A Virtual Tour of the Lens Production

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Dear Visitor,

Welcome here directly in front of the gates of the virtual optical production of Carl Zeiss. Please come in and allow us to start by giving you some valuable information about Carl Zeiss lenses.

If you prefer, you can of course start immediately with our lens production tour.

Carl Zeiss. A Living Legend for over 150 Years.

For over one and a half centuries now, Carl Zeiss has shown others the way in the field of precision optics. Time and time again, the technology pacesetter has succeeded in pushing back the frontiers of precision technology.

Today, as in the past, the name Carl Zeiss is a byword for pioneering performance in camera lenses a long tradition that dates back to an invention of Prof. Dr. Ernst Abbe, the scientific and entrepreneurial genius of Carl Zeiss.

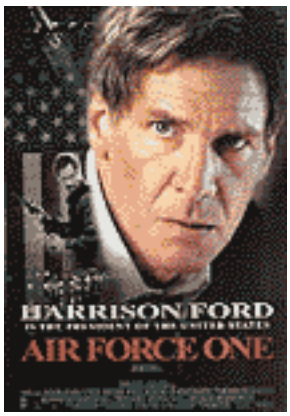
As far back as 1886, he recognized the unique suitability of calcium fluoride crystals for the chromatic correction of lenses and

invented what is now known as "apochromatic correction".
To this very day, this forms the basis of the premium lenses praised by so many discerning and demanding photographers all over the world. Further milestones in lens production were to follow.

Worthy of special mention here is the fact that Carl Zeiss actually invented the antireflective coating of optical surfaces in 1935 and was the first manufacturer to commence the industrial production of aspheric lenses in 1937.
Carl Zeiss has always risen to even the most daunting challenges in camera lens production and with resounding success.

Hollywood, NASA, and the chip industry put their trust in Carl Zeiss

Traditionally, the movie industry has always been a major customer for high-speed movie lenses from Carl Zeiss.



For the US space agency NASA, Carl Zeiss developed and built the 50 mm Planar® f/0.7 lens the world's highest speed camera lens, permitting photos to be taken of the dark side of the moon for the very first time.

Another example of Zeiss excellence is the Luminar set of photomicrography lenses used by scientists and criminologists alike.

With these outstanding optical tools, tiny objects can be imaged larger-than-lifesize and with stunning detail.

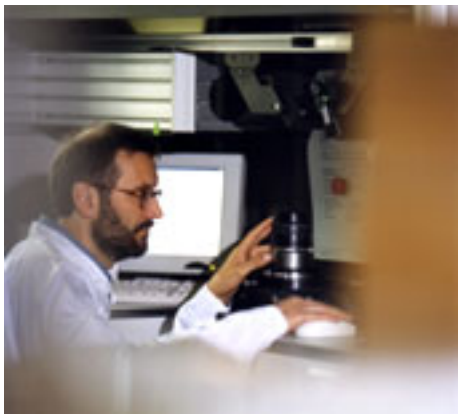
The high resolution Zeiss lenses for aerial reconnaissance and aerial mapping cameras are indispensable tools for landscape planners, cartographers, scientists, reconnaissance experts, and defence agencies.

And in the dramatically expanding semiconductor industry, optics from Carl Zeiss now play an absolutely pivotal role.

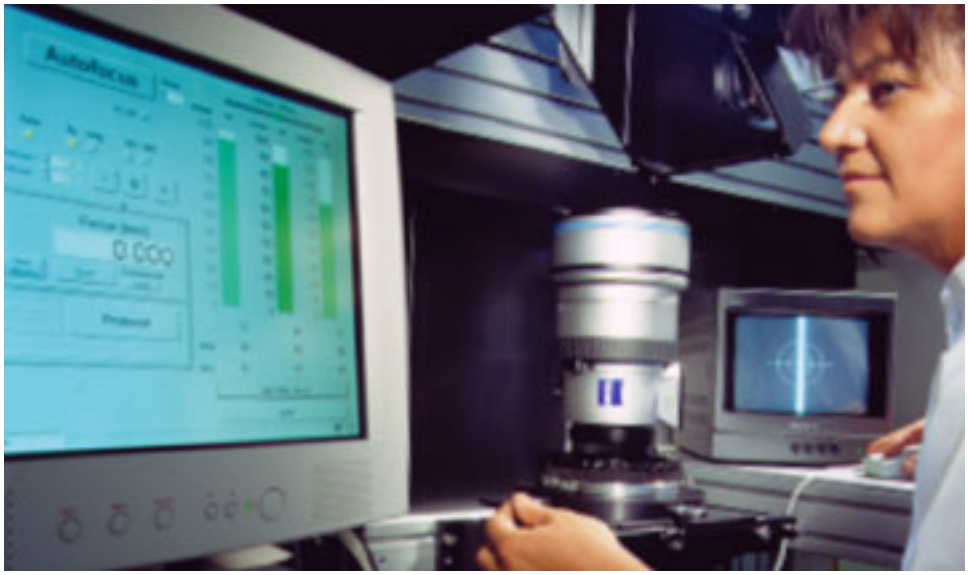
The high performance S-Planar lenses and Starlith microlithography optics now achieve a relative aperture of 1:0.55 and a resolving power of 5000 line pairs per millimeter undoubtedly the most powerful lenses in the world. Using deep ultraviolet light, they produce extremely fine structures with a width of only 0.18 micrometers on silicon wafers and hence play a key role in determining the capabilities of semiconductor technology and the performance of computers. The list of examples is virtually endless: practically no day goes by at Carl Zeiss without scientists and researchers improving upon what has already been achieved.

Production in a class all of its own

Needless to say, pioneering developments and products a Carl Zeiss way of life can only be achieved in a flawless and precise production process incorporating constant intermediate and final inspection tests. This is all performed by a large number of highly qualified and specially trained staff. Whether a dedicated scientist, a creative engineer or an experienced optical technician they all guarantee that customers will continue to enjoy the legendary quality associated with Carl Zeiss in the future.



At Carl Zeiss, lens production means much, much more than simply combining glass and metal: during production, the surface perfection of every single lens element is tested by highly skilled optical technicians, and every lens is aligned by experienced staff to ensure maximum lens quality.



To be able to work with the highest precision here, Carl Zeiss has developed special instruments known as MTF (=Modulation Transfer Function) real-time measuring systems.

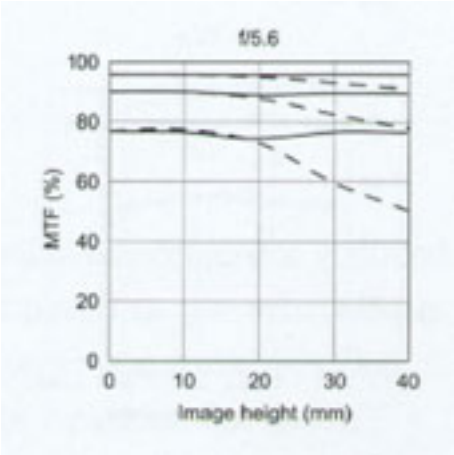
Zeiss is the only lens manufacturer to use these MTF systems in lens production to tune every single lens to maximum performance. For other manufacturers, MTF systems are either too slow for their mass production or too expensive for the small quantities of lenses they produce.

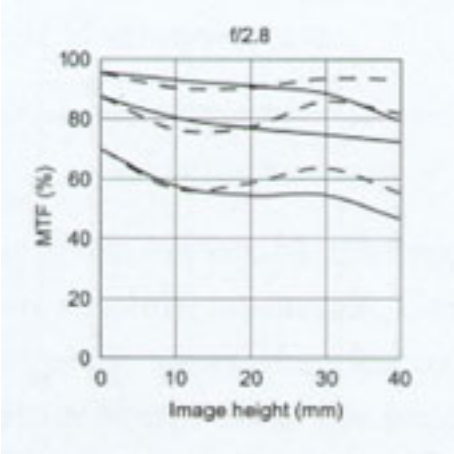
Every lens tested over one hundred times

In this way, Zeiss achieves 100% quality assurance, with every lens being tested exactly for more than 100 different criteria during its production. Carl Zeiss does not rely on statistical process control and/or spot inspection, like it has become the cost saving standard in mass producing industries.

Zeiss rather performs a 100% quality control, like it is done for airplane components and other very demanding industrial products.

In addition, some decades ago Carl Zeiss was the first lens manufacturer to publish MTF performance diagrams for its lenses. Several manufacturers have, in recent years, followed this example but with one decisive difference. The curve diagrams of Carl Zeiss show not just optimistic computer simulations, but the properties of lenses which have actually been built. They are not merely computer-generated curves which give no indication whatsoever of how good and uniformly the supplier manufactures this lens in volume production.





Results of unparalleled quality

In conjunction with high quality cameras, Zeiss lenses produce photos of such astounding detail that the resolving power of even the best color films can be fully utilized. At the Photokina fair in 1996, Carl Zeiss presented color photos with structural detail of 200 line pairs per millimeter. No other manufacturer has yet been able to rival this astonishing performance.

With these lenses and professional films, a high quality medium format camera can now take photographs, for which a large format camera had to be used just ten years ago in order to obtain the desired image quality.

This advance offers many benefits. Medium format cameras are more mobile, faster, and easy to load, and do not require assistants. The result: substantially more profit than with any other system. Small wonder, therefore, that they are the first choice of successful business-oriented photographers.

Frame size: 24 x 36 mm
Film used: Kodak Ektar 25 Professional

The Red City Hall in Berlin.
85 mm Planar f/1.2, f-stop 8,
Contax RTS III,
distance: approx. 300 m.

Although the lens was focused on the portal of the building, we chose the spectacular clock for enlargement.

The clock is located approx. 15 m behind the front of the portal, i.e. it is not in the plane of maximum sharpness. Nevertheless, the Roman numerals are clearly resolved even the three very close lines of the VIII. Bricks and joints are clearly visible. The bricks are just under 6 cm thick and the joints are not wider than your little finger.

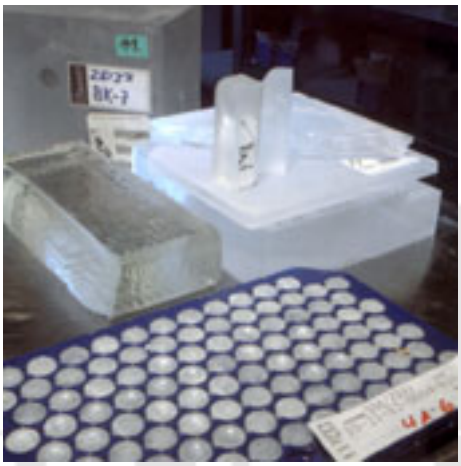
Zeiss lenses: an investment for life

Not only the optical performance of Zeiss lenses is exceptional. They can also withstand more of the punishment associated with professional use than many other makes.

Even with considerable damage, Zeiss lenses can be repaired and then continue to provide their owners with many years of enjoyment. This is all accomplished by the use of high-grade materials for optics and mechanics alike, the fast, reliable supply of spare parts, and optimally trained service engineers around the globe.

Please come in and allow us to explain each of the many individual manufacturing stages to you. You will quickly understand how, time and time again, we succeed in attaining the unique level of quality and high performance which have made camera lenses from Carl Zeiss world-famous.

Optical glass in different shapes: pressings, plates, bars, blocks



We purchase our optical glass preferably from the Schott Glass Works. Of particular importance here are the optical properties of the different glass materials and their tolerances. When choosing our suppliers, we also take into account their delivery capabilities and delivery times, their prices and the environmental soundness of their products. In our optical production, we currently process 114 types of optical glass with different refractive indices, color

dispersion, weight, etc. This results in a spectrum of approx. 350 different types of lens elements with approx. 700 different radii. Each lens consists of several optical glass materials and crystals, with some almost as heavy as steel and others more expensive than gold.

We mainly process pressings for serially produced camera lenses. Glass blocks are used for the production of prototypes and special components. The blocks are first cut into plates which are then rounded and further processed to produce lens elements.

Cutting of optical glass blocks and plates

Depending on the intended use of the glass, glass blocks are cut into the shapes required for further processing. To ensure maximum precision in this process, we use only computer-controlled diamond-studded tools.

Grinding and lapping of lens elements using computer-controlled machines

The pressing blank is first ground. During this work cycle, the first radius of both element surfaces is generated. Multi-axis (x, y, z axis) CNC (= "computerized numerical control") machines from renowned manufacturers are used for this purpose. These machines use two spindles.

During the first step, approx. 1 mm of glass is removed with a deviation of 5 µm from the standard radius.

During the second step, i.e. lapping, approx. 1/10 mm of glass is removed with a deviation of 1 µm from the standard radius.

Zeiss only uses environmentally sound grinding emulsions which are recirculated and used over an extended period of time.

Polishing of lens elements using computer-controlled machines

In the second work cycle, the lens elements are polished. This process also uses multi-axis multi-spindle CNC machines which allow the high-precision polishing of surfaces already provided with the specified radius.

This work cycle takes between 4 and 25 minutes per surface, with its duration being dependent on the diameter of the element and the sensitivity and hardness of the glass type processed.

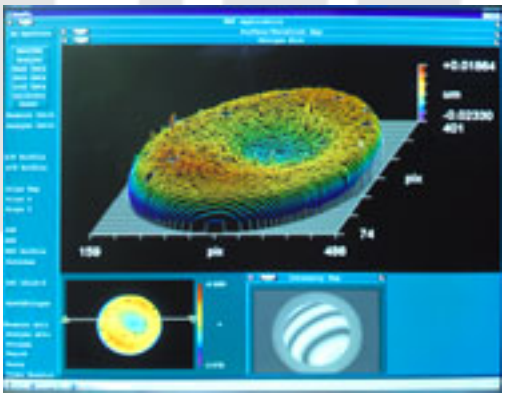
In this work cycle, the polished surface is optimized using Newton's rings. Two Newton's rings are spaced 3/10,000 mm from each other.

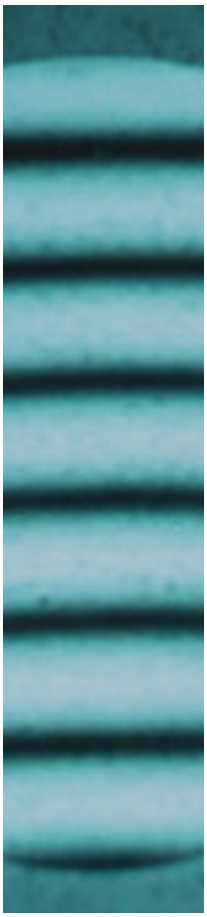
Our technicians can perform a fine correction process within these 3/10,000 mm during the polishing process. The polishing emulsions used contain rare earth compounds such as cerium oxide.

Feeding lens elements to computer-controlled machines

Using high-precision interferometer testing technology, we exactly check each individual optical surface during and after the polishing process.

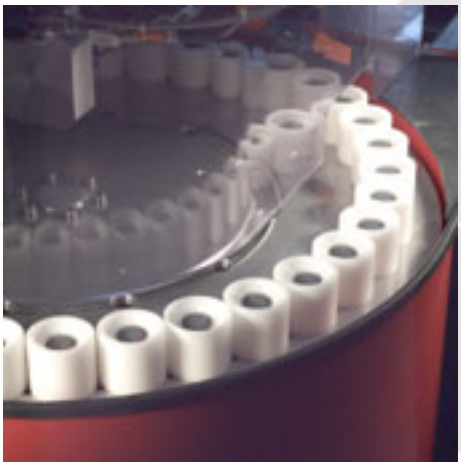
This allows us to always rule out even the slightest possibility of a defective or inaccurate surface occurring during the polishing process.





Centering of lens elements

Some of the work cycles on the CNC machines are automated. One example of these auomated processes is the lens feed to the CNC machines.



During the centering process, the optical and mechanical axes of the element are brought into coincidence. To be more exact, the edge cylinders of each element are processed using high-quality diamond-studded tools to achieve the diameter specified and are thus also given the direction specified. In this process, the accuracy achieved for the mechanical diameter lies in the h6 ISO tolerance field, corresponding to a deviation of only a few µm from the nominal figure.

To protect the lens element surfaces already processed against mechanical influence during the centering process, we have coated them with a blue protective laquer before.

Checking the diameter of an element after centering

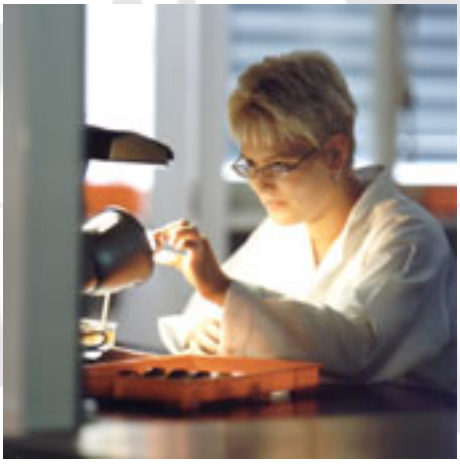
Both during and after the centering process, we check the accuracy of the diameter of each individual lens element.

In this way, we make sure that each lens element which is to undergo the next work cycle is free from geometrical errors.

Ultrasonic cleaning of lens elements

On completion of the geometric shaping process, we remove all protective and auxiliary substances required during production from the lens elements using gentle cleaning methods. In the process, the lens elements pass through a system of up to 15 different cleaning stations, some of them ultrasonic, whose cleaning agents are exactly matched to the type of glass and the protective and auxiliary substances used.

Checking the cleanliness of the lens elements

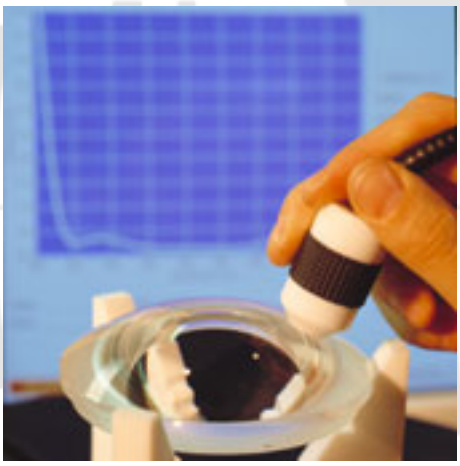


To detect minute defects in the element surface, specially trained staff check the lens elements using a special light source and a high quality achromatic Zeiss loupe. If necessary, the lens elements are re-processed until they meet the stringent quality requirements of Carl Zeiss. Machines would not be able to perform this inspection with the accuracy and reliability required by Zeiss.

Antireflective coating

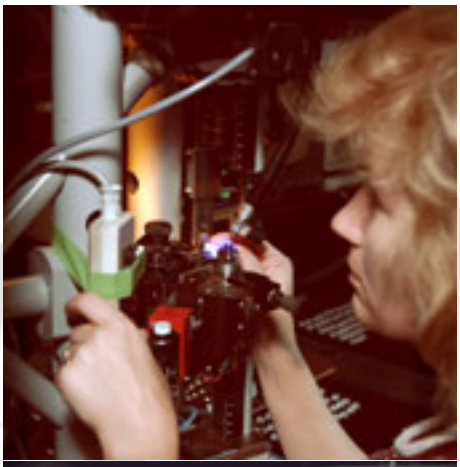
For antireflective coating, we deposit antireflective layers on the surfaces of the lens elements. For this purpose, special substances are evaporated one after the other using a very elaborate process in high vacuum, causing the substances to be deposited on the lens surface with precisely controlled thickness, resulting in the desired reduction of reflection.

Reflection measurement after antireflective coating



After the reflection-reducing layers have been vacuum-deposited on the surface of the lens element to minimize residual reflection, our engineers perform a 100% check of each individual lens element surface using testing technologies specially developed by Carl Zeiss. This also allows us to reliably rule out the possibility of any errors here.

Cementing lens elements to form cemented groups

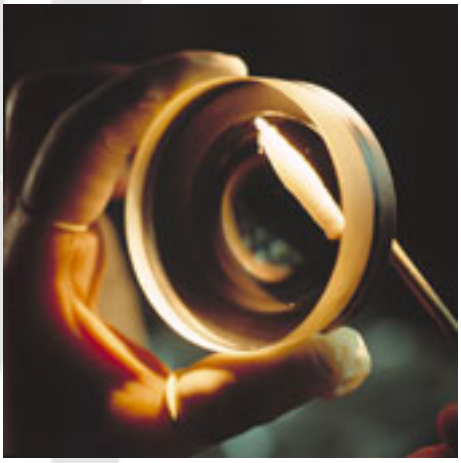


Hardening of the cement using UV light
For some lenses, individual elements must be combined into groups called cemented groups, as they are joined using special optical cements (adhesives). These cements special developments by Carl Zeiss are hardened using UV light. Zeiss cements are optically neutral and resist even pronounced temperature fluctuations. If it were possible to take photographs in the Sahara in the morning and photographs in Antarctica in the afternoon, Zeiss lenses would take these temperature differences in their stride.

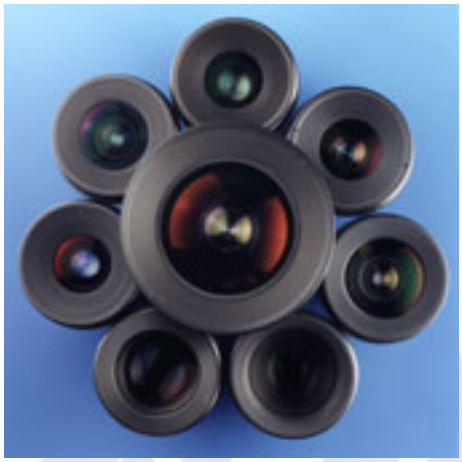
Centering the cemented groups
While the elements are being cemented together, the cemented groups are centered at the same time. This means that optical and mechanical axes are brought into perfect coincidence.

Final cleanliness check of cemented groups

Again, after the cementing process, all cemented groups are subjected to a final and extremely thorough cleanliness check. At Zeiss, these checks are also performed by experienced specialists, and not by machines.



That completes the optical production process. Afterward, the finished lens elements and cemented groups are transferred to the lens assembly department where the mechanical and optical components are assembled to form the complete movie or still camera lens. As you have seen, the long process involving the many checks and inspections required to guarantee the world-famous Zeiss quality every time and for each individual lens is a real Odyssey.



In other words, our lens elements are not simply spewed out as cheap ready-made mass-produced goods by a machine. Instead, they are meticulously and accurately manufactured in a procedure requiring a lot of highly skilled manual work and high-precision measuring technology. No robots are used to assemble the elements and lens barrel components as quick as a flash. People are the key to Zeiss quality - people with a lot of experience and know-how mount and align the mechanical and optical components piece by piece to create a valuable lens. The result: "...amazing quality of the optics" to quote Charlie Waite, a Hasselblad photographer.

This is the only way to ensure that Carl Zeiss continues to be what it has been for many decades: the innovative and visionary optical company for which maximum precision in each individual work cycle is a way of life. Incidentally, you should visit our website more often in the future, as we are currently in the process of providing you with even more interesting information.

Until then, we hope that you have enjoyed this tour through our virtual lens element production.

Yours faithfully,
the Carl Zeiss internet team