



TECHNOLOGY REPORT NANJING SPECIAL EDITION

Precious Partnership, Green Growth
2018





Heraeus Holding GmbH

Communications & Marketing
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Ladies and gentlemen,

Since Heraeus was founded, the company has continuously improved its expertise and fortified its market position. The Nanjing factory is a new milestone to strengthen our market leadership in the area of precious metals processing in China, in Asia and around the world.

By expanding our business base, Heraeus solidifies its position as a trader, processor and recycler of precious metals for Chinese growth industries. Over 40 years ago, we started business in China and have developed into a strong and reliable partner in the precious metals business and beyond. Therefore, we view it as a natural step to exploit our market knowledge and experience in one of the most important economies in the world and its existing business potential.

Long-term planning and sustainable development are a core part of a family-owned company like ours. With our sustainable products and services, we also support China's national strategy and initiatives to upgrade its industrial value chain and to improve people's life.

Jan Rinnert, Chairman, Heraeus Holding Board of Management



Ladies and gentlemen,

We are very pleased to be opening the world's most advanced precious metals factory in Nanjing. At this new Heraeus site, we are focusing on cutting-edge technology to be able to offer our customers best in class services and products.

This site is for you, our dear customers.

Heraeus' global know-how and its expertise in the Chinese market make the company a top solution provider for our customers on both national and international levels. Our well-positioned team offers customers access to the full precious metals loop, including recycling, processing and trading at various locations in China. This enables us to support our customers' growth with tailor-made precious metals solutions.

What's more, Heraeus takes seriously its responsibility towards people and the environment. The plant uses leading technologies to meet and even to exceed the strict national, regional and local regulations for recycling and chemical production. In this way, we are contributing to the healthy development of the industry in China. We look forward to working together with you on more mutually beneficial projects and an even better future.

Linda Hu, Heraeus Precious Metal China Commercial Head
Dr. Zhouping Ai, General Manager of Heraeus (China) Precious Metal Technology Co., Ltd.

A precious partner in China and worldwide

Just two years after groundbreaking, Heraeus Precious Metals is opening the world's most advanced precious metals factory in Nanjing. André Christl, President of Heraeus Precious Metals, talks about reasons for and expectations from this significant investment.



What led to the decision to build the new factory in Nanjing?

André Christl: China is one of the world's largest consumers of platinum group metals, which are needed as emission and process catalysts, among other things, for key industries such as the automotive, electronics, glass, chemicals, petrochemicals and pharmaceutical sectors. The country, however, lacks these natural resources and depends on imports and recycling.

As the largest precious metals service provider in the world and experienced in the Chinese market for over 40 years, Heraeus Precious Metals supplies very high-quality products to support customers in China and around the world. This makes us a preferred partner to meet the increasing demand of precious metals as well as the rigorous quality requirements of customers in China—and worldwide.



How does the plant meet the strict environmental and safety regulations?

André Christl: For Heraeus, it is crucial to apply leading technologies and standards. With our own environment, health and safety standards, we meet or even exceed the strict regulations set by national, regional and local authorities. This applies to cleaning exhaust air and wastewater as well as to the safety of our employees.

What makes Nanjing the world's most advanced precious metals factory?

André Christl: The new site will significantly enhance the company's capacity to refine and recycle precious metals, especially platinum group metals. It is equipped with advanced technology, which makes it possible to standardize processes and to achieve consistently optimal results. Thus, the Nanjing plant offers opportunities for more transparency, simplifies processes and enhances customer benefits.

The new factory fits in with Heraeus' claim to combine the entire precious metals lifecycle—supply, hedging, product expertise and recycling services—under one roof. By offering the full loop along with our strong local market knowledge, Heraeus exemplifies a preferred partner for businesses operating in China.



A strong chain

For two years, a team of international experts worked hand in hand to set-up the world's most advanced factory for precious metals recycling and chemical products. The new factory is equipped with leading technologies—and designed for further expansion.



Two years after groundbreaking, the new Heraeus site in Nanjing is ready to start operation. It was an intensive time for all those involved in planning and construction. It was also a time of great team spirit. "Everyone wanted to accomplish something, everyone was enthusiastic," project manager Matthias Dornhecker remembers.

The mixed project team combined German engineering and precious metals experience with Chinese market and industry knowledge. Heraeus experts from various other nationalities contributed their insight, too. "We were able to collect and to combine all the best technologies and processes from Heraeus sites around the world for our new factory," Matthias Dornhecker explains.



The new site is 84,000 m² or almost twelve soccer fields. By 2020, this latest addition to the Nanjing Jiangbei New Material High-Tech Park will be the workplace for over 200 highly qualified employees. At Nanjing, Heraeus offers both wet chemical and pyro chemical recycling as well as a broad range of precious metal chemical products to serve various industries in China. Advanced processes allow for high quality outcomes—a prerequisite for stability in customer's processes.



The new factory is operated by cutting-edge technology, both in processes and environmental technologies. "A new plant is like a chain. One single weak link will reduce the performance of the whole. By working together, we've forged a strong chain and built an excellent plant," says Dr. Daniel Zhang, who as a project member and operations director for the new facility, was deeply involved in the design and construction of the Nanjing site.

Sustainability, environmental stewardship and work safety are also reflected in the design of the factory. Heraeus will apply leading technologies and its own environmental standards meet and even exceed current Chinese regulations for environmental protection. "Only a secure plant guarantees a sustainably successful business," Dr. Daniel Zhang highlights.

The new factory is designed for expansion. A wing of the building for precious metal coatings is now being built and is scheduled to open next year.

Area 84,000 m²

Concrete 35,500 m³

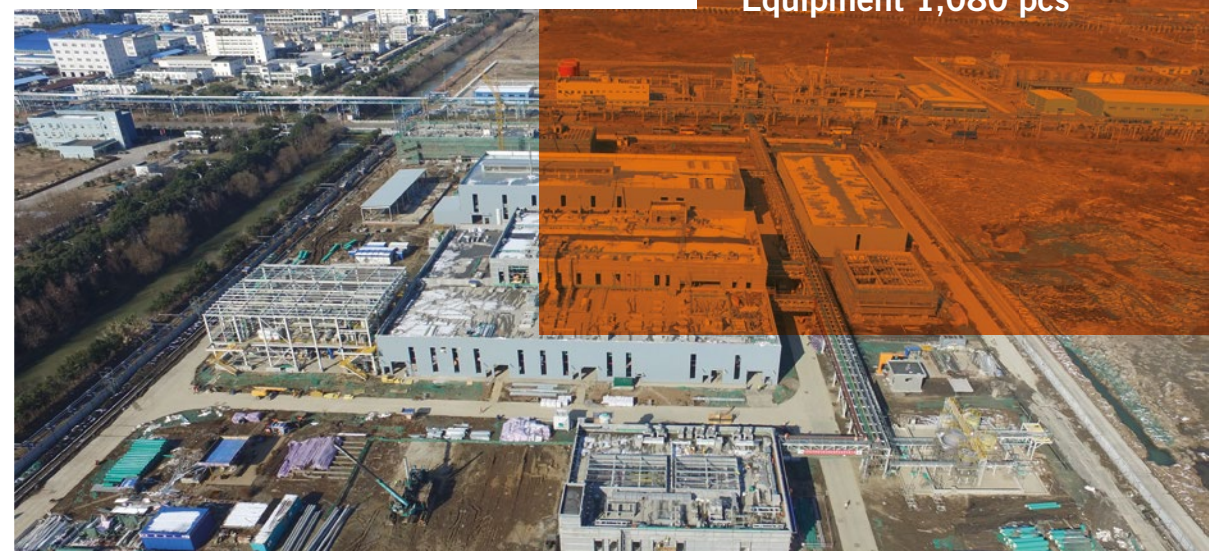
Rebar 3,700 t

Steel structure 1,520 t

Metal pipes 15,000 m

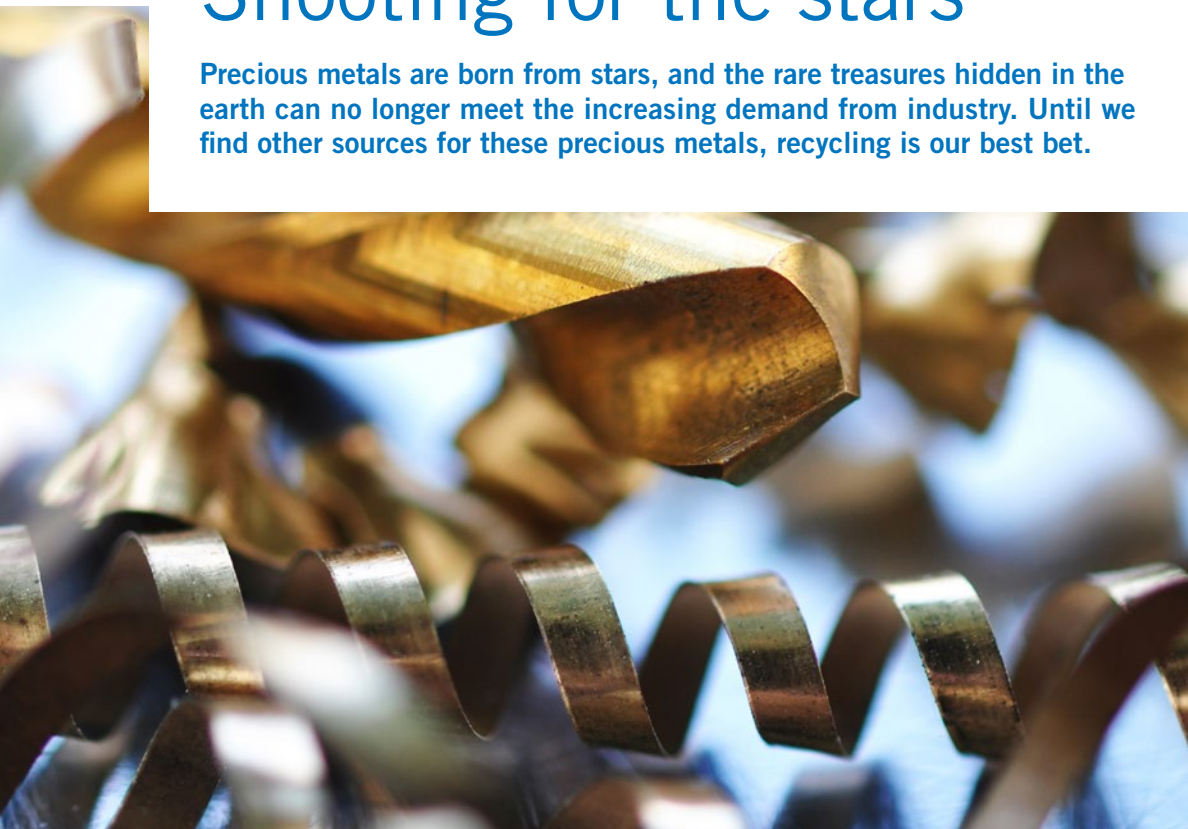
Plastic pipes 19,000 m

Equipment 1,080 pcs



Shooting for the stars

Precious metals are born from stars, and the rare treasures hidden in the earth can no longer meet the increasing demand from industry. Until we find other sources for these precious metals, recycling is our best bet.



The origin of precious metals lies in stars. Gold, silver and platinum group metals were formed when neutron stars collided. Humans have been fascinated by these metals for thousands of years, scouring the earth and mining deep underground in search of these aptly-named precious metals. Long used in jewelry and religious art, their unique physical and chemical properties also made them indispensable materials for industry, too. But the world's recoverable reserves alone are no longer sufficient to meet increasing demand.

In 2017, the Chinese economy, for example, consumed around 29 percent of the platinum used worldwide and around 23 percent of palladium. This demand for palladium, among others, is predominantly driven by the automotive industry to be

used in catalytic converters for exhaust systems. But e-mobility and hybrid technologies, the focus of China's national strategy, also require precious metals for power electronic components. In addition to the automobile industry, China's high-tech industries, such as the electronics, telecommunication, petrochemicals, energy, healthcare and aerospace industries, have increasing demand for high quality precious metals as well.

Furthermore, China is focusing on green economic growth and is currently adopting the most stringent emissions standards worldwide. The technical implementation will additionally increase the demand for precious metals, as platinum group metals especially are needed for catalysts and purification of exhaust gases. However, platinum

group metals do not occur as natural resources in China and the global natural resources are limited.

Recently, an asteroid containing \$4.8 trillion worth of platinum passed by the earth. Experts from Chinese Lunar Exploration Program are already studying ways for robots and astronauts to mine such asteroids for platinum and palladium in the future. Goldman Sachs believes this is a realistic goal, but, before shooting for the stars, we have to focus on earthly opportunities.

Consequently, China is still relying on imports and recycling. Precious metals recycling is becoming increasingly important because it will enable the country to reduce imports over the long term as well as its dependency on external sources. Heraeus is taking this development into account with the establishment of the Nanjing site. Using its many years of experience as a trader, processor, and recycler of precious metals, Heraeus supports the business potential of Chinese customers who are active globally and in the Chinese market.

Recycling critical in future

Recycling has a much smaller environmental footprint than primary sourcing of precious metals. For example, around 250 tons of ore have to be processed to produce 1 kg of platinum group metals, mostly in deep shaft mining, also producing carbon dioxide emissions of 68 tons per kg. Precious metal recycling, however, consumes 70 to 100 times less energy than mining and produces 200 to 300 times less carbon dioxide emissions.

Thus, recycling aligns with two main goals of China's national strategy: reducing carbon dioxide emissions and supporting sustainable growth. Recycling produces far fewer carbon dioxide emissions than mining, while precious metals used in

catalysts, for example, clean air from factories, contribute to the country's green economic growth.

Heraeus' expertise ensures sustainability and efficiency in the recycling of precious metals. The company is the only service provider in the world to offer recycling for all precious metals. Heraeus has recently supplemented its experience in wet chemical processing of materials containing precious metals with expertise in pyrometallurgy. Heraeus is thus helping to meet the Chinese industry's growing demand for precious metals and make the country less dependent on imports. And that gives the experts time to think about other challenges. Such as mining asteroids.



Sustainability worldwide

As a family-owned company, Heraeus values long-term and sustainable development. This is why the technology group deals responsibly with natural resources, business partners and employees—and why compliance, environment, health and safety take center stage.

Dr. Jürgen Müller-Schäfer is travelling the world for Heraeus. As Head of Precious Metals Security, he is responsible for auditing mines, among other things. Since Heraeus doesn't own mines but collaborates with selected mine operators, the company takes its responsibility to source precious metals from responsible sources very seriously.

“Heraeus sources its precious metals exclusively from mines that have been audited onsite to ensure that they comply with the Code of Conduct,” Dr. Müller-Schäfer explains. To ensure this, he checks things out first-hand on site—including talking with the employees at the mine. In addition, Heraeus reviews all suppliers in a multi-stage



Dr. Jürgen Müller-Schäfer is Head of Precious Metals Security and responsible for auditing mines, such as here in the Philippines. He checks things out first-hand on site—including talking with the employees at the mines.



Jonas Shen is a member of the EHS team at the Shanghai location. He is responsible for the development and implementation of activities on site. Here he is reviewing the ongoing lab protocol together with lab analyst Audrey Li.

compliance process with strict and comprehensive rules with regard to environmental protection as well as decent conditions for the workers in the mines.

Heraeus is also aware of its responsibility towards its own employees and the environment. “We introduced fundamental processes on site for a sustainable implementation of workplace safety and environmental protection—they are part of our global goals,” says Jonas Shen, who is part of the Environment, Health and Safety team in Shanghai. Heraeus strives to continue its commitment to environmental protection and safety not only at existing locations, but also as part of any future investment projects as well as the new site in Nanjing.

At the new factory, Heraeus relies on the leading technologies and its own environmental standards that meet and even surpass current Chinese regulations for environmental protection. Exhaust air, for instance, will be cleaned through highly efficient air scrubbers, while wastewater will be treated in a special Heraeus IP protected process and disposed of in compliance with local standards.



Accelerating green development

Petrochemicals, electronics, photovoltaics: Precious Metals are used in key industries in China, generating one trillion RMB (155 billion euros) and providing 3.5 million jobs. In Nanjing, Heraeus is responding to the increasing demand especially of platinum group metals.

Most people have heard of catalytic converters in cars, but may not know about other applications for catalysts. The truth is, that a lot of everyday products are hardly possible without catalysts. For instance, manufacturers require precious metal catalysts in the synthesis of highly complex fragrance, aroma and pharmaceutical substances. Catalysts generally help save energy in chemical production, avoid unwanted byproducts and reduce the emission of hazardous industrial fumes to a minimum.

The oil and petrochemical industry relies on reforming catalysts that play a major role in the processing of crude oil. EO catalysts are essential for the production of ethylene oxide—an intermediate in the production of other chemicals that are the basis for major consumer goods, including plastics, laundry detergent, antifreeze and cosmetics. The pharmaceutical, chemical and agro-chemical industries need carbon based catalysts for hydrogenation.

At the Nanjing site, Heraeus Precious Metals refines for example spent reforming, EO and carbon based catalysts. Catalysts are also among the chemical products that Heraeus offers.

High-quality silicone, for example, is predominantly produced with platinum as the catalyst. The Karstedt catalyst, which bears the name of its inventor, is one of the catalysts used for this purpose. Heraeus Precious Metals constantly improves the efficiency of its own Karstedt catalyst

for the benefit of customers in the dental, automotive, construction, polymer, medical and paper industries.

The product portfolio of Heraeus Precious Metals also comprises various other precious metal containing catalysts as well as chemical solutions for various applications. With the expansion of the site, Nanjing will also offer the portfolio of Heraeus Precious Coatings, a worldwide leading manufacturer of precious metal decorating materials for ceramics and glass.

With the new facility, Heraeus is supporting China's increasing need for precious metals and is providing customers with high quality products originating from both mines and from recycling. As a first class service-provider, Heraeus combines all activities related to a comprehensive expertise in the precious metals loop—from trading to recycling to precious metals products.

Finding the best solutions for customers

Heraeus Precious Metals is the world's largest precious metal service provider. The success story started more than 160 years ago with a challenge—and two kilograms of platinum.

Wilhelm Carl Heraeus was just 24 when he took over his father's pharmacy in Hanau, Germany, in 1851. At the time, platinum was in high demand by jewelry makers. However, platinum posed a major challenge for goldsmiths: Because it is extremely hard and has a melting point of 1,769 °C, platinum had to be forged in a white-hot state.

Wilhelm Carl Heraeus worked with local goldsmiths and was familiar with the problem—and he found a solution. After numerous attempts, he succeeded in melting two kilograms of platinum with an oxyhydrogen gas flame. This revolutionary process brought with it a new era in the precious metal industry and laid the foundation of the present Heraeus Group.

Today, Heraeus Precious Metals is a leading provider of precious metals services and products. The Global Business Unit is one of the world's largest refiners of platinum group metals and a leader in industrial precious metals trading, drawing on the comprehensive expertise of around 2,000 employees worldwide. The precious metals products offered by Heraeus Precious Metals are used in a wide variety of fields, including the chemical, pharmaceutical, glass, electronics and automotive industries.

"By combining precious metal supply, hedging, product expertise and recycling services, we offer our customers the industry's most comprehensive range of services throughout the entire precious metals lifecycle," Linda Hu, Heraeus Precious Metal China Commercial Head, states. She underlines that this management throughout the loop gives customers a clear advantage.



Heraeus Precious Metals is a leading provider of precious metals services and products, combining all activities related to its comprehensive expertise in the precious metals loop—from trading to precious metals products to recycling. The product portfolio includes process and emission catalysts, pharmaceutical ingredients, precious coatings and functional materials.

"We eliminate unnecessary complexity and support our customers in taking advantage of growth opportunities, no matter what their precious metal needs are or where their business is located," she says. With eleven production and four trading sites in all relevant time zones, Heraeus Precious Metals offers its customers a truly global production and logistics network.

For Heraeus Precious Metals, investments and innovations are an essential component of ongoing growth. In 2016, the Global Business Unit took over a plasma furnace for the treatment of material from spent catalytic converters containing platinum group metals. This marked the beginning of an expansion into pyrometallurgical recycling.

Significant investments in additional recycling capacities followed around the world: in Wartburg, USA; Udaipur, India; and now in Nanjing, China, with the world's most advanced precious metals factory.

In 2017, Heraeus fully acquired Switzerland's Argor-Heraeus, a global leader in gold and silver refining as well as the production of value-added products from these metals.

With those investments, Heraeus Precious Metals has moved to the forefront of precious metal recycling and trading. Heraeus Precious Metals also holds a very strong position in precious metals chemistry and other products. There is a simple reason: Heraeus experts work every single day anew to solve the challenges their customers are facing. Just like Wilhelm Carl Heraeus did 160 years ago.



Close to the customer, close to you

Heraeus takes customer proximity literally: Its products accompany you in your daily life, playing key roles in cars, internet connections and even milk.

Heraeus has been present in China's daily life for over 40 years. In order to serve the steadily growing market of the emerging industrial nation, Heraeus focuses on being close to its customers by manufacturing its products in China mainly for the local market. Active in various markets, Heraeus enables its customers to deliver value added solutions that support the economic growth. As a result, Heraeus products play a role in many products and services that are used daily.

It all started with a sales office for precious metals in Hong Kong. But trading precious metals is just one of Heraeus's strengths, and its portfolio covers products and services along the entire value chain, from refining and processing to recycling and trading. This is particularly important for China's growth industries, as Heraeus covers their demand for platinum, rhodium and palladium, which are not found in China. But what are these and other precious metals from Heraeus needed for? The electronics industry in China is growing rapidly. Heraeus supplies bonding wires and assembly materials and has become the largest producer of contact materials for the semiconductor industry. These are driving forward the expansion of electric mobility, a focus of China's national strategy.

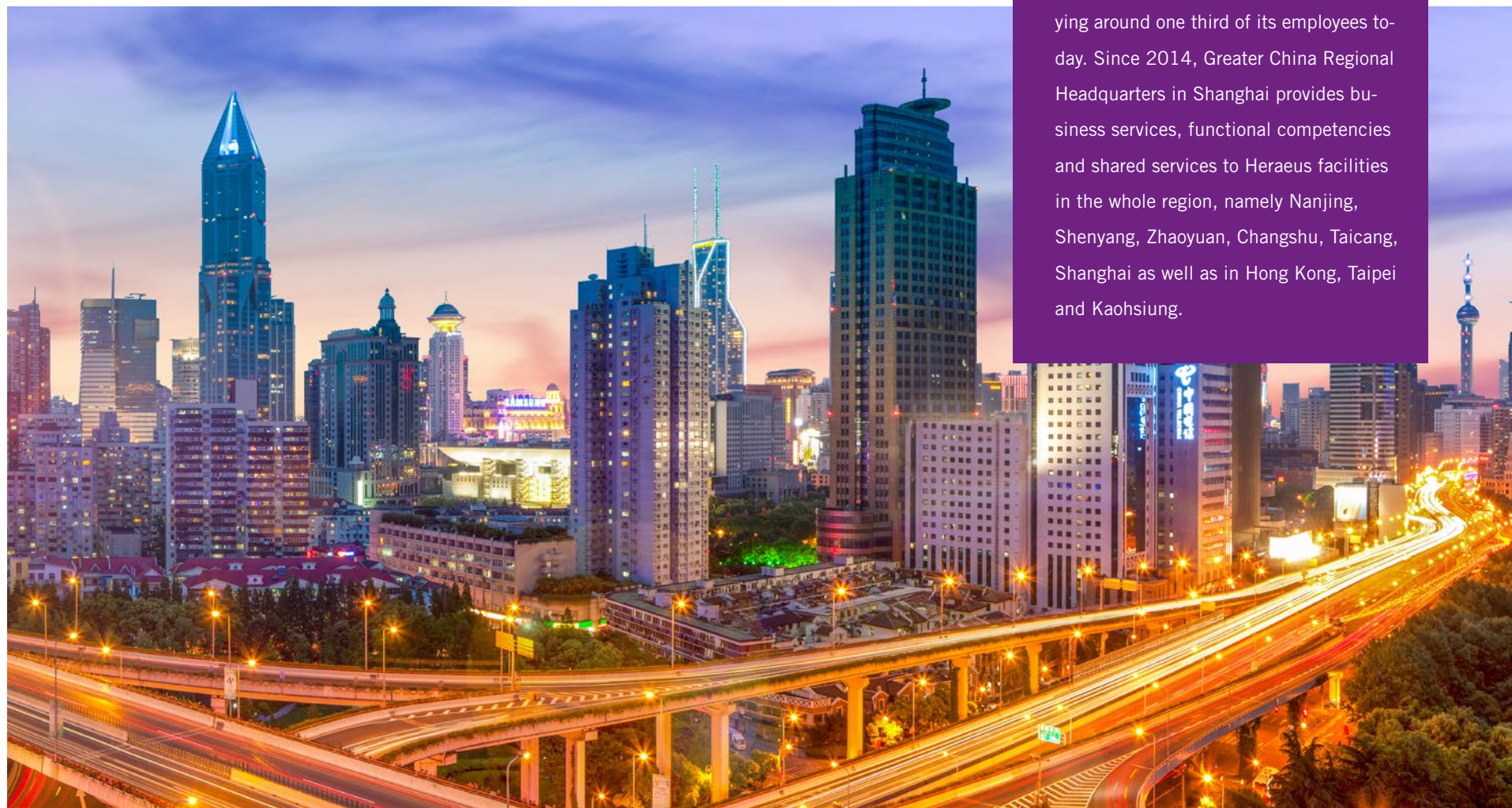
Even if you don't drive an electric car, you probably surfed the internet today and there's a good possibility that you used another Heraeus product: quartz glass. Known for its extra purity, quartz glass is the basis for fiber-optic communication. These glass fibers are used in large infrastructural projects throughout China's cities to connect the country to high speed internet. Fun fact: 7,000 km

of telecom fiber can be produced from just one Heraeus quartz glass cylinder of 200 kg.

Clean energy is a global challenge and Greater China the biggest photovoltaic market in the world. As a technology leader in photovoltaics, Heraeus runs regional research and development centers

in Shanghai and Taipei to better serve this market and increase cooperation with Chinese companies in the photovoltaic industry. Here, Heraeus is the key supplier of silver paste and helps its customers increase the efficiency of photovoltaic modules.

And what about milk? Heraeus Noblelight products play a key role in meeting food safety standards. For example, Heraeus UV solutions are used in dairy industry, disinfecting containers for dairy products in mainland China. So in many different ways, Heraeus is close to its customers and you every day.



Heraeus has been present in China since **1974**.

Focusing on proximity to the customer, more than **80** percent of Heraeus value creation in China is for the Chinese market. Asia thus became one of the **top three** markets for the company, providing around **43** percent of its global revenues and employing around one third of its employees today. Since 2014, Greater China Regional Headquarters in Shanghai provides business services, functional competencies and shared services to Heraeus facilities in the whole region, namely Nanjing, Shenyang, Zhaoyuan, Changshu, Taicang, Shanghai as well as in Hong Kong, Taipei and Kaohsiung.

Heraeus – delivering technology

With high-quality products and solutions that ensure a clear competitive advantage, Heraeus contributes substantially to customers' long-term value creation. All around the world. For more than 160 years.

Founded in 1851 in Hanau, Germany, Heraeus is a family-owned portfolio company that traces its roots back to the pharmacy the family opened in 1660.

Today, the globally leading technology group combines businesses in the environmental, energy, electronics, health, mobility and industrial applications sectors. Its portfolio ranges from components to coordinated material systems, which are used in a wide variety of industries, including steel, electronics, chemical, automotive and telecommunications.

In the 2017 financial year, Heraeus generated total revenues of €21.8 billion. The company is FORTUNE Global 500-listed and employs around 13,000 people in about 40 countries. Heraeus generates around one quarter of its product revenues in the USA and around 40 percent in Asia, where almost one third of its global workforce is located.

Heraeus believes that innovation is the lifeblood of a sustainable economic success, and the company strives for an innovation culture that is dynamic, interdisciplinary and fully attuned to our customer's needs. We meet this aspiration with our newly opened innovation center in Hanau, application centers in all important markets, and start-ups concentrating on future oriented technologies.

With technical expertise, commitment to excellence, focus on innovation and entrepreneurial leadership, we are constantly striving to improve our performance. We create high-quality solutions for

our clients and strengthen their long-term competitiveness by combining unique material expertise with technology leadership.

PRECIOUS METALS

trading, recycling, industrial processing



QUARTZ GLASS

for the telecommunications and semiconductor industries



Successful products from Heraeus

Heraeus produces high-quality technology products for many industries

BONE CEMENT

for securing joint
prostheses in place



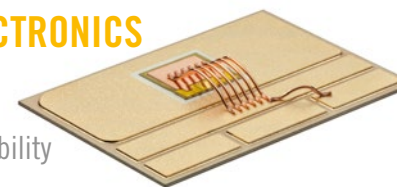
POROCARB

for improving battery
performance



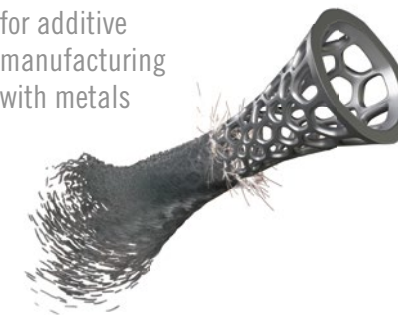
POWER ELECTRONICS

for applications
that demand
the highest reliability



3D PRINTING

for additive
manufacturing
with metals



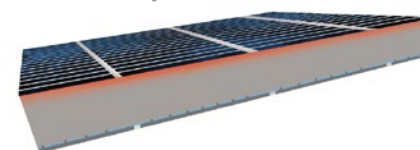
HIGH-TEMPERATURE SENSORS

for treating exhaust gas



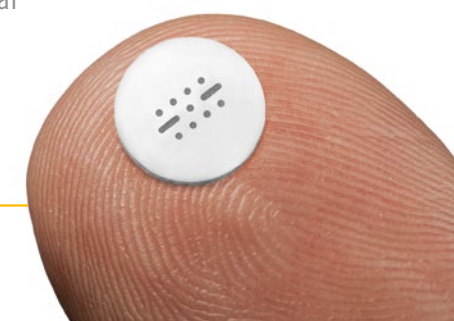
SILVER PASTES

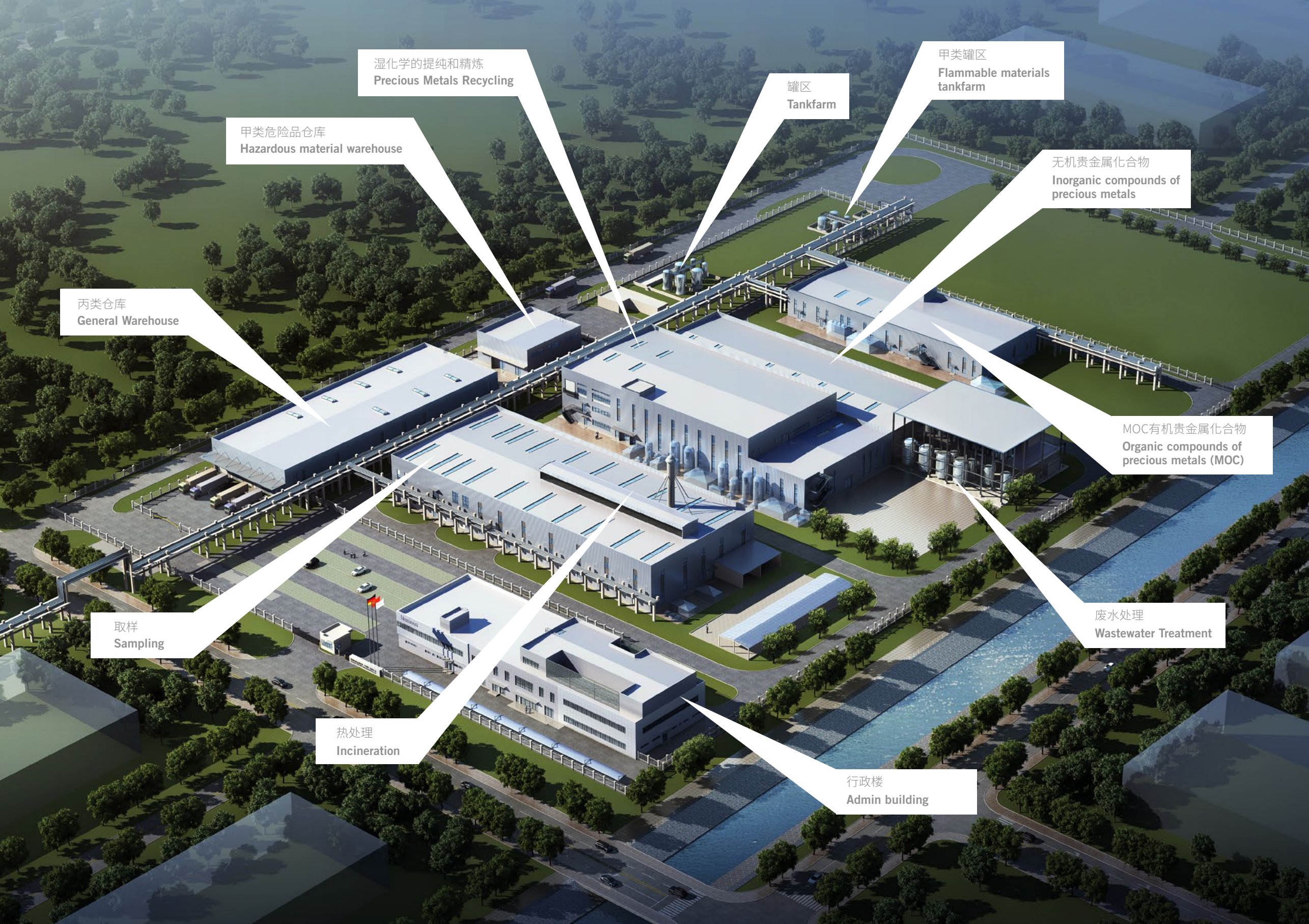
world record holder in
solar cell efficiency



CERMET

for the miniaturization
of medical
implants





湿化学的提纯和精炼
Precious Metals Recycling

甲类危险品仓库
Hazardous material warehouse

丙类仓库
General Warehouse

罐区
Tankfarm

甲类罐区
Flammable materials
tankfarm

无机贵金属化合物
Inorganic compounds of
precious metals

MOC有机贵金属化合物
Organic compounds of
precious metals (MOC)

废水处理
Wastewater Treatment

取样
Sampling

热处理
Incineration

行政楼
Admin building