02

Light creates value.

Innovations require a pioneering spirit: Using light as an industrial tool opens up a great many opportunities. A mixture of competence and research capacity is needed in order to recognize, develop, and make use of such opportunities. This is the basis of the pioneering spirit that Jenoptik embodies, and which is part of its corporate tradition.

We make unique products and solutions possible. In international competition or in everyday life, our customers – and their customers – are thus afforded advantages, security, knowledge, quality, style, and scope for development.

These pages provide a glimpse into Jenoptik's services – whether in the fields of medical technology, digital image processing, industrial measurement technology, traffic safety technology, material processing, the aerospace industry, or security and military technology.

JENOPTIK – SPECIALIST FOR PHOTONICS AND MECHATRONIC TECHNOLOGIES.

LASER & OPTICS | SENSORS | MECHATRONICS

Growing core competencies.

– Serving demanding markets – Jenoptik is expanding, networking, and strengthening its principal areas of competence.
– Thus custom-made investment goods that closely reflect the latest in research are being created.
– From laser technology to micro-optics trough to highly sensitive sensors Jenoptik develops products which make the company one of the heavy-weights in its markets worldwide.

The Jenoptik Group is a network of highly specialized companies, a network which has become more tightly knit from year to year. Each Jenoptik company's particular fields of competence combine to create numerous products, often in connection with the concept of "using light as a tool." Jenoptik normally provides its customers with custom-made investment goods that closely reflect the latest in research. Jenoptik has made it a systematic practice to help these seeds of competence to grow: Customer requirements, their own developmental initiatives, and companies recently acquired by the Group come together to provide the basis for new products, further areas of expertise, and for growth. Jenoptik's customers can rely on a company that provides solutions to extremely intricate tasks; one that can manufacture complex, technologically intensive products, even in large quantities; one that translates existing knowledge into new developments; and one which provides them with access to state-of-the-art technology.

In the field of laser technology, for example, laser material processing, medical technology, and laser projection have developed into areas of particular specialization. Jenoptik, for instance, specializes in laser systems that can be used to process non-metals. And Jenoptik laser material processing has now forayed into flat-panel production as well: Laser-based processes make it possible for new production technologies to be used in liquid crystal displays (LCD) and in displays based on organic light-emitting diodes (OLEDs). OLEDs are currently seen as an innovative candidate to vie for the display market of tomorrow.

TFT displays – "suitable for chip technology".

The layer that allows words and images to appear on LCD screens is typically 50 nanometers thin, consists of silicon, and is deposited onto a glass substrate only 0.6 millimeters thick. The silicon layer is at first amorphous and thus a poor electrical conductor. This is able to change only when the silicon is melted and than recrystallized: Under the necessary conditions, this leads to a polycrystalline silicon film with a level of conductivity between 100 and 500 times higher than that of an amorphous layer. The layer is used to create microscopic

There are fewer than ten manufacturers in the entire world, known as premium suppliers, that are able to attain the same quality in optical production that we can.

DR. HANS LAUTH ¦ DIRECTOR OF OPTICS, JENOPTIK LASER, OPTIK, SYSTEME GMBH

thin-film transistors (TFT) that act as switches that allow each display pixel to be turned on or off. These high-resolution displays are unsurpassed especially for use in the small displays of mobile devices, whether cell phones or GPS systems.

Jenoptik's laser technology comes in to play when amorphous silicon is transformed into polycrystalline silicon using a green thin-disk laser. The laser beam only heats up the thin silicon layer; the glass substrate is transparent in regard to the laser's wavelength, and is thus not affected.

This contrasts strongly with the conventional furnace method, in which the glass substrate also increases in temperature. The process is complicated as it requires additional metal layers, while the display substrates need to be kept free of contamination.
Excimer laser annealing (ELA) is another laser process currently in use. In this process, the substrate is treated with a UV excimer laser beam, which operates in a clean, contactless manner suitable to clean room environments. This system requires little energy to melt the silicon due to its short pulses of 50 to 300 nanoseconds in length. The glass substrates remain cold and are not affected by the process. Green thin-disk lasers, however, allow for an entirely new dimension in quality: They make it possible for crystal structures to be lengthened considerably in a single direction, leading to a strong increase in electron mobility to between 200 and 500 square centimeters per volt-second. The electronic qualities of the silicon layer nearly reach those of single-crystalline silicon wafers as they are used in the semiconductor industry. A high frequency of up to 50 kilohertz makes this possible.

The laser system proceeds on a line-by-line basis in this process, which has already been developed for industrial use. Its intensive and very homogenous laser line is 5 microns wide and between 8 and 100 millimeters high. Its high frequency allows for short exposure cycles and a high production throughput rate. This new type of layer has, moreover, led to new ideas. Since the silicon layer is suitable for chip technology, the drive electronics can be placed on the edge of the displays, using the very same TFT technology. Another feasible option is to produce digital memory and processor technology upon the glass substrate. This will make the products lighter, thinner, and more energy-efficient.

Several different Jenoptik companies have been involved in this laser technology for the displays of the future. INNOVAVENT GmbH was responsible for the product's concept and the development of the corresponding optical

system, as well as the beam quality of the subsystems. For this purpose the company cooperates with system integrators and provides technical service for the display manufacturers in Asia.

JENOPTIK Laser, Optik, Systeme GmbH produces both the objectives optimized for this application, and the unique laser source, which currently provides 100 watts, but which can be expanded to 200 watts. JENOPTIK Laserdiode GmbH provides the diode laser modules that pump the solid-state lasers. This long value-added chain culminates in a product already delivered to the developmental units of major display manufacturers in 2006. These companies are currently working on the development and verification of the processes. This is expected to provide the basis for the next generation of production.

The Jenoptik solution has been met with great interest on the part of LCD manufacturers. The technology is indeed suited for the production of OLED displays as well, which are expected to support future display technology. Once the industry is able to stabilize the organic substances of the OLEDs, thus lengthening the displays' lifespans, the Jenoptik laser technology will be set to serve as a standard for the required TFT glass substrates.

A new concept: Breakthrough in EUV performance.
Jenoptik technology is poised to move into the semiconductor industry as well. XTREME technologies GmbH, a joint venture of Jenoptik and the Japan-based Ushio Group, develops light sources within the extreme ultraviolet spectral region (EUV). These light sources will make it possible to produce chip structures of less than 32 nanometers in size – or conductor diameters of a mere 100 atomic lengths. To make this possible, Xtreme puts extreme ultraviolet light to use, a spectral range beyond visible light and towards the soft x-ray segment. Another hurdle was taken last year when EUV gas-discharge produced plasmas sources reached a usable output of 10 watts, thus coming another step closer to an industrial use for EUV technology.

In addition to the plasma generator that emits the EUV rays, the light source equipment includes a high-precision collector mirror, an optical system that forms the EUV rays as needed, guiding them into the lithographic system. The system was developed in cooperation with Carl Zeiss and the Italian-based Media Lario.

In 2006, Xtreme technologies also reaped the fruit of its unusually flexible research: From the very beginning, the company has pursued two avenues simultaneously – laser

Our know-how is in the tools. We polish the injection molds and not the lenses. And this quality shapes our products in the end, which are produced in high quantities using automation – for medical technology, the automotive industry, photo technology and image processing, and illumination and measurement technology.

DIETER KLEY ¦ DIRECTOR OF TOOLING, JENOPTIK POLYMER SYSTEMS GMBH

produced plasmas, and gas-discharge produced plasmas. Both have now been combined into a laser-based gas-discharge EUV source. In this process, a weak laser beam vaporizes a drop of tin and then continues to heat it until it reaches the plasma stage. A gas discharge between two rotating electrodes then heats the plasma to an extreme point, thus strengthening it. This leads to a particularly efficient laser source.

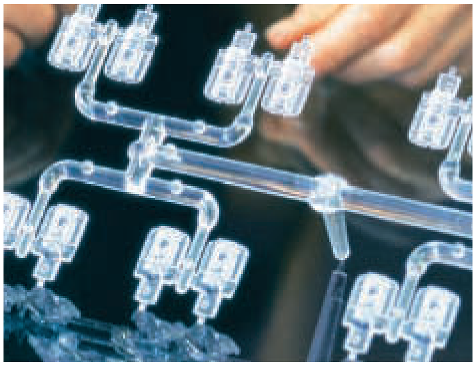
Xtreme researchers are certain that pursuing this principle further will lead to much greater capacities. This would fulfill the minimum power needed for mass semiconductor production.

Several Xtreme sources with an output of up to 3 watts are now being used by semiconductor manufacturers and consortiums to develop new chip production processes. As things now stand, EUV technology will go into the preproduction phase of semiconductor manufacturers by 2010. Xtreme technologies is cooperating with a number of companies in the semiconductor and semiconductor supply industries of Europe, Japan and the United States, with the goal of readying EUV technology for serial production as soon as possible. The company is supported by the German Federal Ministry of Education and Research (BMBF) and the European Union.

Apart from Xtreme, most Jenoptik lasers are diode-pumped solid-state lasers, and specifically thin-disk lasers, which Jenoptik began developing at an early date. In both cases, the lasers are in fact based on two laser sources. The light from the diode lasers excites the laser crystal of the solid-state lasers, which in turn emits laser light. The companies of the Jenoptik diode laser group work on the high-power diode lasers that make this possible. Over the past few years, they have made a splash on the market with particularly reliable and durable high-power diode lasers. Jenoptik Laserdiode is now preparing its product for use in space, in a cooperative project with Jena-Optronik GmbH.

Diode lasers in outer space.

The scientific observation of the earth via satellite would be impossible without reliable high-power lasers. Scientifically relevant information on subjects such as the greenhouse effect, global warming, and the spread of air pollution, can be generated through satellite data. These satellites are equipped with LIDAR laser systems for their tasks. Similar to RADAR, LIDAR carries out measurements, but using light waves.



In LIDAR, a solid-state laser beam is pointed at the target surface. The time that it takes for the light to reflect and return to the source is used by microcomputers to determine the distance. The specific light absorption of different molecules at particular wavelengths can help determine the types of particles under observation, such as aerosols, or to ascertain the local prevalence of gases such as ozone, methane, and carbon dioxide. LIDAR can, however, also be installed in satellites to create contoured images of the earth or other planets.

The solid-state laser that supports LIDAR requires a diode-laser pump source to excite its laser medium. The diode lasers currently used in satellites of ESA, the European Space Agency, however, reflects technical standards of the 1980s, and can be made to run more efficiently, reliably, and productively using today's technological standards.

Jenoptik Laserdiode is now expanding the use of its product for space applications. While industrial lasers can be written off after a certain period of time, lasers in space missions may need to remain in storage for years, to then be reactivated on short notice for subsequent long-term operations in space. The product must also be able to stand up to temperature fluctuations, rocket acceleration, and weightlessness.

Jena-Optronik, which has overall responsibility for the product, validates modules once completed. The modules are subjected to vibration and vacuum tests, and to general simulations of the impact of rocket launches and of space conditions. The product's developmental phase is expected to run through 2009, and the scientific satellites are planned to go into operation beginning in 2013. Both Jenoptik companies will be establishing new standards with this project, and will be able to gain access to new markets.

Jena-Optronik, a company of Jenoptik's Sensors division, already supplies numerous space missions with sensors. This includes attitude control sensors for positioning satellites with reference to the sun and stars, as well as rendezvous and docking sensors for a number of different space missions, such as flights to the International Space Station (ISS). The company's product range continues to comprise instruments such as camera scanners for earth observation satellites as well.

Digital imaging constitutes another Jenoptik core competence, which the company can combine with other areas of expertise in accordance with each customer's needs. Jenoptik's digital imaging range, including an 11-million pixel camera, has meant a competitive advantage for ROBOT Visual Systems GmbH. This advantage is already paying off on the market today.

We have a command of the entire high-power diode laser process chain – starting with wafer structuring. This allows us to harmonize the technologies used for semiconductors, assembly, and further optical processing. That in turn enables us to create better products than the competition, which often does not have a full grasp of all three steps.

DR. DETLEV WOLFF ¦ DIRECTOR OF MARKETING, JENOPTIK LASERDIODE GMBH

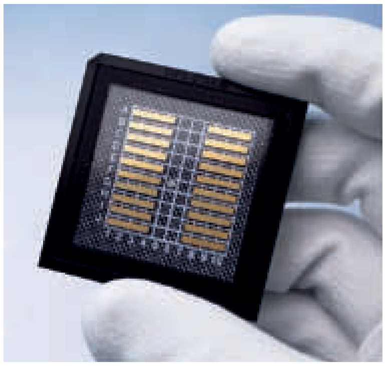
Minutes instead of days: Aspherical lenses at high speed.

Industrial measurement technology, comprehensively provided by Hommel-Etamic, now no longer only works using optics, but also works for optical products such as aspherical lenses, a specialty in optics production at Jenoptik. Aspherical lenses are all-round optical talents. The physical limitations of spherical lenses with curved surfaces lead to imaging errors. Several of these lenses are required to compensate for this weakness. Aspherical lenses, on the other hand, are shaped in a manner that avoids such difficulties. Their unique, less spherical shape, which shifts the angles of refraction, corrects for these errors.

A single aspherical lens can replace several spherical lenses. This is put into action in Jenoptik's high-quality optics and high-performance optics. These elements are used in telescopes, space technology, military applications, laser material processing, optical precision measurement technology, and for lithography for semiconductor production.
High-precision aspherical lenses require a considerable investment of time and technical expertise, as they can only diverge from their planned design by a fraction of a wavelength. The process has yet to be automated and depends on the experience of those involved. Several days are needed for a new lens to be produced in a limited amount. This production costs approximately ten times as much as spherical lens production.

The German Education and Research Ministry's Asphero5 project is quite ambitious in its scope. The "5" in the project stands for its intention to reduce the production time of aspherical lenses to mere minutes, or at least to a duration considerably shorter than is currently the case – all without defective products. In this project, a number of companies have dedicated themselves to the industrial production of high-quality aspherical lenses. This includes Hommel-Etamic and Jenoptik Laser, Optik, Systeme, both Jenoptik subsidiaries, while the coordination is provided by Schneider GmbH & Co. KG, a German optical machinery manufacturer. Carl Zeiss and the Institute of Measurement and Control Engineering of the University of Hanover are also involved in the project.

A polishing and treatment process for aspherical lenses with integrated measurement technology is currently in development. This will reduce set-up times and technological idle periods significantly. The design of the future machines is expected to be completed by mid-2007. Hommel-Etamic specializes in high-precision measurement processes; its Wavecontour® process employs a precision sphere that is driven across the lens surface at a constant



contact pressure. This helps create a profile section in nanometer resolution. The advantage of this contact measurement method over optical methods lies in the fact that the lens surface is not yet reflective during this phase, and thus cannot reflect a measurement beam. Moreover, remnants of the polishing emulsion can still cover the lenses, distorting results. Contact measurement therefore generally promises more precise results.

The task of Jenoptik Laser, Optik, Systeme in the project is to examine the machine in full detail, testing different polishing abrasives or varying the polishing pressure – all with the aim of reducing the need for subsequent treatment. The first complete machine can be expected to be used in production within two to three years. A considerable competitive advantage in the production of aspherical lenses is to be expected as this is the first process of its kind.

Jenoptik, a world leader in optics manufacturing, is thus expanding its production line to include another area of expertise. Jenoptik high-performance optics are used in sectors such as the semiconductor industry. In order to produce semiconductor structures at the nanometer level, utmost precision of the optical system s required to shape and control the laser beam in lithography systems.

For the optics systems, Jenoptik produces interference filters that provide a strictly monochromatic beam, as well as prisms that allow for highly accurate parallel laser beams. Infrared optics as well as complex optical objectives for measurement technology round out Jenoptik's portfolio. The field of microoptics is another relatively recent mainstay at Jenoptik Laser, Optik, Systeme: The diffractive optical elements are based on the principle of diffraction grating, and can form and control laser beams in any way desired.

Jenoptik is now fully specialized in supplying high-end customers – supported by a wide array of materials, coating choices, and the expertise of its employees. Jenoptik – in all its divisions – caters to the most sophisticated of markets, guaranteeing accuracy and reliability for an expanding customer base.

Safety is the top priority when it comes to airplanes. Our aviation technology, used in aircraft such as the Airbus, is always equipped with a strong safety net, and is designed for an extremely long lifespan.

DR. KLAUS STÖLTING ¦ DIRECTOR OF MARKETING, ESW GMBH