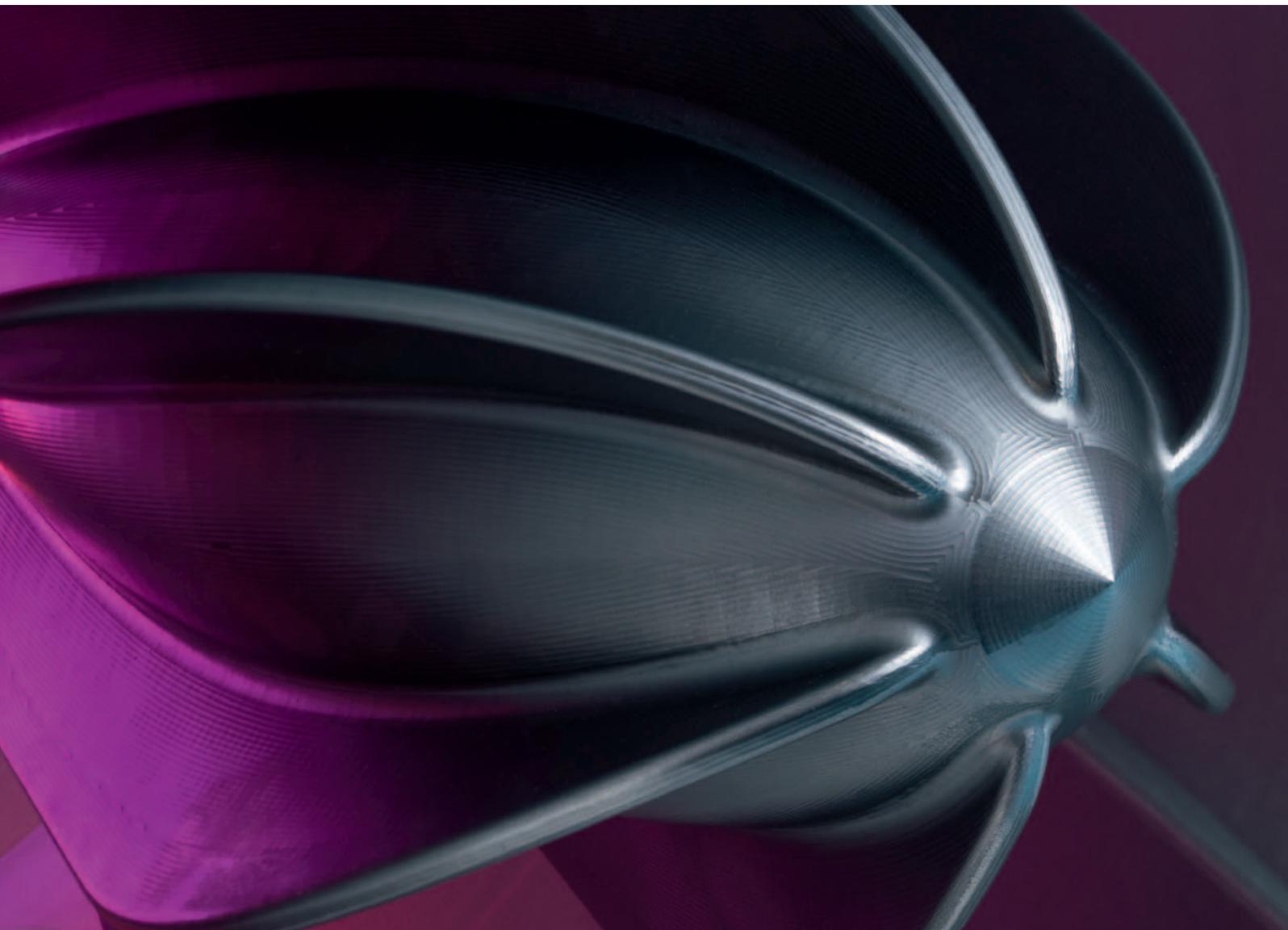


## Raw materials – procurement and **recycling**

- High-tech molybdenum and tungsten solutions
- New products for electricity and hydrogen generation



## Note

The report “Our responsibility for people, the environment and society” is enclosed with the German edition of *livingmetals* at the Plansee Group’s largest production site in Reutte, Austria. An English edition is available for download on the website [www.plansee-group.com](http://www.plansee-group.com).

## A word on the title

A component for a high-temperature installation. This component, which is manufactured from high-tech materials, can withstand extreme temperatures and mechanical stresses.



# Focus on high-tech materials

» Amid the global uncertainty concerning raw material procurement, the Plansee Group has been able to ensure the reliable sourcing of the raw materials tungsten and molybdenum in the West.«

Dear readers,

It is well over 50 years ago that the founder of the company, Paul Schwarzkopf, published his memoirs under the title “Geschichten aus Molybdänemark” (“Tales of Molybdenmark”). And even today the humorous stories told by this multifaceted scientist and businessman are still read with great enjoyment. However, there is one thing that Paul Schwarzkopf does not tell us with his striking and descriptive title: That since the very beginning, the Plansee Group has also focused intensely on another material, tungsten. That is still the case today and since we placed raw materials procurement high on our strategic agenda some five years ago, the modern title for such a work would have to be: “Stories from Molybdenmark and Tungsten City”. It would have to tell how the Plansee Group came to be one of the leading processors of the metals tungsten and molybdenum. And how, over the last five years, amid the global uncertainty concerning raw material procurement, it has ensured the reliable sourcing of these raw materials in the West.

And the story continues: Our customers expect us to supply them with tailor-



made solutions – whether in the form of powders, semi-finished products or customer-specific components. In this edition of livingmetals, you can find out how our materials are providing outstanding performance in a wide range of forward-looking industries and high-tech products. And while we’re talking about the future: It is only logical that we sometimes decide to complement our core focus on molybdenum and tungsten when working on technologies that will ensure future success. For example, our expertise in powder metallurgy is contributing to the development of hydrogen-based energy production – to find out more, read the focus article “Electrochemical cell systems”. I hope you will be inspired by the contents of this edition.

Dénes Széchényi  
Head of Group Communications





### **Voyeurism? Or necessity?**

The fact is: X-rays pass through engine blocks, items of baggage and human bodies millions of times a day. Whether in the automotive industry, in security installations or for medical diagnoses: The challenge is always to reduce imaging times while improving resolution and throughput. The Plansee Group's high-tech materials are the force behind the development of powerful X-ray devices – from the X-ray source through to the detector in which the radiation is converted into images. And our shielding products ensure that the X-rays arrive only where they are genuinely needed – for a healthier, safer world.

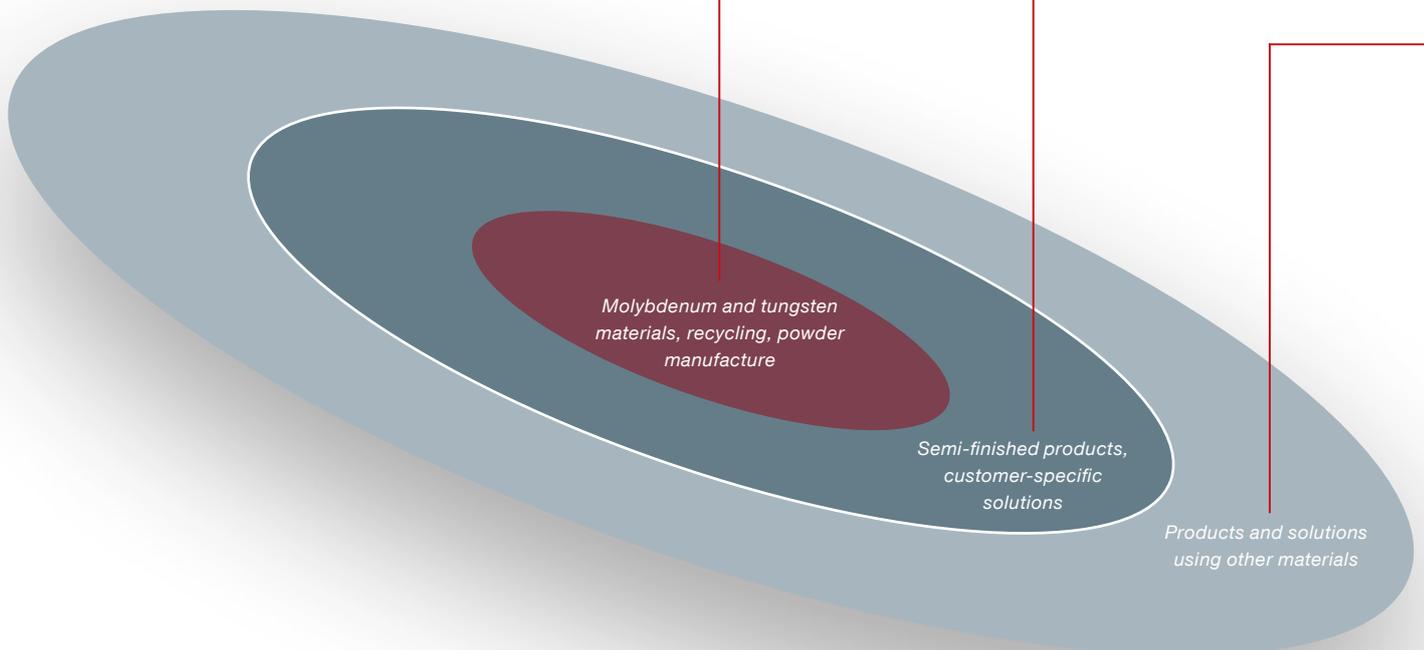
8 **FOCUS ON RAW MATERIALS  
PROCUREMENT**

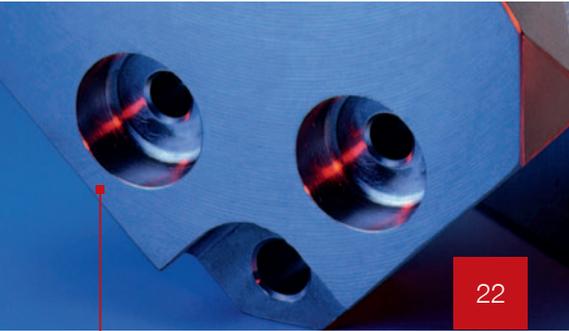
“Actively promoting raw materials procurement”

13 Rare earth recycling: From light source to raw materials source



8

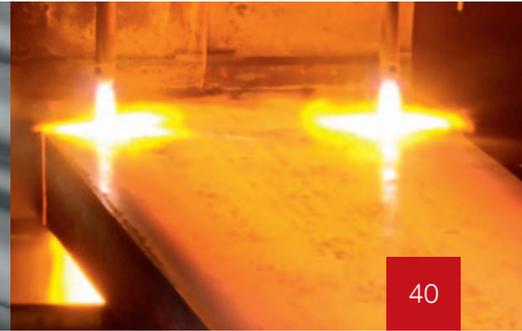




22



34



40

16 **STORIES**

Thermal management in the electronics industry: When hot semiconductor meets cold carrier plate

20 Balancing weights: Flyweights in the heavy metal class

26 High-temperature furnace construction: When trust pays off

30 OLED displays: Perfect layers for sharp images

32 Extended milling program: A cutter like a cake knife

34 **FOCUS ON ELECTROCHEMICAL CELL SYSTEMS**

Membrane reformation: No barriers to hydrogen

37 Production line for interconnects: Keeping in shape

38 Power-heat cogeneration: Turning natural gas into electricity

3 **EDITORIAL**

4 **BASIS**  
Voyeurism? Or necessity?

25 **FACTS**  
Did you know that...?  
Interesting information about the Plansee Group

40 **PEOPLE**  
Laboratories of the Christian-Doppler-Forschungsgesellschaft: Professor Reinhart Kögerler  
"Knowledge can't simply be copied down"

42 **GALLERY**  
In worldwide use: Innovative materials and application solutions

46 **COMPANY**  
Plansee Group achieves sales of 1.5 billion euros

48 **ALIVE**  
Biathlon: Marksmanship and heavy metals

50 **GLOBAL**  
Close to our customers, worldwide: The Plansee Group at a glance

# “Actively promoting raw materials procurement”

Once a processor of tungsten and molybdenum, now a vertically integrated group of companies: In recent years, the Plansee Group has taken some important strategic steps to ensure the long-term reliability of its raw materials sources.

The trend has been evident for a number of years: For a wide variety of reasons, the mining and preparation of many of the raw materials that are important to forward-looking industries have become increasingly concentrated in China. When Chinese exports were restricted, supplies became scarce and prices rocketed. Media reports of shortfalls in the availability of strategic raw materials have repeatedly led to concerns from customers anxious about their suppliers' ability to procure materials and deliver the products they need. As a result, many companies have demanded political support or are attempting to have raw materials supplies regulated at

government level, for example through the creation of a raw materials agency in Germany.

“We have also been monitoring the supply constraints relating to the raw materials that are critical to us,” explains Plansee Group chairman of the executive board, Dr. Michael Schwarzkopf. And while others are still waiting for government help, the Plansee Group has ▶





*From ore concentrate to customer-specific solution: The Plansee Group covers every step in the manufacture of molybdenum and tungsten products.*



*Mining and preparation of tungsten-bearing ore to form an ore concentrate. This is further processed at GTP to form pure tungsten powder and tungsten carbide.*



► taken a different path and placed the issue of raw materials procurement on its strategic agenda. As a result, the last four years have seen the Plansee Group develop into a fully-integrated group of companies that acts as an end-to-end supplier covering the entire value added chain – from ore concentrate, through powder manufacture and on to the fabrication of products ready for installation. What this means is: The Plansee Group no longer – as was the case in the past – simply manufactures products made from tungsten and molybdenum. Instead, it now handles all the processing steps and offers all the manufacturing skills involved throughout the entire value chain. In this way, the Group has also developed into a strategic supplier to many other western companies.

### **Secure tungsten supply**

With the acquisition of the tungsten manufacturer Global Tungsten &

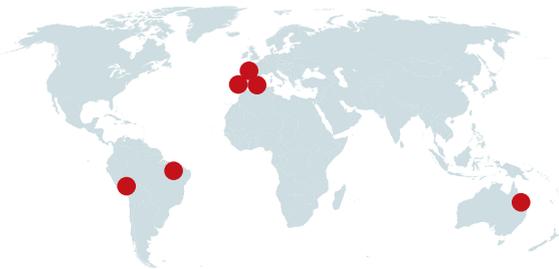
Powders (GTP) and the sale of the sintered parts manufacturer PMG, the Plansee Group was able to take the most important steps toward refocusing its industrial portfolio. Step-by-step, thanks to major investment, the American company GTP was turned into the leading western manufacturer of tungsten powder and tungsten carbide. The commitment to investment was impressive: in the expansion of production capacities for ammonium paratungstate (APT), the most important input during the manufacture of most tungsten-based products including tungsten and tungsten carbide powders. With factories in Towanda in the US and Bruntál in the Czech Republic, GTP is able to guarantee tungsten supplies to its American and European customers meeting whatever quality and quantity they require and within very short delivery periods. The Plansee Group procures its tungsten from two sources: From recycling secondary raw mate-

rial (tungsten containing scrap) and by obtaining tungsten concentrates directly from the mine.

### **Tungsten recycling**

More than 40 years ago, the GTP division had already developed and optimized a process for recycling hard metal scrap. This makes it possible to produce chemically pure tungsten that has the same properties as newly mined tungsten. The Plansee Group has also constructed a recycling plant for hard metal scrap in Europe. This facility, which is run by Ceratizit Austria, started operation in 2009 and its production capacity has increased every year since.

To collect and sort the hard metal scrap, the Plansee Group cooperates closely with waste disposal and recycling companies in the USA, Europe and, more recently, India. These companies collect end-of-life hard metal drill bits, milling cutters, indexable cutting inserts



*The Plansee Group has concluded numerous finance and purchase agreements with western mines for the supply of tungsten ore concentrates.*

and wear parts as well as production waste in which tungsten is present. GTP India was founded nearly a year ago to extend the collection of hard metal scrap to that country. In some cases, the companies of the Plansee Group take back worn-out tools or scrap items directly from their customers or process these to produce fresh tungsten powder on their customers' behalf. "Tungsten can be recycled extremely efficiently. In this way, we help to reduce disposal costs for tungsten-yielding scrap and ensure the tungsten supply in the West," explains Schwarzkopf.

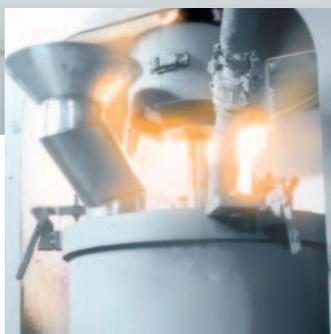
### **Supply contracts with tungsten mines**

In addition to recycling, GTP has concluded long-term finance and supply agreements with tungsten mines in the west in order to satisfy its tungsten requirements. On average, it takes between three and five years to reactivate

an inactive tungsten mine or open up a highly promising tungsten deposit. GTP participates in the financing of this initial phase and, in return, is able to conclude long-term purchase contracts. When negotiating this type of agreement, GTP takes great care to make sure that the tungsten mine is not located in a region of conflict and that the labor conditions in the mine meet the Plansee Group's Code of Conduct. At present, GTP has active partner mines in South America, Europe and Australia.

### **Molybdenum supply**

The Plansee Group took a further step toward refocusing its strategy when it acquired a holding in the world's largest molybdenum manufacturer, the Chilean raw materials group Molibdenos y Metales (Molytmet). By March 2011, the Plansee Group had acquired a 10 percent stake in this listed company which has production sites in America, Europe ▶



*Powder is more than just powder. GTP develops and specifies exactly the right type of tungsten for every application.*

► and Asia. Molymet pursues a similar strategy to ensure the availability of raw materials as the Plansee Group has adopted with GTP. Long-term delivery contracts with mines throughout America guarantee the continued supply of molybdenum ore. To reinforce its leading market position in the global supply of both molybdenum and rhenium (rhenium is a secondary product derived from the molybdenum manufacturing process), Molymet is committed to continuous investment in manufacturing technologies, capacity enhancements and the development of alternative production processes. The Plansee Group has now also gained a foothold in the Chinese market which will allow it to pursue its global raw materials procurement strategy. This has been achieved, on the one hand, through the founding of the joint venture CB-Ceratizit. This hard metals manufacturer produces tool blanks,

rods and wear parts from raw materials sourced in China. On the other, the construction of a plant in Shanghai will allow the Plansee Group to meet the demand of many suppliers to produce locally manufactured refractory metal products for the Chinese market. Here again, the raw materials are sourced in China.

### **Recycling of rare earths**

The situation with regard to the supply of the rare earths that are essential for the manufacture of many of the Plansee Group's products is also critical. For example, the GTP division needs rare earths in order to manufacture red and green phosphor for the fluorescent lamp industry. These materials are being recycled within GTP (see page 12 "From light source to raw materials source"). The division Plansee High Performance Materials uses various rare earths as alloy additives to optimize the technical

properties of its products. Molymet also helps ensure the flow of rare earth supplies and has acquired a 13 percent holding in the US company Molycorp. Molycorp operates and has expanded the West's largest mine for the extraction and preparation of rare earths. In the future, the Plansee Group will continue to work actively to ensure the supply of important raw materials. "To do this, we shall continue to invest in specific areas throughout the value chain," explains Dr. Schwarzkopf. Both through the provision of newly mined raw materials and through the recycling of new raw materials groups – with the aim of further increasing the recycling level throughout the Group from its current value of approximately 40 percent. ■

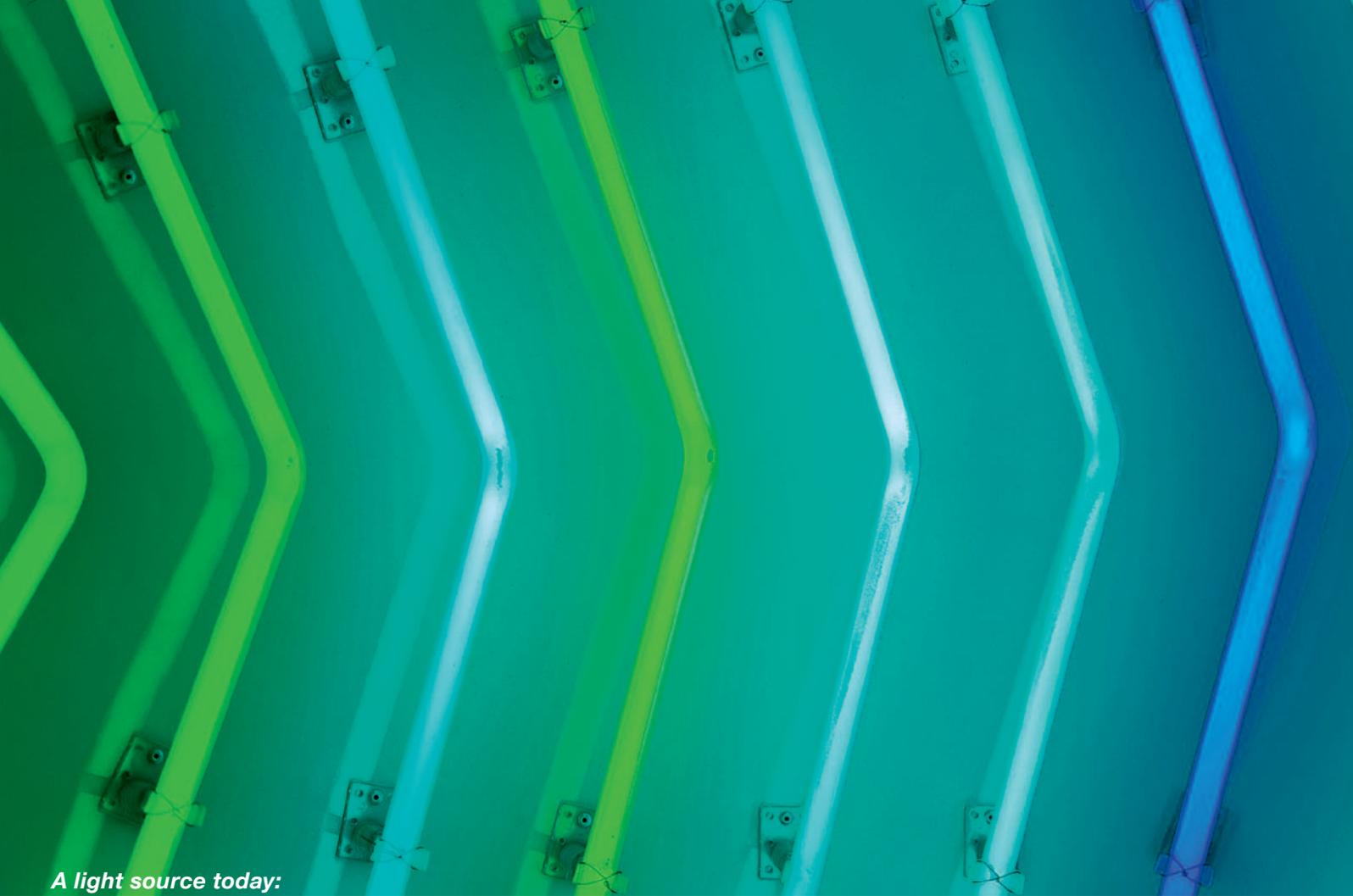


*GTP uses rare earths to produce phosphors for fluorescent lamps.*

Recycling of rare earths

# From light source to raw materials source

Using several rare earth oxides, GTP produces green and red phosphors for use in fluorescent lamps. Thanks to a new recycling process, the company is now able to close the raw material loop: 80 percent of the rare earth metals from fluorescent lamps are recovered.



### **A light source today:**

*It is phosphor that allows fluorescent lamps to emit visible light.*

- For many years, recycling has been considered to be an option rather than a necessity. Recently that paradigm has shifted with an increased interest in recycling, particularly rare earth recycling. Some of the reasons for the new interest include an exponential increase in market price for virgin or mined rare earths, fluctuating availability due to the current supply situation, and global environmental legislation. Not to be overlooked are the environmental benefits of recycling which include the recovery of critical materials, a reduction in waste sent to landfills, smaller environmental impact from production and the safe disposal of additional hazardous impurities.

### **Closing the reusable materials loop**

With all these factors in mind, GTP has developed a process to recycle rare earth material found in fluorescent lamp scrap. Working with recycling partners

across the US, GTP's process will capture rare earth metals found in these lamps in a cost effective manner. The recovered rare earth materials will be used in GTP's phosphor manufacturing process.

The process developed by GTP will capture approximately 80 percent of the rare earths found in used fluorescent lamps. The key materials recovered are yttrium, europium, lanthanum, cerium and terbium. Of the recovered elements, europium and terbium are heavy rare earths which are in the shortest supply and considered the most critical. The process has been optimized and running in our pilot plant operation for well over a year.

### **Tungsten recycling as the template**

In the development of this process, GTP borrowed technology from its tungsten recycling process, a system it pioneered over 40 years ago. Rare earth

recycling relies on similar equipment and processes as tungsten recovery – making rare earth recycling a natural fit for GTP. As with tungsten recycling, the materials recovered from rare earth reclamation are indistinguishable from virgin or mined and refined rare earths. This point is critical when approaching customers regarding the purchase of phosphor made from recycled material. Even though the recycling process is not yet in full production, GTP is already taking delivery of retorted lamp scrap. GTP works closely with lamp recyclers all over the country. Our recycling partners crush the used lamps and remove many of the impurities from the scrap through a process known as retorting. When the GTP recycling plant is running at full capacity, a significant portion of our raw material requirement will be met by using recycled rare earths. When the retorted powder arrives at GTP, additional sifting takes place to remove remaining glass and metal pieces.

***A raw material tomorrow:***

*Recycled phosphor that is once again used for the production of fluorescent lamps.*

After sifting, the material is chemically treated using a series of acid washes and filtering steps. Through the chemical treatment additional impurities are removed from the scrap, greatly concentrating the percentage of rare earths in this intermediate material. A critical step in this process is the removal of residual heavy metals including mercury from the lamp scrap. Trace amounts of these materials remain after the retorting step and must be removed as part of the recycling process.

**Separation into pure elements**

After the chemical treatment known as digestion, two concentrates are produced – one containing yttrium and europium and the other containing lanthanum, cerium and terbium. These materials are then dried and prepared for chemical separation. Through additional chemical treatment, the concentrated powders are broken down into their individual elements. These

elements are used by GTP as raw materials to produce red and green phosphor. GTP sells red and green phosphor to manufacturers of fluorescent lamps. At this point, we have completed the circle – old fluorescent lamps are re-used to make new ones. ■

# When hot semiconductor meets cold base plate

Higher performance in a smaller space: The semiconductor components used in the electronics industry produce ever more heat during operation. Efficient cooling requires the use of high-tech materials.

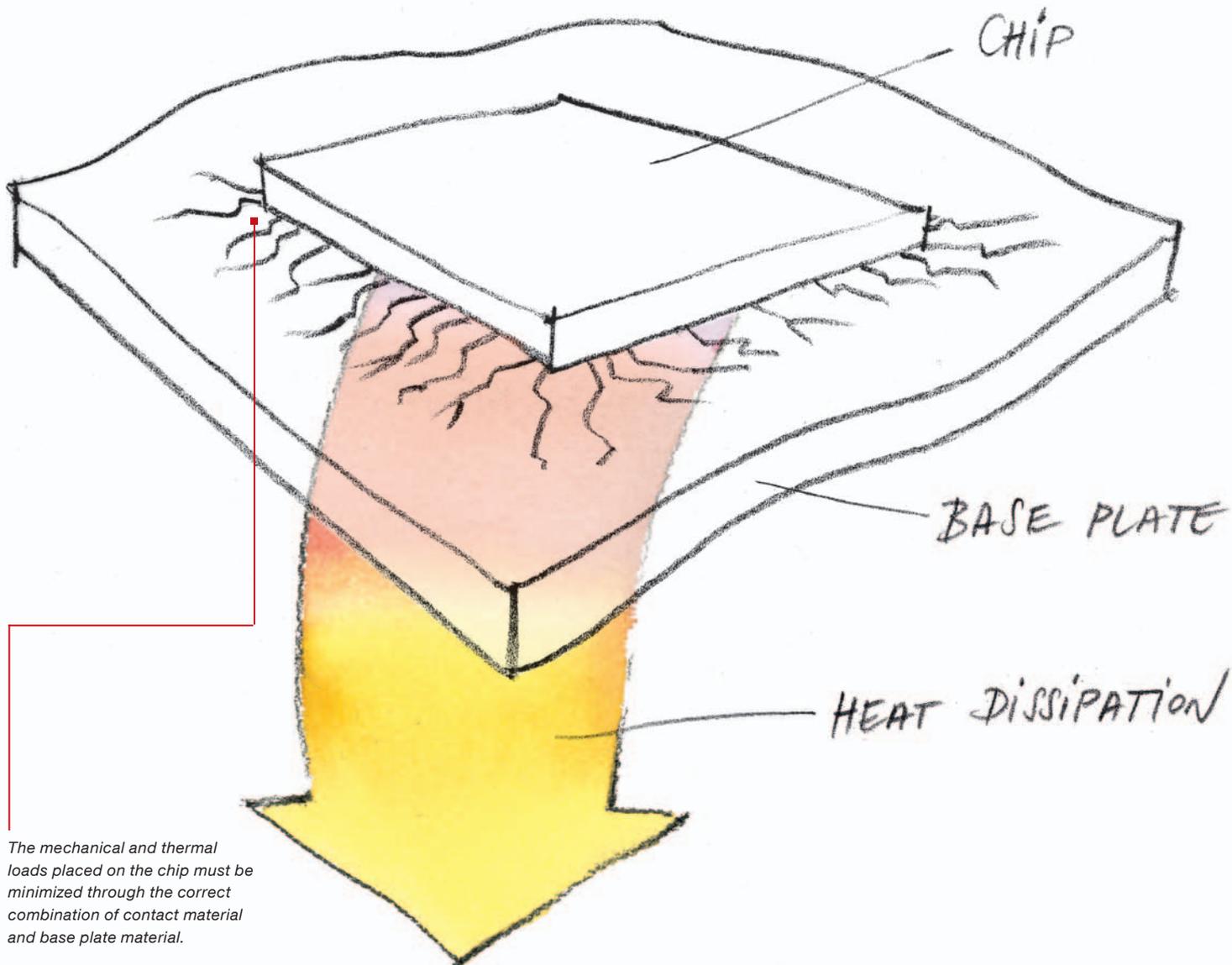
The rapid pace of technology development in semiconductor electronics is due in part to the increasing power densities provided by the components. But progress, miniaturization and continuous improvements in performance have their price: As the operating power increases, so, too, do the demands relating to thermal management in electrical systems. The power loss must be drained in the form of heat via increasingly small contact surfaces. Although state-of-the-art semiconductor technology makes it possible to reduce the level of power losses, these cannot be completely eliminated. Inadequate cooling considerably impairs the efficiency and reliability

of semiconductor components. This is because well over half of all electronic component failures are due to thermal influences. It is much rarer for such failures to be caused by vibrations, moisture, dust or other effects. Efficient thermal management is therefore of vital importance for the functionality and durability of electronic systems.

## **The search for a stable material microstructure**

Basically, to overcome this heat-related problem, it is necessary to answer two key questions in the field of electronics packaging technology: How can the heat be dissipated as quickly as possible

from the electronic system? And how is it possible to prevent harmful stresses in the material assembly between the semiconductor and the base plate? Increasingly, the designers of electronic packages are having to address the vital issue of the difference between the temperature at which semiconductors can operate reliably and the ambient temperature of the installation. The thermal design of electronic components is also dependent on the heat flux, that is to say the quantity of heat that has to be reliably dissipated via the available surface area. This problem is exacerbated by the fact that the greatest power dissipation is often concentrated in tiny surface areas



*The mechanical and thermal loads placed on the chip must be minimized through the correct combination of contact material and base plate material.*

of the chip which are known as hotspots. In the components used for power electronics, the local heat flux can vary from a few hundreds to over 1,000 Watts per square centimeter – at a maximum operating temperature of less than 150 degrees Celsius. By way of comparison: Although heat fluxes of a few kilowatts per square centimeter also occur in rocket nozzles, the temperatures in these applications however climb higher than 2,500 degrees Celsius. By contrast, a hot stovetop ring barely reaches 8 Watts per square centimeter.

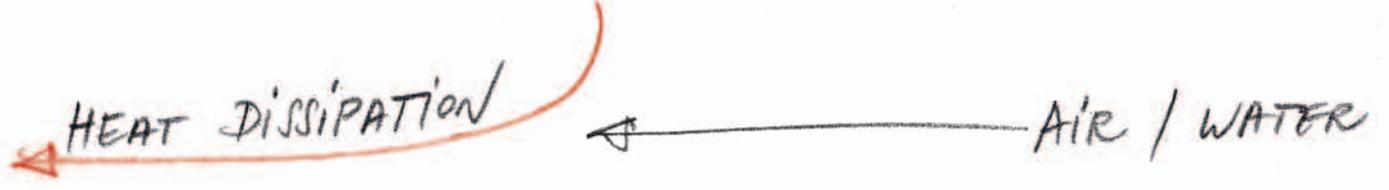
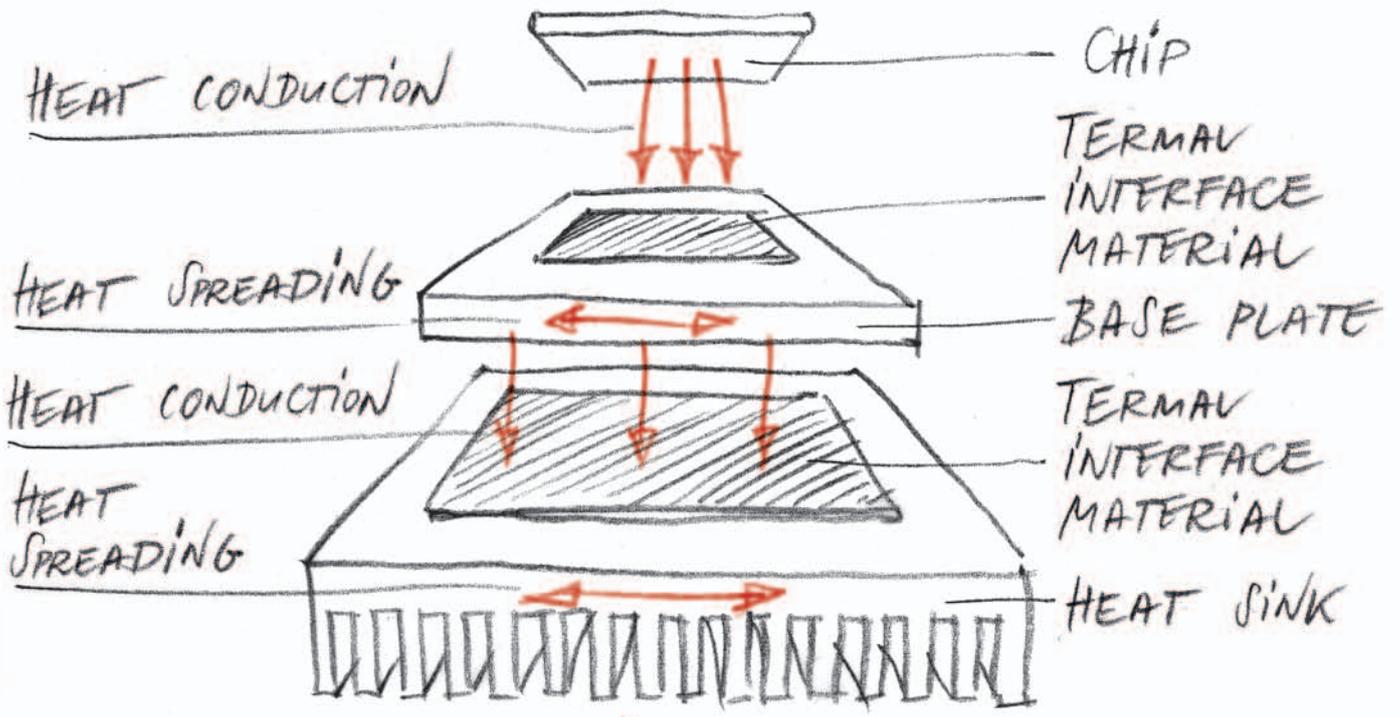
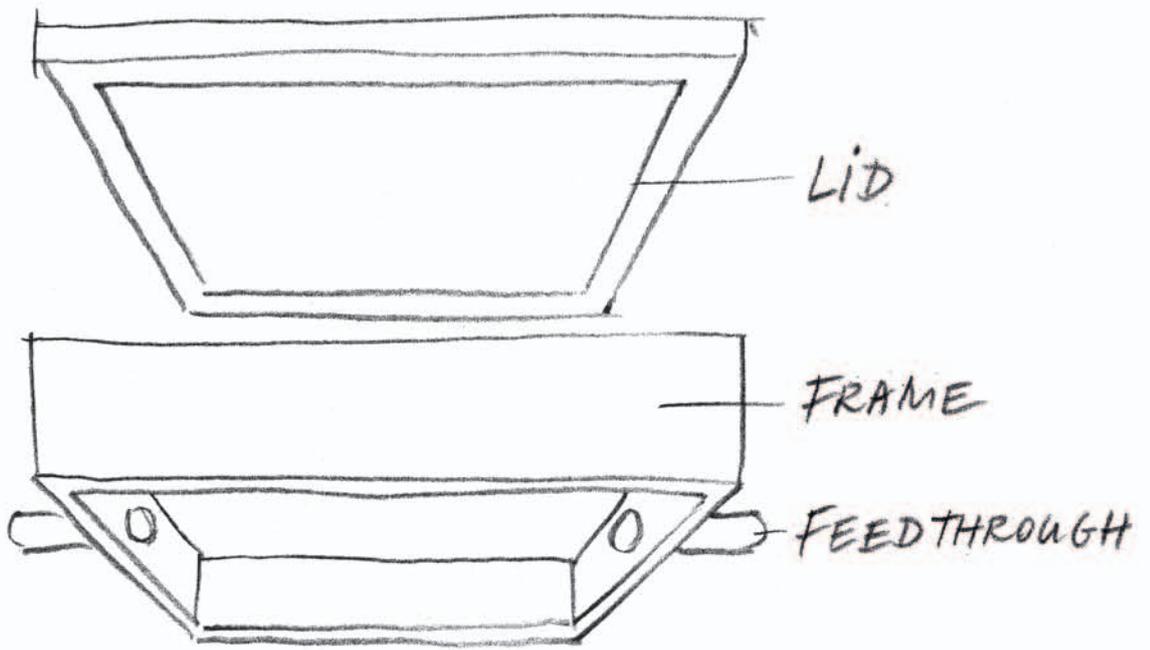
The second key question relates to the configuration “hot semiconductor meets cold base plate”. If the thermal conductiv-

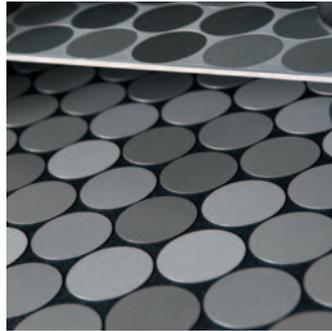
ity and thermal expansion characteristics of the semiconductor and the base plate are not optimally harmonized then undesired distortions to the semiconductor or even damage and subsequent failure are unavoidable. Which, if you look at things the other way round, means: The better harmonized the properties are, the better the semiconductor module is to withstand soldering processes involved during manufacture and the temperature cycles that occur during operation. Overall, this means: First of all, the base plate material must provide suitable thermal expansion characteristics that broadly match those of the semiconductor. In addition, the level of the expected

heat fluxes is critically important for the choice of a suitable base plate material. The greater the heat fluxes, the better the thermal conductivity of the material must be.

#### **Low expansion in hot environments**

Copper and aluminum are relatively good heat conductors and are in widespread use as heat sinks and contacts in the electronics industry. However, the great drawback lies in their high coefficient of thermal expansion. As a result, these materials are not suitable as base plate material for high-performance semiconductors that are exposed to ▶





*How a semiconductor is cooled during operation (drawing on page on left). Blanks used to manufacture base plates for RF amplifiers. Molybdenum discs for bipolar transistors in the power electronics industry. Base plate for LDMOS transistors for telecoms base stations (photos on this page, left to right).*

► significant thermal loads. The refractory metals molybdenum and tungsten are ideally suited for use as the base material due to their low coefficients of thermal expansion. These materials have been used for many years as base plates for power transistors. Composite materials based on molybdenum, tungsten and copper have also been developed for applications with demanding thermal conductivity requirements. The copper content of these composite materials can be specifically adjusted to optimally adapt the thermal properties of the base plate to the complete assembly. Due to their lower weight, molybdenum-copper composites are particularly suitable for this type of application where every gram counts. For example, in the automotive industry where they are used as carrier plates for the IGBT modules that act as inverters in electric drives.

Advanced composites possessing a number of different molybdenum and copper layers can more than double the thermal conductivity of base plates compared to pure molybdenum. Laminates of this sort are required, for example, as base

plates for high-frequency amplifiers in mobile radio base stations. Despite this, even these high-tech materials come up against their limits in electronic components subject to extreme loads, for example in newly developed GaN power transistors for radar systems and satellite communications. That is why base plates made of silver-diamond composites are currently being developed and tested. These materials, which are not as yet commercially available, offer more than twice the thermal conductivity of the carrier materials currently present on the market.

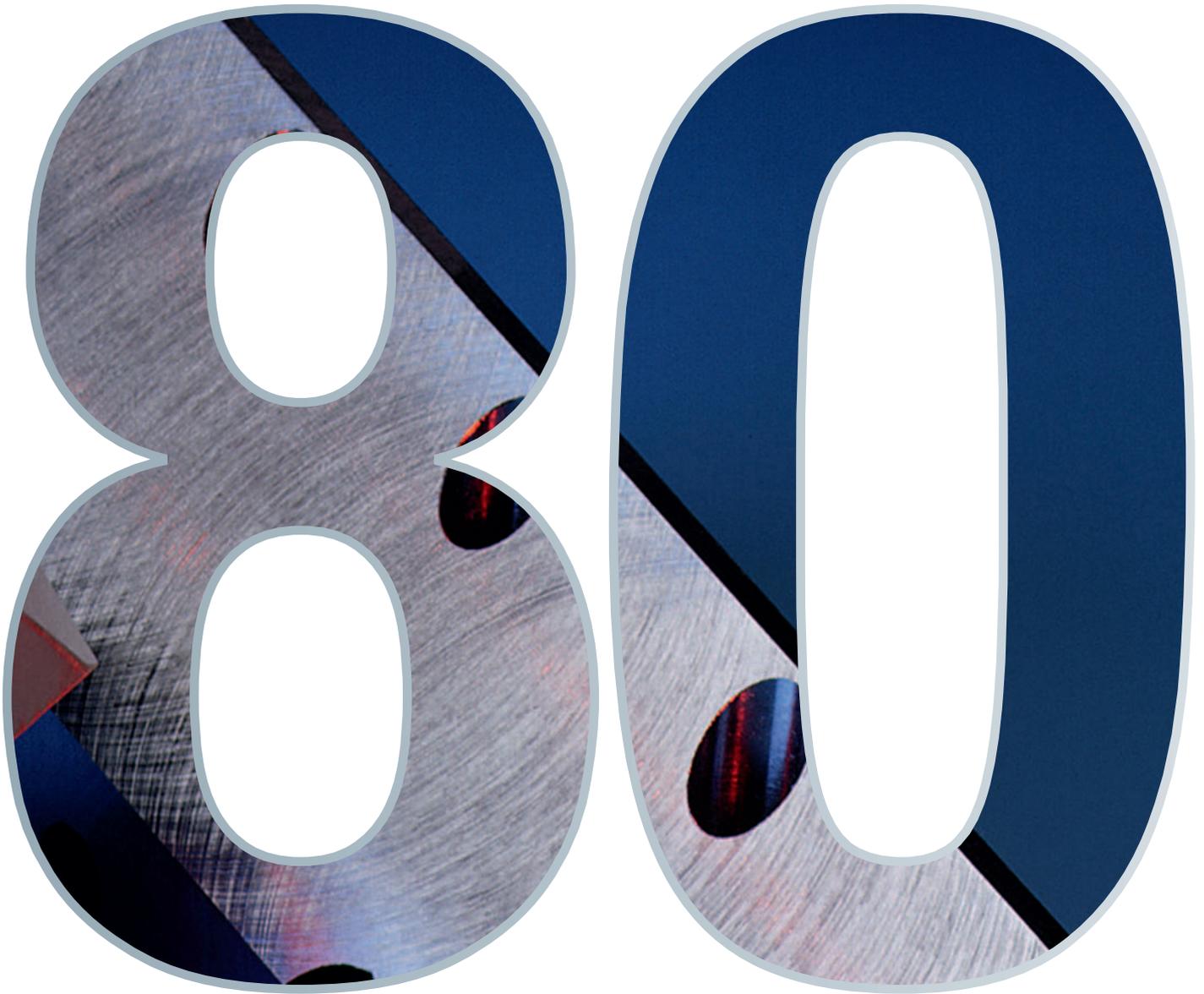
### **Economical production processes**

Plansee offers semifinished products as well as components such as heat spreaders, heat sinks and base plates for a wide range of thermal management applications in the electronics industry. All these products are fully manufactured by Plansee – from the raw material through to the finished, coated component. As well as developing prototypes for new applications and continuously optimizing its standard

products, Plansee considers the development of alternative, economical production processes to be an important way to ensure that it remains an innovative partner for the manufacturers of electronic modules and systems. ■



Flyweights in the  
heavy metal class



Doping for precisely targeted effects: Weights with a density of 18.80 grams per cubic centimeter can noticeably improve the performance of generators, golf clubs or vibration hammers.



# 18.80

*Grams per cubic centimeter. That means a lot of weight in a tiny space and the highest density that is technically viable.*

► They can either create or attenuate vibrations. They can be used in moving bodies – or in static objects. They can be extremely small or large and heavy. But heavy metal weights manufactured from tungsten alloys all have one thing in common: They make a crucial contribution whenever a lot of weight is needed in a very small space. And with a maximum value of 18.80 grams per cubic centimeter, they achieve the highest density that is technically viable for the engineering materials used in product and machine applications. By way of comparison: Iron has a density of 7.87 grams per cubic centimeter.

### **Finding the right balance in sport**

Let us take the example of the golf course. Amateurs and professionals alike are constantly working to perfect their swing, contact at the tee and ball trajectory. An appropriate balancing weight in a golf club concentrates the head of the club on the ball and can be a great help in reducing the user's handicap. By contrast, marksmen are looking for grip and stability when shooting with a pistol or

small caliber rifle. Here, balancing weights help reduce the impact from the recoil. The balancing weights used in formula 1 racing cars ensure outstanding engine performance and a stable position on the track. In this case, tests conducted in wind tunnels help achieve the perfect balance across the vehicle chassis. And even better performance and smoother engine running are made possible by applying the crucial weights at specific points on the crankshaft.

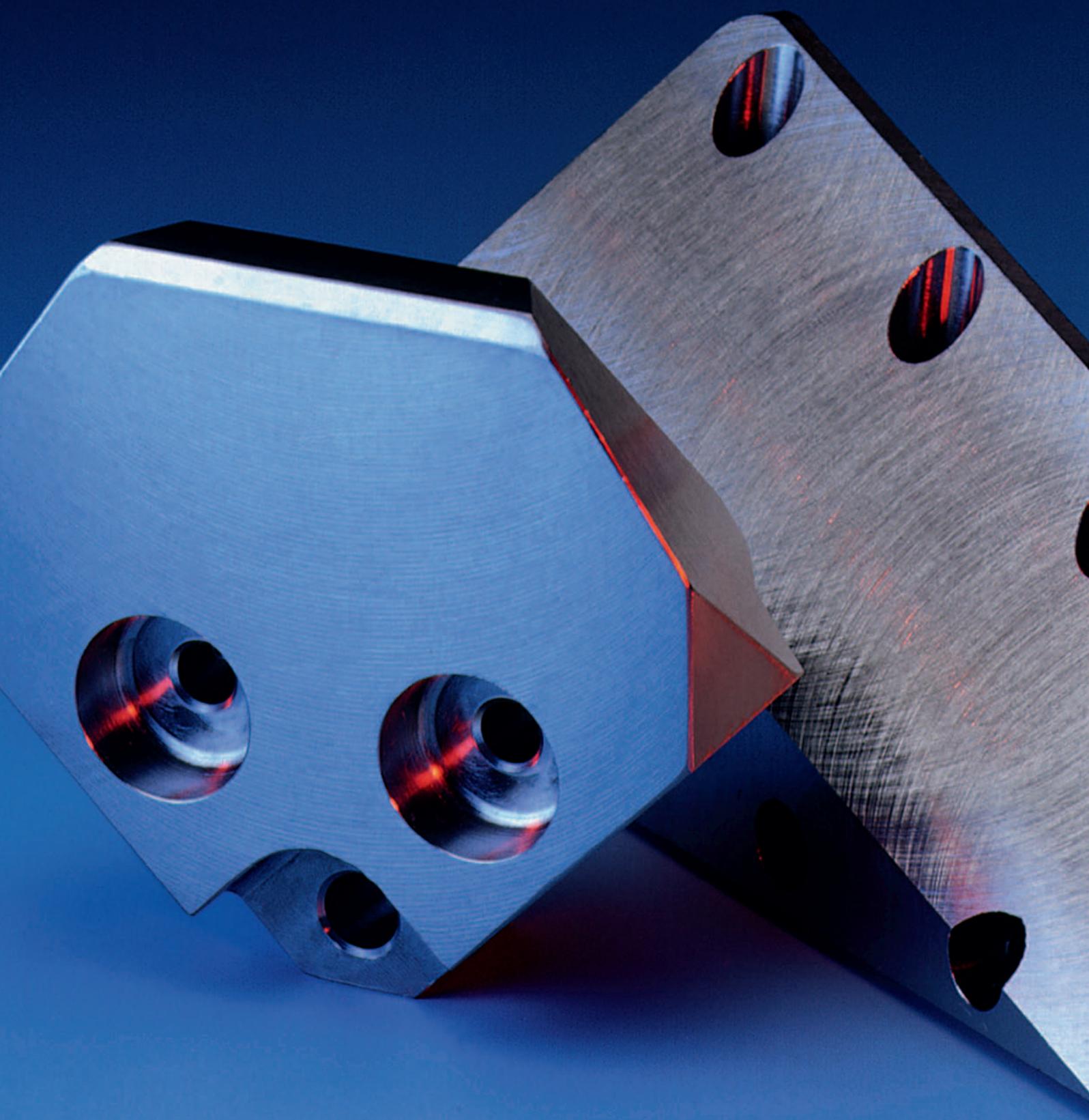
### **Indispensable – whether large or small**

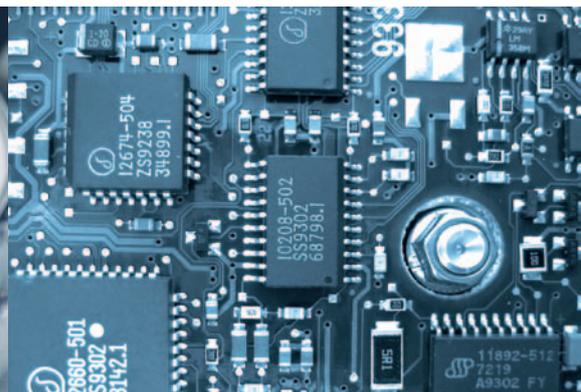
And the designers of dump trucks are looking for exactly the same qualities. These high-powered giants, which measure up to 15 meters long and ten meters wide, are the hard workers of the open-cast mining sector. To cope with the enormous stresses involved; all the components from the gears and chassis through to the axles and suspension must be perfectly adjusted. Several balancing weights weighing approximately twelve kilograms each are mounted on the large crankshaft and dampen unwanted vibra-

tions. In this way, they allow the various components to run smoothly and help greatly prolong the lives of the engines which can weigh as much as ten tonnes. The same principle can also be observed in a stationary application: The massive generators used for the extraction of natural gas in remote areas of the world. By contrast, crescent-shaped heavy metal flyweights are a thousand times lighter. These ensure movement and energy in luxury watches. These laminated flywheel masses, which weigh just ten grams, provide the precise heartbeat needed by these delicate timepieces.

### **Vibration-free operation ...**

High-precision is also essential in large optical devices where every nanometer counts. Here, however, heavy metal have the completely opposite job to do. In these systems, they must completely eliminate all vibrations in order to guarantee outstanding precision. In quiet-running tools, the task is once again to minimize excessive and unwanted tool vibration during metal machining operations. The advantage: The metal is machined faster and more ►





# 18.80

*Weights made from heavy metals compensate for oscillations, weight transfers, imbalances and vibrations, create or shift centers of gravity and more generally ensure the optimum balance. The mechanical stresses placed on components are reduced and service lives are prolonged – whether in engines, watches or helicopter blades, in rudders, optical equipment, tools or sports items.*

► quietly and the tools produce top-quality surfaces which do not have to be ground. Vibration-damping properties also have beneficial effects for the health of the users of hand-held riveting hammers. Medical examinations have shown that the presence of heavy metal in this riveting equipment attenuates vibrations to such an extent that the strain on the worker's entire arm is permanently reduced right up as far as the shoulder.

### ... or the power of vibrations

Vibratory pile driving, in contrast, calls for exactly the opposite extreme. This technique is used to insert tubes and sheet piling in the ground. At the core of any such vibratory device lies the exciter unit. This contains unbalanced masses made of heavy metals. The rotation of the shaft and resulting unbalance generates vertically oriented vibrations that drive the sheet

pilings into the ground. Even though it makes one hell of a noise: The so-called eccentric weights are of enormous help to ensure that the sheet pilings can be buried in the ground as quickly as possible – and pulled out again just as fast. In this way, they help speed up building operations. What is more, vibratory pile driving is quieter than other methods and causes less earth movement.

### From one-off products to large runs

For decades, Plansee has been supplying tailor-made (balancing) weights of all sizes and geometries to thousands of customers throughout the world. The volumes range from one-off products for particularly demanding crankshaft applications to large runs for quiet-running tools. Customers also benefit from Plansee's long-standing processing skills: From the production of the powder

through to the weight manufactured ready for installation, Plansee covers the entire value chain. Here, outstanding precision is not just desirable, it is guaranteed: State-of-the-art processing equipment ensures that no parts depart from a tolerance of only five micrometers. This precision is documented in comprehensive measurement reports.

So there only remains the question of doping which we can answer as follows: Whether creating momentum or damping movement, whether large or small, all these heavyweight helpers have one thing in common: they always make their weight count. ■

# Did you know that...

**1,000 Watts**

Materials used for thermal management applications are able to withstand heat flux densities of 1,000 Watts per square centimeter. That is 120 times the heat flux density of a hot stovetop ring.

**700 millimeters**

Ceratizit successfully stands out through its ability to supply extra-long, solid hard metal rods for the machining of large crankshafts.

**40 years**

GTP has been recycling tungsten scrap to obtain pure tungsten since the 1970s. The company has now adapted this recycling process for the recovery of rare earths from fluorescent lamps.

**99.95**

**percent** The purity of the hydrogen produced from reformed natural gas using a hydrogen separator. The hydrogen is separated using an exceptionally thin palladium layer.

**4**

**Laboratories**

The Christian-Doppler laboratories in Austria support companies in the field of applied fundamental research. With four laboratories, the Plansee Group makes intensive use of these services.

**2,000 degrees Celsius**

The sapphire used for the production of LEDs melts at this extreme temperature. Only crucibles manufactured from the high-tech materials molybdenum and tungsten are able to withstand such temperatures.

High-temperature furnace construction

# When trust pays off

Wherever annealing, pressing, sintering, melting or incineration are performed at temperatures of well over 1,000 degrees Celsius, equipment and furnace manufacturers need components produced from high-tech materials.

High-temperature systems are used whenever the requirements in terms of purity, quality or product safety are especially high. Hot isostatic presses (HIP) have the task of compacting powder metallurgical components, turbine parts for the aviation and aerospace industries or worm shafts for the plastics sector. Components for aviation and aerospace applications or the medical technology sector or power engineering sectors are annealed in high-temperature furnaces. The production of single sapphire crystals, which represents the first step during LED manufacture, takes place at approximately 2,100 degrees Celsius – an environment that places severe demands on the melting operations performed in the production crucibles as well as on the heating technology. The case of waste incineration plants provides a particularly clear example. The higher the temperature at which the waste is treated, the lower the level of environmentally harmful toxic residue. Consequently, here, too, materials that are able to withstand high temperatures are required for the combustion chambers. High-temperature furnaces are able to cope with these

demands. They are often pushed to the limits of what is physically possible. And it is precisely in such hot-to-handle applications that high-tech materials made from molybdenum and tungsten are indispensable: As hot zones or heating elements. As shielding. As charge carriers or boats. Or as crucibles. And all this in a way that is ever more energy-efficient, guarantees a longer service life and permits increasingly large dimensions. Furthermore, it is important to remember: Almost every furnace is a unique product that has been optimized for the temperature, cycle time and atmosphere that characterize the customer's specific application.

## A single supplier to cover all needs

To ensure the success of this type of project, customers worldwide count on Plansee's many decades of experience. The customer can source everything required from a single supplier – from engineering through development and design and on to the manufacture of the highly complex products. And the more solid the basis of trust that underpins the collaboration, the better, in all probability, the result will be. Because the more detailed the under-

standing that Plansee's engineers have of the customer's processes and applications, the better able they are to develop a tailor-made solution.

That is how Plansee was recently able to deliver the largest ever hot zone for a high vacuum furnace. The furnace-maker received an end-to-end solution – from design and manufacture through to the assembly of the 50,000 individual parts. 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. Of crucial importance for the purely metallic design of the hot zone was the fact that the equipment and products were protected by exceptionally high-purity materials guaranteed to be free of carbon. And thanks to the new hot zone, the electricity bill for running the high-vacuum furnace has also been drastically reduced. Due to its lightweight construction and the use of new materials combinations, the hot zone developed by Plansee requires up to 25 percent less energy than conventional metal hot zones. Plansee's outstandingly equipped machine pool represents a crucial prerequisite for ►



*Metal hot zones for high-temperature furnaces consist of thousands of individual parts.*



*Hot zone for a high-temperature installation. The customer can source everything required from a single supplier – from engineering through development and design and on to manufacture and assembly.*

► the completion of such record-breaking projects. As a result, Plansee has exactly the right tools to manufacture the components required for such large-scale products extremely efficiently, precisely and in the necessary quantities.

### **Protective layer to prevent oxidation**

Plansee has also achieved a new milestone in the field of high-temperature equipment construction with a massive cylinder for the world's largest hot isostatic press. The cylinder, which is five meters long and 2.2 meters in diameter, was manufactured completely from the high-tech molybdenum alloy TZM (titanium-zirconium-molybdenum). One crucial factor in such large-scale projects is the fact that Plansee is able to perform all the manufacturing steps itself – in this case, from the powder, through the production of the metal sheets and on to the spray-sealed cylinder. High-temperature waste incineration represents a growing market. The higher the temperature, the more inorganic material there is at the end of the combustion process. More and more governments are introducing legislation to make this process mandatory. Rotary furnaces can be

used, for example, for the highly efficient thermal disintegration of hazardous waste. The rotary tube inside the furnace is able to withstand temperatures of up to 1,400 degrees Celsius. In non-stop use. Because it is continuously being filled with material. Rotary furnaces usually work for 24 hours a day – for weeks on end. To protect the Achilles' heel of the tube, which is manufactured from molybdenum, a material that oxidizes at temperatures as low as 400 degrees Celsius, it is sealed with a hard, dense layer. The result: Protection against oxidation is now effective at up to 1,500 degrees Celsius. Plansee has also recently constructed and delivered a prototype burner nozzle with an extremely complex design for the efficient incineration of biomass and old oils.

### **Series production up and running fast**

However, it is not always simply the sheer size of a project that inspires Plansee's designers and planners to achieve exceptional performances. Faced with last year's boom in demand for LEDs, they were confronted with the challenge of creating huge production capacities for hot zones

and crucibles for sapphire melting. The melting of sapphire is the first production step during LED manufacture. Whereas in the past, the crucibles used for production had only been manufactured on a one-off basis, Plansee suddenly had to get a series production solution up-and-running in just a few months. But success came as no surprise – the technologies and equipment required for manufacturing were all already available and simply had to be adapted to the requirements of this new large-scale order.

However, as in other sectors, market launch is once again only the beginning. As a result, Plansee helps its customers to continue to succeed in dynamic markets such as the LED sector through the ongoing further development of its products. This is possible because Plansee's engineers are fully familiar with every detail of their customers' application technologies. And because they use their in-depth understanding of the loads placed on the molybdenum and tungsten components in high-temperature applications to develop a stream of new ideas and solutions that set new standards in the field of high-temperature plant construction. ■



# Insights

## Gain new insights

18 | PLANSEE  
SEMINAR  
2013

3 – 7 June 2013

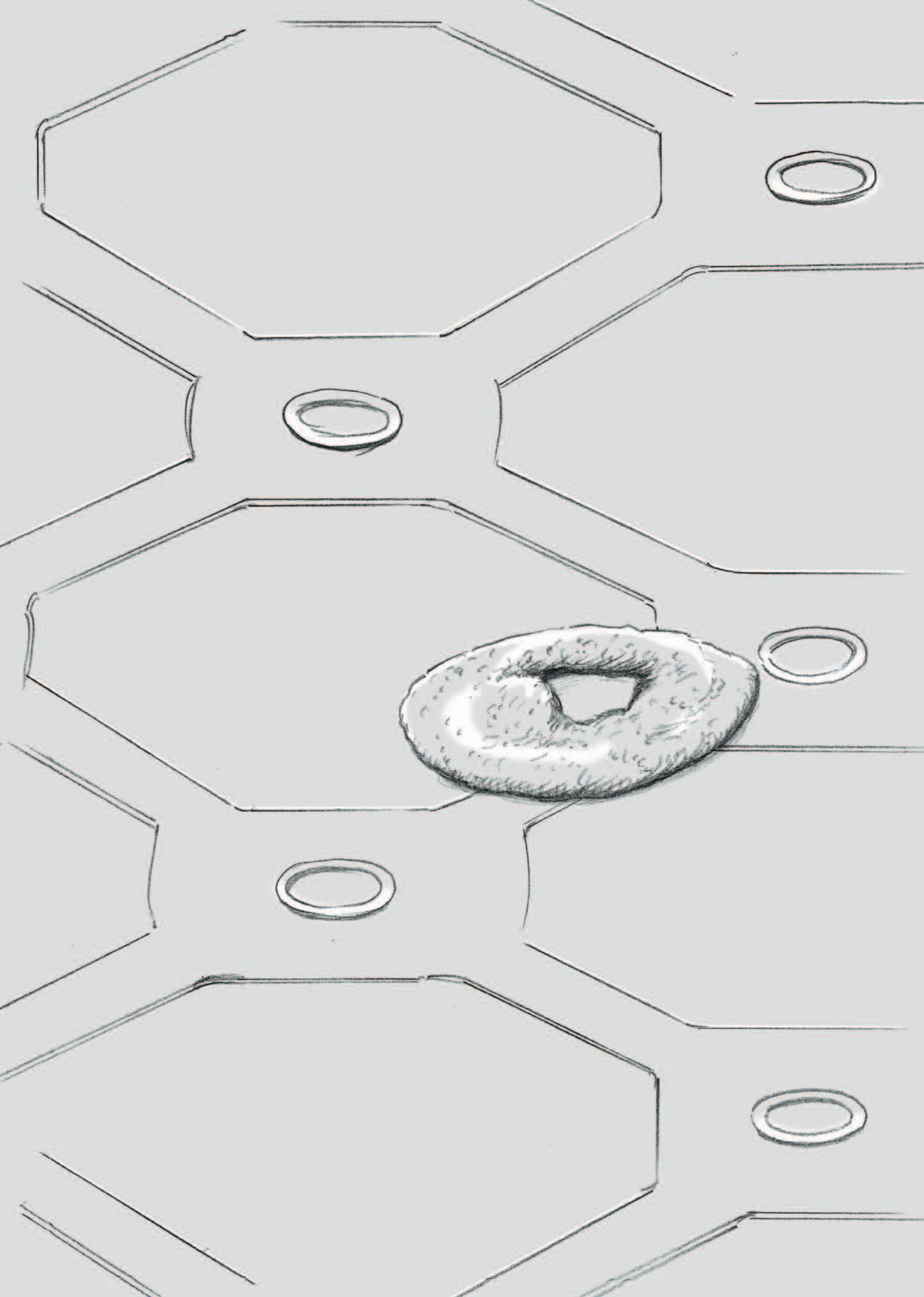
World's largest conference on powder metallurgical high performance materials

- 3 – 7 June 2013 in Reutte/Austria
- Provisional program and registration at [www.plansee-seminar.com](http://www.plansee-seminar.com)
- 250 oral and poster contributions
- 500 industry and research experts from 40 nations expected

Register before April 5, 2013 and pay 1,090 euros for the full five-day program

- entry to all oral and poster presentations
- comprehensive seminar documentation
- catering, transfers, evening program

**plansee**  
GROUP



OLED displays

# Perfect layers for crystal clear images

Crystal clear images on OLED displays. TV and smartphone users may take them for granted. For manufacturers they mean the interplay of many different ultra-thin layers.

*Only visible under a scanning electron microscope: Flaws during coating that can impair the correct functioning of displays.*

Whereas the LCD technology used for displays consists primarily of a color filter that needs background illumination, OLEDs actually emit colored light.

In simple terms, an OLED color television consists of a thin glass substrate coated with numerous exceptionally thin layers. Each of these films has a very specific function and only the right combination of all these layers results in an excellent image quality. Provided, however, that each layer has been deposited without defects. To guarantee this, it is necessary to use coating materials of the very highest quality.

## Electrically conductive layer

It takes a scanning electron microscope to reveal the fine difference between top quality and an unusable product. During the deposition of the thin films as part of the production process, particles may form and remain on the glass substrate. As soon as crater-like structures or “splashes”, which resemble tiny molehills, form over or next to the correctly aligned conductor strips then the display is fit only for scrap. This is because these particles can cause short-circuiting in the thin-film transistor

and the associated pixel then lights up either permanently or not at all. No-one would want to have a television set like that in their living room.

At least one of the many layers found in an OLED display is made of pure molybdenum which acts as an electrode in the thin-film transistor that controls the brightness of individual pixels. To perform coating, the display industry is increasingly turning to tubular coating materials. In this particular case, an extremely pure, non-porous molybdenum tubular rotary sputtering target with a density of almost 100 percent. Such targets permit a deposition process that all but excludes the possibility of particle formation. The result: flawless thin films.

## Soldered to carrier tubes

Plansee has solved the technological challenges involved in the series production of these rotary targets. The manufacturing chain covers all the necessary steps: From the preparation of the employed raw materials through to the delivery of the rotary target ready for use as soon as it has been installed in the customer's coating system.

The sputtering targets manufactured by Plansee have to be soldered (“bonded”) onto backing tubes before they can be used in coating systems. Plansee performs this operation at its own production sites located locally close to its customers: In Japan, China and Taiwan and now, since the recent acquisition of the company TCB, also in Korea. In this way, Plansee is able to supply Asian display and electronics firms directly with ready-to-use coating materials. These coating materials are developed and tested in Plansee's own application center. This houses a PVD coating system together with a clean room and high-resolution analytical instruments. The application center's scientists and engineers develop the layers required for the customer's application in pilot scale. If testing is successful and accepted by the customer then the first coating materials are produced for use in the customer's own systems. With the aim of achieving the perfect coatings that TV or smartphone users justifiably expect from their OLED displays. ■

Extended milling program: the MaxiMill 274

# A milling cutter like a cake knife



*In great demand for the machining of turbine blades for ships and airplanes: A milling cutter as soft as butter.*

When conditions are unstable or milling cutters are used in low-performance machines then the resulting cutting forces are weak. Ceratizit has developed one of the sharpest milling systems ever to cope with precisely such circumstances.

The cutting tools industry tends to make use of terms such as “exceptionally hard” or “toughness”. At first glance, concepts such as “soft cutting” seem out of place in such a world. But that is exactly what makes the advanced MaxiMill 274 milling system special. And it is precisely this type of system that is required when the conditions under which parts are machined are unstable or machines with only low performance capabilities are used. Because the sharper the system is, the gentler the resulting cut. The cutting forces applied to the workpiece are reduced and this in turn improves surface quality and dimensional accuracy.

One everyday example makes this clear: If you want to cut a slice of cream tart using a cake knife, it gives way under the pressure, the surface becomes uneven and the tart may even fall to pieces. This example also applies to the mechanical cutting industry. The machining of the blades on turbine wheels is usually performed with the workpiece in a relatively unstable position. This is because each of them is manufactured from a single block of material and is

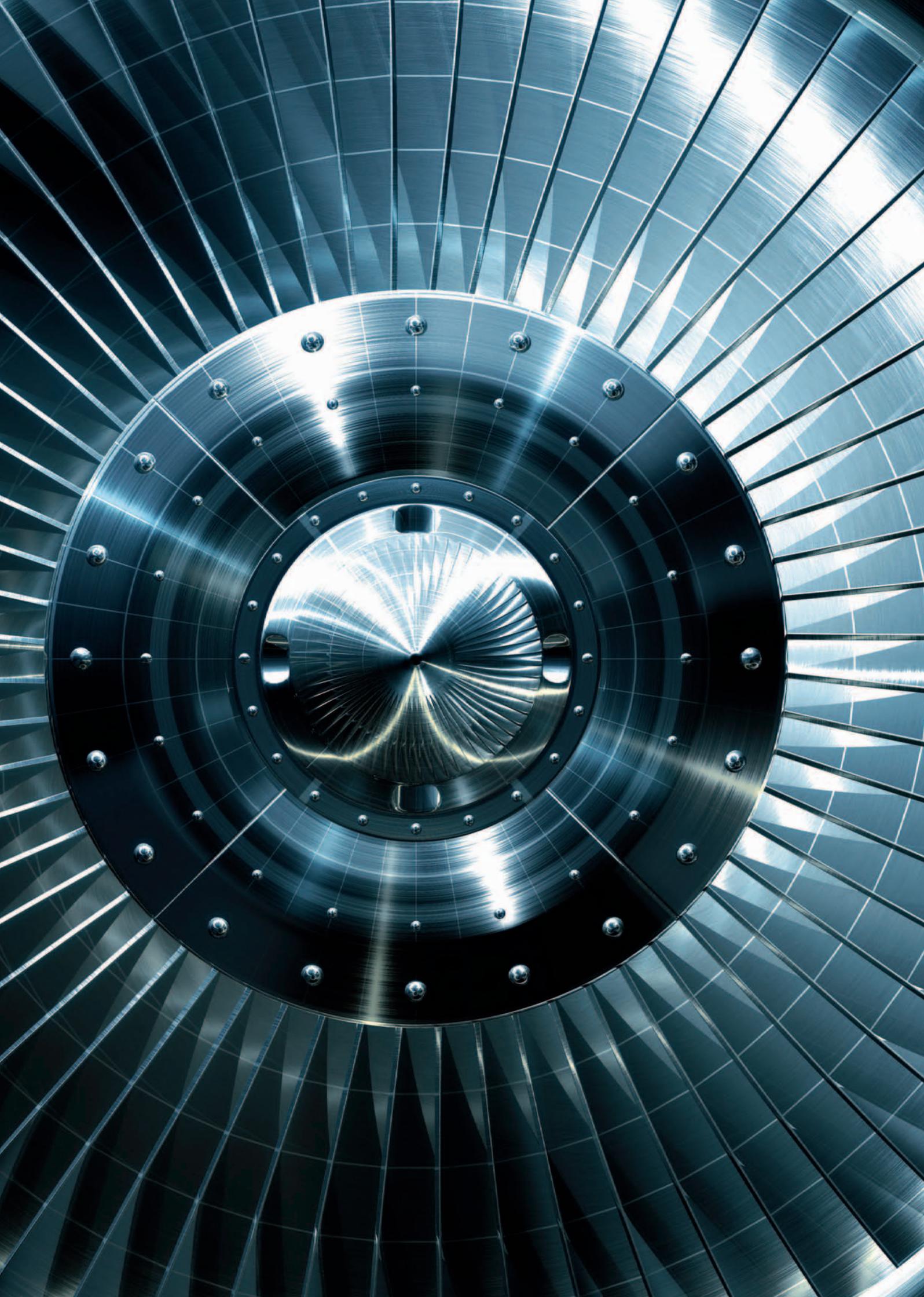
machined as a single item. This is necessary because they are subject to heavy loads when in operation in power stations and may break at high speeds of rotation. For machining, the blade is clamped between a chuck and a drive axis, with the result that oscillations and vibrations may arise. This represents a challenge for both the user and the machine. The turbine blade will only have the required quality if the cutting forces applied to the workpiece by the milling cutter are low. That is to say if a sharply pointed cutting edge is applied to the blade and it is cut softly.

The sharp cutting edge makes it possible to leave a considerable space between the indexable cutting insert and the workpiece. The system therefore has a greater clearance angle. In this way, Ceratizit has developed one of the most positive and soft-cutting milling systems available. Compared to similar systems, the MaxiMill 274 reduces the cutting forces by up to 20 percent. This has made it possible to prolong the service life by up to 50 percent. The milling cutter has also proved successful when used in low-performance

machines. In this type of machine, lathing can be performed at the same time as milling. The drive power at the turret head is not the same as that found in a normal milling machine and it is therefore not possible to achieve a high cutting performance.

## **For all materials and milling types**

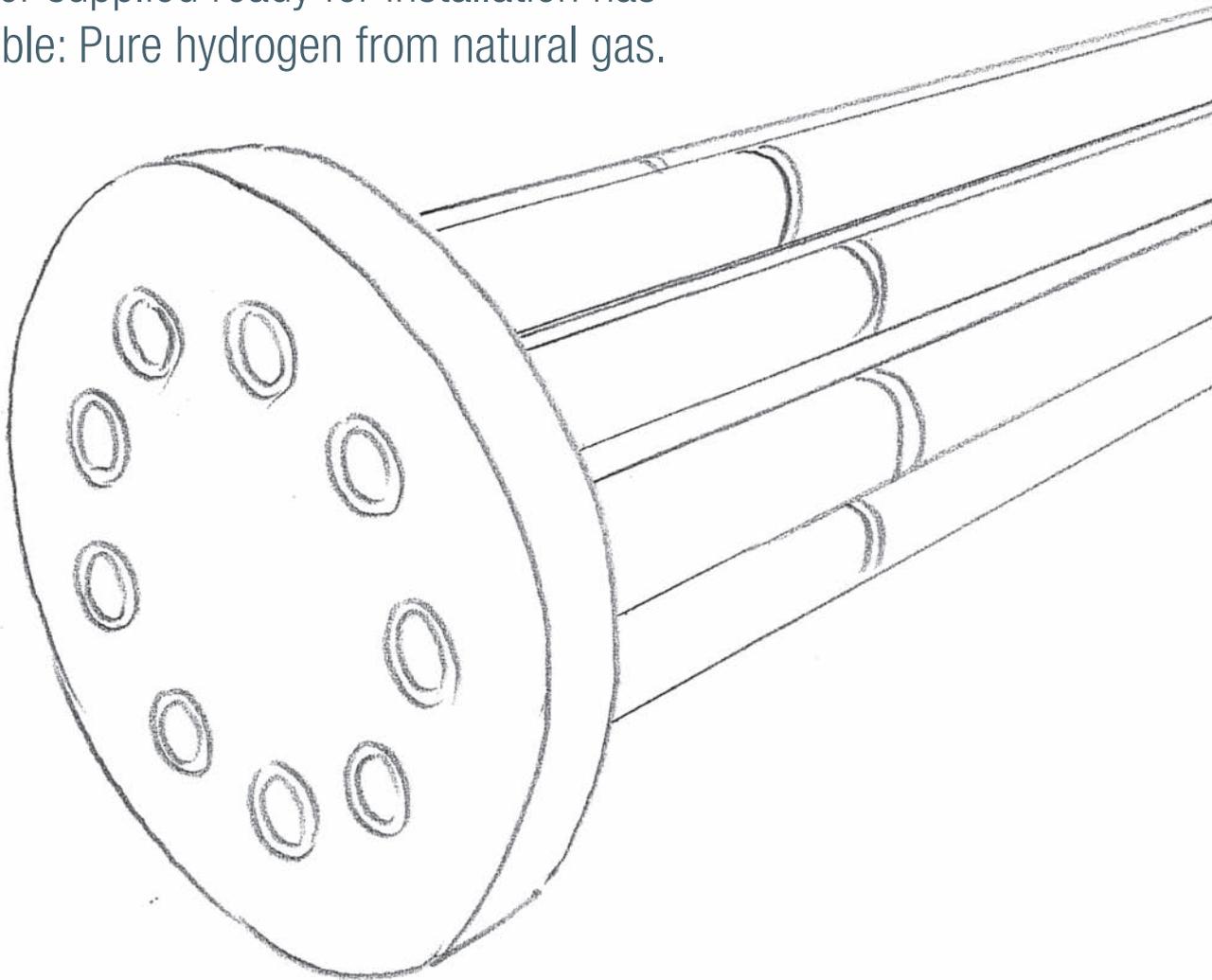
Ceratizit has extended the milling system, already equipped with an eightfold indexable cutting insert, to include a fourfold cutting insert. This means that alongside the previous cutting depth of 2.5 millimeters, it is now possible to achieve cutting depths of 3.8 millimeters using this milling system. In addition, the milling system possesses a number of different groove widths and is therefore suitable for use in a wide range of applications: Steel materials or stainless steel through to castings and titanium alloys. What is more, the different machining methods such as slot milling, chamfer milling and rotary plunge cutting cause it no problems, despite the fact that its primary area of use is face milling. An all-round performer with an exceptionally soft cut. ■



Membrane reformation

# No barriers to hydrogen

A hydrogen separator with an extremely thin palladium layer supplied ready for installation has made it possible: Pure hydrogen from natural gas.



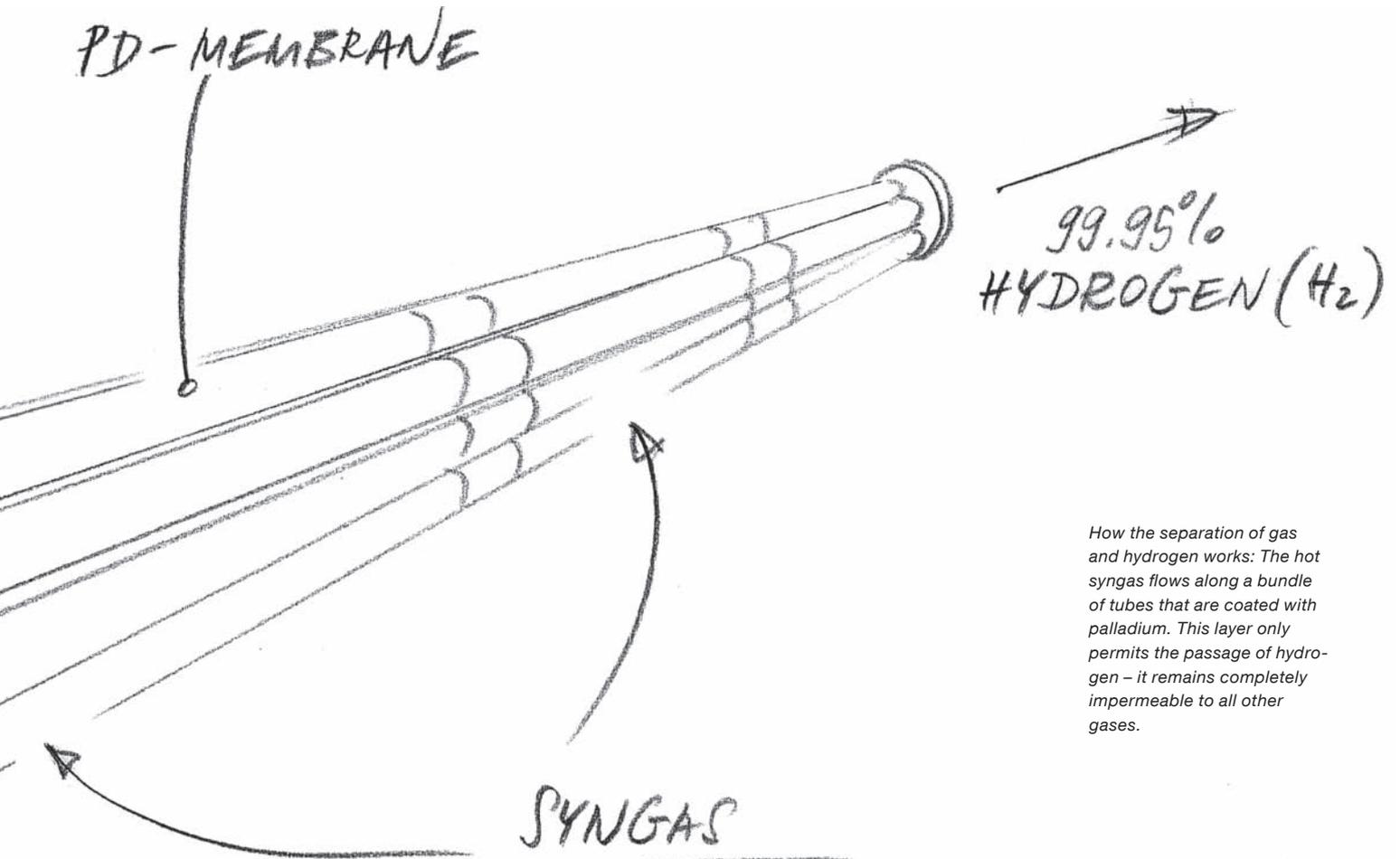
In the past there was only one economically viable way to produce hydrogen: Steam reformation. When it comes to producing large volumes of the gas, the use of this process is undisputed. But for users with smaller requirements, steam reformation is not economical. In the past, such users who consume less than

500 cubic meters per hour had to be supplied with hydrogen by truck – a complex and expensive solution.

## Green light for hydrogen

Thanks to a newly developed system, the company Linde has now managed to close the gap between large-scale

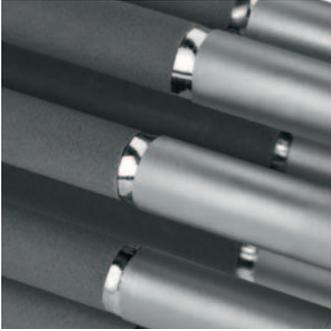
hydrogen production and the supply of very small consumers using gas bottles. Using a membrane reformation method, customers can now be reliably supplied with pure hydrogen on-site. The key to the successful industrial implementation of the membrane reformation technique: A hydrogen separator supplied ready for



*How the separation of gas and hydrogen works: The hot syngas flows along a bundle of tubes that are coated with palladium. This layer only permits the passage of hydrogen – it remains completely impermeable to all other gases.*

HYDROGEN ( $H_2$ )  
 CARBON MONOXIDE ( $CO$ )  
 CARBON DIOXIDE ( $CO_2$ )  
 METHANE ( $CH_4$ )  
 WATER ( $H_2O$ )

installation. This consists of a number of tubes made of a porously sintered special alloy coated with an exceptionally fine palladium layer. This thin palladium layer possesses one outstanding property: It only permits the passage of hydrogen – all other gases are refused entry. ▶



*Hydrogen separator ready for installation: Multiple carrier tubes are welded together and equipped with connectors.*

### ► **How the layer works**

So much for the principle. But, as ever, the devil is in the details. The problem lies in designing the manufacturing process in such a way that two key aims are achieved. One challenge consists in ensuring that the palladium layer remains genuinely impermeable to absolutely everything other than hydrogen. The layer must therefore be thick and gastight enough to act as an effective barrier against all other gases. But the aim pursued by the design engineers is practically the opposite: For them, the layer cannot be thin enough. The thinner the layer is, the greater the hydrogen flow through it. And a higher flow means a more efficient system. For Plansee's coating experts, the aim was therefore to develop a gastight layer that ensures a maximized hydrogen flow. The result: The eight micrometer thick palladium layer makes it possible to

produce hydrogen of a purity of at least 99.95 percent. It is expected that this level will be improved in the future. This will also make the system attractive to customers who have even more exacting requirements regarding hydrogen purity.

### **Iron-chromium carrier tube**

However, before it was possible to extract the pure hydrogen, the design engineers had to overcome another challenge. This results from the enormous load placed on the components during operation. The gas mixture that is fed into the tubular reformer has a temperature of around 600 degrees Celsius. The carrier tube, which is manufactured from iron and chromium, must withstand these temperatures undistorted for over 20,000 operating hours. In addition, the carrier material and palladium layer must expand and contract as little as possible when heated and cooled to prevent

stresses in the material microstructure. And, finally, it was also necessary to insert a ceramic separator layer between the iron-chromium tube and the palladium layer to prevent any interaction between the properties of the two materials.

The hydrogen separator, which is the fruit of an intensive development partnership between Linde and Plansee, represents another building block for the hydrogen-based economy. Plansee's porous metal substrates have already been used for many years as carrier materials for electricity and gas distribution in high-temperature fuel cells. ■

High-temperature fuel cell

# Keeping in shape

GTP's first automated production line for interconnects came on line in the spring.



Interconnects are key components in fuel cells where they make a crucial contribution to ensuring a clean, reliable, economical energy supply. With its production line in Towanda, the Plansee Group now manufactures interconnects at two sites: In Towanda, Pennsylvania and Reutte in Austria – and in proximity to its American and European customers. Below is an overview of the series production of interconnects: The process starts with a homogeneously mixed chromium-iron powder. The interconnect is given its geometrically demanding shape and surface properties in a large-scale press.

The production steps that follow are of crucial importance if the interconnects are to withstand the massive stresses they are exposed to during continuous fuel cell operation. These harsh conditions are caused by the extreme heat produced by the electrochemical reaction in the fuel

cell. Here, temperatures climb as high as 850 degrees Celsius. During operation, the surface of the interconnect is exposed on one side to the oxygen in the air. Simultaneously, the opposite side has to withstand high hydrogen concentrations. All this is no problem for our interconnects: Thanks to the heat treatment during sintering and the protective layer that is subsequently applied to them, the interconnects permanently retain their mechanical, chemical and physical properties as well the necessary geometry.

## **Second production line planned.**

The Plansee Group is one of the world's largest manufacturers of interconnects for high-temperature fuel cells and is currently planning to respond to the high level of market demand by building a second production line for interconnects at the Towanda site. ■

*New powder-metallurgical production line for the manufacture of interconnects for high-temperature fuel cells in Towanda, USA.*

Power-heat cogeneration

# Turning natural gas into electricity

Prototype fuel cell device that runs on natural gas with an output of over 5 kilowatts and an electrical efficiency of over 50 percent.

*Metal interconnects link together the anodes and cathodes of the individual cells and distribute fuel gas and air.*

The conclusion of the test phase should result in a prototype that offers industrial companies active in this sector a solid base on which to develop and market their own products. Because the system possesses a modular architecture, the developed platform can be scaled up to 20 kilowatts.

There is a great demand for highly efficient, low-noise power-heat cogeneration systems that combine low emissions with output levels of between 5 and 25 kilowatts. Motor-driven generators are not viable here because of the low level of efficiency they provide. By contrast, SOFC fuel cells reach levels of efficiency in this output range that thermal engines are able to achieve only when implemented on a correspondingly larger scale. SOFC fuel cells are suitable for use in apartment blocks, small businesses, supermarkets, restaurants, hotels and public facilities. However, SOFC fuel cells also represent an interesting option for, and are already being used in, applications requiring between 100 kilowatts and 1 megawatt such as data centers or hospitals.

## Successful tests

A solid oxide fuel cell (SOFC) operates at temperatures of between 650 and 1,000 degrees Celsius. Unlike other types of fuel cell, the SOFC is able to use oxygen not only to transform hydrogen into water but also to convert carbon monoxide (CO) into carbon dioxide (CO<sub>2</sub>). During these electrochemical reactions, more than 50 percent of the energy present in the gases is converted into electrical current.

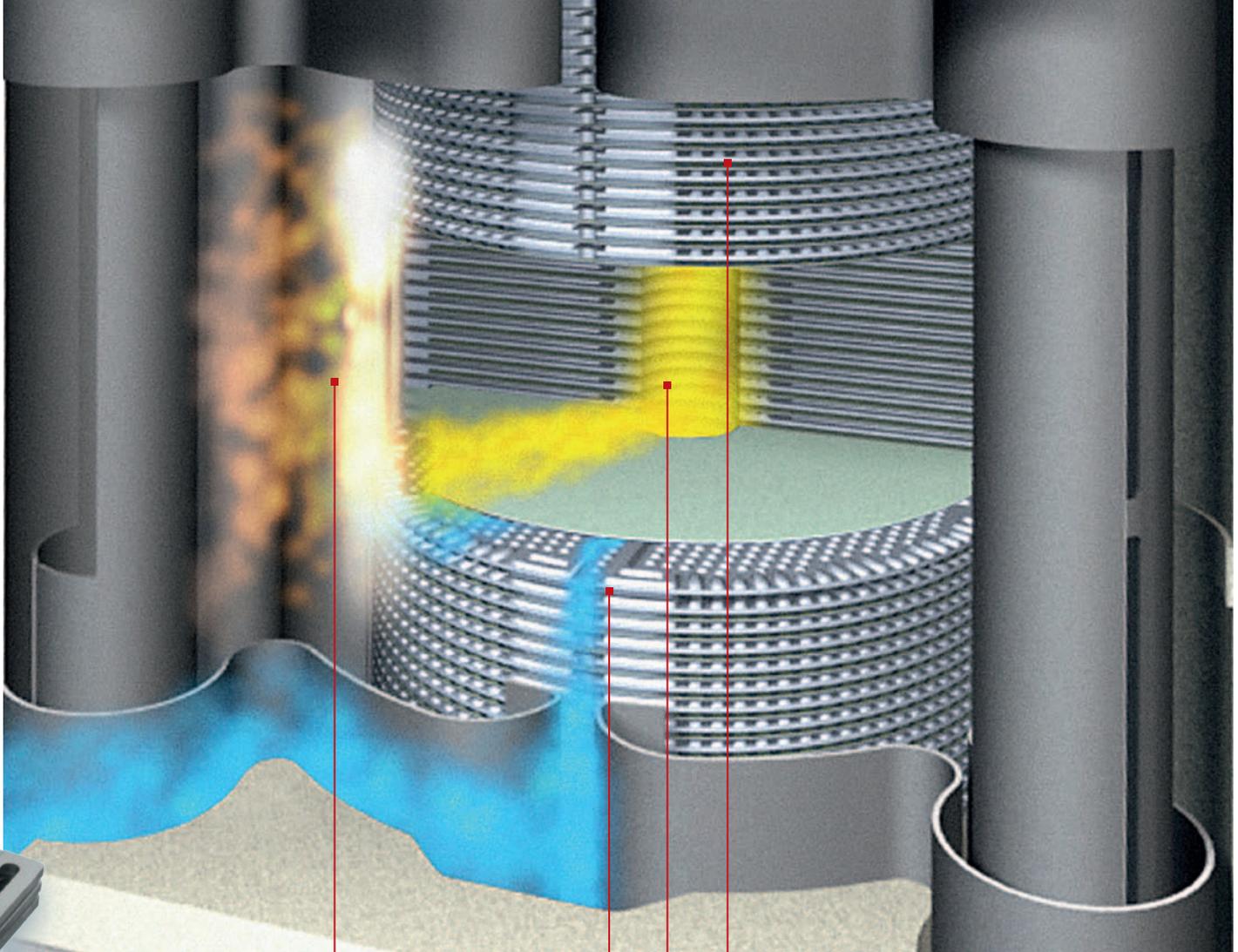
The high operating temperature in the SOFC represents a decisive advantage: The fuel cell system converts gases which have a hydrocarbon content, such as natural gas or biogas into hydrogen and CO or CO<sub>2</sub> by means of a reforming reaction. By contrast, the operation of other types of fuel cell that have lower operating temperatures, such as PEM (Proton Exchange Membrane) fuel cells for example, demands the use of extremely pure hydrogen. These constraints concerning the fuel, combined with the low electrical efficiency of such systems, significantly limits their scope of application.

## Structure of the fuel cell

Metal interconnects link together the anodes and cathodes of the individual cells and distribute fuel gas and air to the active surfaces. The cells are arranged one above the other to form a stack. The stacks in an SOFC are housed in the hotbox. This hotbox protects the remaining structure of the fuel cell system from the high temperatures and contains not only the stack but also the electricity, fuel gas, air and sensor lines. Initial tests of a 5 kilowatt hotbox containing eight stacks connected in series were successfully concluded in March 2012.

The peripheral equipment supplies the stacks with all the necessary media. Among other things, it contains a desulfurization unit for the fuel gas, all the control mechanisms for the fuel gas and air, heat exchangers, a fan and an inverter





*Presentation of the operating principle of the SOFC fuel cell based on the example of a 1 kilowatt fuel cell system manufactured by Hexis AG.*

that converts the DC current produced by the fuel cell into an AC output.

### **Interconnect with protective layer**

Measuring 150 x 130 millimeters, the interconnects supplied by Plansee for this project are the largest SOFC interconnects with integrated protective coating so far manufactured using powder metallurgical methods. The interconnects are made of chromium, iron and yttrium. Their coefficient of expansion is optimally adapted to that of the electrolyte. Unlike customer-specific, protected designs, this stack platform is the result of in-house developments and is therefore freely available for all potential project partners and customers. ■

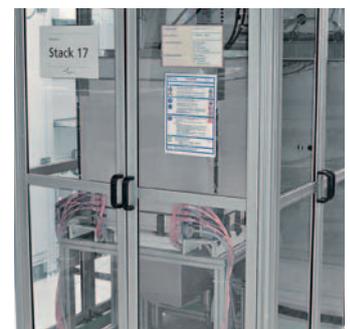
*Air supply to the cathodes. The oxygen ions that are formed here pass through the electrolyte to the anode.*

*Post-combustion area: The residual hydrogen emitted from the anodes and the airborne oxygen emitted from the cathodes are combined here. The combustion reaction results in the formation of water vapor.*

*Every cell level in the fuel cell stack consists of a metallic CFY interconnect as well as a cathode, electrolyte and anode (light green).*

*Fuel gas supply to the anodes. The hydrogen in the fuel gas reacts with the oxygen that are transported through the electrolyte to produce water. This reaction releases electrons.*

*Assembly of the fuel cell stack and installation in the 5 kilowatt hotbox.*





# “Knowledge can’t simply be copied down”

The Plansee Group calls on the services of the laboratories at the Christian-Doppler-Forschungsgesellschaft set up to advance basic research that has relevance for practical applications. An interview with the President of the research association Professor Reinhart Kögerler.

**livingmetals:** What are the objectives of the CD laboratories?

**Prof. Dr. Reinhart Kögerler:** We provide support for companies in basic research that has relevance to practical applications.

**livingmetals:** Why is basic research important?

**Prof. Dr. Reinhart Kögerler:** We constantly hear that we should leave such things to the powerful countries such as the USA, China or Germany. Essentially, this knowledge is already available, but it is not possible simply to copy it down. You have to be pretty deeply immersed in the research to make it usable for a given application.

**livingmetals:** When is a laboratory set up?

**Prof. Dr. Reinhart Kögerler:** When one or more companies come with a research question that can be looked into over a period of seven years. This allows us to

give the researchers the time and space they need to get to grips with a particular issue, to deliver practical benefit to the company and to advance the boundaries of scientific knowledge. The laboratory is almost always located at a university and makes use of the university’s staff and infrastructure. The company and the state share the financial commitment equally.

**livingmetals:** Why do companies set up CD laboratories?

**Prof. Dr. Reinhart Kögerler:** A laboratory allows companies to substantially reduce the risk involved in R&D outlay. In addition, there is a good chance that the research results and fundamental innovations delivered by a laboratory will give them a longer-term competitive edge that they would not be able to achieve as rapidly by simply improving processes and products incrementally. Not only that, they obtain a broad overview of the current state-of-the-

art in their own field of activity, which is something that companies themselves are rarely able to invest in. And all this can be achieved at a reasonable cost and with a minimum of administrative outlay.

**livingmetals:** So CD laboratories are like a continuous flow heater for good scientists?

**Prof. Dr. Reinhart Kögerler:** I want to make a distinction between the heads of the laboratories and the staff. For a scientist at a University, heading up a laboratory is the absolute dream job. A budget of up to 4.2 million euros over the seven year lifetime of the laboratory represents the largest individual subsidy that is possible anywhere in Europe. And for the young staff and PhD students, the laboratory gives them the chance to be involved in research that has a high level of practical application. And all this is coupled with clear terms of reference that take the form



#### About Professor Reinhart Kögerler

Until his retirement in 2009, Reinhart Kögerler was Professor of Theoretical Physics at the University of Bielefeld. For many years, he headed the “Technology and Innovation” section of the Austrian Federal Ministry for Economic Affairs. In addition to many periods spent overseas, Kögerler spent several years at the CERN nuclear research center in Geneva.

of budgets, milestones and regular reporting. As a first step on a technical career path, this is often more attractive than what companies have to offer. And, once they have completed their PhD, they are likely to be popular choices in the employment market. We know that, on average, four employees from each laboratory will make the move into industry.

**livingmetals:** Where do you personally see the potential for research in the field of powder metallurgy?

**Prof. Dr. Reinhart Kögerler:** I believe that there is a tremendous scope in the field of materials science when you consider that we are increasingly able to get down to the level of molecular and atomic structure. Molecular coatings, surfaces, the problems associated with the aging of coatings: These are all questions that will undoubtedly concern us for the next 30 years. ■

#### CD laboratories in the Plansee Group

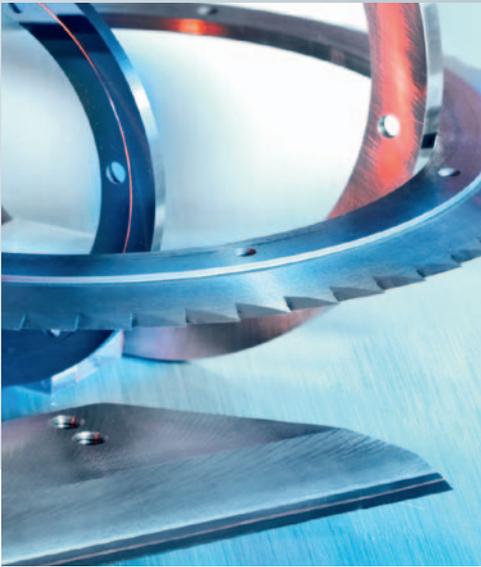
In 2004, the Plansee Group set up the first laboratory in the Christian-Doppler-Forschungsgesellschaft, which came to the end of its work at the end of 2011. There are currently three laboratories in which the Plansee Group is involved.

**Advanced Hard Coatings:** This laboratory focused on developing and characterizing innovative hard coatings designed to increase the service life of machine tools and slow down the wearing process (terminated in 2011).

**Application-Oriented Coating Development:** This focuses on the intelligent coating of materials using composites.

**Early Stages of Precipitation:** The aim here is to improve our understanding of microstructures and how these microstructures influence the characteristics of materials.

**Modeling Particle Flows:** This laboratory is researching the mathematical description and the development of models for simulating particle flows. Plansee hopes to gain deeper insights into the question of filling press dies with powder.



*Hard metal cutters for micrometer precision.*

## One knife – and a million perfect cuts

They last longer and do not need to be sharpened as frequently. The service life of knives manufactured from hard metal is up to 10 times that of traditional steel knives.

But the reasons for this superiority lie not only in the high level of wear resistance, resilience and sharpness, but also in the precision that can be achieved. Tolerances in the printing and paper industries are measured in micrometers. And in order to ensure that these tolerances are met, Ceratizit handles the entire manufacturing process for its knives themselves. This guarantees top quality from the preparation of the powder right up to sharpening, lapping and polishing. The Starcut knife from Ceratizit is heading for a record: During a customer test, the cutting quality was still perfect after a million cutting operations.



*Molybdenum  
contact optimized  
with tantalum.*

## Corrosion protection for solar cells

Thanks to its good adhesion to glass and high level of electrical conductivity, molybdenum is used for the rear electrical contacts on CIGS solar cells. However, because the molybdenum is liable to oxidize in corrosive environments, Plansee has developed a corrosion-resistant alternative.

Molybdenum is alloyed with small quantities of corrosion-resistant

tantalum. The superior corrosion protection offered by molybdenum-tantalum has been emphatically proven in an extensive series of tests.

But the new material, molybdenum-tantalum, is not only used for rear contacts. The material can also replace molybdenum as a contact and protective layer on the underside of flexible substrates.



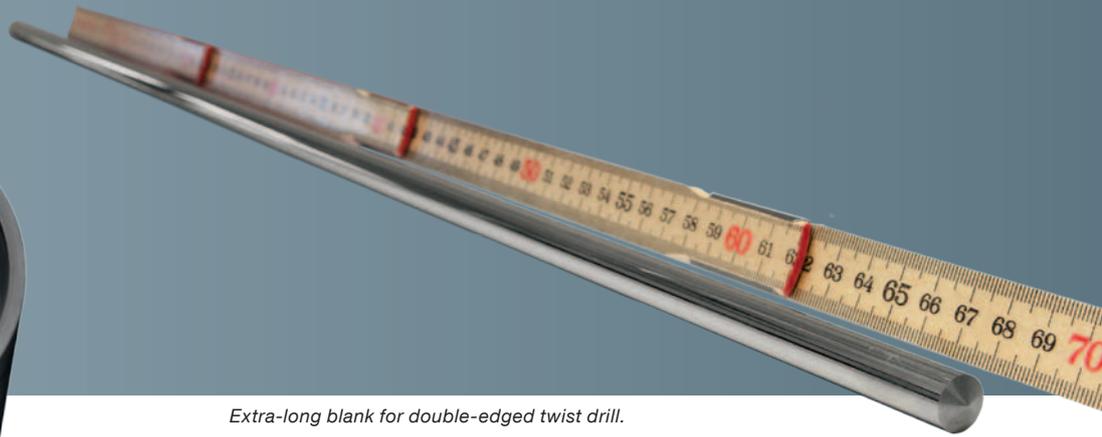
*New crucible  
with exception-  
ally smooth  
surface.*

## As smooth as silk

Growing sapphire in a crucible has become child's play thanks to tungsten crucibles from Plansee. Their particularly smooth surface gives them a longer service life and reduces costs.

Ultra-pure sapphire is used in the production of LED lights. The Kyropoulos method is in widespread use. This involves melting a sapphire crystal in a heat-resistant crucible made from molybdenum or tungsten. One particularly critical stage during this production process occurs when the sapphire crystal is extracted from the crucible. The easier the sapphire can be

released from the crucible, the greater the yield and quality of the sapphire. The advantage of Plansee crucibles lies in the fact that they have an ultra-smooth surface with a roughness of less than 0.8 micrometers and a high level of corrosion resistance. The crucibles have a very high material density of over 93 percent coupled with an extremely homogeneous density distribution, which means that they retain their shape even when exposed to high temperatures and rapid changes of temperature. And the tungsten used is particularly pure at 99.97 percent.



*Extra-long blank for double-edged twist drill.*

## Extra-long and made completely from hard metal

Up to now, drilling the lubrication holes in large crankshafts for truck or ship engines has always been a time-consuming operation.

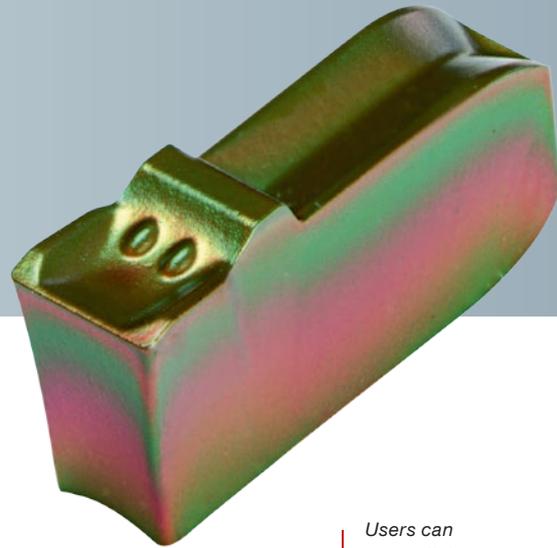
The extra-long solid hard metal rods from Ceratizit mean that drilling is now six times faster. Tool manufacturers use these XXL rods to produce double-edged twist drills with a length of 700 millimeters and a diameter of between 6 and 12 millimeters. The developers had to pay particular attention to the cooling ducts that are arranged in a spiral throughout the length of the solid hard metal rods. It is necessary to ensure that the ducts retain their inclination and position despite the exceptional length of these rods.



*Machining stainless steels.*

## Three exceptionally tough sisters

The mechanical engineering, automotive, petrochemicals, aviation and aerospace industries have one thing in common. They are all making increasing use of stainless steels. Stainless steels have one great advantage: They are not just resistant against rust but also against acids and corrosion. The disadvantage is that they are not easy, and sometimes very difficult, to machine. Chip breakage is almost impossible to control and the level of tool wear is high. Ceratizit has developed a coated tool for the machining of stainless steels that is both tough and wear-resistant (CTPM125). The quality and surface finish of the steel are noticeably improved and the tool service life is greatly prolonged. Three variants of the tool are available: The “fine-cutting” variant is ideally suited for finishing work. The “smooth-cutting” version provides excellent swarf control thanks to its curved cutting edge. And the geometry of the “universal” variant means that it can cope with practically any application.



*Users can cut until the black hard metal shows through.*

## Colorful inserts

The indexable cutting insert gleams colorfully between the gray blocks of steel. This is the latest highlight in the field of coating technology: Multiple aluminum oxide layers give the indexable cutting insert its color – a mixture of red and green. However, it is not just the coloring that makes this coating, which was developed and patented by Ceratizit, so very impressive. During steel and heavy-duty cutting activities, the service lives of these grooving and parting inserts have

been shown to be between more than 30 percent and 50 percent longer than those of conventional indexable cutting inserts. Another benefit: Users can see the level of index wear at a glance. Because the more worn the cutting edge becomes, the more strongly the color of the tool changes until the black hard metal shows through. As a result, processes are even more reliable and top quality is always guaranteed.



The largest offering for precision tools in the cutting industry.

## Good advice and quick delivery

It all began with the idea of a service concept: Experienced cutters would advise other cutters on the purchase of cutting tools. And WNT has been putting this idea into practice successfully for 25 years now. With the commissioning of a largely automated stock picking system in their central warehouse in Kempten, Germany, WNT has created one of the most efficient logistics centers for cutting tools. And so, to coincide perfectly with their 25th anniversary, WNT is able to supply its customers across the whole of Europe even more reliably. After all, the brand-new WNT anniversary catalog boasts 45,000 products, making it the largest offering for precision tools in the cutting industry.

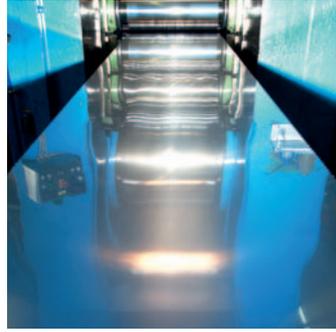


*CB-Ceratizit has opened a new Tooling Academy in the Chinese city of Tianjin.*

## On the test bench

Ceratizit has long been testing new tools for its European customers and optimizing them for their specific applications at its Tooling Academy based in Reutte, Austria. In addition, employees and customers can benefit from training courses covering the entire range of cutting tools. Since the end of 2011, Ceratizit has also been offering this service locally to its

Asian customers. To make this possible, CB-Ceratizit has opened a new Tooling Academy in the Chinese city of Tianjin. The site was carefully chosen: many businesses active in the automotive and aviation industries have moved to the area around Tianjin along with a large number of companies that specialize in heavy-duty machining.



*All the steps involved in producing tungsten and molybdenum are covered: The Plansee Group manufactures powder, semifinished products and custom components from ore concentrate.*

Investments exceed 300 million euros

# Plansee Group realizes sales of 1.5 billion euros

Consolidated Group sales increased by 22 percent in the last fiscal year (ended February 29, 2012) to reach 1.52 billion euros.

According to Plansee Group's executive chairman, Dr. Michael Schwarzkopf, "business developed satisfactorily in all divisions and in all important regions for Plansee. Increased sales volumes and raw material prices, acquisitions and changes within the group portfolio had a significant impact on sales growth." At the regional level, the Plansee Group benefited from the robust US economy and Germany's export strength. Strong growth was also achieved in China and India. Sales outside of Europe slightly increased to 52 percent of the Group total (America 32 percent, Asia 18 percent and Europe 48 percent). More than half of Group sales were achieved in three market sectors mechanical engineering, automotive and consumer electronics.

## **Focus on high-technology materials molybdenum and tungsten**

With the acquisition of a 10 percent share in the Chilean company Molibdenos

y Metales (Molymet) in March of last year and the sale of the sintered parts manufacturer PMG at the end of 2011, the Plansee Group is now focused on the two key-materials molybdenum and tungsten. As a vertically integrated supplier Plansee covers all the expertise from ore processing to the production of customer-specific components. "We will continue expanding our global market position in this business field," explained Schwarzkopf. Due to the sale of PMG which employed 1,150 people worldwide, the Group's workforce was down from 6,730 to 6,120 employees at year-end.

## **Total investments of more than 300 million euros**

During the last fiscal year, the Plansee Group made investments of well over 300 million euros. These included investments in new production capacities (96 million euros) and improvements to the Group's global market position through acquisi-

tions such as the shareholding in Molymet (approximately 200 million euros), the closing of the joint venture with CB Carbide in Taiwan/China and the takeover of the Korean company TCB. 31 million euros were spent on product and process innovations.

"During the fiscal year 2012/13 we will continue to expand in the targeted areas. We are planning significant expansions to our production capabilities at a number of sites including Austria, Luxembourg, China and India," explained Schwarzkopf. A new plant of the Plansee High Performance Materials division is scheduled to come on stream in the greater area of Shanghai in late 2012.

## **Outlook**

Over the last quarters of the past fiscal year, business settled at a lower but nevertheless still satisfactory level. According to Schwarzkopf, there is considerable uncertainty on the markets and customers are evaluating carefully before placing



*Dr. Michael Schwarzkopf at a major construction site in Reutte: Ceratizit Austria is extending its production facilities.*

new orders. This makes forecasts for the months to come difficult. Schwarzkopf: "It is not possible to predict how current problems of national debts and the financial markets will impact the real economy."

Overall, the Plansee Group is expecting to achieve a lower growth rate than in the last fiscal year. "We are monitoring the current economic situation very carefully. The high level of market volatility forces companies to stay extremely flexible their cost structure," Schwarzkopf explained. As a group, Plansee is better positioned than ever before. Schwarzkopf: "With an equity ratio of more than 55 percent and a strong cash position (negative gearing) we are well equipped to cope with any potential downturn and will continue to pursue our global expansion strategy." ■

### **Ticket to top management**

In order to achieve its objective of using internal candidates to fill 8 out of 10 management posts, the Plansee Group is making use of a three-phase development program for management.

At the International Introduction Seminar, talented young people have the chance to get to know the world of the Plansee Group better: This includes topics such as strategy, products and technologies.

A few years working successfully as a project manager or team leader qualify staff to participate in the Emerging Leaders Program. Here, talented employees are equipped to set up a professional organizational structure and to further develop both customers and products.

The General Management Training course prepares those who have the potential to master the challenges of heading up a large department or an entire organizational unit. The focus is on the development of certain personality traits, the capability of developing strategies, markets and innovations and on shaping change.

But the GMT is more than just a training arena, it is also a stage where the participants, their technical expertise and their leadership skills can be seen by top management, with whom they can talk, and from whom they can receive direct feedback. And if everything goes well and a vacancy arises, they have a ticket into top management.



ERDING  
ALKOHOL



ERDGAS

VIESMANN

DKB

Roeki

Roeki

BIATHLON.COM

42

RUHOLDING  
BAYERISCHE

ERDGAS



Biathlon

# Marksman- ship and heavy metals



Try as they might, the hunters in Otfried Preubler's classic German children's book, "The Little Witch", always fire wide of the mark. A spell has been cast on their guns. But even without the powers of magic, the inevitable recoil can spoil a marksman's day. And yet, there is a magic spell: balancing weights made from high-tech materials. The heavy metal absorbs the power of the recoil, giving the athletes the purchase, steadiness and certainty they need for their next shot.

The Plansee Group at a glance

# Close to our customers, worldwide

Vista (California, USA)

Warren (Michigan, USA)  
Towanda (Pennsylvania, USA)  
Franklin (Massachusetts, USA)

USA



Molymet (Chile)

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

- ▶ 29 production sites in three continents worldwide
- ▶ Sales offices and representatives in 50 countries
- ▶ 6,120 employees



Austria



Luxembourg



St. Pierre en Faucigny (France)

Niederkorn (Luxembourg)

Mamer (Luxembourg)

Livange (Luxembourg)

Biel (Switzerland)

Seon (Switzerland)

Alserio (Italy)

Germany



Bulgaria



Italy



Hitzacker (Germany)

Empfingen (Germany)

Lechbruck (Germany)

Reutte (Austria)

Liezen (Austria)

Bruntál (Czech Republic)

Gabrovo (Bulgaria)

Mysore (India)

Kolkata (India)

Zhangzhou (China)

Xiamen (China)

Tianjin (China)

Shanghai (China)

Seoul (Korea)

India



China



Taiwan



Japan



Wugu (Taiwan)

Tamsui (Taiwan)

Sakura (Japan)

Esashi (Japan)

## Imprint

**Proprietor and publisher:**

Plansee Group Service GmbH  
6600 Reutte, Austria  
living-metals@plansee.com  
www.plansee-group.com

**Editor-in-chief/contact person:**

Dénes Széchényi, Group Communications  
Tel. +43-5672-600 2243

**Contributions from:**

Dr. Thomas Franco, Dr. Wolfgang Glatz, Barbara Heuß, Patrick Hosp, Nadine Kerber, Dr. Bernd Kleinpaß, Dr. Sven Knippscheer, Dr. Andreas Lackner, Matthias Rüttinger, John Schoonover, Paul Sedor, Dr. Lorenz Sigl, Stefan Skrabs, Dr. Johannes Schröder, Dr. Michael Schwarzkopf, Dr. Andreas Venskutonis, Hermann Walsler, Dr. Jörg Winkler

**Editing, Layout, Publishing:**

mk publishing GmbH  
Döllgaststraße 7–9, 86199 Augsburg, Germany  
Tel. +49-821-3 44 57-0, Fax -19  
www.mkpublishing.de

**Photo credits:** Plansee Group, Michael Paetow, mk publishing, Fotolia.com/Falko Matte/Ahmad Faizal Yahya/Prodakszyn/Stefan Balk/dieter76, istockphoto.com/plug and draw/visdia/motionmediagroup/ricardoazoury, thinkstockphotos.de/Digital Vision, pixathlon.de/pituremaxx, Christian-Doppler-Forschungsgesellschaft