

Production technology for the **LED Industry**

- Heating element supplied for giant furnace
- Niobium tubes accelerate electrons to the speed of light



A word on the title

Good things take time. Two to three weeks are needed to produce a monocrystalline sapphire crystal like the one depicted here. Aluminum oxide is heated to over 2,000 degrees Celsius before being slowly cooled. This process takes place in Plansee crucibles. The crystal is then cut into wafer thin slices which are used as a substrate for the semiconductor structure of the LED.



90 years of powder metallurgy

» Many forward-looking applications and markets such as LED production, medical technology and mechanical engineering would now be inconceivable without highly load-resistant parts and components.«

Dear readers,

When, 90 years ago, Paul Schwarzkopf laid the foundations for what is now the Plansee Group, powder metallurgy was still in its infancy and bore the name “metal ceramics”.

At the end of the 1920s, powder metallurgy started to become an industry in its own right. One of the new products to emerge from it was sintered hard metals to whose development and industrial manufacture Paul Schwarzkopf was fully committed.

And by 1952, after the first Plansee Seminar involving scientists and engineers from around the globe, one thing was perfectly clear: Reutte is the Mecca of powder metallurgy.

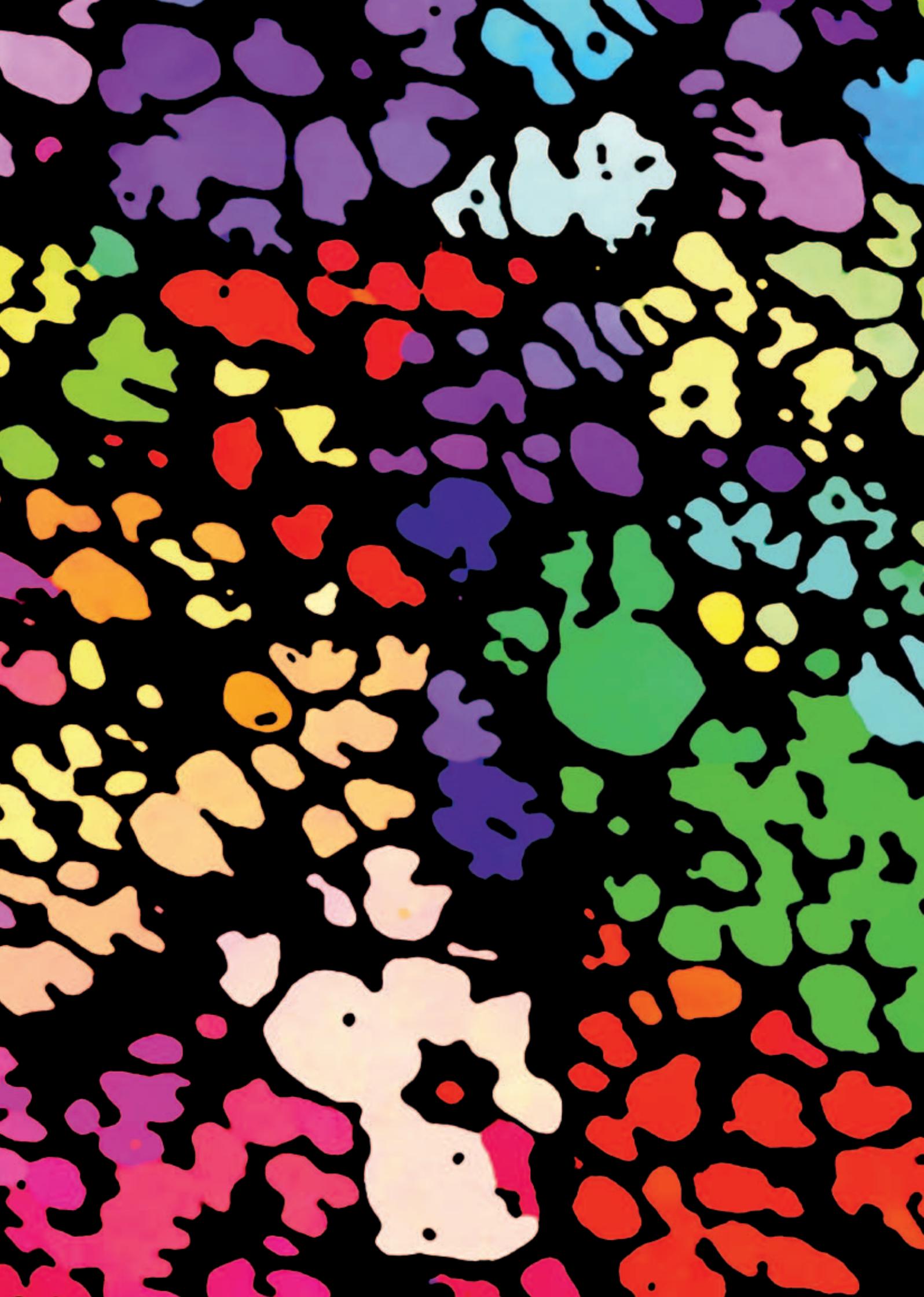
90 years of Plansee Group history also means: 90 years of technological development and continuous progress in the field of powder metallurgy. The Group has constantly developed new applications for forward-looking industries. Together with a constant flow of new and enhanced high-technology materials. Many applications and markets such as LED production, medical technology and mechanical engineering would now



be inconceivable without our highly load-resistant parts and components. And we are convinced: In the future, our materials will continue to be in demand for many applications that we can only dream of today. To enable us to ensure the best possible supply to these markets, we are continuing our efforts in the field of powder metallurgy and are continuously expanding our value-added chain which stretches from the processing of the ore concentrate through to the realization of customer-specific solutions.

I hope you will be inspired by the contents of this edition.

Dénes Széchenyi
Head of Group Communications

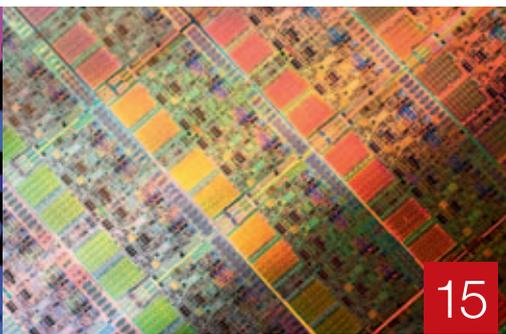


Modern art?

That depends on your point of view. Here we have enlarged the surface of a switching contact made from copper and chromium. The task of this switching contact is to protect the power distribution network. The basic material is a powder consisting of various metals with precisely defined grain sizes. The art is now to ensure that every grain occupies a very specific position in the material structure. This is possible thanks to the powder metallurgical production process. Through fine adjustments to the microstructure, it is possible to achieve greater power densities and integrate increased power levels on a smaller surface area. The result: the switching contacts are more compact and can be built in a resource-saving way.



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No. 09 | 2011

THE MAGAZINE OF THE PLANSEE GROUP

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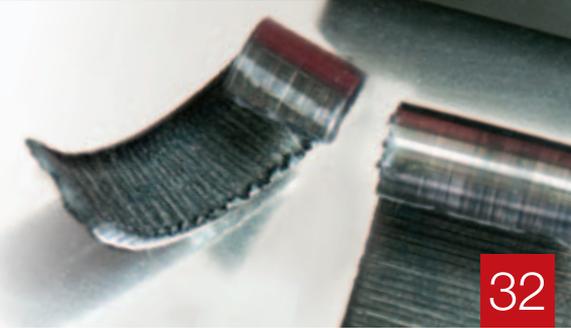
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The Plansee Group at a glance

Products and materials for the LED industry

From single crystals to lighting modules

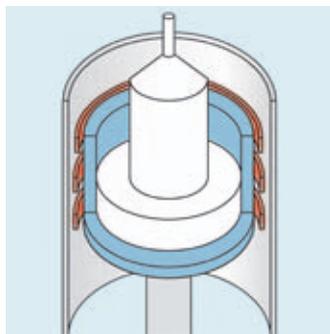
The mass production of LEDs demands the use of a high-performance production technology. The Plansee Group has the right solution for many of the steps involved in manufacture.

The forecasts are impressive. From 2015 onwards, sales of LEDs are expected to exceed 230 billion every year. This would correspond to an average annual growth rate of 33 percent. At the same time, the LEDs that are being developed are becoming increasingly powerful, for example for use in the automotive industry. If it is to cope with this rate of growth, industry must overcome two challenges: on the one hand, it must design and maintain the necessary production facilities; and, on the other, it must significantly reduce production costs. LED manufacture is a multiple-stage process which closely resembles semiconductor manufacture in many of its aspects. The Plansee Group helps its customers with the technological advances in LED manufacturing and enables them to boost their productivity. The Plansee Group companies do this by developing and supplying both the tools needed for LED production and

the components and coating solutions that are integrated directly in high-performance LEDs.

The LED market is a fast-moving arena. Not the least of the challenges it involves is the need to enhance the performance of the production equipment and bring new technologies onto the market. To achieve this, Plansee collaborates closely with its customers and in particular with the leading OEMs in the rapidly expanding LED market. It is therefore vital to ensure the fast, efficient provision of a comprehensive portfolio of products and solutions that help customers realize their ambitious objectives and lower their costs. At the same time, the Plansee Group is already working on the solutions of the future. The performance offered by newly developed LEDs is constantly growing. This trend demands the development of innovative products such as the ultra- ▶





Single crystals are produced from aluminum oxide in crucibles manufactured from high-performance materials (left) before being processed to form ultra-thin wafers.

► thin coatings and temperature spreaders (heat sinks) of which Plansee is already in a position to provide samples. At the same time, Plansee is targeting investment in its manufacturing capacities for all the process steps. This gives customers a double reassurance: Availability is guaranteed and all the products can be sourced from a single supplier – from powder through to the finished part – anywhere in the world. This is ensured by the Plansee Group's worldwide production and distribution network which has plants and offices in the US, Europe and Asia. Proximity to customers and their cultures, short reaction times and tailor-made solutions thus combine to make Plansee the partner of choice for ambitious companies in the LED industry.

Crucible for melting sapphire crystals

Every LED is born in a crucible. In this crucible, aluminum oxide (Al_2O_3)

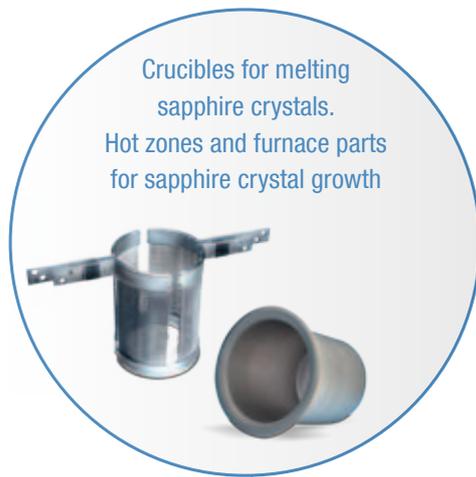
is melted and structured into a monocrystalline sapphire crystal. Depending on the method used, this process takes between two and three weeks. The art of growing single crystals: The material is first heated to over 2,000 degrees Celsius and is then allowed to cool slowly in a controlled environment. Only a few materials can be used to produce these crucibles. This is because they must meet two requirements: on the one hand, they must be resistant to the high temperatures involved and, on the other, they must not contaminate the melted sapphire. Plansee's high-performance materials are able to meet precisely these requirements. The resulting sapphire crystal is cut into thin wafer slices before being polished ready for use as a substrate for the subsequent semiconductor structure of the LED. Furthermore, the crucible must be heated up by a high-performance furnace which can generate the high temperatures required and also be precisely controlled

and cooled. Here again, Plansee's expertise in the materials and applications field comes to the fore. The heart of the melting plant, the so-called hot zone, is designed to respond precisely to each customer's requirements before being constructed from high-performance materials. The thermal process technicians of Plansee's production facilities in Austria (Reutte), the USA (Franklin) and Japan (Esashi) are closely working together to equip the high-temperature furnaces required for the production of sapphire crystals worldwide with furnace-making components.

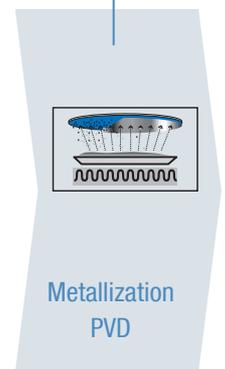
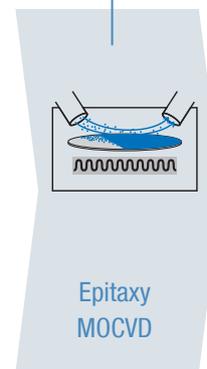
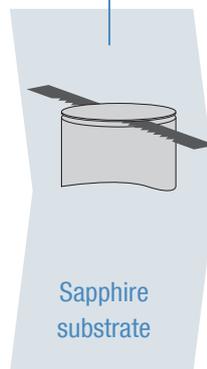
Heating elements for reactors

Step-by-step, the semiconductor layers that give the LED its required lighting properties (luminescence) are now applied onto the substrate (sapphire crystal). This process is performed in high-performance MOCVD reactors under aggressive chemical conditions and at a process temperature of approxi- ►





The Plansee Group has the right solution for many of the manufacturing steps used during LED production. The products include semi-finished products and components with superior material properties.



► mately 1,300 degrees Celsius. The heating elements themselves even reach temperatures up to 2,000 degrees Celsius. Generating these temperatures is a significant challenge in itself. Even more difficult, however, is the task of keeping the temperature constant across the whole area of the substrate material since even the tiniest fluctuations can have an enormous influence on the efficiency of the LED. And another demand makes things even more complex: To make production more efficient, the reactors and substrates are becoming ever larger.

In close cooperation with its customers, Plansee designs and optimizes reactor parts or assemblies in a team that consists of simulation, coating, materials and design engineers.

First of all, simulation engineers mimic real reactor operation by means of model-based calculations: What would the temperature distribution look like during furnace operation? How can the

heat output, screening and electrical connections be optimized and implemented? By answering these questions, it is possible to work out a reactor's specific sizing and performance limits to a high level of precision. Plansee's coating team plays an important role in the design and development of the heating elements. This team helps identify the coating solutions that are best able to fulfill the following requirements: maximized thermal radiation from the heating elements, maintenance of a constant temperature, minimized material fatigue and, finally, maximized equipment service life.

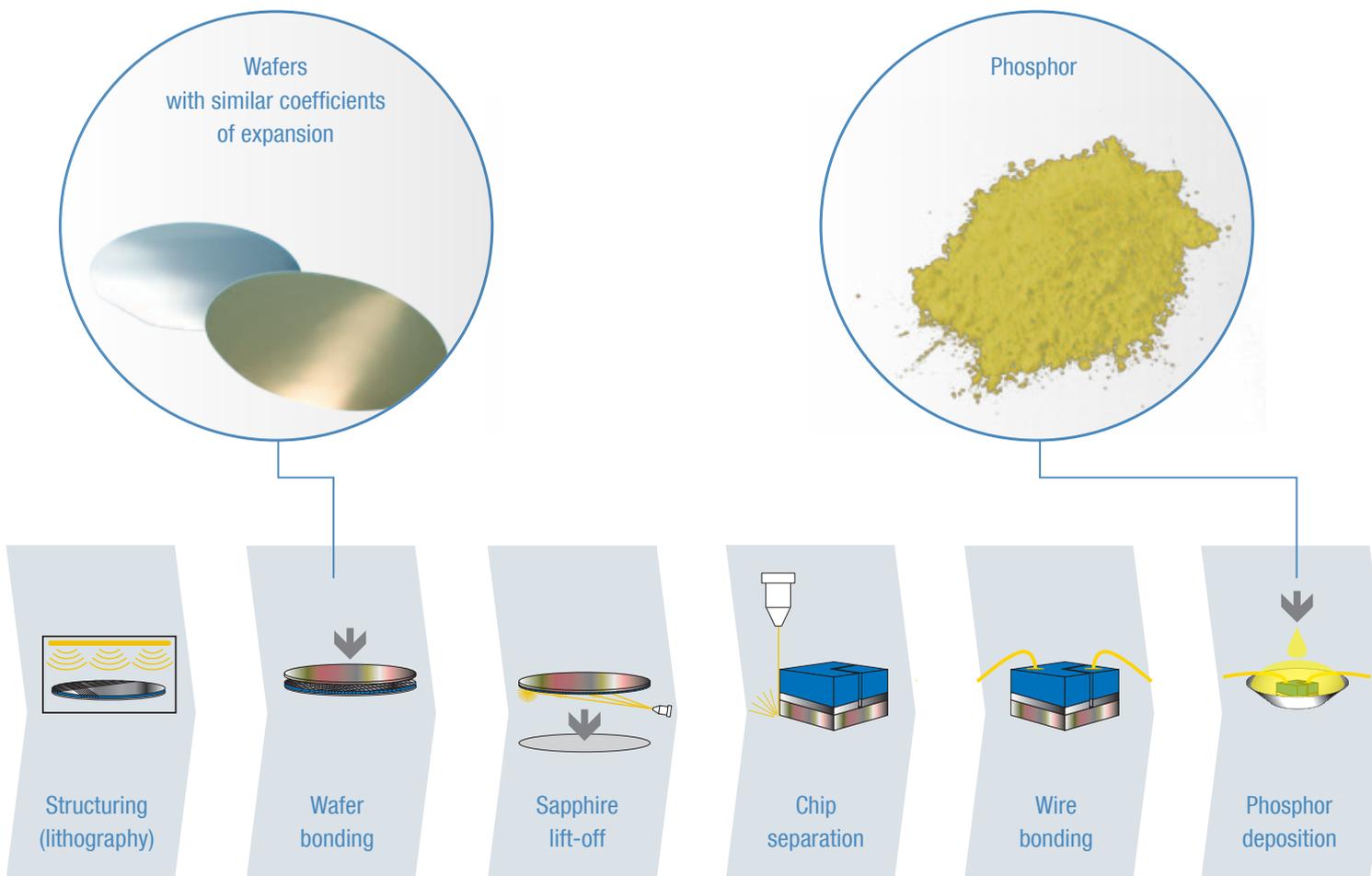
Once the calculations and preliminary tests have been completed, it is time for the design engineers to start work. They examine the question of which mechanical machining methods need to be used to give the heating elements manufactured from Plansee's high-performance materials the required shape.

Reflector layer for optimum light yield

In theory, the light produced during LED operation would radiate in all directions. That is why the back of the chip used in the new generation of LEDs has a reflective surface. Thanks to this so-called reflector layer, most of the produced light is directed forward and the efficiency of the LED is increased. The coating material, for example gold or chromium, is heated in crucibles specially designed by Plansee. These so-called liners are heat-resistant and the material properties ensure that the coating material is not contaminated.

LED base and heat spreader

Finally, the LED chip is soldered or glued to a metal wafer. This wafer has two functions: It absorbs the temperature from the semiconductor and acts as the connection for the so-called back-end components such as the printed circuit board or heat



sink. Important: The wafer and sapphire must have similar coefficients of expansion so that no microfissures appear in the extremely thin semiconductor layers when soldering is performed at temperatures of up to 800 degrees Celsius. These composite materials designed and manufactured by Plansee specifically for this purpose are particularly suitable because of their outstandingly well adapted coefficients of expansion. Under certain circumstances, the soldering process may require coating solutions to be applied to the wafer. Here again, Plansee is optimally placed to contribute and implement the necessary expertise.

Phosphor for luminosity

To take greater advantage of the possibilities offered by LED technology, the GTP division is working closely with its customers to develop and produce new phosphor-based materials for high-performance, economical, long-lasting and

energy-efficient LEDs with different colors.

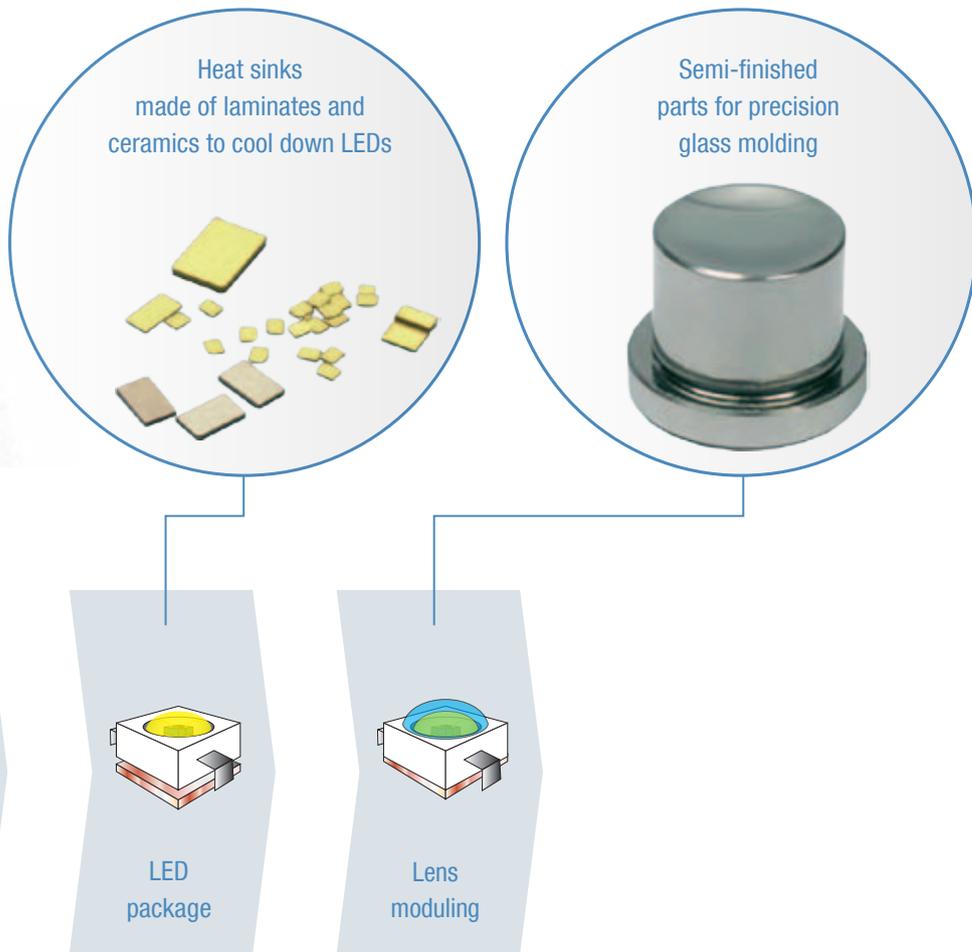
Heat dissipation in LEDs

The trend is also unmistakable in the LED field: Constantly increasing performance bundled into a compact volume. In general lighting applications and for automobile headlamps in particular, high energy densities and light intensities are in demand. However, meeting these demands also means generating more heat. Unlike conventional incandescent or H4 bulbs, the LED chip does not radiate heat forwards. Instead, the heat must be drawn off via the package (or housing). So far, the lighting industry has been able to use relatively cheap heat sinks made of copper, aluminum and ceramics. However, as the energy output from LEDs continues to rise, manufacturers are calling for heat sinks made from materials that offer the highest possible

thermal conductivity coupled with a coefficient of expansion that is better adapted to the semiconductors used in LEDs. If such heat sinks are not used then mechanical stresses between the chip and heat sink arise as early as the production stage and then subsequently during operation. In the worst case, these stresses may result in the premature failure of the product. Plansee has therefore developed heat sinks made from high-performance metal materials. Their properties cover a wide range of requirements and applications. In this way, it is possible to adapt the thermal conductivity, coefficient of expansion and costs to the requirements of the LED performance category in question.

Press tools for glass lenses

To reduce the costs involved in the processing of glass and accelerate the process, increasing numbers of manu-▶

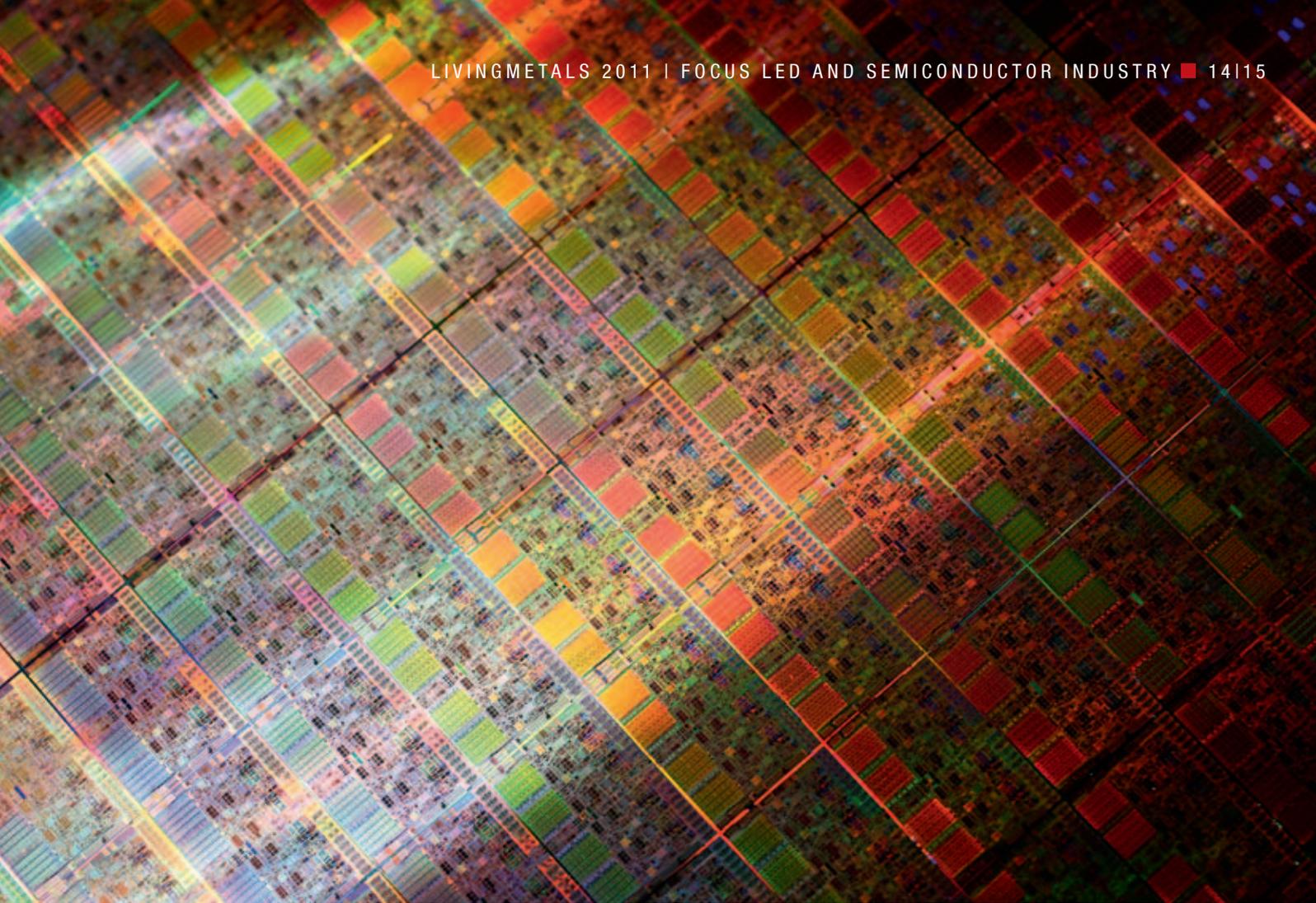


► facturers are turning to precision glass molding technology to shape their products. That is why the Group's Ceratizit division has developed tools that are ideally suited for press applications. The glass lenses can be

shipped pre-polished to meet individual requirements. To meet the exacting optical requirements placed on the glass lenses, Ceratizit uses the hard metal variant CTNO1L with grain sizes of less than 0.2 micrometers. First of all, the glass preforms are placed in the die and heated

to 700 degrees Celsius in a protective gas atmosphere. This makes the glass soft and ready for shaping. The Ceratizit hard metal tool or die is then used to give the glass lens the required shape. Ceratizit's processing tools are considered to be crucial for the development of optical technologies in Europe. ■





Spare parts for semiconductor manufacture

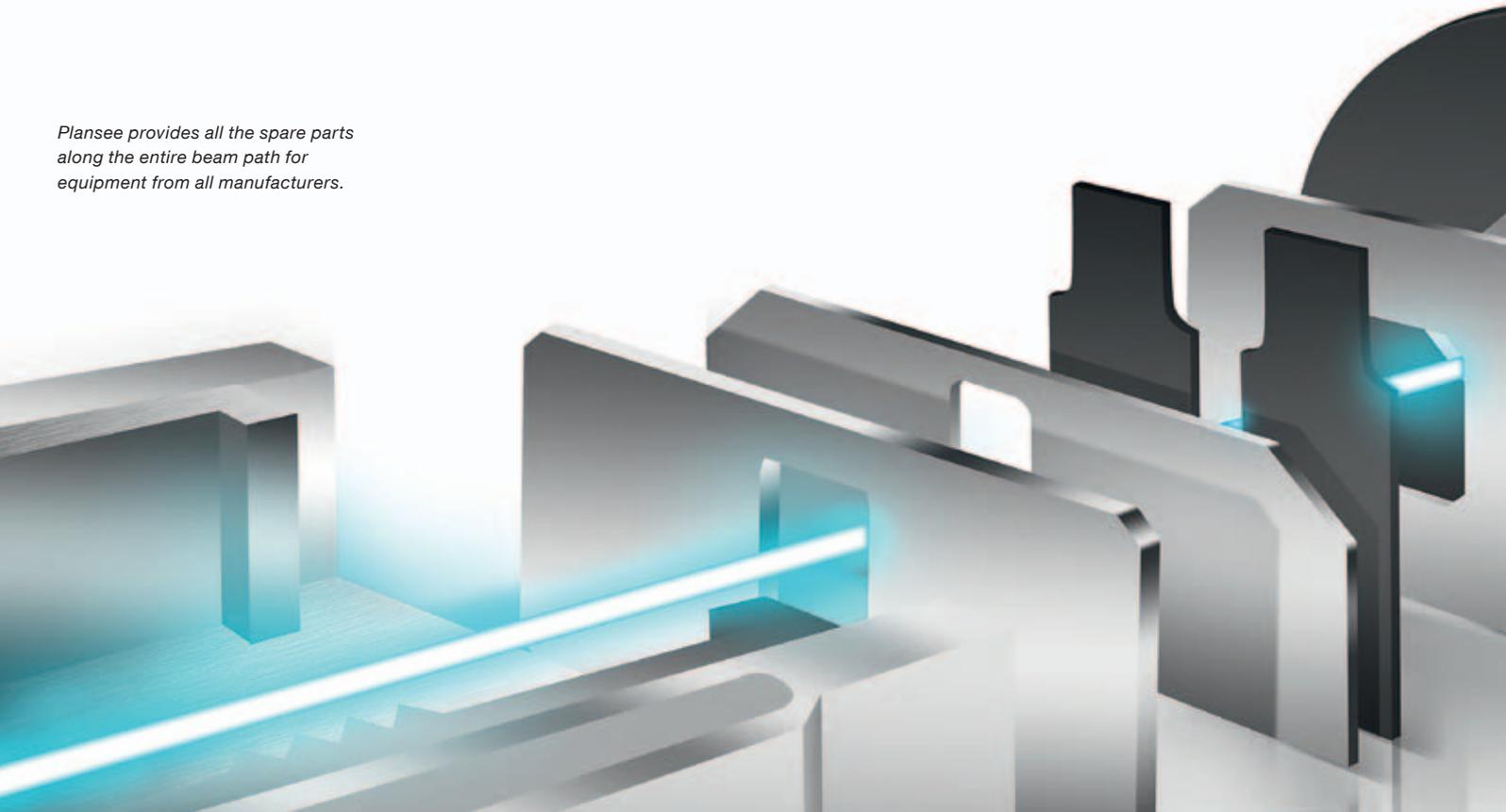
Better than the original

To be better than the original. This is the claim spare parts made from Plansee's high performance materials for the production of computer chips have to fulfill.

The semiconductor industry builds the brains behind the electronic systems we use in our everyday lives; mobile phones, computers, iPods, TV's, automobiles, machining centers, and even washing machines and refrigerators are being

asked to perform ever more complex tasks. It therefore comes as no surprise that the chips produced by the semiconductor industry are constantly offering higher performance at a more economical cost. ▶

Plansee provides all the spare parts along the entire beam path for equipment from all manufacturers.



► However, as chips become increasingly commonplace in our everyday lives, the tasks they are being asked to perform are also growing in complexity. That is why they need a versatile range of properties. These are fine-tuned during the manufacturing process in hundreds of individual process steps. Including in the field of ion implantation in which the chip's fundamental electrical properties are modified. And this is where Plansee has a role to play. In a production environment characterized by aggressive chemicals and high temperatures, the chip industry knows it can rely on Plansee's high-performance materials for its ion implantation applications. Thanks to its decades of experience in the refractory metals sector and, since the acquisition of the US company ElectroGraph, also in the fields of graphites and ceramics, Plansee is now one of the leading suppliers of spare parts and enhanced solutions for ion implantation.

Spare parts for ion implanters

The manufacturing methods are well established. Commonly built on wafer thin slices of high purity single-crystal silicon, most semiconductor devices are constructed using highly complex, techniques. Photo, etch, and deposition are used to define and build the circuitry of a device. Ion implantation, combined with thermal annealing, can precisely introduce impurities into areas of the silicon so that it can carry and store electrical charge.

Exacting materials requirements

Purity of the implanted materials, stability of the electrostatic systems, and uniformity of ion energy, density, and angle are all key factors for the production of good devices.

That is why along the entire ion implantation beam path (ion source, extraction optics, mass and energy separation and many other components), manufacturers need materials that can meet

extreme requirements and guarantee the performance capabilities of the ion implanter.

High operating temperatures of more than 1000 degrees Celsius, corrosive chemicals and the risk of chip contamination mean that only a few materials are suitable for use along the ion beam, the most important of these being refractory metals and graphite.

From powder manufacture through to the component ready for installation – Plansee ensures that these materials possess the right mix of properties by combining high melting points, low vapor pressures, high corrosion and wear resistance and an outstanding level of material purity. Materials solutions from Plansee are used in most of the world's leading chip production plants.

And standard products are just as much in demand as premium solutions which bear the label "Plansee Advanced Standard". These are developed in close collaboration between the customer and



the Plansee product management team in Japan and the USA.

Advanced Standard helps cut costs

An excellent example of an advanced standard is the Plansee designed “Shaftless Cathode.” Ions are created by igniting plasma between two electrodes inside an arc chamber (see info box). In the original design, the cathode is held in place by a small shaft. When the plasma is lit, the cathode reaches temperatures in excess of 1,000 degrees Celsius. These high temperatures cause the cathode to sag. Since deposition may occur at the cathode, short-circuiting against the side wall of the chamber can occur. In contrast, the “Shaftless Cathode” uses a much stronger contact ring to support the cathode. The ring supports the cathode in its correct position for up to three times longer than the original design thereby significantly reducing implanter downtime due to source maintenance. ■

At a glance: Ion Implantation

The implanter works by producing and accelerating ions of a known material, referred to as dopant, into the silicon lattice. In this way the implanter defines the fundamental electrical structures and properties of the device.

The dopant ions are produced in a subsystem of the implanter called the ion source which contains several refractory metal components referred to as the arc chamber. Inside the arc chamber a voltage is applied between two electrodes which ignite a plasma. Electrostatic fields “extract” the plasma from the arc chamber. Once extracted, the ions form an ion beam which is purified using mass-analysis and electrostatically manipulated to produce the correct energy, density, and alignment at the wafer. The major segments of the implanter “beamline” are the ion source, extraction, analyzer/flight tube, acceleration/ deceleration column, scanning system, flood gun, and end station.

Components for computer tomographs

The trap in the tube

With a scattered electron trap supplied ready for installation, Plansee has developed another key component for computer tomographs. Thus Plansee products are now used along the entire beam path, from the cathode through to its detector.

The electron beam of the computer tomograph starts at the cathode and emitter. Here, a high-energy electron beam is generated at temperatures of approximately 2,400 degrees Celsius. No other component in the computer tomograph is subjected to such extreme stresses. Furthermore, as a key component in the X-ray tube, it must offer an extended service life. For the emitter, Plansee has developed a tungsten-potassium-doped film that meets the most exacting thermo-mechanical requirements.

From electron beam to X-ray Another component that makes a crucial contribution to the performance of the tube is the x-ray target. Here, the electron beam generated in the emitter meets the so-called focal path. The x-ray target absorbs a significant proportion of the energy from the electron beam in the form of heat. This results in the generation of temperatures of over 2,000 degrees Celsius on the focal path. Only one percent of the energy is converted into the X-ray. Depending on the medical

device manufacturer, the x-ray target may be produced from various combinations of materials. The design is also customized for the relevant diagnostic application and its associated load profile. Among other things, Plansee has developed an x-ray target with relief slits. These slits compensate for any material stresses that arise during operation.

Robust electron trap

During the generation of the X-ray, scattered electrons are generated as a by-product. These are particles with a high energy level. They disrupt the high-voltage stability in the tubes and have to be eliminated. This is the task of the scattered electron trap. The trap absorbs the scattered electrons that are present in the computer tomograph's X-ray tube.

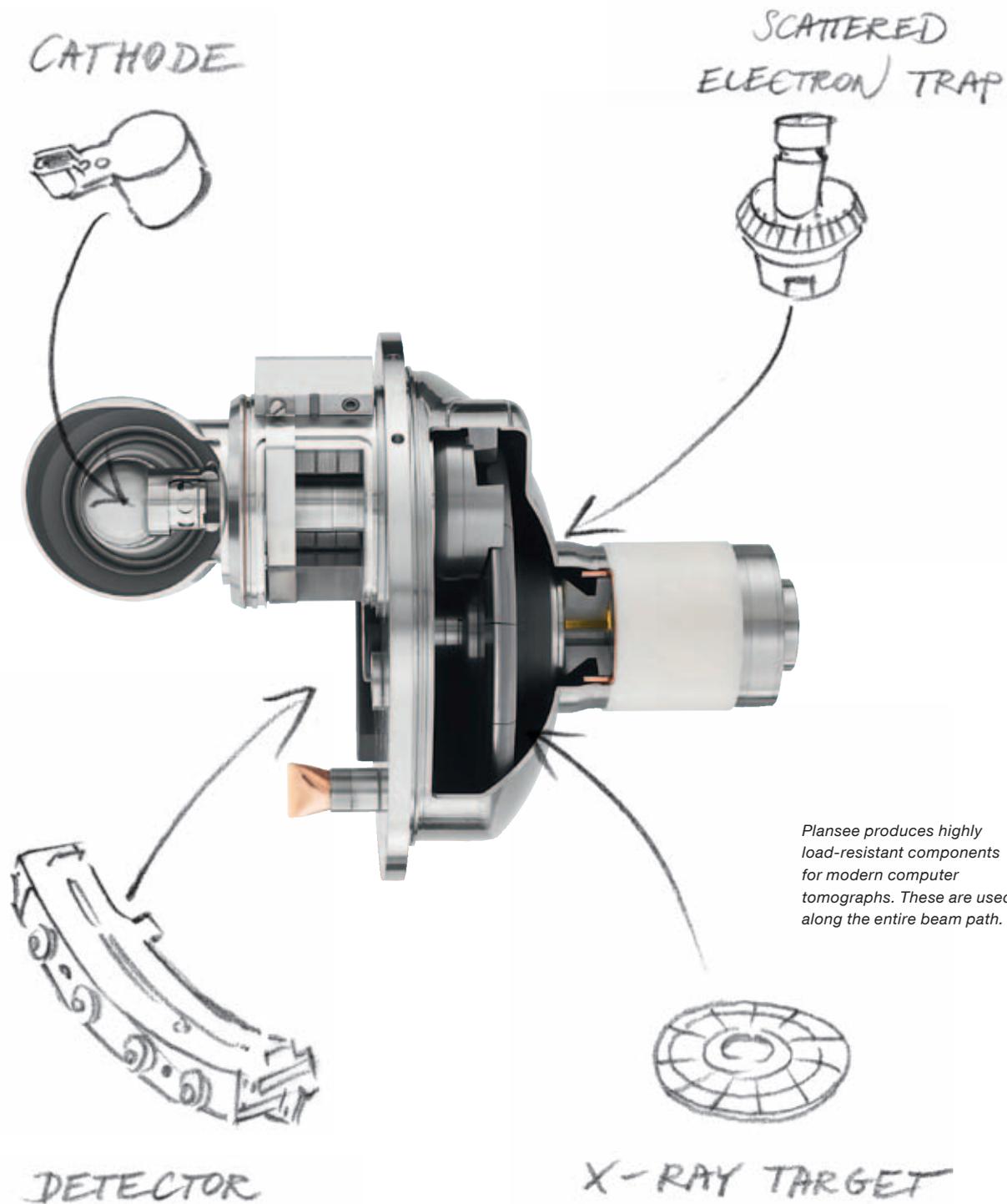
Due to the high volumes of energy applied to the device, the scattered electron trap must have an extremely robust design. In addition, the component must be able to dissipate thermal energy as fast as possible. The scattered electron trap produced by Plansee for the computer tomographs shipped by a major Dutch manufacturer of

High performance materials for computer tomographs

High-resolution images of individual sections through the body would not be possible without modern computer tomographs. The beam path constantly changes to pass through the structures that are being examined section-by-section. This process generates enormous thermal and mechanical loads.

High-performance materials are able to resist these loads and their screening properties guarantee maximum protection for the patient.

To measure the attenuation of the laser beam in the body, the film material habitually used in conventional X-ray devices has been replaced by an array of electronic detectors which are much more sensitive. These convert the acquired data into three-dimensional images practically in real-time. They now offer a significantly improved level of contrast.



medical devices makes use of high-performance materials in combination with copper and steel. The materials are cast or combined using proprietary joining technologies.

However, before this stage is reached, the components are subjected to intensive processing. To meet the high quality requirements demanded in the field of medical technology, every step in the manufacture of the scattered electron trap is completed at Plansee – from the basic material, through mechanical machining

and on to the provision of the component ready for installation.

From X-ray to image

Plansee often also supplies collimators for detectors. Once the X-ray has passed through the patient, it is captured in the detector and converted into image signals. Detectors make use of wafer-thin plates (collimators) manufactured from high-performance materials whose good absorptive properties make them suitable for dealing with the unwanted X-ray scat-

tering. The combination of a number of different processing methods, coupled with optimized punching or cutting technology, ensures that these components meet the high precisions required in terms of thickness and evenness. The design of the detector can make it possible to improve the image resolution and minimize the patient's exposure to the beam. ■

High-temperature fuel cells

“Omnivore” provides power and heat

The high-temperature fuel cell could hold the answers to some urgent questions relating to energy generation: Whether in private houses, trucks or office buildings.



“We see enormous potential in the domestic energy supply sector”

Alexander Dauenstein, Vaillant GmbH

livingmetals summarizes a panel discussion conducted at the Hanover trade show in April 2011, which was organized by Plansee.

The heating manufacturer Vaillant is already fairly far advanced. “We see enormous potential in the domestic energy supply sector,” says Marketing Manager Alexander Dauenstein. Starting in the fall of 2011, Vaillant will be dispatching over 100 heating appliances equipped with SOFC fuel cells for field testing. Project name: Callux. The appliances offer total efficiency of 85 percent. This puts them on a par with large thermal power stations. While many customers seem to want to take on more responsibility for ensuring the power supply to their own dwellings, Dauenstein explains that the installation companies still need to be convinced by the new technology. Similarly, Jürgen Rechberger of the Austrian AVL List believes that the US truck market also represents a great opportunity for the SOFC. New legislation in many states prohibits the use of the truck’s main engine for the on-board power supply (air conditioning, cooking, TV) except when the vehicle is traveling. Rechberger concedes that this is not yet a “done deal”. However, using the SOFC, it is possible to convert reformed diesel fuel into electricity extremely efficiently. According to Rechberger, “what we are actually taking about here is a battery charger.” At full capacity, the SOFC operates at approximately 800 degree Celcius. When the batteries are

fully charged, the SOFC automatically switches to stand-by operation at approximately 300 degrees Celsius. Klaus Rissbacher reported on the “Power Purchase Agreement” concluded by the Californian company Bloom Energy. Bloom installs so-called “Bloom Boxes” at its customers’ premises. These are 100 kilowatt systems for decentralized power generation. Customers are only billed for the electricity they consume. Bloom Energy takes care of installation, operation and maintenance. This model helps reduce energy costs while simultaneously making users independent of the electricity network. The so-called

“In our development work, we place the focus on efficiency and power density”

Dr. Mihails Kusnezoff, Fraunhofer IKTS

“Bloom Box” has so far mostly been used for supplying energy to office buildings and server rooms. Nevertheless: To become competitive across a broad range of applications, the SOFC still has some homework to do. “In our development work, we place the focus on efficiency and power density,” says Dr. Mihail Kusnezoff from the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS). The research institute has devoted itself to stack development. The stack is the heart of the high-temperature fuel-cell in which gas and oxygen are converted into electricity and heat. Its interim goal: 60,000 operating hours. “To achieve that, we must still do a lot

in terms of material optimization and then take another look at the design,” explains Kusnezoff.

In contrast, Dr. Hans-Peter Buchkremer of the Jülich research center believes that there is still a lot of potential at design level. Today’s stacks have a typical edge length of 10 to 20 centimeters. “To increase efficiency and performance, we should consider significantly larger formats in order to make SOFCs attractive for use aboard ships or in aircraft,” claims Buchkremer. He summarized the advantages of the SOFC: As an “omnivore”, it can be operated with natural gas or reformed diesel just as well as with pure hydrogen. In addition, it should be possible to extend SOFC technology to many other applications: as an electricity-generating high-temperature fuel cell as well as a hydrogen-producing high-temperature electrolyzer. ■

SOFC

is a scalable, decentralized, safe technology designed to cover basic electricity requirements. It represents both a bridge leading to, and a solution for, an age that will see energy differently. The solution: A seamless concept for the use of wind or solar power to generate hydrogen which can be stored by the SOFC and converted into electricity whenever required. The bridge: To do this, the SOFC uses reformed diesel or natural gas. At the heart of the SOFC is the stack, a combination of fuel cells which are responsible for the inflow and outflow of gases and their chemical reaction with oxygen to create heat and electricity. It consists of thin electrochemical units (ceramic cathode, anode and electrolyte) and metallic interconnects. The latter are developed and produced by Plansee HPM.

Ulrich Walter, moderator;

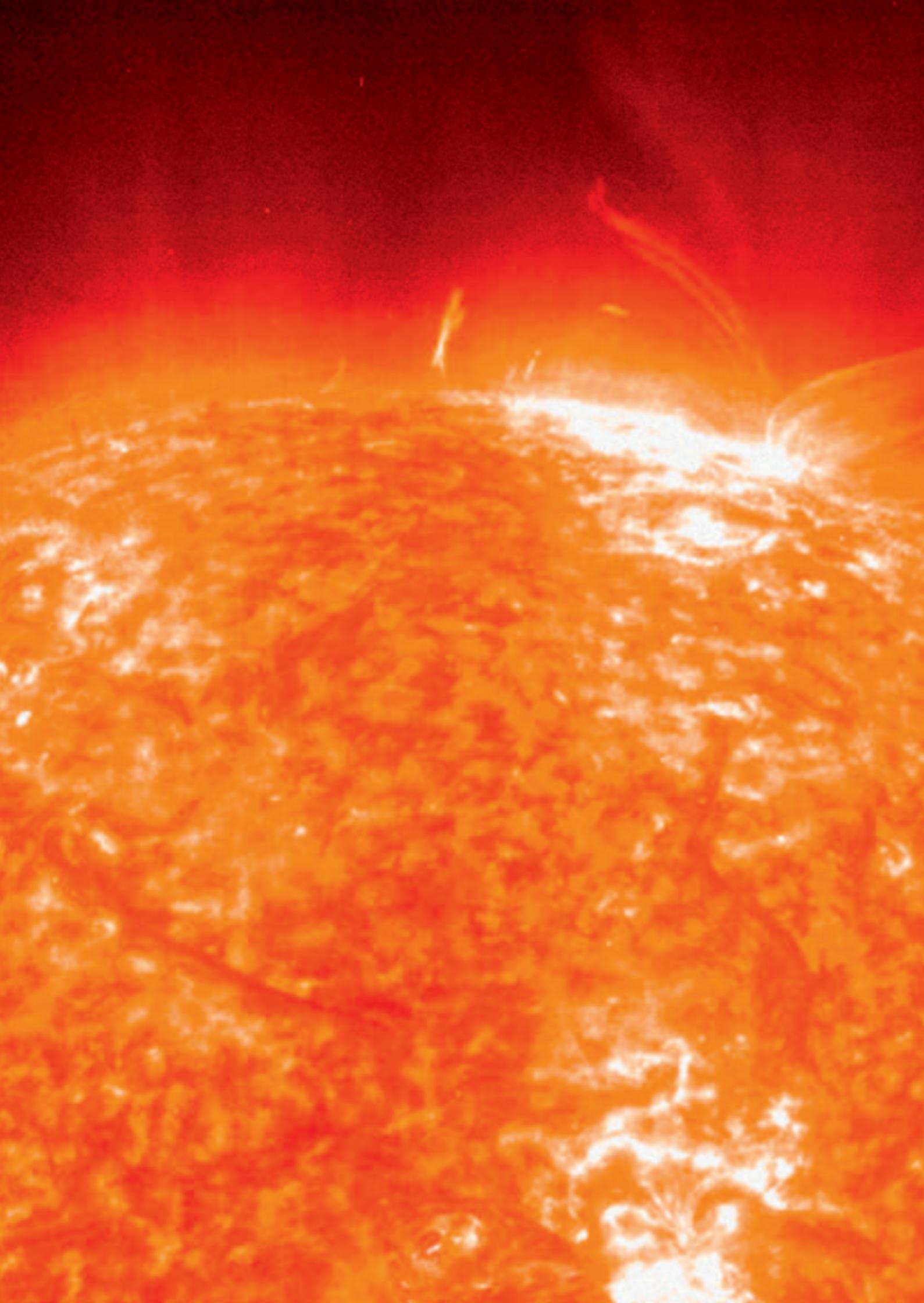
Dr. Hans-Peter Buchkremer, Jülich research center;

Dr. Mihails Kusnezoff, Fraunhofer IKTS;

Alexander Dauenstein, Vaillant GmbH;

Jürgen Rechberger, AVL List GmbH;

Klaus Rissbacher, Plansee SE (from left).



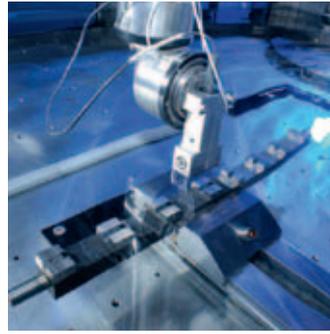
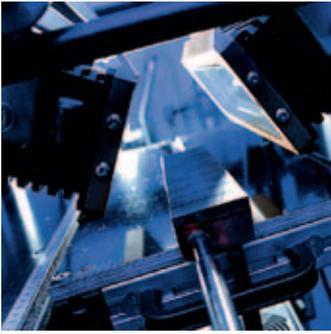
Fusion research

At the limits of the technologically possible

Developing materials and joining solutions for high-performance heat exchangers in nuclear fusion reactors, Plansee is pushing the limits of today's technical capabilities. Series manufacturing parts have already been delivered.

Research in the field of nuclear fusion aims at developing a power plant that uses the same energy source as the sun: To release energy by fusing light atomic nuclei. To achieve this on Earth, a sparse electrically charged hydrogen gas, a so-called "plasma", needs to be created as the fuel, heated to an ignition temperature of over 100 million degrees Celsius and kept in magnetic confinement. The greatest challenge is to keep the reaction stable over plasma pulse durations up to 1 hour. Being involved in several large Fusion experiments, Plansee participates as development partner or contributes as a supplier of serial components. For example Plansee is an established Partner in the development of the ITER fusion reactor currently under construction in Southern France and the Wendelstein 7-X fusion reactor on the Baltic coast of Germany. During operation the hot plasma ring is suspended close to the first wall of the

plasma without touching it. Nevertheless, escaping particles and intentional heat fluxes hitting the first wall can create extreme loads and stresses in certain areas. This occurs in particular in the location of the so-called divertor to which the plasma boundary layer is guided to remove from the fusion reaction contaminants and helium, the product of the reaction. Additionally, the level of the heat flux to be removed by the divertor is extremely high: While the heat flux removal capacity required for Wendelstein 7-X is 10 megawatts per square meter of the divertor area, this value is already doubled to 20 megawatts per square meter for the ITER reactor. By way of comparison: The heating power of an induction plate on a modern cooker is approximately 0.01 megawatts per square meter. These extremely high heat flows are bordering on the limits of today's technological limits. ►



Non-destructive quality control: Thermographic inspection of diverter elements (left) and ultrasound analysis of the armor (right).

► In a word: A fusion power plant requires the use of new, high-performance materials which have to possess a wide range of properties. Activation due to the yield of fast Neutrons emanating from the fusion reaction must be avoided. This means that the materials should be either resistant to activation or at least create only short-lived radio isotopes. In addition, they should be heat-resistant, thermally conductive and resistant to physical and chemical erosion. This mix of properties can only be achieved using complex composite materials. To develop these composites, Plansee calls on its expertise in high performance materials as well as its many years of experience in joining technologies.

Based on its experience in manufacturing composite materials in the field of X-ray technology (joining of graphitic materials with refractory metal bodies) and high-voltage switch gear (joining of various refractory metals with copper), Plansee

has been committed to the development of high-performance components for nuclear fusion since the early 1990s.

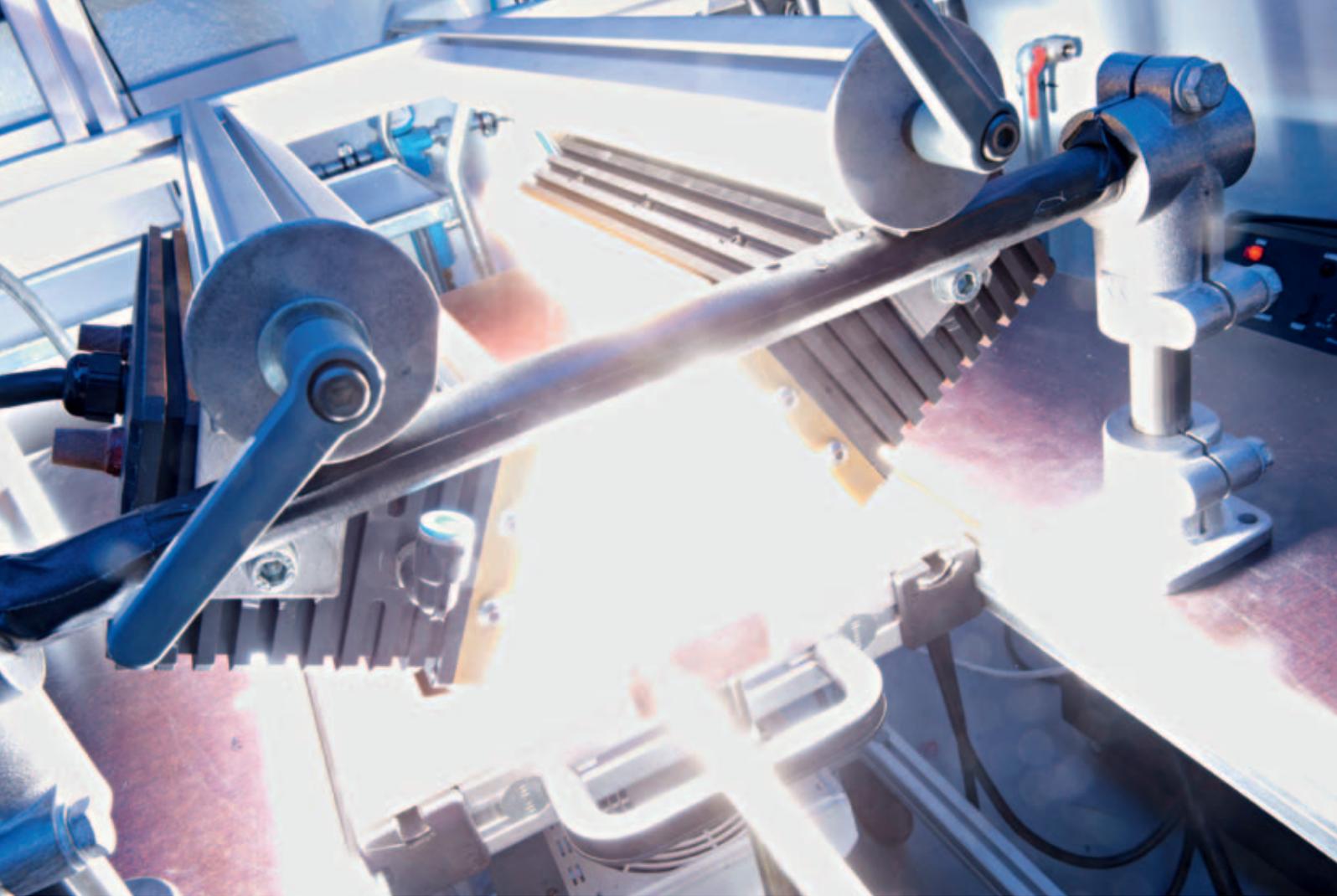
The results so far: Numerous developments and patents that make it possible to build components meeting the extreme stress-related requirements involved in nuclear fusion. For example, Plansee has been successfully using the patented Active Metal Casting process within series manufacturing divertor target elements. These are currently produced and delivered to the Wendelstein 7-X fusion reactor. Wendelstein 7-X is an experimental fusion reactor operated by the German Max Planck Institute for Plasma Physics (IPP).

Requirements placed on divertor elements

The divertor elements function as a high-performance heat exchanger. A highly efficient heat sink is protected by a so-called armor to withstand the plasma and

the high temperature conditions during operation. Materials having high thermal conductivity such as copper or copper alloys are used for the heat sink. To further increase the heat removal capacity the heat sink is actively cooled by introducing cooling channels to guide the coolant (either pressurized water or Helium) through the heat sink.

For the armor tiles or blocks made from 3-dimensional graphite or Tungsten are used. The resulting quality of the joint between the armor and the heat sink is therefore of crucial importance. During plasma operation, the face of the armor exposed to the plasma can reach temperatures exceeding 1,800 degrees Celsius. Just one centimeter below inside the heat sink the temperature of the composite structure has already dropped to that of the coolant. In the case of water, this is approximately 130 degrees Celsius (at a pressure of 40 bars). This leads to extreme



temperature gradients within the composite material. However, the greatest challenge is still to come: If the plasma is ignited or disrupted, the temperature of the component instantaneously changes by several hundred degrees. This results in an extreme cyclic thermo-mechanical load due to the different coefficients of ex-

pansion of the employed materials. During subsequent research or in permanent operation, the fusion components must not lose the required properties even after hundreds of such heating/cooling cycles. To assure this, suitable non-destructive testing methods need to be developed and implemented in parallel for the

respective production operations. As a result, Plansee has tailored its own thermography methods to permit monitoring during manufacture. These techniques are complemented by other optimized image-guided procedures such as ultrasonic testing and CT (Computed Tomography) analysis. ■

If successful, the advantages of fusion technology are undeniable:

Fuels. The Hydrogen isotopes needed to fuel the plasma reaction can be extracted from sea water or bred within the reactor itself. There are almost unlimited resources on Earth.

Safety. Unlike nuclear fission, nuclear fusion does not give rise to any self-sustaining chain reactions. This means that uncontrolled reactions or even meltdowns of the reactor core are impossible. The reactor can be shut down at any time.

Environmental responsibility. Power generation using nuclear fusion does not produce any carbon dioxide. The radioactivity of the activated

construction materials due to exposure to the irradiation from the plasma reaction decays to below legally required values in less than 100 years. Therefore they can be relatively quickly disposed of or recycled normally. In addition, it is not necessary to transport any radioactive fuels or dispose of any long-lived, highly radioactive residues.

Security of supply. As primary energy providers, fusion power plants would be able to ensure a reliable electric power supply to regions of high consumption like large cities or industrial areas. Independently of time of day, season and weather.

Hot zone for a high vacuum furnace

A puzzle with 50,000 pieces

Plansee has delivered the world's largest hot zone for a high vacuum furnace. And supplied the furnace-maker with an end-to-end solution – from design and manufacture through to the assembly of the 50,000 individual metal parts.

The dimensions and heating power demand of the high vacuum furnace were predefined by the furnace-maker. The furnace will be used to anneal aviation industry turbine components at temperatures of 1,300 degrees Celsius.

Plansee's task was to construct the heating elements. The greatest challenge: The sheer length of the furnace which measures over eight meters. At lengths like these, the hot zone parts expand by approximately ten centimeters when heated.

Excellent material properties

Of crucial importance for the purely metallic design of the heating elements is the fact that the equipment and products are protected by carbon and binder-free materials.

To manufacture these, Plansee has, for decades, been using proven materials such as tungsten and molybdenum. These refractory metals are characterized by their excellent resistance to high

temperatures, as well as by their low energy consumption due to the minimal heat capacities and small distortions they exhibit at rapidly changing temperatures. Despite all its routine activities and decades of design and production experience, (almost) every heating element manufactured by Plansee is unique. Consequently, the entire hot zone was first of all constructed as a 3D drawing and the behavior of the employed materials in the furnace was tested using simulation software. At the same time, throughout the planning stage the design engineers never lost sight of the fact that it had to be as easy as possible to install and maintain the hot zone components in the furnace.

Thanks to a new, patented design, Plansee has also considerably increased the service life of the heating elements. In the past, heating elements were flat. If they were heated, the risk that they would sag as they expanded increased. This could lead to short-circuits or fractures.



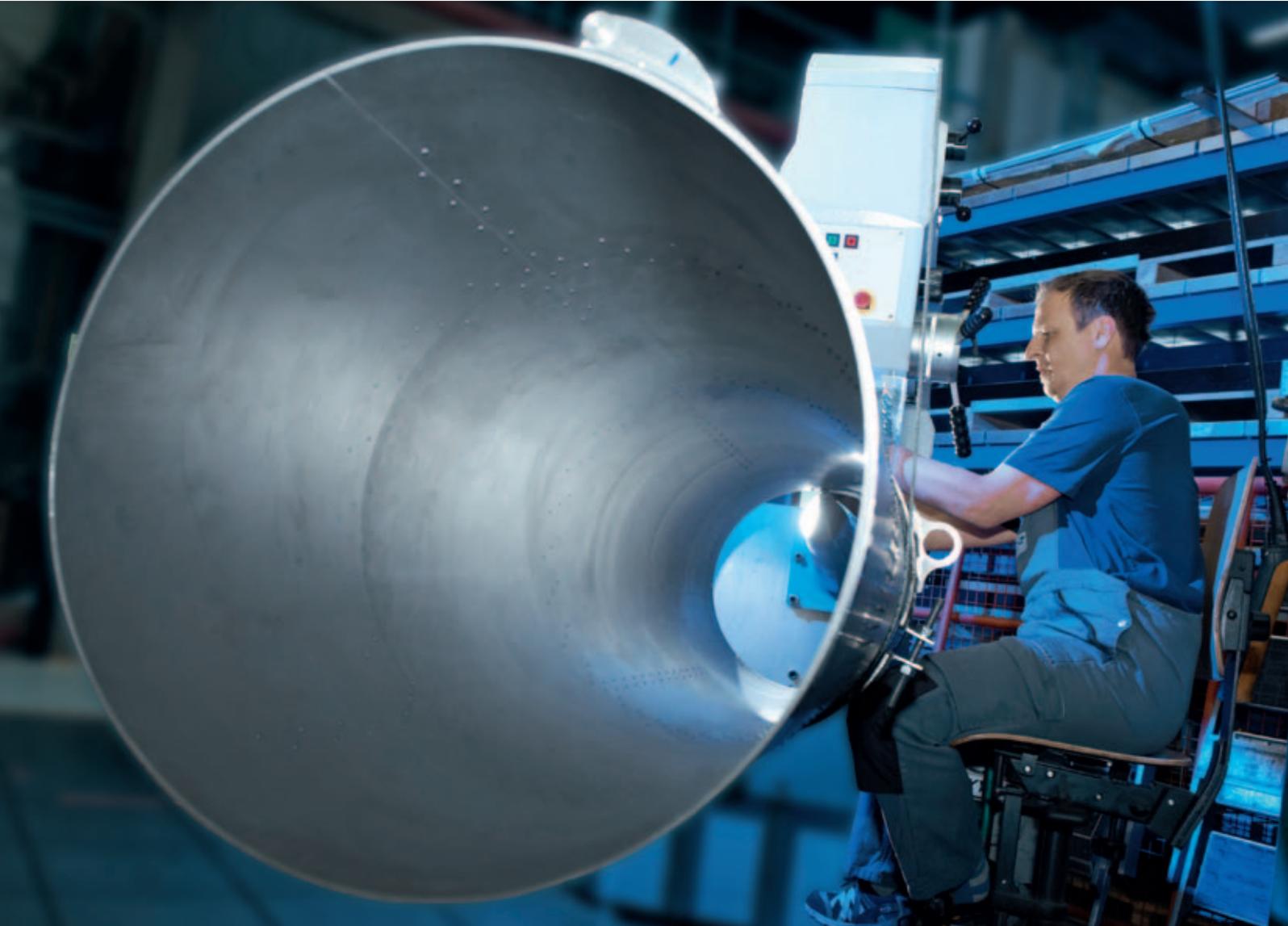
Heating element for a high vacuum furnace: The heating element that Plansee has designed, manufactured and assembled for use in a high vacuum furnace consists of 50,000 individual parts.



At Plansee, (almost) every heating element is unique: The manufacturing process combines technologies and skills such as laser and water jet cutting, chip removal, hot forming, joining technology and flame spraying.

The new sickle-shaped design prevents the hot zone components from sagging. Although the solution is more time-intensive to produce and therefore more expensive, the service life of the heating elements is vastly increased. Powerful arguments for the customer. This is because the cost of procurement is not the only consideration. The running costs for the maintenance of the furnace are also important.

Thanks to their high melting point, Plansee high-performance materials are suitable for use in high-temperature and high vacuum furnaces at temperatures of up to 2,800 degrees Celsius. Components made from refractory metals are used for high-temperature furnaces and thermal processing systems in countless industries and applications: during vacuum brazing, in sinter technology and heat treatment as well as in the Research and Development field. ■



Innovation in engine construction

Extremely lightweight cutting wheel

Rapid tool changes without a crane – until recently, that was just a far-away dream in the field of crankshaft production. But now, Ceratizit has made the dream a reality thanks to its innovative lightweight cutting wheel.

In the past, if the conventional tools used for crankshaft machining had to be changed then a heavy crane was used. This was moved into position before lifting the cutting wheel, which could weigh up to 80 kilos, out of the machining center. Both the effort involved in the tool change itself and the time until the machine was completely ready for use again reduced the productivity of crankshaft manufacturers significantly.

A leading producer of machine tools for crankshaft manufacture and its development partner Ceratizit wanted to eliminate these restrictions. They put the cutting wheel on a radical diet and turned the former heavyweight into a very trim flyweight. Nowadays, the machine operator is easily able to lift the cutting wheel, which weighs no more than 15 kilos, out of the machining tool by using a tool change device. What is more, the machine downtime is greatly reduced.

The time it took to develop this lean, new cutting wheel is also something for the record books: After only a few months, the machine tool manufacturer and Ceratizit were able to produce a prototype with an internal milling diameter of 275 millimeters. And the demands they set themselves were nothing if not exacting: the cutting wheel had to be light, easy to handle and, simultaneously, intrinsically rigid in order to guarantee repeat accuracy.

A new era in crankshaft production

The formula used by Ceratizit and its customer to provide innovative solutions in this new era in crankshaft machining was “Lightweight cutting ring + Replaceable cartridges + Compact tool change device”. A lightweight cutting ring mounted in a support is equipped with a certain number of cartridges arranged along its internal face. The cartridge, in turn, acts as a holder for the different indexable cutting inserts. Ceratizit developed the cartridge concept to avoid the need to replace the entire cutting ring when the seating of an index becomes

worn. Instead, only the affected cartridge has to be replaced.

However, the developers still had to overcome the challenge posed by the issue of tool stability. To do this, Ceratizit made use of the X-Lock system which was developed and patented last year. This system, which has already proved invaluable in the automotive industry, made the cartridge design possible. In the new cutting wheel, the extremely compact X-Lock solution guarantees high and precisely reproducible tensions throughout the component’s entire service life.

The X-Lock clamping system is used to secure the cartridges in the cutting ring. ■



A lightweight cutting ring mounted in a support is equipped with cartridges arranged along its internal face. The cartridges hold the various indexable cutting inserts. Each cartridge can be replaced independently of the others.

Exploiting shale gas reserves

Engineered powders developed for drill bits

Huge gas deposits are bringing a gold rush atmosphere to the USA. To make it possible to exploit these reserves, GTP has developed several new material formulations for the drill bits used in exploration and drilling gas pockets.

One of the largest shale gas deposits is the Marcellus Formation, located in the North-East of the USA. The quantities of gas concealed here could cover US supply needs for up to 20 years.

Shale gas is a natural gas that is produced and stored in shale. Shale gas is considered to be an unconventional source of natural gas. The quantity of gas stored in the stone is generally lower than in conventional deposits. Furthermore, the recovery of shale gas is a technologically demanding process. Consequently, the extraction of reserves at depths of 2,000 to 3,000 meters was barely economically viable. However, that has changed in recent years: this is due to increases in global oil and gas prices as well as the desire of western nations to reduce their dependence on oil and gas imports. And finally, conglomerates have come up with a number of ways to improve the efficiency of gas extraction.

The process involves a combination of two methods: Directional drilling together with the hydraulic fracturing of the shale layers.

New drilling methods

The term “directional drilling” refers to methods which make it possible to influence the direction of deep wells. Directional drilling is now also commonly used on dry land. It is possible to drill up to 200 wells from a single drilling site. As a result, it is possible to reach deposits of oil or natural gas from the side, for example when these are located under populated areas, difficult or protected terrain, or sites reserved for military activities. Directional drilling can also be used to correct boreholes or to avoid well sections that have become unusable.

Hydraulic fracturing involves the high-pressure injection of a fluid into the wellbore, thereby inducing fractures along the borehole. Once the fluid has been

removed, the gas is able to flow through the fractures to the earth's surface.

The drilling companies have now erected approximately 500 rigs over the Marcellus Formation. At present, the drill holes are being put in place and the pipelines constructed. The large-scale extraction of the natural gas is expected to start in just a few years' time. GTP has not only developed new powders for the drill heads – the company can now observe how they are used at first hand.

Polycrystalline diamond cutter

The drilling companies have developed extremely durable drill heads for directional drilling.

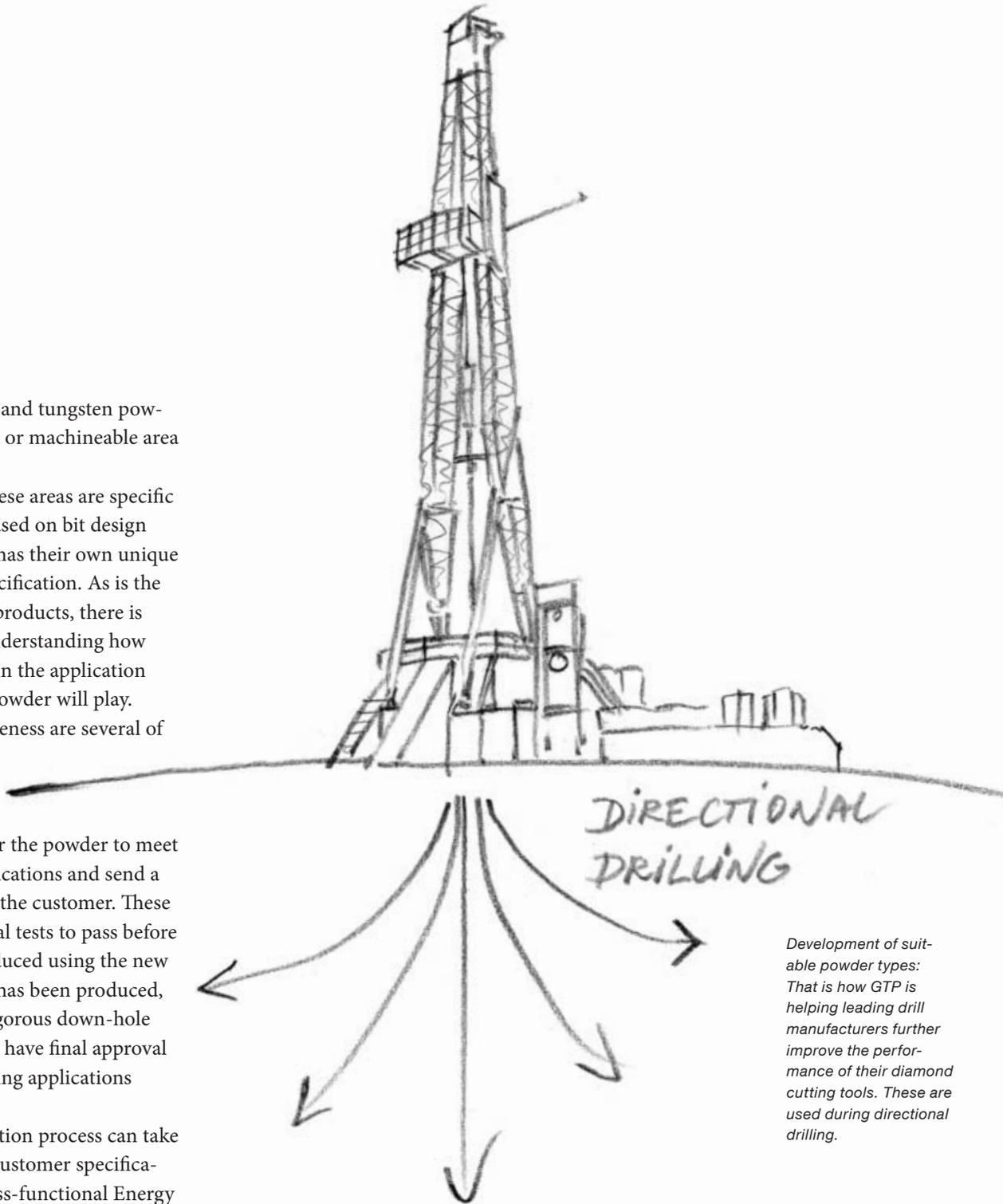
GTP has been working closely with several of the largest drill bit manufacturers in the world on developing powders that are used in the manufacture of these fixed cutter bits also known as PDC (polycrystalline diamond cutter) bits. There are two major uses of our tungsten powders – matrix powders used for the

body of the drill bit and tungsten powder for the shoulder or machineable area of the drill bit.

The materials for these areas are specific to each customer based on bit design and each customer has their own unique and demanding specification. As is the case for many new products, there is the early stage of understanding how the powder is used in the application and what role our powder will play. Erosion and abrasiveness are several of the key characteristics needed for bit performance.

GTP has to engineer the powder to meet the customer specifications and send a series of samples to the customer. These powders have several tests to pass before a full size bit is produced using the new powder. Once a bit has been produced, it has to undergo rigorous down-hole testing before it will have final approval and be used in drilling applications around the world.

This entire qualification process can take 12–18 months per customer specification. GTP has a cross-functional Energy team that meets regularly and is comprised of R&D, Manufacturing, Quality, Sales, Marketing, and Finance. The major thrust and significant effort has been in the R&D and scale up phases. Our R&D team has put a significant effort into this project and will continue their efforts with the next generation of powders. ■



Development of suitable powder types: That is how GTP is helping leading drill manufacturers further improve the performance of their diamond cutting tools. These are used during directional drilling.

Heavy-duty cutting

Hard metals to cut stainless steel

When the job is to machine a 100-ton turbine shaft, Ceratizit's tools are just what is needed. Because they can guarantee safe and stable processes.



Tools from Ceratizit make the machining of stainless steel turbine shafts even more secure.

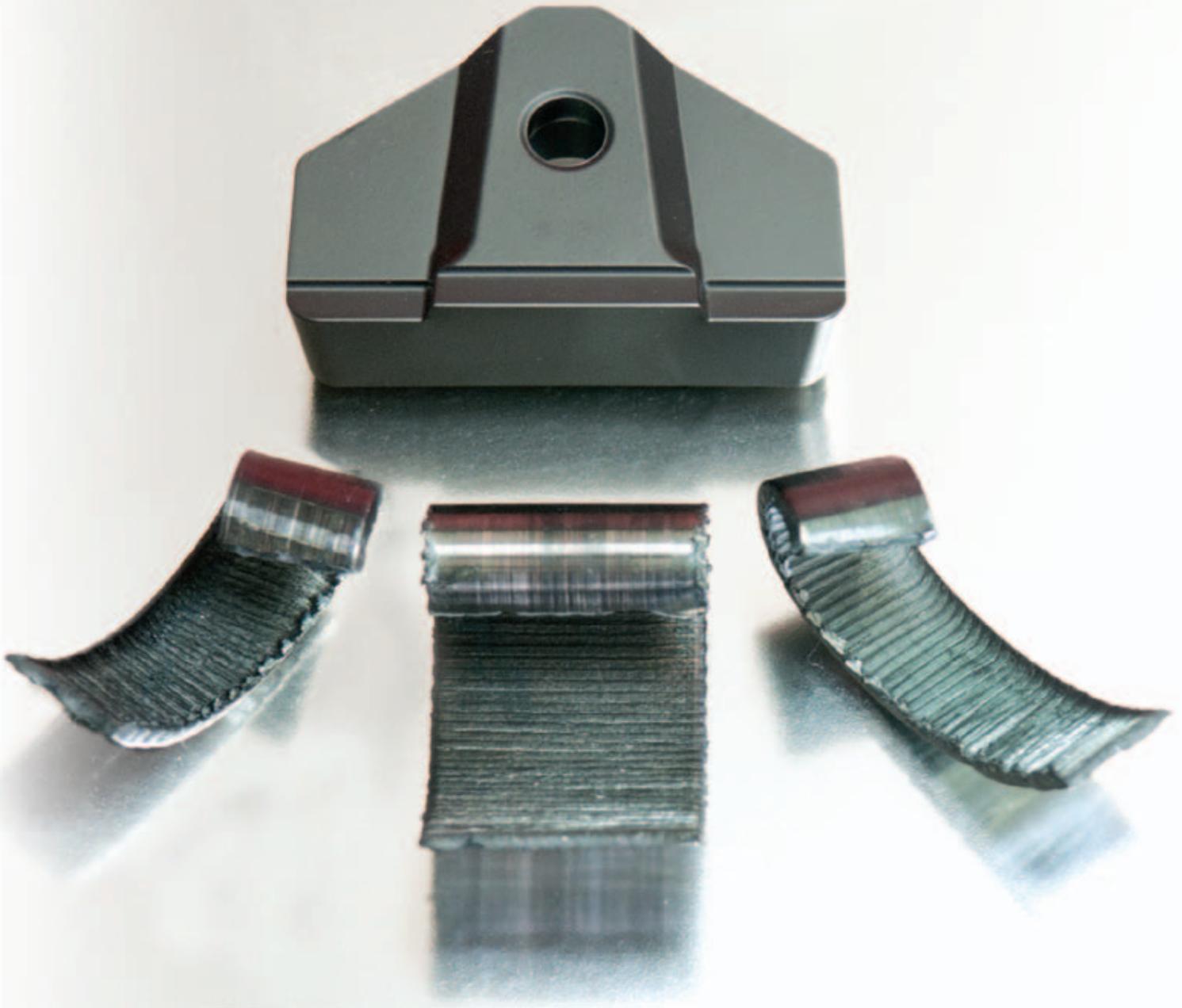
During the heavy-duty chip removal process, these open-die forged parts are subjected to a series of machining operations which give them the desired shape. For example, in the case of a turbine shaft for use in a power station: more than 50 percent of a forging blank weighing 100 tons is cut away. During this process, the grooving tools are subjected to cutting forces of up to 75 kN. This corresponds to a weight of approximately 7.5 tons. The machining operation imposes extreme safety requirements both in terms of the machine operators and the product. Machining stainless steel is anything but easy: Turbine shafts are made of an extremely robust stainless steel since they have to withstand temperatures of up to 550 degrees Celsius during operation.

That is why enterprises that use stainless steel are increasingly turning to hard metal tools. Despite this, in the past it was not possible to guarantee absolute security because of the non-existing swarf control during grooving operation. If chip breakage is uneven during the parting and grooving of turbine and generator shafts then the long chips start to wind around the workpiece. This leads to chip jamming which usually causes the parting and grooving insert to break. One major challenge was therefore to be able to control chip breakage. To do this, Ceratizit worked together with a specialist in the stainless steel industry to develop the new R81 parting and grooving insert. In a number of development steps, a series of gradual modifications were made to the

cutting capabilities of the insert until the required properties had been achieved.

Wear to the insert is reported

The innovative parting and grooving insert greatly improves the security and stability of the process: the chips are subdivided into three parts and short, comma-shaped chips are produced. In addition, the direction of rotation of the turbine shaft was changed and the tooling apparatus is fixed in such a way that work is now performed overhead. As a result, the short chips fall to the ground and the swarf no longer accumulates in the grooves. Furthermore, Ceratizit's developers made sure that the user is notified of wear to the parting and grooving insert. This also prevents the insert from breaking.



Due to the grooving width, companies previously required two different parting and grooving inserts in order to be able to groove into solid materials and create relief grooves. Thanks to the new parting and grooving insert, these two operating steps are now performed using the same insert. This reduces tool changing and warehousing costs. During grooving operations, the new parting and grooving tool can reach a depth of up to 300 mm at a grooving width of 40 mm. However, Ceratizit is currently extending its product range to include a number of additional groove widths. As of Fall 2011, the new range of R81 inserts will be available for widths of 16 mm to 60 mm. ■

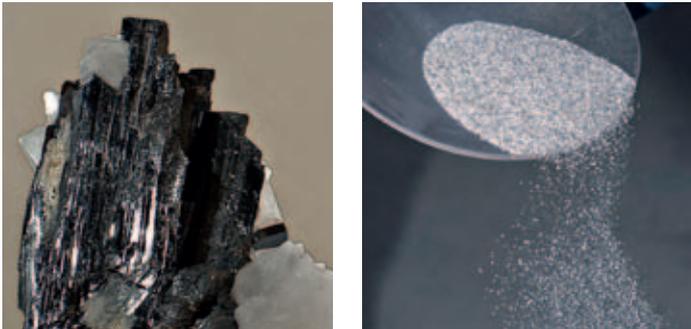


Chip breakage under control: The new parting and grooving tool (left) divides the chips into three parts (top) and lets them drop to the floor (right).

Tungsten and molybdenum supply

Irreplaceable raw materials

Thanks to long-term supply contracts, expansions to its capacities and acquisitions, the Plansee Group has been able to safeguard the supply of its most important materials: tungsten and molybdenum.



From the ore through to high-purity tungsten powder.

Following the take-over of the tungsten manufacturer Global Tungsten & Powders (GTP) in 2008, the Plansee Group acquired a holding in Molymet at the beginning of the current year. The Chilean company Molymet is the world's largest processor of molybdenum ore concentrates.

“As in the case of many other metals, there is also a shortage of molybdenum worldwide. Thanks to our holding in

Molymet, we can guarantee our customers a secure, long-term supply of molybdenum powder in both the quantities and quality they require,” explains Plansee Group CEO Dr. Michael Schwarzkopf. Molymet was founded in 1975 and specializes primarily in the manufacture and marketing of molybdenum and rhenium products. The company employs approximately 1,400 people at six sites around the globe.

Global molybdenum deposits are estimated at approximately 19 million tons. The main sources can be found in China, USA, Chile and Canada. Of the many minerals that contain molybdenum, molybdenite (molybdenum disulfide, MoS_2) is the only one that is currently suitable for commercial processing. Operating exclusively as a processor, Molymet has been collaborating closely with the mining industry for decades. ►





GTP's partner mines include one of the largest quarries producing tungsten-yielding ore in the Western hemisphere, the Pasto Bueno tungsten mine in Peru. Pasto Bueno has been producing high-quality tungsten concentrate for almost 60 years. Of the 79 veins of ore detected so far, only five have as yet been exhausted.

- ▶ Its long-term supply contracts with mines in Chile, Peru, Mexico, the USA and Canada ensure the continued supply of molybdenum ores.

Long-term supply contracts

Global Tungsten & Powders (GTP) has concluded a number of long-term supply contracts with mines in Spain, Portugal, Peru and Brazil. Other projects in Europe and Australia are in preperation. Thanks

to these agreements, GTP is able to guarantee its customers a secure supply of tungsten, tungsten carbide, and ready-to-press powders. At the same time, GTP has increased its production capacities in order to meet the growing worldwide demand for tungsten powder. GTP processes the tungsten concentrate to produce pure tungsten powder and tungsten carbide.

Tungsten has long been a critical raw material in key areas of the world. Although Chinese production currently meets more than 70 percent of global demand, the country is an importer of tungsten. Furthermore, the element's unique material properties mean that there are very few applications in which it can be substituted. ■

Did you know that ...

50.000 **individual parts**
The largest heating element ever manufactured by Plansee consists of 50,000 individual parts.

3.400 °C

Operating temperatures of up to 3,400 degrees Celsius are generated in the video projector lamps for which Plansee supplies components.

3.000.000 LEDs

The basic material for 3 million high-performance LEDs can be produced in a single crucible manufactured by Plansee. The crystals that emerge from the crucible are subsequently cut into flat wafers and cut into pieces of approximately one square millimeter.

8 **minutes**
Four 18-inch aluminum sports car wheels can be manufactured from start to finish in less than only eight minutes using Ceratizit cutting tools.

5.000
flat screens

Approximately 5,000 medium-sized TFT flat screens can be coated using a single sputter target produced by Plansee.

8.500.000.000 balls

The number of ball-point pens manufactured using Ceratizit balls last year was greater than the estimated population of the Earth. 8.5 billion balls have been produced from hard metals.

High purity niobium plates

Getting electrons up to speed

In XFEL, Europe's largest X-ray laser, electrons are to be accelerated to the speed of light in superconducting niobium tubes. Plansee supplies carefully prepared plates for this research project.

With a length of approximately 3.4 kilometers and buried up to 38 meters below the ground lies the particle accelerator for Europe's largest X-ray laser, the XFEL, that is currently being constructed in Germany and is due to be commissioned in 2015. It takes an enormous amount

of energy to accelerate the electrons. In the XFEL, the electrons are accelerated in superconducting niobium tubes – at a temperature just above absolute zero (minus 273 degrees Celsius). At this temperature, the current flows without electrical resistance and therefore without

any loss. Many tons of exceptionally pure niobium will be used for the XFEL project.

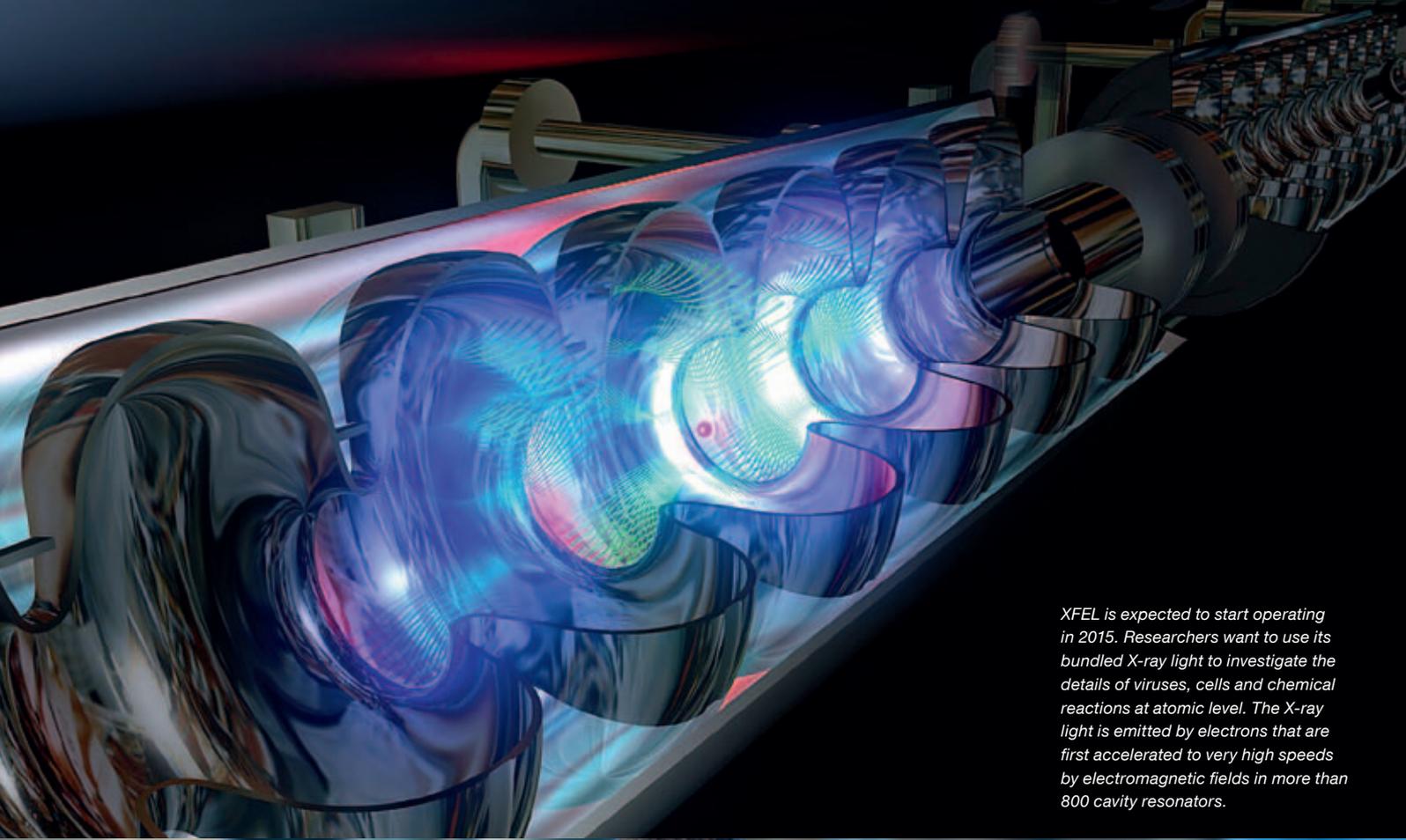
A flawless surface

Exact requirements are placed on Plansee's niobium plates: The niobium must be exceptionally pure and have the minimum possible gas content. At the end of the complex rolling, annealing, grinding and etching processes, the niobium plates boast a flawless surface. This represents a great challenge for Plansee's machining experts. Because niobium is so soft that even measuring equipment can leave small scratches on its surface. And according to the specifications, these must not exceed a few micrometers. But the hard work is worthwhile: Significantly larger particle accelerators are already being planned. For example, the International Linear Collider (ILC) which will require approximately 20 times as much niobium. ■

An insight into the realm of molecules

Instead of being used for particle physics, growing numbers of particle accelerators worldwide are being employed for research using photons, that is to say practically as light sources. This is also the aim behind the European XFEL in Hamburg: a giant free electron laser that emits X-ray light.

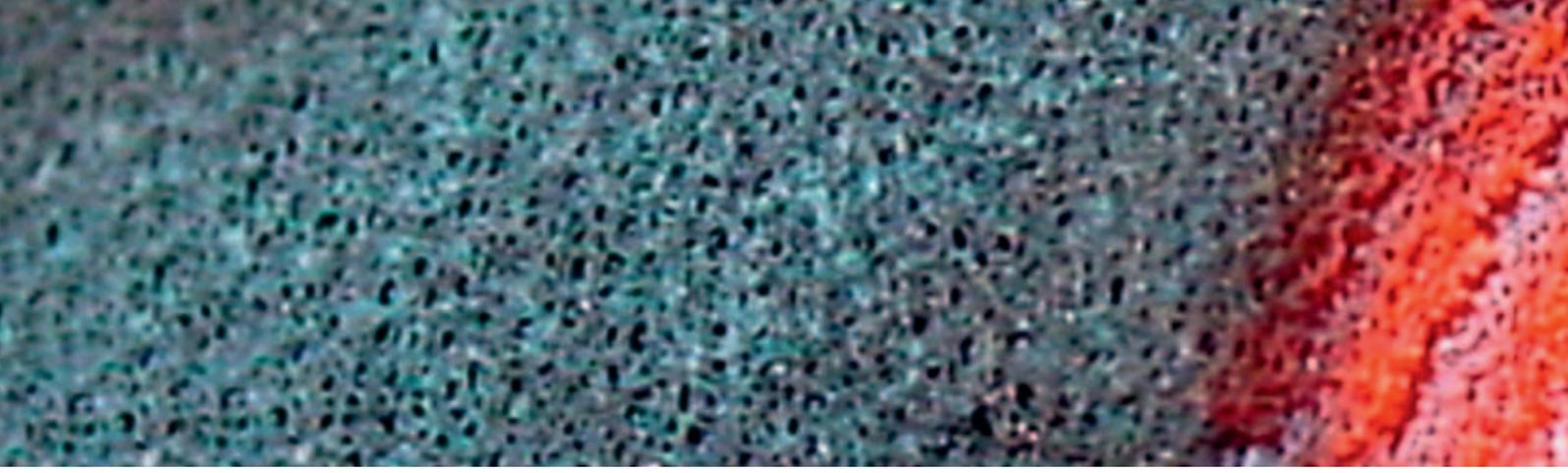
Using high-energy photons, it is possible, for example, to reveal the secrets underlying the three-dimensional structures of complex organic molecules in just a few days. In the past, it took researchers years to do this. X-ray lasers also make it possible to track the progress of chemical reactions or the actions of catalysts almost live as they unfold. Scientists hope that one day they will be able to extend their investigations to living cells.



XFEL is expected to start operating in 2015. Researchers want to use its bundled X-ray light to investigate the details of viruses, cells and chemical reactions at atomic level. The X-ray light is emitted by electrons that are first accelerated to very high speeds by electromagnetic fields in more than 800 cavity resonators.



Input material for cavity resonators: extremely pure niobium plates with a flawless surface. In several reduction stages Niobium bars are rolled to the thickness necessary for the niobium plates in the world's biggest rolling mill for refractory metals.



The growing importance of special materials

Professor Bernd Kieback talks about the significance of products manufactured using powder metallurgical techniques for demanding niche applications – and how new special materials and technologies are being developed for them.

livingmetals: What do you consider powder metallurgy's main tasks to be?

Prof. Bernd Kieback: The emphasis has shifted. The focus is no longer placed on structural materials, such as sintered materials which are primarily exposed to mechanical stresses, but on the functional properties of materials. In addition to thermal conductivity or expansion, this may include electrical, magnetic and thermoelectric properties or combinations of these.

livingmetals: Why powder metallurgy?

Prof. Bernd Kieback: Because we possess design capabilities during the materials forming process which are not available using other technologies. By selecting specific powders, we are able to bring together components which cannot be combined using the melting route. Thus we can create extremely homogeneous materials with fine grain sizes. Powder metallurgy also gives us elegant ways of producing pores and these pores, in turn,

permit a great range of materials properties. Additionally, powder metallurgical technologies enable energy and resource efficient production. Arguments that are becoming increasingly important.

livingmetals: What megatrends do you see in the fields in which powder metallurgy is used?

Prof. Bernd Kieback: If you are asking me where the main innovations can be expected, I would say in the field of power engineering which is affected by many material-related problems. And in the changeover to electric mobility. Those are the most exciting fields for us. Another trend can be seen in the growing interconnection between mechanical engineering and electronics.

livingmetals: Especially in electronics, high-performance materials for thermal management are in increasing demand.

Prof. Bernd Kieback: In the microelectronics field, we are faced with heat

flows equivalent to those observed in a hot cooking plate. To disperse the large quantities of heat generated, the heat sinks must possess a high level of thermal conductivity and must be able to resist mechanical stresses at changing temperatures. We therefore need a suitable coefficient of thermal expansion. Thanks to powder metallurgy, we are able to produce composite materials which cannot be manufactured using the melting route.

livingmetals: What is currently driving the development of short-time sintering?

Prof. Bernd Kieback: If metal powders are compacted and sintered in the conventional way then the metal bodies often have a residual porosity. As a result, pressure-based densification processes are of great interest since they permit more complete densification at lower temperatures. This process, which has become known and established as "hot pressing", has grown considerably in significance in recent years in the form of Spark Plasma



About Professor Bernd Kieback

Since 1993, Professor Bernd Kieback has held the Chair of Powder Metallurgy, Sintered and Composite Materials at Dresden's Technical University. In 1992, he founded the Dresden branch of the Fraunhofer Institute which deals with Production Technology and Applied Materials Research and which he still heads today.

Sintering (SPS). It offers some major advantages: Instead of the hours required in the conventional hot pressing process, short-time sintering takes just a few seconds or minutes. The heat is generated directly in the material by means of many brief current pulses. Productivity improves thanks to the short cycle times and we make considerable energy savings. The passage of the electrical current means that we can heat bodies of almost any size evenly. The areas of application include diamond tools or sputtering targets. The reduction of the grain size makes it possible to produce hard metals with very high wear resistance. In the case of refractory metals, the properties at high temperatures can be improved even further by integrating nanoparticles in the structure. These are referred to as dispersion strengthened materials.

livingmetals: How significant are three-dimensional manufacturing processes for powder metallurgy?

Prof. Bernd Kieback: In principle, they are suitable whenever we have to produce small parts with complex shapes and this involves us in difficult, time-consuming machining operations. Further criteria are: The quantity of material lost due to machining must be minimal due to high material cost and it must be possible to charge a high market price for the end product. These criteria are most frequently fulfilled when we are working with very hard, high-resistance materials such as refractory metals, hard metals or titanium. Technologies such as three-dimensional screen printing or electron beam and laser beam melting are currently gaining ground in various sectors of manufacturing.

livingmetals: Will the importance of materials produced using powder metallurgical techniques increase?

Prof. Bernd Kieback: Bulk materials such as steel will remain bulk materials. However, the orientation toward niche materi-

als will increase: At present, I often find that I need a very specific material for a particular technical solution. You can't just turn up and choose from the existing materials. Instead, very often, a material has to be specifically designed for the application. And this is often the case for just a single application.

livingmetals: In 2013 the next Plansee Seminar will take place – you have been a member of the Scientific Committee for many years. Why do you recommend taking part?

Prof. Bernd Kieback: The Plansee Seminar is characterized by its consistently high quality – both scientifically and organizationally. Also important is the focus on refractory and hard metals. Young scientists understand it as an honor if their papers are accepted for the Plansee Seminar. These are potential “recurrent visitors” who keep coming back, in part because of the already mentioned increasing importance of special materials. ■



Milling machine for aluminum and cast iron parts.

Increasing productivity

Ceratizit has developed an indexable insert tool with ultrahard cutting materials for small milling diameters that replaces soldered and solid hard metal tools. This permits more efficient machining because service lives are extended and the tools are easier to maintain. The tool has shown its value, for example, in the automotive industry: This flexible tool concept can be adapted to most machining situations involving the milling of aluminum and cast iron – for example, in terms of the number of teeth, the shape of the milling body, the cooling properties, the geometry of the cut edges, as well as the cutting angle and the cutting materials.



Greater corrosion resistance for TFT monitors.

Tested in the climatic chamber

Marine climates can cause major problems for TFT monitors. Thanks to new coating solutions, corrosion resistance can be improved by up to a factor of five. Many modern TFT screens are produced in Korea, Taiwan, China and Japan. Due to the warm, sultry climate and the proximity to the coast, the air humidity here can often be very high. Tiny droplets of water form on the molybdenum-coated glass plates on which the electronics are mounted and affect the coatings. This can cause the

loss of individual pixels and the monitor is often then only good for scrap. It is possible to improve the monitor's resistance to corrosion by introducing certain alloy components such as chromium, tantalum or niobium. To achieve this, countless alloy variants have been produced and tested in climatic chambers. Overall, it has been possible to improve the corrosion resistance of the new molybdenum coatings that Plansee is currently bringing onto the market by a factor of between two and five.



Plansee balance weights ensure a smooth, stable drive.

Optimum driving characteristics

When fractions of a second make the difference between victory and defeat, nothing should be left to chance. With its heavy-metal balance weights, Plansee is ensuring stability and smoothness in the Formula 1 world. Wind tunnel tests help adjust the chassis perfectly using balance

weights. At the same time, the balance weights on the crankshaft ensure smooth engine running. The balance weights have a density of almost 19 grams per cubic centimeter and are supplied ready for installation in accordance with the customer's drawings.



Coin with red niobium core.

Gray niobium gives a colorful glow

For the ninth time, Plansee has manufactured the niobium core for the Austrian mint's new bi-metal coin on the theme of "robotics". The color of the niobium – in this case, a bright red that can shade to orange depending on the angle of the light – is the result of a coin production procedure developed by Plansee. This creates a thin, transparent oxide layer. The refraction of the light gives the niobium its color. Different colors may emerge depending on the thickness of the oxide layer, which measures only a few nanometers.



A striking advertising message: Upgrade your tools with Ceratizit.

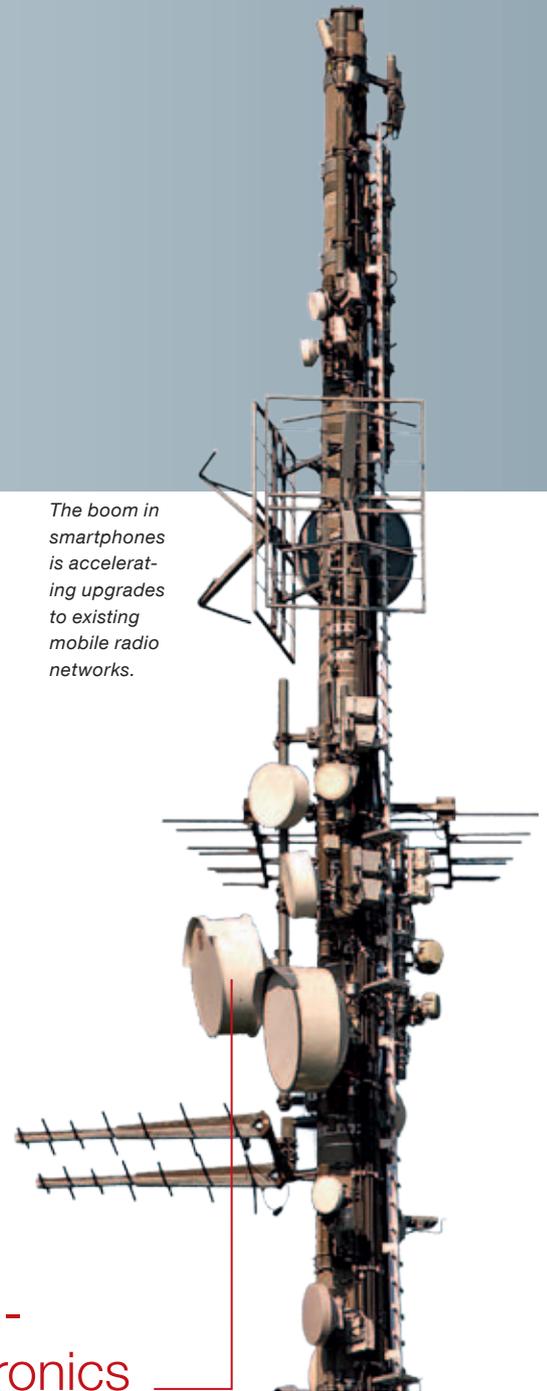
Doing more with wood

Thanks to Ceratizit's new hard metals, woodworking companies are able to extend the life expectancy of their tools and optimize manufacturing costs. These metals were demonstrated to customers under the slogan "Upgrade your tool with Ceratizit" at the Hanover Ligna, the world's largest and most prestigious trade show for the sector. As a partner to the manufacturers of woodworking tools, Ceratizit supplies hard metal blanks, semifinished products and ready-to-use indexable knives.

Heat sinks for high-performance electronics

More and more applications used on smartphones call for higher mobile data transmission bandwidths. Therefore base stations for mobile communication are being upgraded all over the world. Important base station components are high-frequency power amplifiers. These high power density transistors generate a considerable amount of heat. For efficient cooling, the electronic components are attached to base plates made from high-performance materials with low thermal resistance.

The boom in smartphones is accelerating upgrades to existing mobile radio networks.



During manufacturing and in operation the assembly is exposed to considerable temperature variations and thermal cycles. So that the material coefficients of expansion of electronic components, ceramic housing and heat sink must also match. Plansee's engineered thermal materials optimally meet these criteria. Thanks to its wide range of materials for the electronics industry, Plansee is able to supply tailor-made solutions. The heat sinks are supplied to customers for further processing or as finished products.



Blanks for cutting and punching tools.



Phosphor materials for the LED industry.

Order more from stock

Ceratizit has extended its stock program for manufacturers of cutting and punching tools. Erosion blocks and dies are available in many new dimensions, including in the form of surface-ground blocks.

Available from the online shop at www.e-techstore.com or from the Sales department. The Sales department also acts as the point of contact for additional services such as technical consulting, customer training, service life analyses and metallurgical studies.

Products for the lighting industry

GTP is one of the world's leading suppliers of phosphor for use in lamp technologies based on fluorescence or electroluminescence.

GTP has developed a range of new phosphor materials for the LED industry. In addition, GTP is also working to further improve the brightness and color

hue of fluorescent lamps. The different phosphor combinations permit the generation of different light effects that can be adapted to meet the customer's specific requirements. In addition, GTP has developed new coating technologies designed to extend the lifetime of its phosphor materials.



Sales increase by 46 percent

Basis for future growth

The Plansee Group realized record sales of 1.24 billion euros in the fiscal year 2010/11 (year ended on 28 February 2011). “We recovered from the downturn that was caused by the financial crisis more quickly than expected and performed very well in the last fiscal year – from both an operational and a strategic point of view,” said Michael Schwarzkopf, CEO of the Plansee Group.

Consolidated Group sales increased by 46 percent in the last fiscal year to a total of 1.24 billion euros. This is 13 percent higher than the previous record-breaking sales that were achieved in the 2008/09 fiscal year, before the global economic crisis. “All four Group divisions performed well,” commented Schwarzkopf on the operational success of the Group. The total number of employees rose from 6,000 in 2009/10 to 6,730 in 2010/11.

50 percent of the Group’s total sales were accounted for by Europe, followed by the Americas with 31 percent and Asia with 19 percent. The USA was once again the company’s biggest single market, followed by Germany and Japan. The Plansee Group achieved well over 50 percent of its sales in three key sectors: automotive, mechanical engineering and consumer electronics.

One billion euros invested over ten years

In the last fiscal year, the Plansee Group invested 62 million euros, and an additional 29 million euros in innovation projects. In total, the Group has invested one billion euros – or an average of 11 percent of sales per year – over the last ten years in machinery, technology, processes and new products.

“Our clearly defined positioning in our markets, our focus on developing new products as well as making sustainable investments are the foundations for our future growth,” said Schwarzkopf. In the last fiscal year the Group built a first production line for components used in high-temperature fuel cells (SOFC) in Towanda, Pennsylvania, USA. And the booming LED industry enables substantial growth. “Taking into consideration these developments, we should be able to

increase the amount of sales that we realize from new products, which currently stands at 30 percent,” said Schwarzkopf.

Expanding in Asia

According to Schwarzkopf, the Group has made a good strategic move by increasing its presence in China and India and securing the long-term supply of raw materials. After successfully building a production site for automotive components in Shanghai the year before, in the last fiscal year the Ceratizit division acquired 50 percent of CB Carbide, headquartered in Taiwan. The acquisition enabled Ceratizit to further strengthen its global position in the field of hard metals for wear applications. In December 2010, the Plansee High Performance Materials division acquired a majority stake in Indian private company Wolfra-Tech. The acquisition enabled Plansee to enter the Indian market with its own

Dr. Michael Schwarzkopf presented the record figures: This year, the Plansee Group celebrated its 90th birthday. One of the factors behind the success of this private company is continuity at top management level. The poster in the background shows all the previous Chairmen: Grandfather Paul Schwarzkopf, father Walter Schwarzkopf and Dr. Rudolf Machenschalk.



production facility – a market with an increasing strategic importance for Plansee. According to Schwarzkopf, the Group is planning further expansion in Asia. A production facility for Plansee HPM division products near Shanghai is scheduled to start operation in 2012.

At the start of the current fiscal year, the Plansee Group acquired a 10-percent stake in the leading global molybdenum ore processor Molymet. Molymet has been listed on the Santiago stock exchange since 1983. “The recent investment in Molymet and the acquisition of Global Tungsten & Powders (GTP) in 2008 have significantly helped us to secure the supply of our two most important raw materials, molybdenum and tungsten,” said Schwarzkopf.

Planned divestment of PMG

The Plansee Group has decided to divest the PMG division. “We want to concen-

trate on further developing our molybdenum and tungsten activities globally and cover every stage of the value chain, by starting with processing the ore and offering powders, semi-finished products and ready-to-use components that are tailored to our customers’ needs,” said Schwarzkopf. An investment bank has been commissioned to look for a new owner for PMG.

Outlook

In the first three months of the current fiscal year, demand has remained strong. At the same time, Schwarzkopf believes that there is evidence of overheating effects in some industries and at raw material prices. Evaluating the overall business environment, Schwarzkopf said he remained cautious because the ongoing critical situation of countries’ national budgets and global capital mar-

kets makes business downturns possible at any time. Overall, the Plansee Group is expecting to achieve lower growth figures this year than in the last fiscal year. However Schwarzkopf believes that the Group is well prepared for any potential slowdown. “We have learnt a lot from the crisis. Cost flexibility remains a major issue,” said Schwarzkopf. Financially the Group has the necessary means to expand further and make acquisitions, thanks in part to the record-breaking 2010/11 fiscal year. The Plansee Group intends to make investments in the coming years in order to improve the competitiveness of its European production sites, globally expand its core activities and further increase the security of its raw material supply. ■



Metals that make the world go round

Galloping with more grip

Whether to ward off evil spirits or as a bringer of good fortune – the horseshoe has held a special significance for people for hundreds of years. Even in ancient times, people wanted to find ways to protect their horses' hooves against the wear caused by hard or rocky ground. Whether for a carhorse working in the fields, a post horse pulling a bumping coach or a charger riding into battle, the correct footwear has always been important.

However, when peak performances are demanded in modern show jumping or point-to-point events, the good old horseshoe comes up

against its limits. With horseshoe studs made

from hard metals or with a hard metal core – rather like the studs used in

football boots – both the horse and its rider can count on a

reliable grip. In mud, snow or

ice – thanks to the wide range of horseshoe studs, the four-

legged athletes are on a sure footing whatever the weather and

however difficult the terrain.



The Plansee Group at a glance

Close to our customers, worldwide

Carlsbad (California, USA)
San Diego (California, USA)

Columbus (Indiana, USA)
Warren (Michigan, USA)
Philipsburg (Pennsylvania, USA)
Towanda (Pennsylvania, USA)
Franklin (Massachusetts, USA)

The Plansee Group is represented worldwide by Centers of Excellence which focus on market needs and are located close to the Group's customers.

- ▶ 36 production sites located in three continents worldwide
- ▶ Sales offices and representatives in 50 countries
- ▶ 6,700 employees



Mieres (Spain)
 Mondragón (Spain)
 St. Pierre en Faucigny (France)
 Niederkorn (Luxembourg)
 Mamer (Luxembourg)
 Livange (Luxembourg)
 Biel (Switzerland)
 Seon (Switzerland)
 Alserio (Italy)

Hitzacker (Germany)
 Empfingen (Germany)
 Lechbruck (Germany)
 Füssen (Germany)
 Reutte (Austria)
 Liezen (Austria)
 Bruntál (Czech Republic)
 Gabrovo (Bulgaria)

Mysore (India)
 Kolkata (India)
 Zhangzhou (China)
 Changtai (China)
 Xiamen (China)
 Tianjin (China)
 Shanghai (China)

Wugong (Taiwan)
 Tamshui (Taiwan)
 Sakura (Japan)
 Esashi (Japan)



Imprint

Proprietor and publisher:

Plansee Group Service GmbH
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Photo credits: Plansee Group, Werbefotografie
Weiss, Michael Paetow, mk publishing, Fotolia.de/
Petinovs/Dusan Kostic/focus finder/cjruslan/
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