forceps – hard to tell with the naked eye

Alcon Grieshaber AG in Schaffhausen, owend by Alcon, Inc., the world´s leading eye care company has played a major role in advancing minimally invasive retinal surgery and its handheld precision instruments still lead this market segment today. The company has promoted the switchover to single-use instruments worldwide and perfected the instruments for minute dimensions. The tiny tools – scissors, forceps, hooks, knives, fluid handling instruments – fit through an incision smaller than a millimeter wide, the smallest of them measuring a mere 0.5 millimeter when closed. "Our technological lead cannot be seen by the naked eye, it is microscopic," Jürg Attinger, Manager of Alcon Grieshaber AG, describes his precision instruments.

"Our technological lead cannot be seen by the naked eye, it is microscopic."

Microscopes at all workplaces – from incoming inspection to final cleaning

At Alcon Grieshaber, quality control begins before the products are even made. Even semi-finished goods that are turned, milled and EDMed are measured under the microscope. "We have found an optimal inspection frequency solution that considers time, cost and risk, and luckily, we have an extremely small reject rate", explains Heinz Etter, Head of Facility Management at Alcon Grieshaber. "All components are checked after two to three production steps at the latest throughout the entire production process. At the end there is always a 100% inspection. No instrument leaves the factory without thorough examination under the microscope." Almost all the employees work with a microscope – in inspection of incoming material, in production and quality control through to final cleaning and inspection of the finished product in the cleanroom as well as in R&D. We have 118 stereomicroscopes here and 140 employees – although it is mainly the 65 members of production staff that use them.

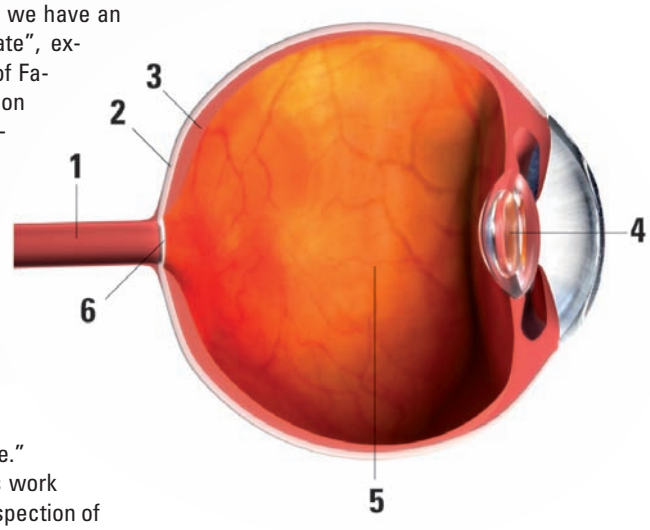


Fig. 1: Surgery in the posterior segment of the eye may be standard practice in ophthalmology today, but it is not easy to perform. It demands sensitivity and experience as well as complex technology – from the surgical microscope to the microinstruments directly applied by the surgeon at the site of the retina or macula requiring treatment. Retina surgery is only possible using a surgical microscope, and three incisions have to be made to access the posterior segment: one for illumination, one for the instrument and one for the infusion to stabilize inner eye pressure. **1**: Visual nerve, **2**: Sclera, **3**: Retina, **4**: Lens, **5**: Vitreous humor, **6**: Macula

The trained eye is unbeatable

Besides the quantitative analysis facilities for 2D measurements offered by the microscope and appropriate software, and traditional mechnical measurements, visual inspection is indispensable. For example, microscissors have three-dimensional free form surfaces with a dimension of only 0.5 millimeter. The part for inspection is compared with a reference sample under the microscope. "For this application, there is no other technique to date that can compete with the eye of an experienced employee – particularly in terms of time and cost," stresses Etter. "Inspecting surface roughness with a 3D scan or profilometry would be far too costly and time-consuming

for us. Despite all the potential risks of visual control, experienced employees are unbeatable." One example: One of the instruments is made from a wire 0.14 millimeter thick with a tolerance of 0.01 mm. The staff are trained to tell whether the tolerance has been adhered to just by holding the thread under the stereomicroscope without a comparison sample.

"The true challenges in our quality control begin where the criteria start to soften, where reference samples or photos are called for," says Attinger. "We can and do have a lot of confidence in our staff.

The quality motto at Alcon Grieshaber: "Check each product as if it were to be used to operate on you."

We recover the 'discretion' quality we lose by good training. And so far we have been successful – despite the fact that we make our products in expensive Switzerland and even make single-use instruments."

Optically brilliant and cost-saving stereomicroscopes

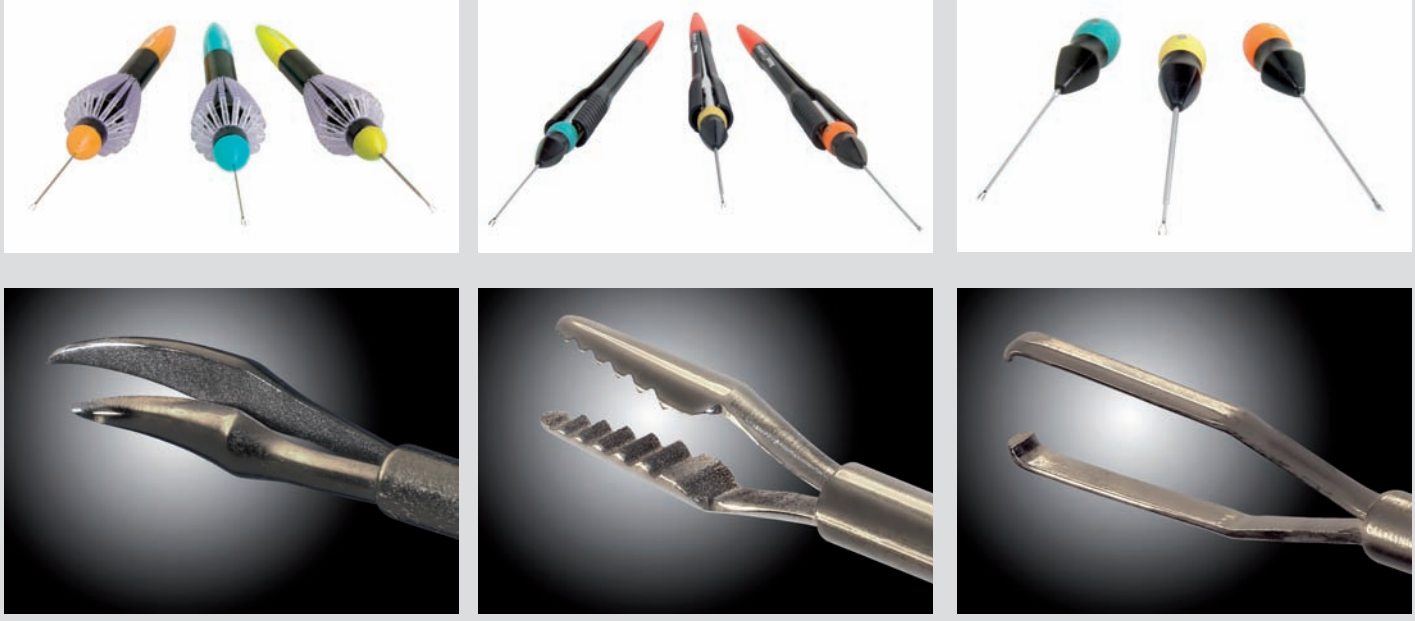
When it comes to microscopy, Alcon Grieshaber trusts in the stereomicroscopes of Leica Microsystems. Besides the optical quality, the Schaffhausen specialists appreciate the LED illumination, the easy and convenient operation, the ergonomic design and the large field of view, especially the 23 mm field of view offered by the new generation of Leica M80 and M50. The Leica M205 with FusionOptics™ additionally provides the excellent depth of field and high resolution that are specifically useful for R&D applications.

Nearly all microscopes at Alcon Grieshaber are equipped with LED illumination. 20,000 kWh a year has already been saved with this energy-saving light source. The company also saves because of the much longer lifetimes of LEDs compared with conventional microscope lamps.

Ergonomics for all

Many employees at Alcon Grieshaber spend eight hours at the microscope every day. Alcon Grieshaber is one of the pioneers in ergonomics within the Alcon, Inc. Ergonomic chairs, height-adjustable desks, elbow rests to take strain off the shoulders are all automatically provided. The company also places great value on individually adjusted, ergonomic microscopes and uses Ergo tubes and eyepieces that are matched to different body sizes and physiques.

The fact that Leica Microsystems offers the widest range of ergonomic accessories for stereomicroscopes is one of the main reasons for



Figs. 2: The hand-held precision instruments of Alcon Grieshaber that are used for the various steps of an eye operation have a worldwide reputation of excellence. Depending on the surgical technique employed by the surgeon or the exact reason for surgery, he needs instruments that fit through an incision of 1.15, 0.72 or 0.62 mm to access the inner eye. That is equivalent to an instrument diameter of 0.9 (20-Gauge), 0.6 (23-Gauge) or 0.5 mm (25-Gauge). The surgeon does not open the scissors or forceps until they have been introduced into the eye. The instruments are freely rotatable. When performing surgery, the surgeon just has to correct the pressure angle. The trend towards smaller incisions has the key advantage that the smallest incisions heal by themselves without suturing. For the instruments, miniaturization means more and more sophisticated manufacturing techniques and materials and the fact that only single-use instruments can be effectively utilized. Even the smallest damage that is inevitably entailed in a conventional sterilization process renders the microinstruments useless.

Videos and information on surgical techniques in vitrectomy:

http://www.alconretina.com/surgicalTechniques.asp

Alcon Grieshaber's long-standing loyalty to Leica Microsystems' products.

Periodically, a specialist from the parent company, Alcon, Inc., comes to Schaffhausen to check site ergonomics and give the staff advice if necessary. But that's not all: "We offer every member of staff a weekly 30-minute shoulder and back massage. The cost is shared by the company and the staff," says Attinger. "If our staff feel good at the workplace and the microscope, they are more efficient, too. And that is ultimately good for our overall result. We carry a great responsibility for our staff, after all we depend on them for our success."

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Figs. 3: The manufacture of microinstruments for eye surgery demands a great deal of precision work – skill, experience, a trained eye and a good portion of perfectionism. Most quality inspection tests are carried out at 20x magnification. Higher magnification would tend to have the effect that even the smallest details that do not impair product quality would be interpreted as defects. In production, higher magnifications are required, mostly 60x. Alcon Grieshaber attaches great importance to individual ergonomic features of the microscope and the workplace. Leica Stereomicroscopes offer the widest and most flexible range of accessories for this purpose.

Fig. 4: Like nearly all the employees, Jürg Attinger, Manager of Alcon Grieshaber, has a steromicroscope at his workplace. The qualified precision mechanic and engineer knows the business from the bottom up. Although now a manager, he still wants to be close to the products, to be able to see and understand them and make his own judgement.

Accessories for Stereomicroscopes

Leica Microsystems ergonomics program is the world's most comprehensive for stereomicroscopes, enabling every user to match the instrument to work procedures, environment and to personal physique.

Leica ErgoTube 10 – 50°
Perfect tool for multi-user workstations

Leica Inclined binocular tube 45°
Increases productivity and improves profitability

Leica ErgoTube 45°
Brings the microscope closer to you

Leica Trinocular ErgoTube 5° – 45°
Provides a wide range of adjustment options

Leica Straight binocular tube
Provides ergonomical horizontal viewing

Leica ErgoLens
Fine focusing in the 90 mm range without changing the viewing height

Leica ErgoModule 30 – 120 mm
Comfortable observation even for tall users

Leica ErgoRest
Enables precise, fatigue-free work at the stereomicroscope

Leica ErgoWedge 5 – 25°
Accommodates the human need to change position

Leica ErgoWedge 15°
Improves viewing conditions

More information:
www.leica-microsystems.com

Stereomicroscopy Ensures Quality of Intraocular Lenses

Delicate Acrylics for New Eyesight

Kerstin Pingel, Leica Microsystems

Only a few decades ago, the diagnosis 'cataracts' meant loss of vision in the near future. Today, cataract surgery is the most common operation worldwide. Thanks to new types of artificial lenses like the ones developed and produced by the HumanOptics AG in Erlangen, Germany, physical discomfort is reduced to a minimum. In the quality control department of HumanOptics, a high-end stereomicroscope from Leica Microsystems ensures the best possible product quality and therefore optimal safety for the patient.

Fig. 1: Diffractive Lens: Thanks to their special optical design with seven diffractive steps, diffractive lenses enable cataract patients with an artificial lens to focus close-up and medium-range as well as over long distances.

When vision gradually becomes like looking through a pane of frosted glass, it is usually due to opacification of the eye lens, a disorder known as cataracts. Cataracts are mainly age-related and are most common in people in their fifties.

A quarter of an hour for clear vision

In the 15-minute operation, which is often performed as outpatient surgery, the clouded lens is fragmented by ultrasound and then removed by suction. An artificial lens, the intraocular lens (IOL) is inserted into the intact capsular bag to restore the patient's visual acuity. Thanks to a wide choice of different artificial lenses, it is even possible to correct vision defects or astigmatism.

Artificial lenses are made of various materials: plexiglass, silicones or acrylics. "We prefer materials which have been used as implant for 20 years and which have therefore been proven successful in contact with the eye and are absolutely safe," says Christian Fleischmann, Production Manager at HumanOptics. "This is particularly important nowadays as more and more young people are requiring cataract surgery and the artificial lens will have to stay in their eye for many years."

In Erlangen, IOLs are made of hydrophilic acrylate. In its "dry state", this material has similar properties to plexiglass and is therefore easily machinable. As a finished product in a "moist state", however, it is highly flexible and can be folded several times. This has the advantage that only a tiny incision has to be made to insert the lens and this incision heals quickly and often without requiring sutures. HumanOptics has plants in Erlangen and St. Augustin

Fig. 2: Working at a magnification of 160x, the staff check the lenses for the tiniest defects.

for developing, producing and marketing intraocular lenses for various indications. With its 100% subsidiary Dr. Schmidt, it has more than 30 years of experience in the IOL sector. "We are one of the few companies in this line of business that can offer the entire vertical range of manufacture," says Fleischmann. HumanOptics commands a particularly strong position in innovative lenses and high-quality standard lenses. The special lens Aspira-aAY, for example, is a leading-edge solution for cataract surgery.

Fragile lenses milled by special machinery

The lenses are pre-contoured on precision turning machines with diamond tools. This is the only stage where they are clamped mechanically in precision chucks. The IOLs are then milled in ultra-precise milling machines. Here, the parts are already clamped in a vacuum before the contour of the lens is milled with diamond milling tools. The next step is finishing

on ultra-precise turning machines with specially polished diamond tools, again using vacuum clamping technology. A 10 cent-sized piece of acrylic material is thus gradually turned into a lens with a diameter of 7 mm in polish-free quality. The haptics, i.e. the miniature wires with which the lens is streched in the eye, are only 70 µm thick.

Leica M205 C: High magnification, high light yield

The delicate lenses are inspected time and again under a microscope to ensure they meet the highest quality standards and offer the greatest possible safety for the patient. A Leica M205 C stereomicroscope is at hand for precise quality control. "The deciding factor for the choice of this microscope was the high magnification and optimum light yield," says Fleischmann. Working at a magnification of 160x, the staff check the lenses for the tiniest defects, which may be caused in the machining process when particles the size of a few nanometers adhere to the lens or tool and leave marks on the material's surface.

Quality inspection of tools for special lenses

The Leica stereomicroscope is also used to check the quality of special tools used at the Erlangen plant to produce toric and diffractive lenses. Toric lenses have a special surface design and are used to regulate astigmatism. Diffractive lenses enable cataract patients with an artificial lens to focus close-up and medium-range as well as over long distances.

"This is achieved with a special optical design based on the principle of diffraction," explains Fleischmann. "Our lens has diffractive steps with sharp optical edges. The production tolerances for the step heights are in the order of a few nanometers, roughness in surface quality may be in the subnanometer range." These types of lenses are made of silicone, so the mold has to meet top precision specifications, too – another job for the Leica stereomicroscope.

Long-lasting implants

Before the lenses leave the production line in Erlangen, they are subjected to preliminary cleaning. The staff work in a flowbox and thus in a dust-free environment. Under the microscope they detect the finest specks of dust and other particles and clean the lenses with soap solution, alcohol and ultra pure water.

At the HumanOptics plant in St. Augustin, the IOLs are cleaned again under cleanroom conditions and measured. The company produces up to 15.000 lenses a month. Central Europe and the German speaking countries are covered by the trade mark Dr. Schmidt. Most of the IOLs with the trade mark HumanOptics are exported worldwide. North, Middle and Eastern Europe, Asia, Australia and the Middle East are key markets for IOLs. "In these countries, quality is a key criterion for special lenses and customers accept that it entails higher cost," says Fleischmann. "Quality has top priority for us, too: after all, our implants are designed to last for decades."

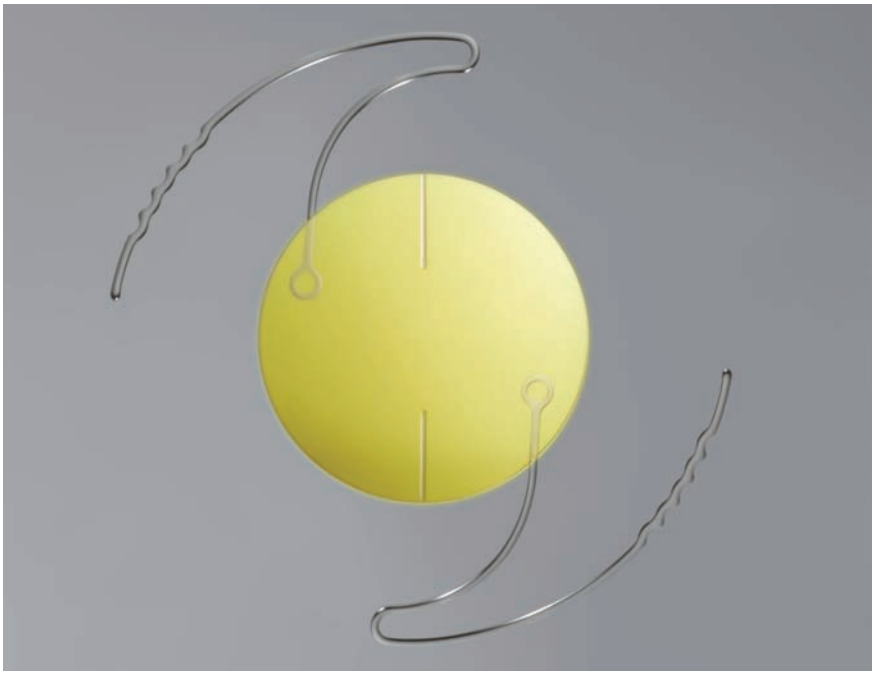

Fig. 3: Foldable toric intraocular lens

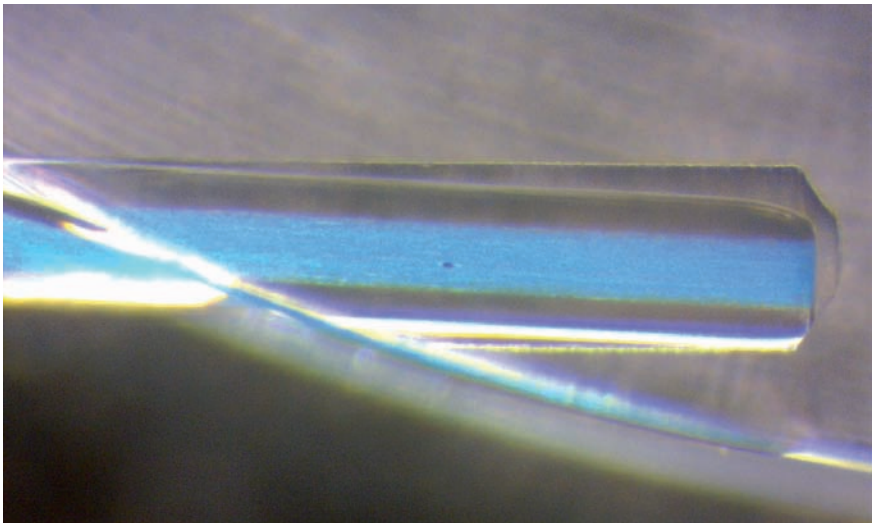

Fig. 4: Microscopic image of the contact between haptic and lens

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Quality Control for Special Steel

Steel – the All-Rounder That Has to Pass Many Tests

Jürgen Paul and Anja Schué, Leica Microsystems

Steel is a real all-rounder. However, each application requires a specific sort of steel grade. Without steel there would be no Olympic stadiums, wind energy plants, bridges, skyscrapers, trains, planes, cars, razor blades or knives for medical and home use – at least, not of the quality and design we know today. Buderus Edelstahl GmbH in Wetzlar, Germany is one of the world's top producers of special steel. The company's own accredited testing laboratory guarantees exceptionally high quality standards – and stereomicroscopes and compound microscopes from Leica Microsystems support the lab team. Holger Wörner, Head of the Testing Laboratory at Buderus Edelstahl, explains the quality control specifications and the roles played by light microscopy and image documentation.

Fig. 1: Holger Wörner, Head of the Testing Laboratory at Buderus Edelstahl GmbH, Wetzlar, Germany

Mr Wörner, do you see any other industrial materials with the potential for taking over the role of steel in the foreseeable future?

Definitely not. There are a few special applications today where ceramic materials or titanium alloys are used instead of steel to save weight. But they are comparatively expensive and often more prone to cracking. On the contrary, steel is conquering new areas of application due to the improved strength and mechanical properties or the potential for being used in smaller cross sections offered by new variations of alloys. Even a slight change of the alloy may significantly alter the properties of the finished product. Every year, steel manufacturers develop countless new types of steel for specific requirements. Steel is not replaceable in the foreseeable future.

Many of your products are safety-relevant components. What does this imply for your quality control?

If we wouldn't comply with the highest standards of quality, we would not rank among the world's best companies. As an accredited testing laboratory, we have to meet stringent specifications and are therefore able to vouch for the reliability, objectivity and accuracy of our results – irrespective of whether we inspect our own products during the production processes or, for instance, inspect damage and write appraisals on behalf of a customer. Quality control begins from the very moment the steel is melted.

The chemical composition of the melt, the so-called melting lot, is of fundamental importance for the properties of the material for the entire duration of the production process. Only non-destructive examinations can provide the engineer with the necessary information for assessing whether each volume element of the component will bear the required load when in use. The interior of the component is examined with ultrasound to detect any defects, the surfaces are subjected to magna flux or dye penetrant testing to check for the finest cracks. Mechanical inspection, purity testing and structural analysis under the microscope of samples from defined test positions of the components yield further data on the properties of the products. The type and number of samples at the various test positions depend on the component, of

course. To obtain further information on process influences we also analyze specific samples in the scanning electron microscope.

Generator and turbine shafts weighing up to 70 tons are complex one-off parts from our open-die forge. They are rigorously inspected during the long manufacturing process. If defects are not found until the end, we not only lose money, but also risk losing our reputation with the customer. Most of the series-produced components from our closed die forge or the rolling mill, such as vehicle gear components, also have to meet high quality specifications. The customer has to be sure that the entire series is O.K.

Fig. 2: Mechanical testing laboratory at Buderus Edelstahl.
© Buderus Edelstahl GmbH

Quality testing is considerably time-consuming. An ultrasonic inspection of a large generator shaft takes between three and five days, depending on the number of test positions. Everything has to be documented – even structural effects under a critical size have to be registered. Mechanical and microscopic testing usually takes us one to two days. Most of the time is spent on taking samples and preparing them for inspection. All the test results related to the criteria defined by the customer are finally documented in a certificate that is given to the customer together with his component.

What role do light microscopy and image analysis play in the quality control of your steel products?

High-quality light microscopes and image analysis software are mainly used for products – whether rolled or forged – for which the microscopic purity is important. After all, the German word 'Edelstahl' that is part of our company name refers to the purity, i.e. microscopic inclusions. Another standard inspection is the examination of the microstructure we carry out at different stages of production. Microstructure examinations are not only useful for detecting defects, but also for finding the causes within the production chain. A deviation in tensile strength or toughness can be identified via the microstructure. In the case of a defect in a forged or rolled product, the microscope image can tell us the point in time when the defect was originated.

... and for damage inspection?

For damage inspection, examinations with a light microscope, and sometimes also a scanning electron microscope, are particularly important. Further information can be provided by chemical analysis. When a component fails, we are able to find out the reason for the failure. In about 95 per cent of cases, it's not the steel itself that is defective. Sometimes it is being incorrectly used or the failure is due to an engineering error such as wrong dimensioning of the component.

We can trace almost everything with light microscopy. When inspecting a fracture, we use a stereomicroscope after an initial visual check, which already reveals a lot to the expert. The stereomicroscope often shows the starting point of a fracture. Light microscopic examinations of samples taken from the fracture area show whether the fracture was caused by an unacceptable inclusion, for instance. For this purpose, we produce microsections for structural examinations and purity inspections in order to get to the bottom of the problem. If necessary, we do an additional point analysis under the scanning electron microscope. Naturally, the component is also always subjected to mechanical-technological tests to check for criteria such as tensile strength and toughness.

Any material can fail as a result of fatigue due to its microstructure, load or environmental conditions. Even if the material is always under a cyclic load in the elastic range – so that there are no apparent signs of permanent distortion-, submicroscopically small cracks may eventually form the gradually growth via inclusions in the component, grain boundary disorders and fractures at unfavorably oriented grains and may develop into cracks of a critical size. The ensuing decrease in cross section then ceases to bear the load and there may be a sudden forced rupture. A danger like this can develop unnoticed over many years. That's why appropriate regular maintenance

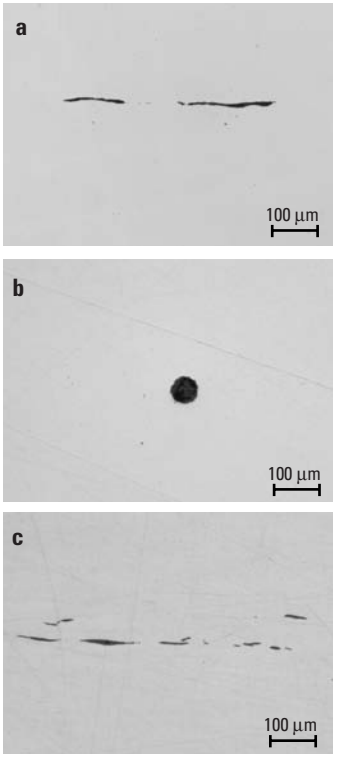

Fig. 3: Steel inclusion ratings at 100x magnification: examples of oxidic inclusions (a, b) and sulfidic inclusions (c).
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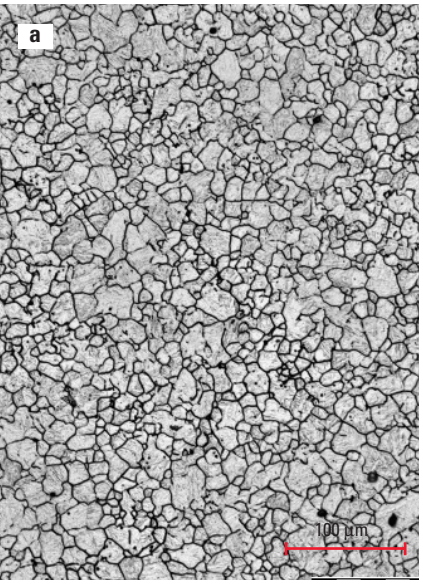

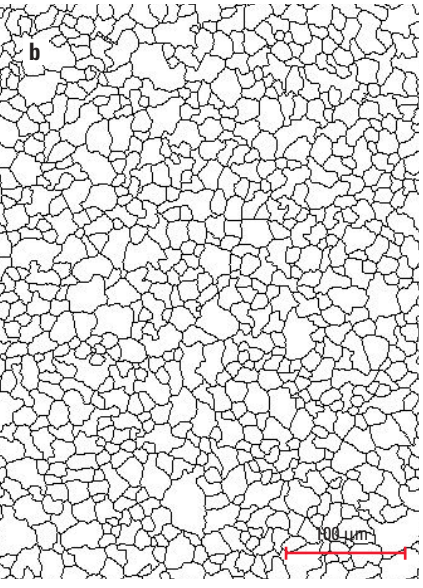

and monitoring of safety-relevant structural components is essential.

How important is a reproducible preparation technique and what contrasting methods and magnifications do you use?

Reproducible starting conditions are particularly important for the automated purity tests. For microsections, we clamp the material in sample holder plates and grind them. They are then fine-ground and polished on another machine according to standard parameters. A properly prepared section has no scratches or grooves, nor are there any signs of chipping.

We mainly use brightfield microscopy, in some cases interference contrast. The magnifications vary from 50x to 1000x. Purity testing is done at 100x or 200x, microstructure examinations between 50x and 1000x.

What about "reproducible microscopy", in which automated microscopes are controlled by software and application-specific settings are reproducible?

Automated microscope systems are mainly an advantage for purity testing, which we perform according to the latest standards. Here it is essential that all the settings are reproducible. The grain sizes are also measured automatically and therefore reproducibly, as this is a heat-dependent variable. We are a leading manufacturer of gear steel, especially for large gears in wind energy plants. These large gears have to withstand tremendous dynamic loads. It is therefore important that we inspect the grain size reproducibly and document it before delivering the material to the customer.

Do you use microstructure examinations for the selective development of new alloys as well?

If a customer wants to make a product for which there is no ideally suitable type of steel grade, it is naturally up to us to design the right steel grade. Varying the amounts of various trace elements that are added to the melt along with carbon, chromium or nickel is the key to creating the demanded properties of the steel. After hot forming, such as forging or rolling, and subsequent heat treatment, an examination of the microstructure shows us whether we have achieved the result we were aiming at or have to change process parameters.

The development of a new steel grade is always a combination of mechanical inspection to determine the quality values for the engineer in the application and structural assessment. If we detect poor toughness properties in the component, we examine the microstructure and grain size. We use the structural examination as a basis for altering the relevant process parameters for reworking or new production – and then inspect the effectiveness of the measures we have taken. The microstructure is the link between the manufacturing parameters and the properties.

When we analyze the microstructure (phases, grain size, purity) we can look in two directions, to the past and to the future. The microstructure tells us how the

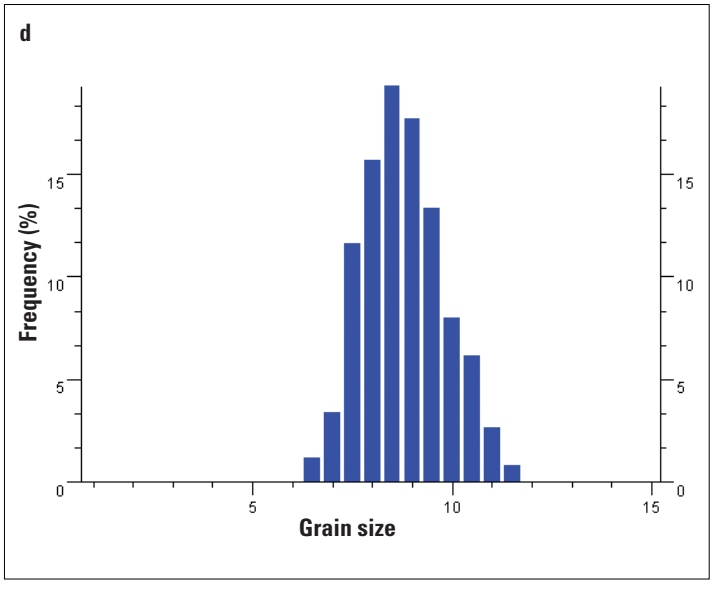

Fig. 4: Grain size determination of a special steel sample, a: microscope image with 200x magnification, b: reconstruction, c: measurement, d: results of the grain size distribution. © Buderus Edelstahl GmbH

steel has been originated. And we can predict the mechanical properties it is likely to have.

How important is image documentation for you?

Image documentation has always been indispensable in metallography. Many customers like to have image documentation of the microstructure and we generally provide this when examining cases of complaint or damage. Image documentation is equally important for our research and development activities. For example, database systems help us to file microstructure states of the various steel types and quickly retrieve them when needed. The image documentation comprises overview photographs and representative photographs taken at high magnifications that show the microstructure and, if possible, the homogeneity of the entire component.

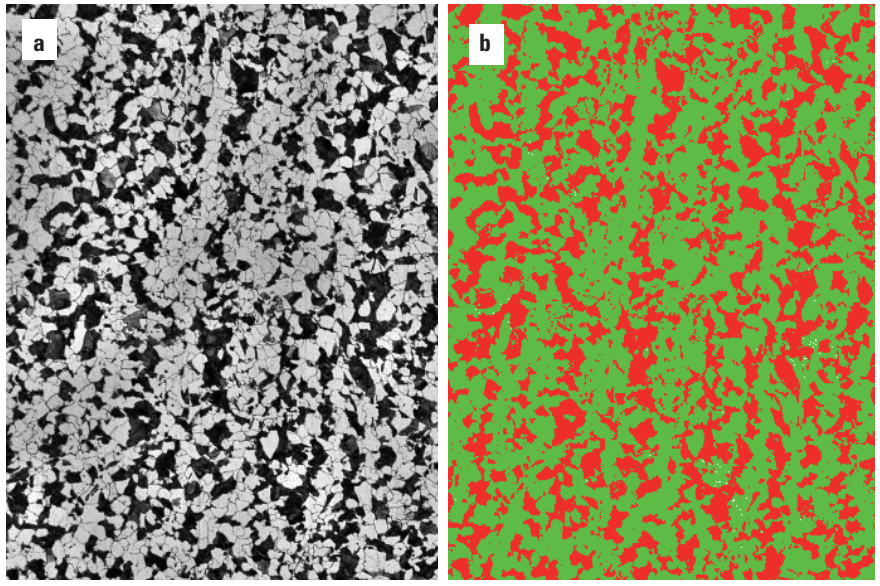

Fig. 5: Phase analysis of a ferritic-perlitic: microscope image (a), visualization of the different phases (b).
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Leica Steel Expert – Fully Automatic Steel Inclusion Rating

Leica Steel Expert is a complete system solution that consists of high-end quality software, a sensitive Leica DFC color camera and a Leica DMI5000 M automated inverted industrial microscope (alternatively a Leica DM4000 M or DM6000 M upright microscope). The system performs fully automatic classifications and analysis of non-metallic inclusions of all types of common steel, based on their color, shade, shape and arrangement. Measurement data is available in raw, processed and histogram format all of which can be displayed simultaneously and easily compared when applied to the established international standards.

Leica Steel Expert supports all international steel inclusion rating standards including ASTM E45 A, D, E, ISO 4967 A, B, DIN 50602 K, M, JK and JIS 0555. In addition, the latest European standard EN 10247 is fully implemented.

Firing Students With Enthusiasm for Research and Technology

Confocal Microscope With an Educational Mandate

Anja Schué, Leica Microsystems

If nanotechnology is the key technology of the 21st century, it makes sense to arouse the interest and enthusiasm of young people in this subject when they are still at school. After all, it is they who will write the next chapter of the nano success story. For this reason, the information and further education of teachers and students is a central aim of the Nanoinitiative Bayern GmbH, which operates under the umbrella of the Bavarian Cluster Nanotechnology in Southern Germany. And a Leica DCM 3D Measuring Microscope has a role to play in this mission: On visits to schools, it gives students as well as teachers the opportunity for hands-on experience of confocal microscopy.

Fig. 1: Christoph Petschenka is responsible for the school and university program of the Nanoinitiative Bavaria GmbH.

Fig. 2: Dr. Matthias Nüchter from the Nanoinitiative Bavaria GmbH looks after Research and Applications.

By the year 2010, global sales on the nanotechnology market are expected to top the 200 billion Euro. There is a growing number of companies operating in this sector and innumerable nano research projects. However, the subject does not feature in the school curriculum yet, nor are there many university courses devoted to nanotechnology. The Nanoinitiative Bayern GmbH and the network association Nanonetz Bayern e.V., which are based in Gerbrunn near Würzburg, are helping to close this gap. The initiative may only be regional, but it is extremely successful.

As well as the usual tasks of a high-tech cluster to network industry and research, the Bavarian Cluster Nanotechnology has initiated an extensive agenda for schools and universities. In workshops and study groups with universities it promotes the establishment of nanotechnology degree courses or modules and offers practical help for this process.

Be amazed today, do research tomorrow

Touch and Try Nanotechnology – that is the motto of the school program. One of the key projects is a 'NanoShuttle' packed with high-tech analysis and presentation equipment that has been traveling from school to school in Bavaria for over two years. In September 2009, a Leica DCM 3D Confocal Measuring Microscope was added to the atomic force microscope and particle analyzer already aboard the NanoShuttle.

When the NanoShuttle visits a secondary or grammar school or a technical college or university, three hours are reserved for science students. After the technology has been explained to them, they are allowed to experiment. The nanostructures or particle emissions of objects and samples they have brought with them are examined and analyzed. Using the

"The interested students of today will be the scientists and entrepreneurs of tomorrow."

Fig. 3: The NanoShuttle brings the exciting nano experience to schools. Presentations, virtual experience trips and every-day experiments promote the fascination of nanotechnology.

DCM 3D, students look in astonishment at the surface structure of their cell phone chips, which on the nanoscale look like high mountains. Fascinated as well by nanostructures of different petals, the students also compare their own hair to industrial carbon fibers. "The DCM 3D is a great addition to our NanoShuttle," emphasizes Christoph Petschenka, who is in charge of the program for schools and universities.

The NanoShuttle reaches approximately 12,000 students and teachers a year. "The interested students of today will be the scientists and entrepreneurs of tomorrow," says Petschenka. "This is why we want to generate interest in this key technology of the 21st century at an early stage." And they are so successful with the NanoShuttle that it is meanwhile fully booked for months in advance. Naturally, the fact that schools don't need to pay for the NanoShuttle is an important aspect. No school could afford equipment as expensive as this. The program for schools also includes in-service training events for teachers and the provision of teaching material.

Encouraging creativity

To foster a creative approach to this subject, the Nanoinitiative Bayern GmbH holds an annual competition for schools in which students have an opportunity to prove their resourcefulness. Leica Microsystems is sponsoring this year's competition, which is the fourth. Students of all grammar schools, secondary schools and technical colleges in Bavaria are eligible to submit projects, coursework or individual contributions. The only rule is that the entry should deal with the subject of nanotechnology in an informative, enlightening, humorous and innovative way.

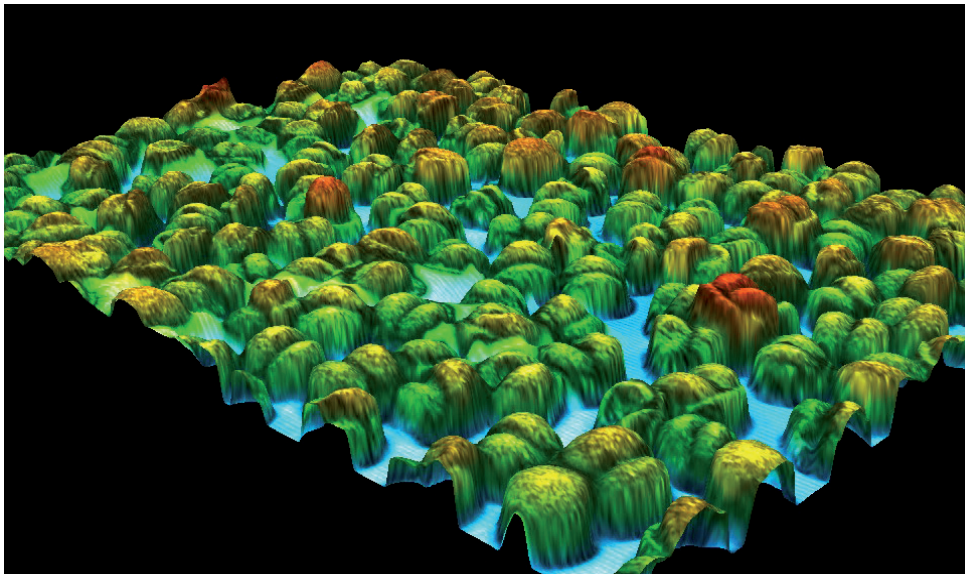

Fig. 4: Students used the Leica DCM 3D to explore the surface structure of pine pollen. One grain has a diameter of 40 µm.

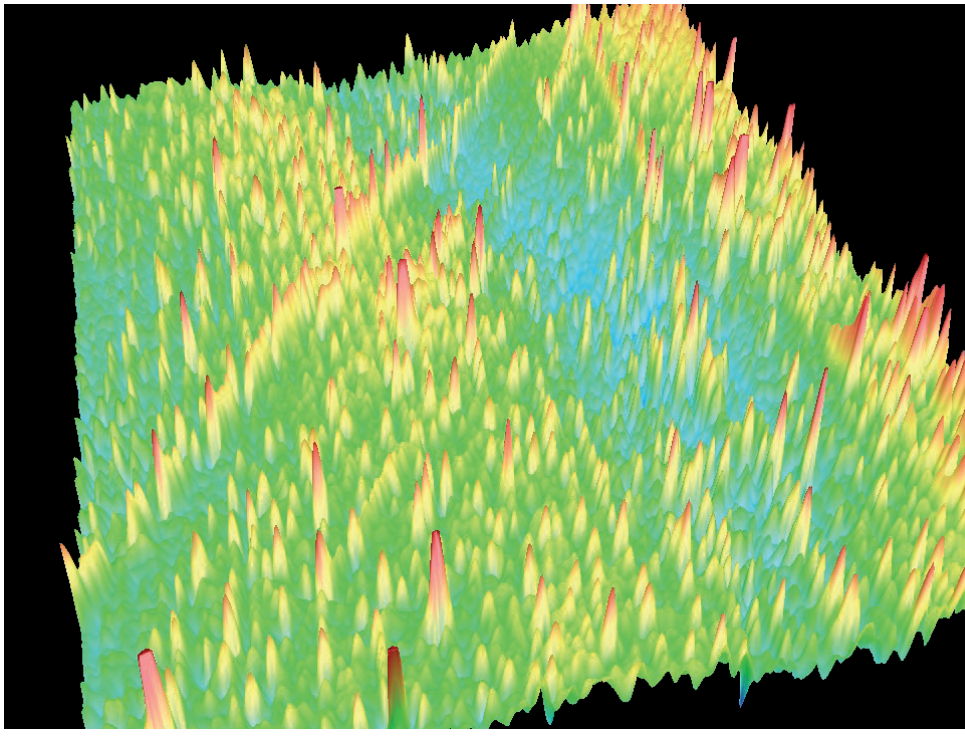

Fig. 5: Glass with lotus effect coating: The 3D view under the Leica DCM 3D shows the complex structure of the surface coating that repels water and dirt particles.

Networking to bring research to the everyday world

Apart from fostering fresh talents, the primary task of the Nanoinitiative Bayern GmbH, which manages the Cluster Nanotechnology as an operating unit, is to promote nanotechnology applications by networking research and industry. This is the department of Dr. Matthias Nüchter. Since the Cluster was founded in 2006, a great number of events have been held, projects kicked off and supervised, participation in trade shows or discussion panels organized. Hardly a day passes without Nüchter having at least one appointment at companies or institutions, giving lectures or appearing at events – and networking. And the activity radius has long spread beyond the Bavarian border. There are now events and co-operations with companies in Europe, with contacts extending even as far as Russia and Japan.

Partner sourcing for companies

"It's usually small and medium-sized enterprises and start-ups that we support," says Nüchter. "Quite often, it's a case of finding the right applications for a new technology. Germany is one of the leading countries in the field of nanotechnology. But we still see too much of a divide between research and industrial application, although the competitiveness of nanotechnological products could be substantially improved if the research of the fundamental physics and the market launch were to go hand in hand. For start-ups it is particularly important that they are integrated in the value added chains." For Nüchter, Partner Sourcing is when he helps to find suitable companies and brings the dialog partners of both sides together.

This often leads to completely new projects and co-operations, with Nüchter and his team providing support for the project management, for example. "Only recently, the outline of a new project we were involved in was recommended by the Bavarian government for sponsoring by the Cluster Project Fund," reports Nüchter. "It's about using innovatively treated raw materials in the porcelain industry. The project partners have commissioned the Cluster to coordinate further applications and to take on the project management."

Contact
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www.nanoinitiative-bayern.de

Microscopes for Schools, Universities, and Vocational Training

Made For Future Experts

Vince Vaccarelli, Leica Microsystems

The more time an instructor has to teach, the more students can learn. The Leica DM500 and DM750 microscopes were specifically designed for "plug and play" ease of use. With many student-friendly features and high-quality construction, the Leica DM500, DM750, and DM750 P invigorate learning and teach the next generation of microscopy experts effectively and efficiently.

Based on the same optical platform as Leica Microsystems' research microscope line, these microscopes give students outstanding optical performance with full access to virtually all accessories from the Leica Microsystems microscope product line.

Especially in educational environments the spread of disease from surfaces is of great concern. Leica Microsystems has integrated the AgTreat™ additive so that all microscope touchpoints are treated to inhibit the growth of bacteria.

Leica DM500
The Leica DM500 with "plug and play" capability is the perfect tool to make teaching entry-level courses easy and fun. The pre-focused, pre-centered condenser and the EZTube™ preset diopter, which prevent incorrect adjustments, provide more time for hands-on teaching. EZStore™ design with integrated handle and cord wrap allows easy carrying and protection against damage.

Leica DM750
The Leica DM750 is ideal for advanced college and university courses. Student-friendly features such as the EZStore™ and EZGuide™, which allows one-handed slide loading and reduces slide chipping, provide a safer classroom environment. EZLite™, which provides over 20 years of LED illumination and automatic time delay shutoff, saves time and energy.

Leica DM750 P
The Leica DM750 P is the ideal polarizing microscope for teaching material and earth science college and university courses such as crystallography and petrography. It includes all features of the Leica DM750.

Upcoming Events

Please also visit our website on www.leica-microsystems.com/events for further information on Leica events in Europe.

CONTROL
May 4 – 7
Stuttgart, Germany

BIEMH
May 31 – June 5
Bilbao, Sapin

MEASUREXPO
June 1 – 3
Paris, France

SMT
June 8 – 10
Nuremberg, Germany

EPHJ + EPMT
June 8 – 11
Lausanne, Switzerland

Congreso Nacional de Materiales
June 23 – 25
Zaragoza, Spain

Microscience
June 29 – July 1
London, United Kingdom

ILMAC
September 21 – 24
Basel, Switzerland

Elektronik
September 21 – 23
Odense, Denmark

Metallographic Conference
September 29 – October 1
Leoben, Austria

BI-MU
October 5 – 9
Milan, Italy

Parts2Clean
October 12 – 14
Stuttgart, Germany

VIENNA-TEC
October 12 – 15
Vienna, Austria

PRODEX
November 16 – 20
Basel, Switzerland

Digital Microscopes Leica DVM5000 – 2000

The New Benchmark for Optical Profiling

Daniel Göggel, Leica Microsystems

Digital technologies have revolutionized both our work and everyday lives in many respects, and there is no end to these innovations in sight. In particular, industrial quality control – which places the most stringent requirements on macroscopic and microscopic imaging and image processing – benefits from innovative, reliable digital technology. Digital Microscopes from Leica Microsystems open new horizons in terms of mobility and speed. For many applications, they offer an ideal supplement to traditional inspection and analysis.

New level of portability and speed

Three Digital Microscope solutions, the Leica DVM5000, DVM3000, and DVM2000, provide a wide range of different configurations – from the "intelligent," portable, all-in-one system to the modular basic model. The microscopic image is displayed directly on a high-resolution monitor. This means that the user does not have to look through an eyepiece. The streamlined zoom optics reach extremely difficult-to-access surfaces, which allows non-destructive inspection of even the largest stationary parts that can be examined using traditional microscope techniques only with great effort. Leica Digital Microscopes not only feature outstanding, high-quality optics, they also offer a wide variety of quantitative analysis options – whether 2D analyses or advanced 3D surface measurements. Each system can be configured for specific applications and individual requirements using an extensive range of components and accessories.

Portable all-in-one-system

Some products cannot be transported and do not allow a sample to be taken for microscopic analysis; only non-destructive inspection is possible, such as production machines or airplanes. The Leica DVM5000 is specifically designed for such situations. Here, you can bring the microscope to the sample. The Digital Microscope, including the optics, monitor and computer, can convert into a compact, portable system with just a few hand movements. The Leica DVM5000 is a highly integrated system that features outstanding performance capacity and speed. Within a very short time, the Leica DVM5000 provides the desired results – even complex 3D models are available in mere seconds.

Fig. 1: The portable all-in-one-system Leica DMV5000 is a highly integrated system that features outstanding performance capacity and speed.

Flexible in every respect

The Leica DVM3000 features outstanding flexibility. It includes all the elements needed for digital microscopy: zoom optics with encoded magnifications, high-performance digital camera, integrated metal halide lamp, and standard interfaces for computer and monitor to enable all sample-related data to be sent to the computer for subsequent evaluation. Its "open" design makes the Leica DVM3000 a compact, versatile Digital Microscope for a wide variety of applications – from simple imaging to 2D measurements to highly specific roughness measurements in 3D with subsequent documentation using conventional Microsoft® Office programs.

Focused on the basics

With the Leica DVM2000, Leica Microsystems offers the ideal entry-level digital microscope. This modular system is composed of zoom optics, digital camera, and software and is based on standard components. However, the Leica DVM2000 also provides plenty of options from a comprehensive range of products and accessories to configure the ideal digital solution for your needs. Also, the Leica Application Suite (LAS) offers a wide variety of software modules for different analyses and evaluations.

Fig. 2: The 360° rotating head offers an all-round view that provides entirely new ways of looking at samples. As an added benefit, rotating the view creates a 3D impression of the sample. In this way, Leica Digital Microscopes open up new perspectives – in the truest sense of the word – and possibilities for viewing and analysis.

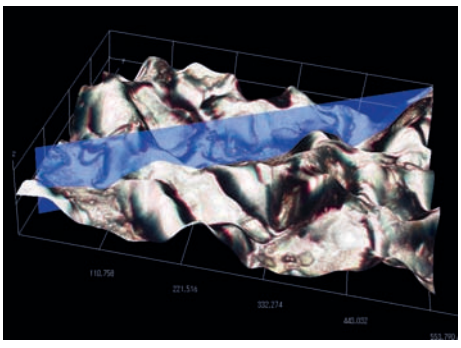

Fig. 3: 3D profiling in all variants: 3D profiles of height, width, and surface irregularities; display as texture, color depth encoding or grid model; height difference and volume measurements; combined 2D and 3D profiling.

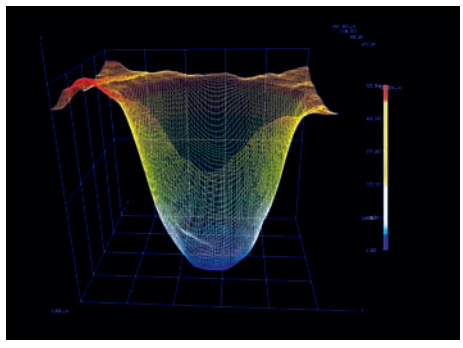

Fig. 4: 3D models in seconds: visualizing desired 3D models within a few seconds and further analyses, such as profile measurement or roughness measurement, with just a few mouse clicks.

Fig. 5: High Dynamic Range (HDR) provides outstanding images. Leica Microsystems has long used state-of-the-art 16-bit individual color detection to provide highly dynamic images, no under- or over-exposed image areas, and clearly display difficult surfaces such as metal sections.

Which microscope is right for you?

Fracture analysis, analysis of inclined or vertical surfaces, and onsite inspections of large parts such as turbine rotors are just a few examples in which the strengths of digital microscopy make the biggest difference. However, there are also applications where a traditional solution with stereo- or compound microscopes is best. Leica Microsystems' sales team has comprehensive application knowledge and can provide onsite consultation. Drawing from one of the most extensive product lines of industrial microscopes, we can create the optimal configuration for your needs based on tried-and-tested Leica Microsystems quality.

Depth of Field in Microscopy

How Sharp Images Are Formed

Ruedi Rottermann and Peter Bauer, Leica Microsystems

In microscopy, depth of field is often seen as an empirical parameter. In practice it is determined by the correlation between numerical aperture, resolution and magnification. For the best possible visual impression, the adjustment facilities of modern microscopes produce an optimum balance between depth of field and resolution – two parameters which in theory are inversely correlated.

In DIN/ISO standards, the depth of field on the side of the object is defined as the "axial depth of the space on both sides of the object plane within which the object can be moved without detectable loss of sharpness in the image, while the positions of the image plane and the objective are maintained." However, the standard does not give any clues on how to measure the detection threshold of the deterioration of focus. The author of the first publication on the subject of visibly experienced depth of field was Max Berek, who published the results of his extensive experiments as early as 1927. Berek's formula gives practical values for visual depth of field and is therefore still used today. In its simplified form, it is as follows:

$$T_{VIS} = n\,[\lambda/(2 \times NA^2) + 340\mu m/(NA \times M_{TOT\,VIS})]$$

T_{VIS}:	visually experienced depth of field
n:	Refractive index of the medium in which the object is situated. If the object is moved, the refractive index of the medium that forms the changing working distance is entered in the equation.
λ:	Wavelength of the light used, for white light, $\lambda = 0.55\ \mu m$
NA:	Numerical aperture on the side of the object
$M_{TOT\,VIS}$:	Total visual magnification of themicroscope

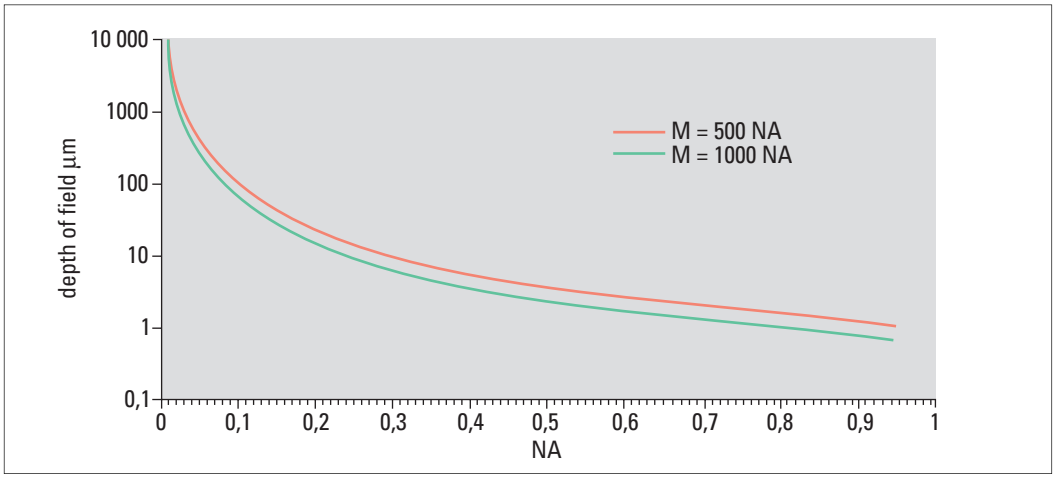

Fig. 1: Depth of field as a function of the NA for λ = 0.55 µm and n = 1

If in the above equation the total visual magnification is replaced by the relationship of useful magnification ($M_{TOT\ VIS}$ = 500 to 1000 x NA), it can be seen that, to a first approximation, the depth of field is inversely proportional to the square of the numerical aperture (Fig. 1).

Particularly at low magnifications, the depth of field can be significantly increased by stopping down, i.e. reducing the numerical aperture. This is normally done with the aperture diaphragm or a diaphragm on a conjugated plane. However, the smaller the numerical aperture, the lower the lateral resolution.

It is therefore a matter of finding the optimum balance of resolution and depth of field depending on the structure of the object. With their high-resolution objectives (high NA) and adjustable aperture diaphragms, modern light microscopes enable flexible matching of the optics to the requirements of the particular sample. In the case of stereomicroscopes it is often necessary to make a certain compromise in favor of higher depth of field, as the z dimension of three-dimensional structures frequently demands it.

Even more depth of field

A sophisticated optical approach of Leica Microsystems that cancels the correlation between resolution and depth of field in stereomicroscopes is FusionOptics™. Here, one of the light paths provides one eye of the observer with an image of high resolution and low depth of field. Via the second light path, the other eye sees an image of the same object with low resolution and high depth of field.

The human brain combines the two separate images into one optimal overall image that features both high resolution and high depth of field.

Another example illustrating the phenomenal capabilities of the human brain is the Greenough stereomicroscope. Here, the object planes of the left and right light paths are at a slight angle to each other (Fig. 2). In the overall image, the entire hatched area appears to be sharply focused, although this is not the case in either the left or the right image.

Depth of field in digital image processing

The Multifocus module of the Leica Application Suite (LAS) was developed to extend the field depth of the automated microscope many times over. The illumination, image brightness and all other camera parameters can be set individually to optimize the quality of the resulting image.

The LAS Multifocus module provides an easy solution to capturing the extended field depth of live images by fully integrated control of the microscope with the motorfocus. The automatic capture of z stacks together with the intelligent image combination algorithms guarantees easy photography and storage of sharply focused images.

Thanks to the automated processing routine, there is hardly any need for user intervention. The settings can be easily altered for working with a wide range of samples. The Multifocus module is useful for applications in materials science, forensic medicine as well as in bio and geo sciences.

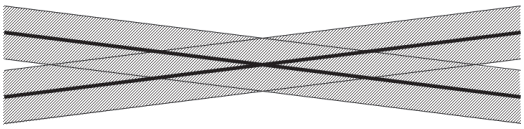

Fig. 2:
Object planes of the Greenough stereomicroscope with depth of field range

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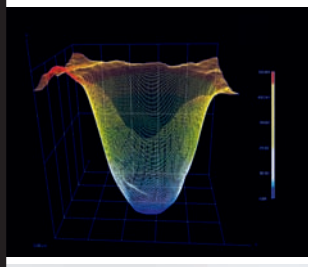

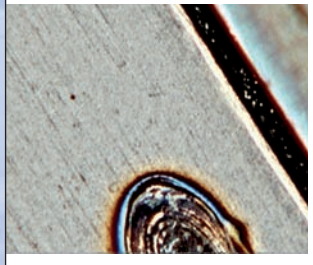

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- **Sharper** – Proven HDR technology for images without hot spots
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