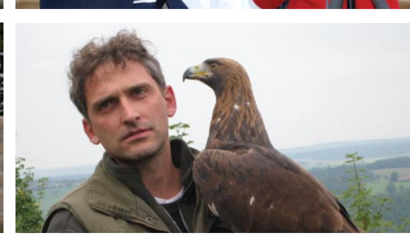
ZEISS Cine Lens Day

Buffeted by a cold, late-afternoon wind from the East, we climbed up a hill to Kapfenburg Castle, two hours northwest of Munich. As usual, our hosts for the biennial Carl Zeiss Cine Lens Day had a surprise for us. We were greeted by the largest raptors I have ever seen. Khan the eagle, Shuhu the owl and Ronja the falcon were guarding the castle's main gate, glowering at us and the town of Laucheim below. The eagle looked like it could carry away a small cinematographer, and the owl was alternately eyeing me as an appetizer and Christoph Chassée as main course.

The raptor wrangler, who has raised these birds since infancy, spent the next hour teaching us about their amazing speed (falcons can reach 242 mph / 390 km/h) and their friendly nature—at least when he is there. However, you may ask, "What does this have to do with making ZEISS Master and Digi Primes?"

Fulfilling anyone's fantasies of becoming National Geographic wildlife filmmakers, an enjoyable, interesting and low-key product tie-in was set up nearby: a collection of every pair of binoculars and spotting scopes that share a similar optical heritage to the cine lenses we use, and would, no doubt, become the objects of every cinematographer's desire for the next birthday or upcoming location scouting trip. After a delicious dinner in the castle's fine restaurant, "Fermata," and conversation with colleagues from around the world, we were ready for serious lectures on optics in Oberkochen the next day.



ZEISS Cine Lens Day, cont'd

The tours begin: Carl Zeiss Lens Day

Dr. Winfried Scherle *(left)*; Dr. Dieter Kurz *(right)*

Lens Day attendees from around the world

On tour: learning how a Carl Zeiss Cine Lens is made. Men in blue clean room gowns, *(l to r)*: Denny Clairmont, Alan Albert, John Bowring, Lutz Senf

We met in the lobby of Carl Zeiss, Inc. An ear-popping elevator ride whisked us to the Board Room on the top floor, overlooking Oberkochen, to be welcomed by CEO Dr. Dieter Kurz.

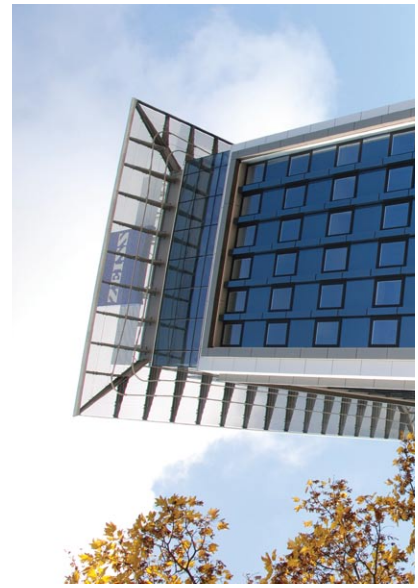
Next, Dr. Winfried Scherle, Vice President and General Manager of the Carl Zeiss Camera Lens Division, presented an overview of the company. Among many things, we learned that 60% of all microchips in the world are made using Carl Zeiss SMT (Semiconductor Metrology Technology) lenses. The lenses focus a laser beam to etch the microchip. These lenses have a resolution greater than 5000 line pairs per mm (more than 20 times better than the best lenses we use in film or digital.) Some of the science of nano lens technology was used in the design and manufacture of modern cine lenses: coating, aspherical polishing, assembly and rapid delivery.

Carl Zeiss metrology is used in aerospace and automotive industries, especially Formula One. ZEISS makes 50% of all eyeglasses in the world along with the instruments that measure the individual shape of your eye. Eyeglass lenses can be individually crafted within 24 hours. Carl Zeiss has a long and distinguished history of making microscopes, and ZEISS Microscopes were used to restore Edvard Munch's *The Scream* after it had been stolen from an Oslo museum.

Carl Zeiss, Inc. is divided into Life Sciences, Industrial and Lifestyle divisions. I am glad to learn that Cine Lenses are considered a Lifestyle.

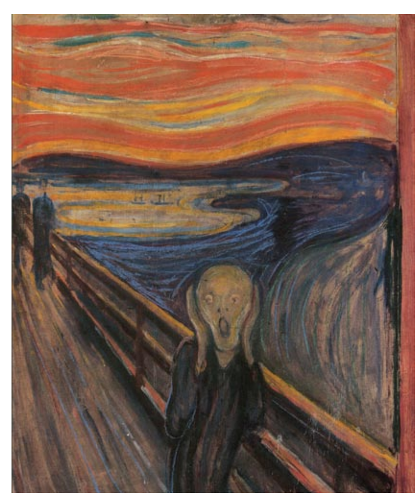
There are over 20,000 Carl Zeiss employees worldwide. ZEISS lenses were made for 50 Million cameras in 2008: one camera every 2 seconds. These cameras included Sony, Nokia cellphones and Logitech. ZEISS makes SLR still lenses for Nikon, Canon and Hasselblad, and rangefinder lenses for Contax. ZEISS Cine Lens Division makes PL mount Master Primes, Ultra Primes, and Zoom lenses with ARRI and B4 DigiPrimes and DigiZooms with Band Pro.

Next, Dr. Hubert Nasse and Dr. Hans Kiening presented lectures on lens design and theory. They were the first ones to explain MTF and Nykvist frequency without reducing me to tears or screams like Munch's. It was especially interesting to learn from Dr. Kiening that resolution is not the same as sharpness, and, although humans were not originally designed to watch movies, detection of rapid movement (MTV-paced editing) was a distinct evolutionary advantage.



Carl Zeiss corporate headquarters in Oberkochen

Carl Zeiss Semiconductor lens. 870 kg.



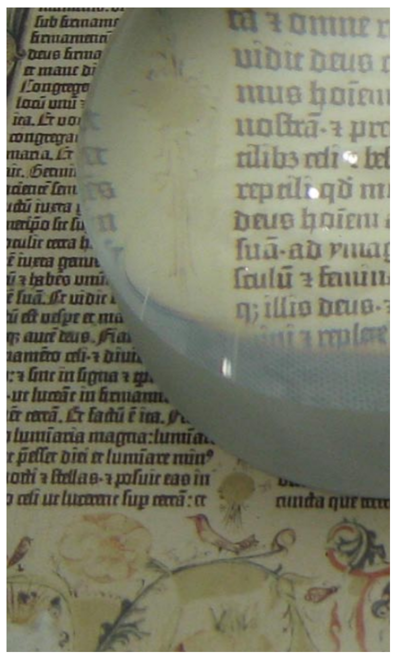
The Scream
Edvard Munch (1863-1944)
1893. Wax crayon and tempera on paper (cardboard), 91 x 73.5 cm (35 7/8 x 29")
Nasjonalgalleriet (National Gallery), Oslo

Building a ZEISS Cine Lens

Let's go on a cinematographer's tour and learn how to build a Zeiss Cine Lens.

Actually, we'll let Zeiss do the building, because the more we find out about lens design and manufacture, the more we appreciate the elegant art and optical, mathematical and physical science at work in the two cities of Jena and Oberkochen.

A cine lens is a collection of glass elements, painstakingly cut, precisely ground, polished and coated, held in a complex mechanical (and sometimes electronic) aggregation of movable groups to maintain focus, aperture and frame size.



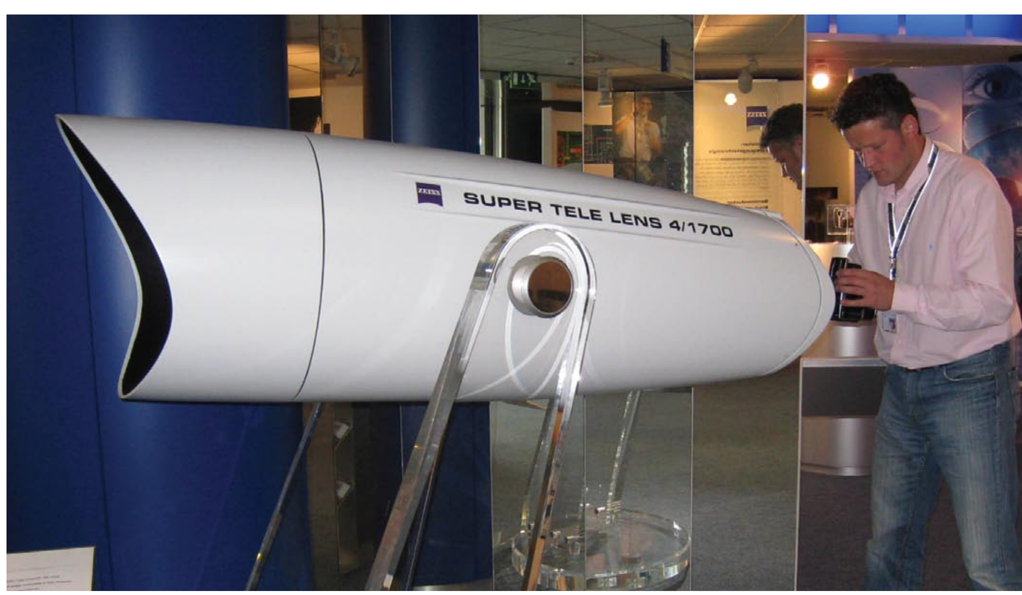
13th century Reading Stone

Dr. Winfried Scherle *(above)* with one of the 55 pound (25 kg) internal optical elements of the 1700/T4 ZEISS Apo Sonnar.

The "Reading Stone, " a 13th century Magnifying Glass in the ZEISS Optical Museum at Oberkochen, shows what happens when one surface of a glass block is ground and polished into a curve. The art of lens design is the math and physics of calculating flat, concave or convex combinations, distances, coatings, and countless variables conspiring to make your image either sharp, brilliant, flared or flawed—and then being able to turn those calculations into practical precision assemblies of glass, brass, steel, or composite.

It's common for lens designers to say that every lens is a compromise—the result of discussions, dialog and debate between cinematographers and rental houses, product managers and designers, scientists, accounting and finance analysts and marketing departments. An optical design may look good on paper or as a computer-generated model. However, the finished production lens will be the result of carefully considered compromises on speed, size, weight, performance and cost. If you want your lens to be faster, it's going to be bigger. But if you want to use it for handheld or Steadicam, it has to be lighter. What happens when lighter costs more?

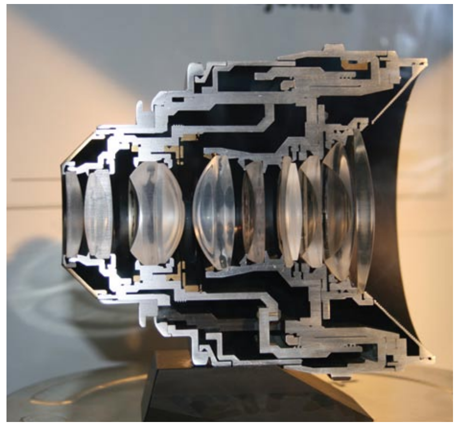
Of course, if cost is no object, you don't have to compromise. Few compromises were made building the world's largest and possibly most expensive consumer lens, the one-off ZEISS Apo Sonnar 1700mm T4, (right) with 15 optical elements in 13 groups, electronic temperature compensation, and a special vehicle to move it.

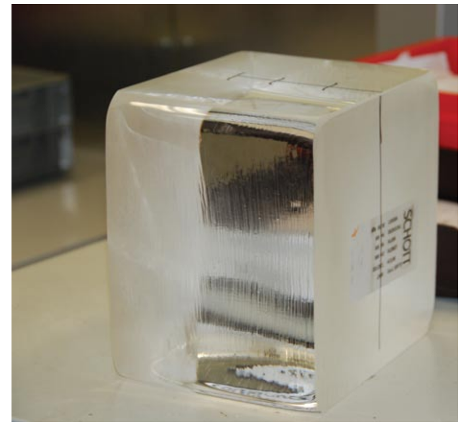


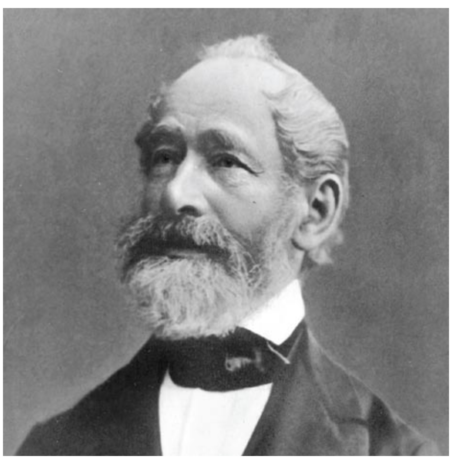
Holger Sehr, Project Manager, Product Development of the Camera Lens Division.

ZEISS History

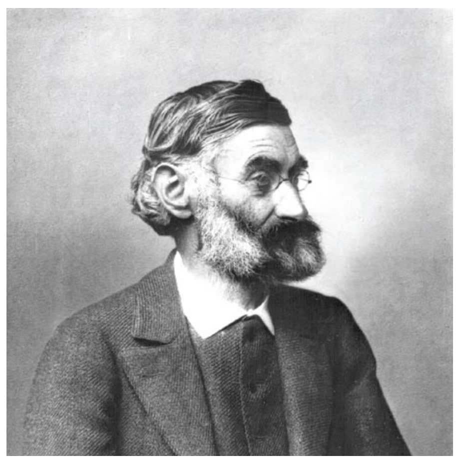
To build a lens, you need blocks of special glass. There are, incredibly, only a couple of companies currently on the planet worthy of blending sacks of secret sand, carefully sprinkled with an alchemist's brew of chemicals and minerals, to become ZEISS lenses. One of these companies is Schott, and the collaboration between Schott and Zeiss goes back to 1884.



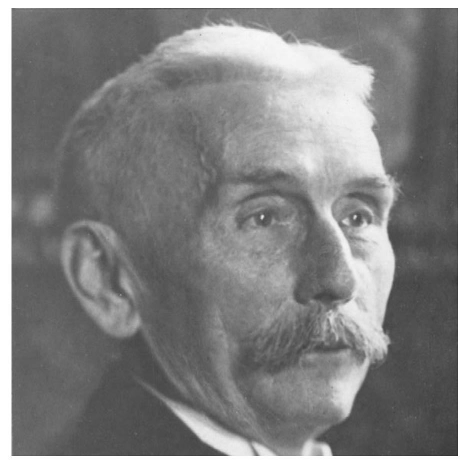




Carl Zeiss (1816-1888) was born in Weimar, the fifth of twelve children. From 1835 to 1838, he attended lectures at the University of Jena (founded in 1558; students, faculty or patrons include Marx, Hegel, Schiller, and Goethe). In 1846, Zeiss set up a small workshop in Jena to build and maintain scientific instruments and microscopes at the University. That workshop would turn Jena into a "city of optics". (*Above, left:* Jena 1910)



Ernst Karl Abbe (1840-1905), professor of mathematics and physics at the University of Jena, joined Carl Zeiss in 1866. He replaced the trial and error manufacturing process with a scientific approach based on math and physics. Abbe is remembered as a social reformer. In 1889, he restructured the company as a Foundation, and by 1900 established the 8-hour workday, minimum wages, medical coverage and pensions for all workers.

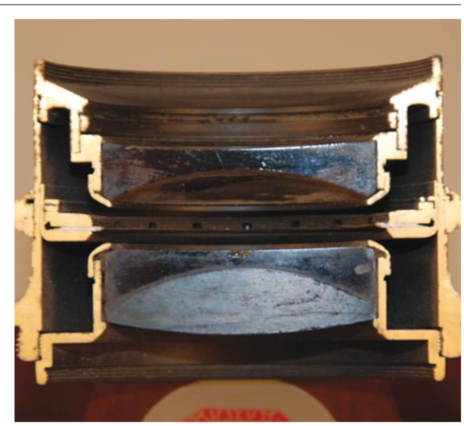


The third member of the Optical Triumvirate was Friedrich Otto Schott (1851-1935), son of a window glass maker, who received his doctorate in glass chemistry at the University of Jena. In 1884, he partnered with Zeiss and Abbe to found the optical glass-making factory Schott und Genossen. Jena became one of the major centers of optics, paralleling Leicester, England and Rochester, NY.

Microscopes to Camera Lenses

A worldwide banking crisis followed the "panic of 1873" (history repeats itself: bank failures, stock market crashes, businesses closing, economic depression). Ernst Abbe, astute businessman as well as brilliant scientist, saw the need to diversify the ZEISS product line, which had, up until then, focused almost exclusively on microscopes. The first steps of a Camera Lens Division were taken in 1888 and completed by 1890. Carl Zeiss scientist Paul Rudolf designed the Anastigmat in 1890, and the four-element Planar in 1896.

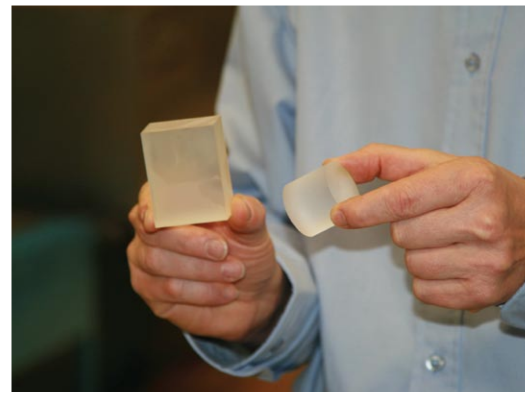
ZEISS Tessar (c. 1905), *right,* from Eastman House Collection.



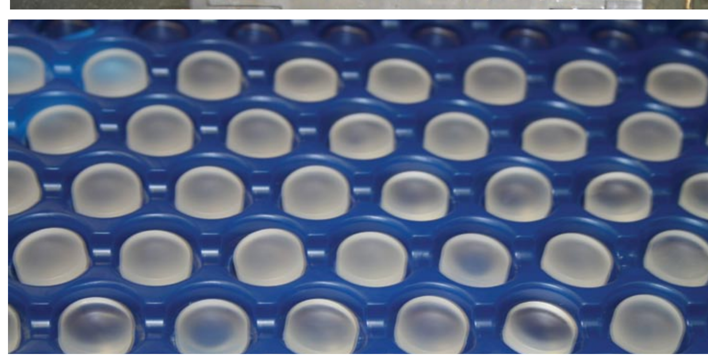
ZEISS Jena

Let's get started building a cine lens. Carl Zeiss cine lenses are made in Jena and Oberkochen.

Grinding, polishing and most of the big machining is done in Jena, about 4 hours northeast of Munich. Assembly, calibrating and testing is mostly done in Oberkochen, about 2.5 hours northwest of Munich. Here's the plant in Jena *(right)*, near the University and the Carl Zeiss Planetarium.



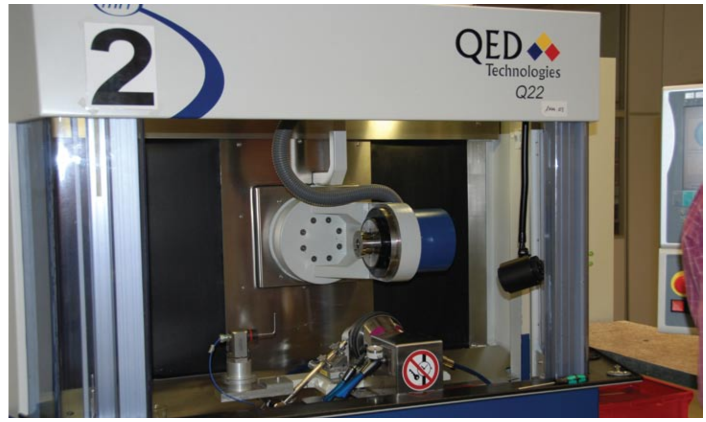
Computer-Controlled machines cut the big glass blocks down to size—about 10mm larger than the finished element. The glass is first cut into smaller rectangles. Next, the rectangles are rounded into cylinders.



Once the blanks are shaped to approximate diameter and thickness, the fine task of grinding and polishing begins, in two different processes: spherical grinding—where the curve of the lens is constant, and aspherical grinding, where the curvature is nonlinear. Both processes will be accurate to 1 micron. Some elements, especially smaller ones for eyepieces, are pre-ordered and pre-cut to approximate dimensions (bottom, right). Master Primes and DigiPrimes may contain up to 21 of these optical elements.

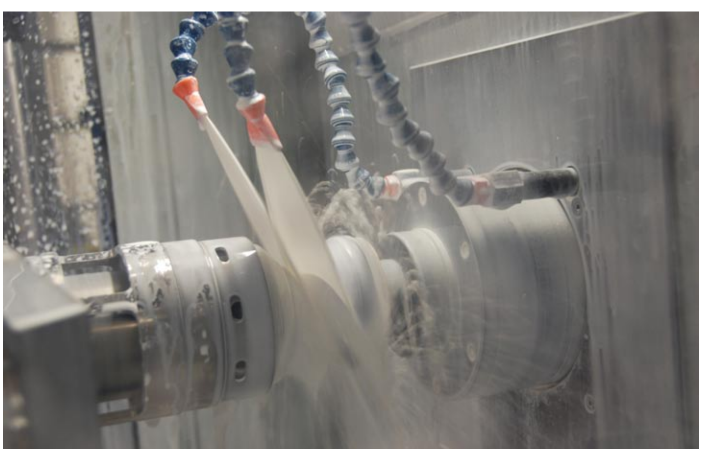
The first polishing cycle begins, using a coarse slurry of abrasive minerals in a chemical suspension. CNC (Computerized Numerical Control) machines are used. The next second step is done with a much finer polish. The "workflow" is: grind, measure, polish, measure, fine polish, assemble, test, finish and pack. After the polishing process every element is measured with interferometry lenses from Carl Zeiss to check image quality, tolerance, and uniformity as well as to reveal any lingering spherical and aspherical aberrations.
To see how polishing with an abrasive makes glass clear, scratch a piece of plexi with something rough. Then rub the scratches with a whitening toothpaste, and watch the scratches disappear.

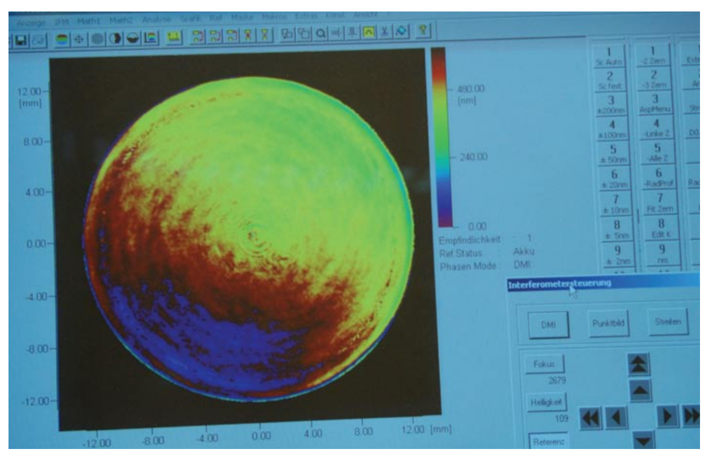
Grinding and Polishing

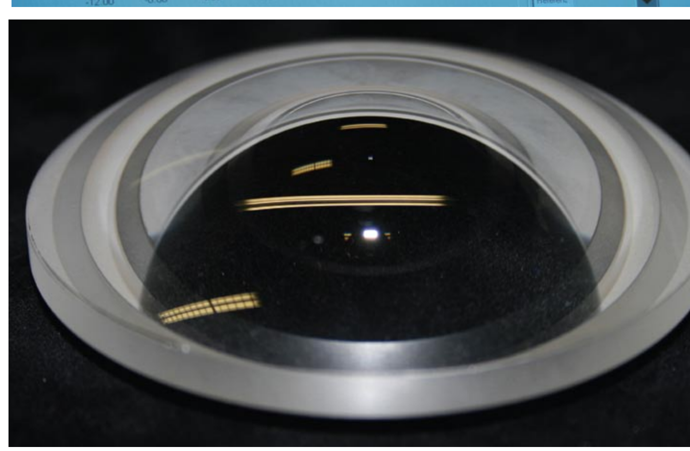


Aspheric elements are crafted by a specialized team in Jena. Aspheric cine lenses include Ultra Primes from 8 to 300mm, Master Primes 14 to 150mm, Ultra 16 from 6 to 50mm, Master Zoom, Lightweight Zoom, DigiPrimes 3.9 to 135mm and DigiZooms 6-24 and 17-112mm. Aspherical grinding takes 1 to 20 hours per element, to an accuracy of 1 to 3 microns. *Above:* QED Magneto Realogical Finishing.

Over 400 aspheric lenses are made each month on 20 machines, in three 8 hour shifts. A computer generated hologram is used for precise interferometer testing; each optical surface is checked for any deviations beyond 1 micron. This technology is a benefit of experience with SMT lenses for computer chip fabrication. *Below*: the computer screen image when testing the optical element's surface with an interferometry lens from Carl Zeiss.







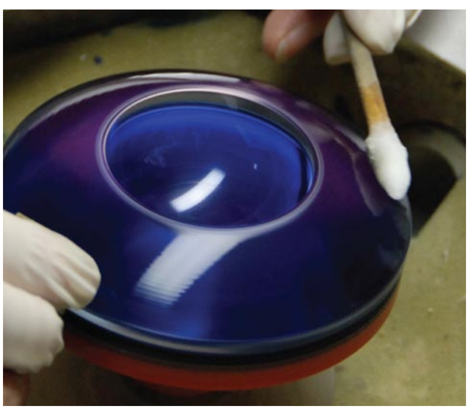
Assembly in Oberkochen

After grinding, polishing, and treating with special anti-reflective coatings, the optical elements and mechanical housings are delivered by truck from the ZEISS plant in Jena to headquarters in Oberkochen for assembling, finishing, testing and packing.

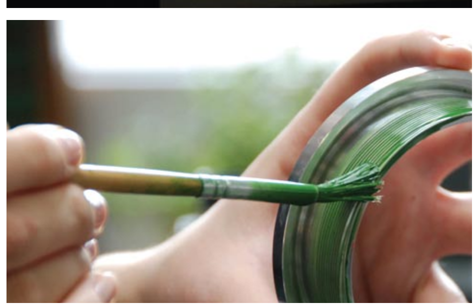
Oberkochen is home to the design department. A concept took shape in Munich or Burbank or wherever else a camera manufacturer mustered user feedback and technical input to provide the designers at ZEISS the parameters and wish lists for a new lens. When Marc Shipman-Mueller *(above, right)* calls you up and asks what Master Prime you cannot live without, or when Amnon Band wants to know what new focal length DigiPrime you'd like to see—those comments go to Helmut Lenhof, Product Manager Digital Cinema Lenses, *(above, left)*, Christian Bannert, Product Development Manager Camera Lens Division *(above, center),* Holger Sehr and many others who will guide the lens design.

For film and digital motion picture lenses, ARRI and Band Pro partner in the development, marketing and sales; ZEISS does the design, implementation and manufacturing. With concepts developed for the SMT semiconductor division, cine lenses are now built faster than ever. A new assembly paradigm means that some lenses can be put together in a day.

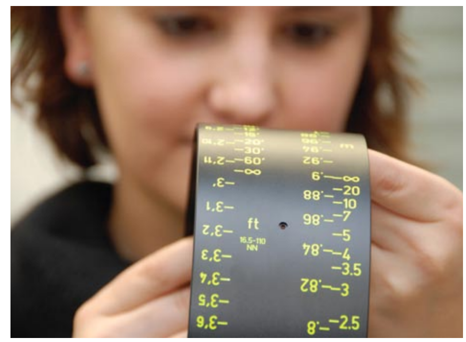
Many procedures require the attention of highly skilled technicians. *On the facing page,* optical surfaces are covered with a blue protective layer while the edges are polished and painted with a special black lacquer that prevents internal reflections. The blue coating is then removed, and the elements are assembled in a clean room.




ZEISS Finishing



Cinematographers and camera assistants might be interested in the way ZEISS calibrates focus marks. Once the lens is assembled, it is checked and double-checked for centering, tracking and focus with MTF test equipment. Next, the precise focus scale is determined and matched *(above, right)*. The scales come in feet or meters, and are identified with a letter. If you're shooting 3D, it's helpful to get lenses with matching letters. After final testing, cleaning and inspection, the finished ZEISS Cine Lens is ready to be shipped to you *(below)*. And that's how Carl Zeiss builds your Cine Lens.