solutions

THE SCHOTT TECHNOLOGY MAGAZINE 2021

SCHOTT.COM/INNOVATION

#glasslovers

Specialty glass is a fascinating material. Versatile, colorful and always surprising. And the reason for a special kind of relationship.

THE ROCK STAR
CERAN® cooktop panels have revolutionized the world's kitchens since 1971.

ZERO CARBON
SCHOTT wants to become a climate-neutral company by 2030.

SCHOTT
glass made of ideas

Long live the pioneering spirit

**Board of Management of SCHOTT AG:
Dr. Jens Schulte, Dr. Heinz Kaiser, Dr. Frank Heinricht (Chairman)
and Hermann Ditz (from left to right).**

Pioneers have vision, defy opposition and single-mindedly pursue innovative ideas to achieve success. Our company founder, Otto Schott, is one of them. Using his insatiable curiosity and passion, he succeeded in developing glasses with precisely defined properties in the 1880s to become a pioneer for an entire industry.

Otto Schott's pioneering spirit is firmly anchored in our company's DNA. It is also reflected in the guiding principles of our new strategy cycle, which sets a series of ambitious goals. Entitled 'Pioneering. Responsibly. Together,' our new strategy features a key milestone: to become climate-neutral by 2030. In doing so, we will be ushering in a new era. No other company in our industry has ever set itself such an ambitious goal and firmly anchored it in its strategy (see page 8).

In addition, we are working hard to make the virtually limitless potential of specialty glass accessible to new markets and target audiences that are adjacent to our current portfolio. Two key areas are 'Material Informatics,' the data-based design of new materials, and the targeted use of artificial intelligence in glass production (page 22).

Of course, the glass pioneers of yesteryear achieved amazing things, all without the benefits of AI. This includes defying widespread skepticism in the early 1970s to prove that cooking on glass-ceramic was possible. Since then, CERAN® cooktop panels have conquered the kitchens of the world and are now fully prepared for the future, even after half a century (page 14).

We also want to share our enthusiasm for glass and its possibilities with the public. Follow our new #glasslovers campaign (page 46) and discover how multi-faceted and ubiquitous this fascinating material is. And in light of current events, solutions from SCHOTT are also playing an important role in the fight against COVID-19. Read more about this and our commitment during the pandemic in the interview. (page 6).

The #glasslovers wish you interesting reading.

Dr. Frank Heinricht | **Dr. Jens Schulte** | **Dr. Heinz Kaiser** | **Hermann Ditz**

CONTENTS

A world made of glass

The smartphone, the car, the stove or even pharmaceutical packaging: It's hard to imagine everyday life without glass. We are all secretly #glasslovers. That's why this issue is all about this fascinating material.

The earliest traces of cooking are **500,000 years** old. These are hearths that contained charred bones and were found in Beijing and Nice.

A British student has calculated how much energy a **laser sword** would need. The result: just under **seven megawatts,** which would correspond to the power of around 70 cars.

In **1841**, the Frenchman Charles-Gabriel Pravaz developed the **first hypodermic syringe** for administering liquid medicines.

Damages to the displays account for **more than half** of all cell phone defects.

You can get **liquid glass** even without much heat: it can be bought in spray bottles and is used as car polish, among other things.

On **May 14, 1796,** English physician Edward Jenner infected an eight-year-old with cowpox and then developed the **first modern vaccine**.

Nothing breaks with them: The **safecrackers** are the most unsuccessful crooks in Duckburg. By the way, the triplets don't have names. You can only tell them apart by the numbers on their sweaters.

At **600 meters,** laser light in vehicles radiates twice as far as LED high beam.

In **2025**, the CO_2 content in the atmosphere could exceed the value from the Pliocene. It is considered the warmest period of the past **3.3 million** years. What makes the recent climate change so dangerous is the human-induced speed at which it is taking place.

Since the 1960s, glass with **low thermal expansion** has been used in the exterior windows of all manned space expeditions, including the **ISS** (International Space Station).

The use of glass spheres as an occult instrument dates back to ancient times. Divination by **looking into reflecting surfaces** is called **crystallomancy.**

Six dots that mean the world to a blind person: Louis Braille, then 16 years old, invented Braille in **1825**.

Vicuña wool is the **most expensive fiber** in the world. The vicuña lives exclusively in the wild in South America – this makes shearing complex and expensive.

Fighting COVID-19 together

Solutions from SCHOTT play an important role in countless applications – including the fight against COVID-19. Chairman of the Board of Management Dr. Frank Heinricht discusses the company's commitment during the pandemic in an interview.

INTERVIEW: THILO HORVATITSCH

Glass vials as primary packaging for a potential COVID-19 vaccine.

75%

of COVID-19 vaccine projects around the world rely on SCHOTT vials.

Dr. Heinricht, where are SCHOTT products used in the fight against COVID-19?
We are involved on several fronts with our products: First and foremost, with our pharmaceutical primary packaging. We supply millions of glass vials in which a potential COVID-19 vaccine or drugs used to treat the disease can be safely stored. We are also involved with our diagnostics business. Our customers develop rapid tests using our coated glass substrates to determine whether a person is infected with the virus. Laryngoscopes equipped with our light-conducting glass fibers are yet another example. These are used by doctors in the treatment of critically ill corona patients to improve vision during intubation.

What is the chance that the first COVID-19 vaccines will be administered from SCHOTT vials?
That's quite likely. Today, three out of four vaccine projects in clinical phases I, II or III use our pharmaceutical vials. We have concluded firm agreements with most leading pharmaceutical companies, including partners in the US government's "Operation Warp Speed." We have already delivered millions of glass vials to SARS-CoV-2 programs. Adding up the volume of all the projects we are involved in, we will supply vials for around 2 billion vaccine doses by the end of 2021. It should be noted that several doses can be filled, depending on the size of the pharmaceutical vial.

How are you mastering this challenge?
SCHOTT produces eleven billion pharmaceutical packaging units each year. Vials made of borosilicate glass account for a large share of these. The vials needed for COVID-19 vaccine projects are ISO-standard vials that we manufacture millions of times a day at our plants. In addition, the demand for pharmaceutical glass and packaging was steadily on the rise even before corona, and, in March 2019, we announced the largest investment program in the company's history to date, namely $1 billion in our pharmaceutical division. We will have already completed 50% of this by the end of 2021. Thanks to the early investment, we are already in a position to ramp up capacity. And we are saving valuable time because our 20 glass and converting plants worldwide have been validated by authorities and major pharmaceutical companies, i.e. are approved for use in the pharmaceutical industry.

Dr. Frank Heinricht discusses the company's commitment in the fight against the pandemic.

For decades, **borosilicate glass** has been the gold standard to package drugs.

SCHOTT produces **11** billion pharma packaging units every year, in which vital drugs are stored.

"WE ARE PROUD THAT WE ARE ACTIVELY PARTICIPATING IN THE FIGHT AGAINST COVID-19."

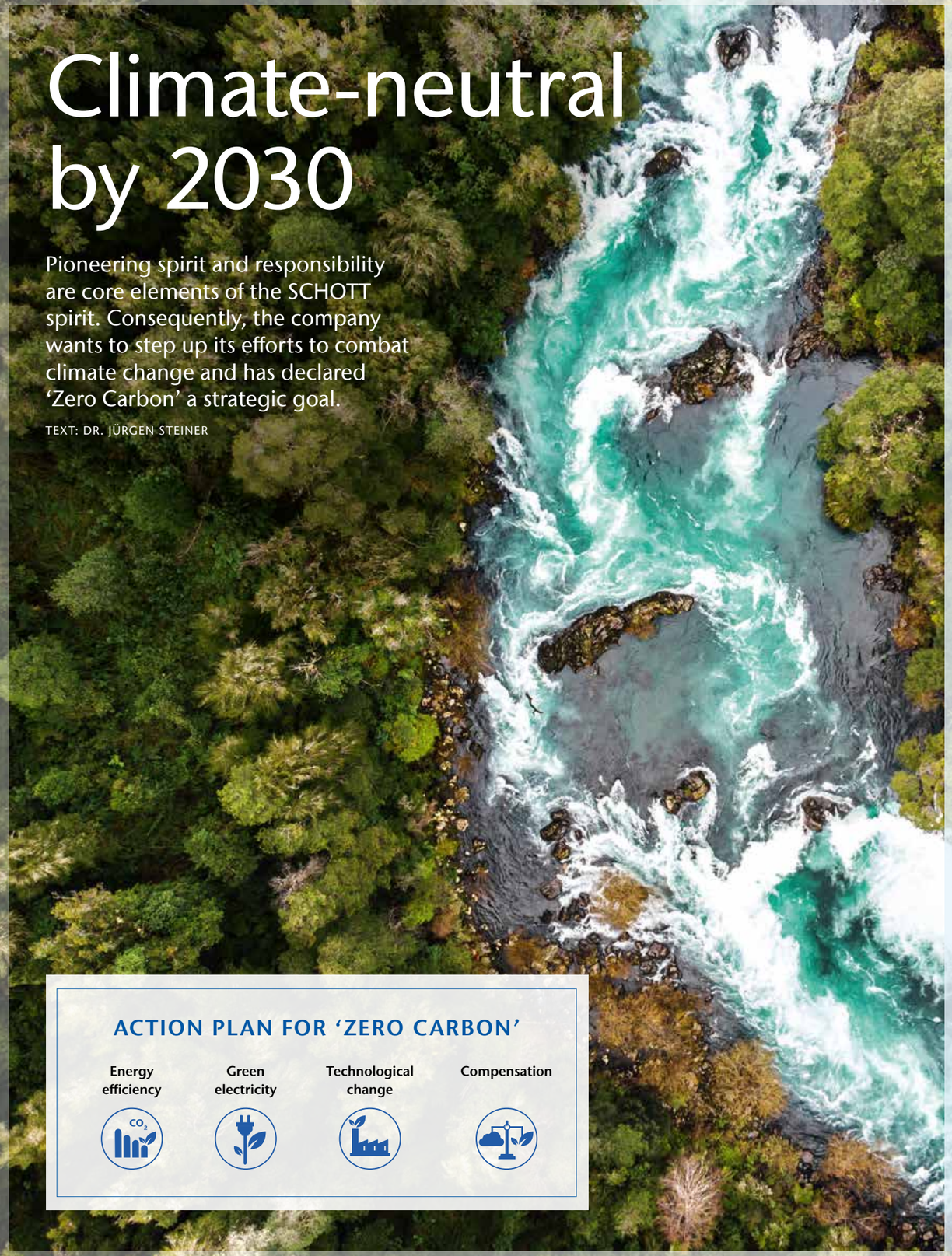
How important are the vials and what responsibility does SCHOTT bear here?
The packaging is an integral part of every medication. Without pharmaceutical vials like ours, vital vaccines cannot reach patients. In addition to the dimensional and cosmetic quality of a vial, the material plays a particularly important role. The main material used is borosilicate glass, which has long been the gold standard for drug packaging. The material is chemically inert, which means that it avoids interaction between the packaging and the vaccine. The effectiveness of the drug is thus preserved. Since we produce the pharmaceutical glass for the packaging ourselves, we are also able to adjust the capacities for glass production in advance.

Do you have a final message for our readers?
I think I speak for everyone when I say that the pandemic poses a major challenge. We are proud that our products receive so much trust and that we are actively participating in the fight against COVID-19. We will continue to do our utmost to support our customers and partners with high-quality solutions. After all, close cooperation is essential, especially in times like these. ●

Climate-neutral by 2030

Pioneering spirit and responsibility are core elements of the SCHOTT spirit. Consequently, the company wants to step up its efforts to combat climate change and has declared ‘Zero Carbon’ a strategic goal.

TEXT: DR. JÜRGEN STEINER



ACTION PLAN FOR ‘ZERO CARBON’

Even if some still refuse to believe it, science has long since proven that progressive climate change is one of the greatest challenges of our time. If we do not succeed in limiting the global rise in temperature, the livelihoods of more and more people will be threatened. Against this backdrop, around 200 countries committed themselves to limiting man-made global warming to 1.5 degrees Celsius in the Paris Climate Agreement in 2015. And the European Union has set itself the goal of making Europe the world’s first climate-neutral continent by 2050.

SCHOTT is much more ambitious and wants to become a climate-neutral company by 2030. No other company in the specialty glass industry has set itself such an ambitious goal to date. “All social players must assume responsibility for the future of our planet. We want to make an active contribution to climate protection,” explains Dr. Frank Heinricht, Chairman of the Board of Management of SCHOTT AG. With this in mind, the company has made the goal of ‘Zero Carbon’ one of the pillars of its new Corporate Strategy.

GLASS PRODUCTION IS ENERGY INTENSIVE

As a manufacturer of specialty glass, SCHOTT requires a great deal of energy – similar to companies in the plastics, steel, paper, and construction materials industries that are positioned at the beginning of the value chain as material manufacturers. Specialty glasses and glass-ceramics are melted in large melting tanks at temperatures of up to 1,700 degrees Celsius. Until now, the melting tanks have been heated with either natural gas and heating oil, both fossil fuels, or electricity. Due to the high energy requirement, the climate-relevant footprint amounts to around 1 million tons of CO_2e (CO_2 equivalents) per year. This equates to roughly the CO_2 emissions of a city in Europe with 150,000 inhabitants.

ACTION PLAN WITH FOUR MAIN AREAS

“On our way to climate neutrality, we want to reduce, avoid or compensate for climate-damaging emissions,” says Chairman of the Board Heinricht. The action plan comprises four main areas: Increasing energy efficiency, switching to green electricity, technological change and compensating for technologically unavoidable emissions.

The technology Group has been working on improving its energy efficiency for decades. The introduction of oxy-fuel melting technology and the increasing use of electricity to heat the melting tanks since the 1990s have already helped the company reduce its specific energy consumption by over 30 percent. The experts are constantly working to identify and exploit further energy-saving potential within the framework of the proven energy management system.

“WE WANT TO MAKE AN ACTIVE CONTRIBUTION TO CLIMATE PROTECTION.”

Dr. Frank Heinricht,
Chairman of the Board of Management, SCHOTT AG

When it comes to electrical energy, SCHOTT will be relying entirely on green electricity in the future. By 2021, the Group wants to cover 100 percent of its electricity needs with renewable energy sources such as hydroelectric power, wind power, solar energy, and biomass with corresponding certificates of origin.

In the long term, the company wants to avoid using fossil fuels by developing new technologies – as far as this is technologically feasible. However, this transformation process takes time and requires enormous development and investment costs. The company sees a promising approach in hydrogen technology. Furthermore, researchers and melting technologists are also investigating the feasibility of other technological approaches.

It will be many years before large-scale CO_2-free solutions are available in specialty glass production. In the meantime, the company intends to compensate for technologically unavoidable CO_2 emissions by investing in climate protection projects. Such an compensation portfolio could include involvement in sustainable reforestation projects, for example.

GUIDING PRINCIPLES, PIONEERING SPIRIT AND RESPONSIBILITY

SCHOTT is heralding a new era in its environmental and climate management with its ‘Zero Carbon’ strategy project. “Pioneering spirit, long-term thinking and responsible action have been deeply rooted in the company’s DNA since the days of its founding. We also want to be guided by these principles in our fight against climate change,” says Dr. Frank Heinricht. ●

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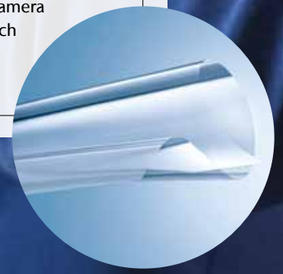
Lightning-fast glass production

They are also called “Petrified Fingers of God.” However, they are not a spiritual, but rather a purely physical phenomenon. The so-called fulgurites are created when lightning strikes into sandy soil and transforms the grains into raw glass. With electrical voltage of 500 million volts and temperatures of up to 30,000 degrees Celsius, the lightning melts hollow tubes around two centimeters in diameter into the ground. Lightning collectors have already found up to five-meter-deep specimens of such tubes and fossilizations that are also called flash glasses. According to the Guinness Book of Records, most of these petrified lightning strikes are owned by a German hobby researcher.

Ideas that strike like lightning

Glass manufacturing at SCHOTT is much less random than when lightning strikes. And the experts also need more than just enormous heat and a pile of sand – namely, first and foremost, a lot of know-how. 70 percent sand, 30 percent other components such as soda or lime and high temperatures – that is the basic formula for manufacturing glass, just as it has been for ages. However, the company now manufactures products from more than 400 different types of glass, including cooktop panels, pharmaceutical vials and optical glass for camera and microscope lenses. The portfolio also includes absolute high-tech specialty glasses with extreme properties such as this flexible ultra-thin glass that is used to manufacture foldable cell phone displays.



The Rock Star

The world is a flat disc - at least the world of cooking. This is evidenced by the more than 180 million CERAN® glass-ceramic cooktop panels sold. They have revolutionized kitchens and cooking around the world since their launch in 1971. Discover the success story of an exceptional material that is still ready for the future, even after 50 years.

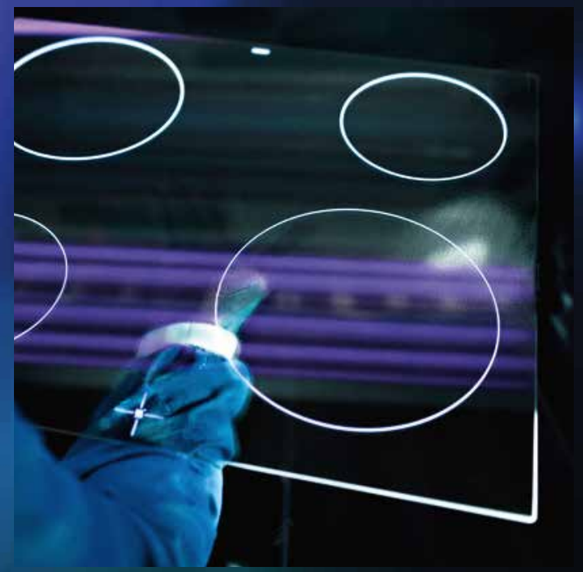
TEXT: MICHAEL THIEM

The revolution in the kitchen continues: SCHOTT continues to push boundaries with visionary concepts such as the FUSICS® cooking table, for example.

MANY PEOPLE CONSIDERED THE NOTION OF GLASS-CERAMIC COOKTOPS TO BE "COMPLETE NONSENSE."

Herwig Scheidler, Head of the CERAN® project team in the late-1960s.

A success story for 50 years: SCHOTT is the world's market leader with its CERAN® glass-ceramic cooktop panels.



The observer twitches involuntarily. Careful, glass! It's fragile. That is what most people think when the 535-gram steel ball is dropped onto the glass-ceramic from a height of 51.4 centimeters (20 inches). But it isn't fragile at all. A simple experiment that has not lost its seemingly magical effect even after 50 years. The same effect is achieved by placing ice cubes on a hot CERAN® glass-ceramic cooktop. It hisses and the water evaporates within seconds. Temperature shocks from +700 to -200 degrees Celsius have no effect either. So the motto must be: Attention, glass-ceramic! because it is extremely resilient and temperature stable. It doesn't age, is translucent and is suited for use with all heating technologies – including induction and gas.

Glass-ceramic represents the SCHOTT success story like hardly any other material. The brand name CERAN® has enormous appeal, is a product synonymous with high-quality and innovative glass-ceramic cooktop panels, and has been a guarantee of quality for more than 50 years. Available in black, white or transparent, every year several million pieces currently leave the CERAN® Technology Center and are installed in kitchen stoves all over the world.

"We have always pursued a clear goal: We want to bring unique, economically attractive products to the market that are suited for cooking applications and all the related requirements. Today and in the future," says Dr. Matthias Bockmeyer, Head of Development for Cooking.

"CERAN® opens up a particularly exciting field for material development," explains Dr. Friedrich Siebers, who has had a decisive influence on its success story since 1985. The material developer knows every tiny detail and has faced many challenges. Glass-ceramic is a demanding but reliable material due to the complex interplay of the material and the process. "If you make the right adjustments in the tenths of a weight percent range or change the parameters during processing, properties can be customized for the application," Dr. Siebers emphasizes.

3x

SCHOTT CERAN® has been awarded the title "Brand of the Century" three times. Thanks to its successes in 2013, 2016 and 2019, glass-ceramic has joined the league of German brands that have become the standard for an entire industry worldwide.

The efficiency of SCHOTT CERAN® cooktop panels in combination with electric radiation is more than

70

percent, with induction more than 80 percent – depending on the output of the respective stove. Glass-ceramic is therefore extremely energy efficient.

What sounds simple is actually complex in terms of the details. Even the name glass-ceramic contains a contradiction and thus the challenge becomes clear – the green glass needs to remain homogeneous during melting and shaping. If crystals were to form, they would affect the strength. In a second process, it must no longer be stable glass, but allowed to form fine crystals very quickly during ceramization. The glass that is specially mixed with seed images for this purpose is brought to ceramization in a time-temperature process. In the end, a glass-ceramic that has the desired properties is manufactured – a material for cooktops that combines the aesthetics of glass with incredibly high heat resistance and stability.

SCHOTT has continuously developed the process over the course of five decades. In order to achieve sustained success, central research and all related business departments, including Product Management and Sales and Marketing, work together very closely. The goal is to make basic research suitable for everyday use and to bring innovations to the point where they are ready for series production. Experience helps here, and SCHOTT knows a great deal about the material. The basis for this is an empirical model that maps the product and the manufacturing process on the basis of around 40 material and process properties. "These key properties can be measured in laboratory samples in our Analytical and Application Technology departments," Dr. Siebers explains. Thanks to the well-founded database of compositions and properties, it is possible to optimize the product according to the specifications in the requirement profile. For this purpose and to exclude later conflicts of interest, the experts use highly developed statistical methods. The quality of the data is crucial. The higher, the better. It can be used to make predictions about future properties, save development time, avoid risks in the production process and achieve the desired quality. This knowledge is protected by more than 160 patent families relating to the materials and the product. The brand name CERAN® was first registered in 1962.

Its beginnings more than 50 years ago were hardly easy. Even internally, at the end of the 1960s, many people considered the notion of glass-ceramic cooktops to be "complete nonsense," Herwig Scheidler, who was head of a small project team at that time, recalls. The idea came from the sales expert Arno Roth (†), who discovered white plates for cooktops that a household appliance manufacturer in the US was using. But the industry was skeptical. If you want to revolutionize a conservative market, you need courage and perseverance. Pioneers need to be able to convince others – and they need the right partners. Together with the German manufacturer Imperial, SCHOTT presented the innovative cooktop solution at the "Domotechnica" home appliance trade fair back in 1971 and started serial production in Mainz, Germany, a short time later. Cooking on glass? The reactions were hesitant, the reservations large. But SCHOTT accelerated the paradigm shift in the kitchen by assisting customers with installation, performing demonstrations of the unusual material quality and the ease of cleaning. These demonstrations are still being offered today.

Nearly as hard as a diamond! SCHOTT CERAN Miradur® is the first and only scratch-resistant glass-ceramic cooktop panel in the world. This means:

95

percent fewer scratches from sand

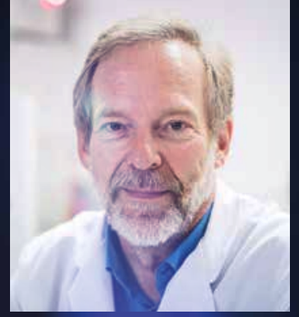
70

percent fewer scratches from abrasive sponges.

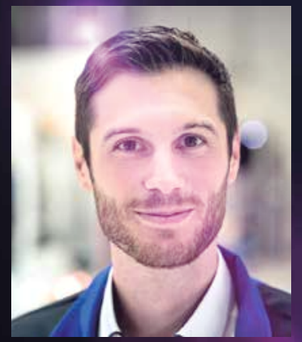
MARKET RESEARCH IN THE CAFETERIA

These first prototypes were manufactured in the optics division using an old melting technique. The cooktop panels were 600 by 600 millimeters in size, four millimeters thick and black. Herwig Scheidler recalls the design decision. "We gave employees in the cafeteria samples in black ▸









GLASS-CERAMIC PRODUCTION

In accordance with the methods commonly used in glass technology, a glass melt is first produced by melting the right raw materials, purifying, homogenizing and finally hot-forming it. After cooling and stress relieving of the glassy ingot, a temperature treatment follows in which the glass is transformed into a glass-ceramic by controlled volume crystallization. In its interior, substances already added to the melt now form crystal nuclei on which tiny crystals grow as the temperature rises. These have the property of contracting when they are exposed to heat. In this way, they counteract the thermal expansion of pure glass. Glass-ceramics from SCHOTT can thus withstand temperature shocks of +700 to -200 degrees Celsius without shattering or changing their shape even slightly.

and white, and had them vote on them. The vote was a draw. We then decided on black because the red-glowing elements were still clearly visible," says Scheidler. The first hand-polished surfaces contained open bubbles. The iron oxide, the so-called polishing red, could be seen. For the trade fair premiere, this was hidden by using a black felt-tip pen. These were exciting times indeed. In 1973, series production on rollers started, but only three percent of the surfaces manufactured met the quality standards. The challenges were enormous, but so were the opportunities and SCHOTT quickly found the right set screws. That same year, CERAN® glass-ceramic cooktop sales numbers increased and the success story began.

"Back then, we jumped on a moving train." This is how Dr. Jürgen Petzoldt († 2011), materials specialist and later the member of the SCHOTT Board of Management responsible for Research & Development, once described the situation. The company is not the inventor of glass-ceramics, but it was instrumental in driving forward and shaping industrial mass production. Petzoldt developed the glass-ceramic ZERODUR®. The first large order in 1968 was for mirror substrates of various sizes and a 3.6-meter mirror substrate for an optical telescope. "ZERODUR® has taught us a great deal in terms of technology, especially the ability to control high melting and shaping temperatures," Dr. Siebers says.

SCHOTT is the world's market leader with its CERAN® glass-ceramic cooktop panels. Above all, the holistic approach to the system of heated cooktop panels, which is pursued together with customers, remains a decisive success factor. The material now has Rock Star status. New developments are celebrated in the spotlight on the stages of the world together with customers. SCHOTT continues to set milestones with CERAN® regularly outperforming itself. Customization also plays an important role here. "Post-processing is a source of innovation," says Dr. Bockmeyer, "but our starting point is the overall package." And close cooperation with customers. "We don't want to be just a supplier of a panel, but rather as a partner, we want to help our customers use the product," emphasizes Evelin Weiss, who, as Head of Material Development Projects, is responsible for CERAN®. "And being able to deliver a product in small batches worldwide in a very short time is an enormous advantage."

"WE WANT TO BRING UNIQUE, ECONOMICALLY ATTRACTIVE PRODUCTS TO THE MARKET, NOW AND IN THE FUTURE."

Dr. Matthias Bockmeyer, Head of Development for Cooking

LIGHT OPENS UP NEW DESIGN WORLDS

The basic recipe of CERAN® has been further developed at crucial points over the past decades because the knowledge has constantly grown. Major milestones included the development of a new refining technology that made it possible to dispense with adding the heavy metals arsenic and antimony, and the development of cooktop panels that not only allowed the light of red LED displays to pass through, but also enabled differently colored displays with blue or white light. SCHOTT received the 2010 German Innovation Award for CERAN HIGHTRANS® eco, the product the company developed in 2007. More than 200 tons of heavy metals are avoided each year.

Cooktops have been developing into design objects for years because kitchens are also changing and becoming open, integral components of the living area. CERAN® is becoming the material kitchen dreams are made of. CERAN CLEARTRANS® is the first step in this direction. Coated glass-ceramics allow for various color possibilities. CERAN HIGHTRANS® rubio, an important part of the CERAN EXCITE® portfolio, allows for completely new design concepts in connection with the color scheme of the user interface and the hot zone in a cooktop. SCHOTT received the renowned iF Gold Award for this in 2019.

And cooking is becoming smart. With the support of glass-ceramics, innovative lighting concepts are being created that ensure intuitive and intelligent operation. Brilliant white light, clear shapes and bright accents underscore the cooking area. Cooking is fun. "Light accompanies us every day. It determines our rhythm and our everyday life. It shows us the way, guides our eyes and hands. It gives us security and comfort. It creates fascinating experiences and is simply fun. In short: light is a highly emotional component that makes products more exciting," says Dr. Jörn Besinger, Head of Product Management & New Business Development for CERAN®. Other milestones include CERAN Miradur®, the world's only cooktop panel with a scratch-resistant coating, and visionary concepts such as the FUSICS® cooking table. The award-winning prototype gives a foretaste of the future that has long since begun at SCHOTT.

"There are always trends that place new demands on our material. This allows us to differentiate ourselves," says Dr. Bockmeyer. For example, for some years now, the cooktops have been fitted with special recesses for the use of appropriate ventilation variants. And Smart Home does not stop at cooking. "There will be more and more intelligence in the cooktops, which will be networked with other household appliances," Weiss explains. "Integrated TFT displays will lead to us not only using black glass-ceramic, but increasingly transparent ones with black coatings on the underside." SCHOTT is striving to further increase the design variety. Weiss: "Customers from all price segments will be able to differentiate themselves in the future not only through the décor, but also through the color scheme. User interfaces via touch control combined with the display of all conceivable colors will then be possible." Definitely a much sought-after innovation, CERAN® remains the Rock Star among the materials used in the kitchen – and is getting better and better as time passes. ●

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The word mark CERAN® is registered at the German Patent and Trademark Office under the registration number **768198**
All information can be found here:
https://bit.ly/3aEEavR

Temperature shocks from plus **700** to minus **200** degrees Celsius have no consequences.

More than **5,520,000** hits result from the Google search for the term "Ceran." When one enters "glass-ceramic," the search engine "only" finds 1.3 million entries.

Writing glass history

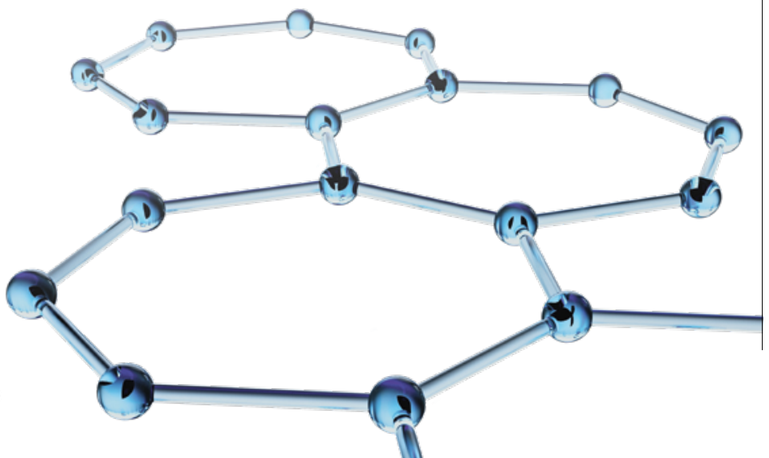
Dr. Matthias Müller, Executive Vice President RD, on why he enjoys working with glass and tackling the challenges of climate-friendly glass production in the future.

INTERVIEW: CHRISTINE FUHR

What did you want to be when you were young?
I was fascinated by materials, especially wood and ceramics, even at an early age. But I also found classical archaeology very exciting. Thanks to my studies and my doctorate degree from the University of Erlangen, materials science has become my career, in which my main focus is on semiconductor materials, glass, and ceramics.

How does working with glass every day motivate you? Doesn't it ever get boring?
What motivates me the most is my great international team, which we recently expanded by five more employees at our new Chinese R&D center. And, of course, glass fascinates me due to its variability and complexity. I enjoy exploring and tailoring its properties for applications in nearly all areas of life. The potential this material offers is almost inexhaustible – I never get bored with it!

"THE POTENTIAL OF THE MATERIAL IS ALMOST LIMITLESS – FOR US IT NEVER GETS BORING."



What do you tell people when they ask you about SCHOTT and your job?
I start with CERAN® glass-ceramic cooktop panels, as these are familiar to almost everyone. Then I explain that most of the products we develop are not even evident to the consumer–airbag igniters that save lives or smartphones, for example. Or that we use our know-how to make pharmaceutical packaging such as syringes or ampoules more stable and optimize them for use in individual cancer therapy. When the importance of glass becomes clear, most people are quite excited about it. It then becomes obvious that SCHOTT, as a 'hidden champion,' enables many technical innovations by further developing glass.

How do you feel about your role as Head of Research?
Otto Schott was the first Head of Research over 130 years ago; other outstanding glass pioneers followed in our company's history. For me, it is a responsibility and an honor to stand in this tradition and to continue to advance the history of glass that has shaped the 20th century.

Constantly fascinated by the material glass: Dr. Matthias Müller has been Head of Research and Development at SCHOTT since 2018.

What do you want to achieve?
Together with my team, I would like to push the technological limits of glass even further and use our creativity and profound knowledge to set further milestones in the line of outstanding SCHOTT products. To achieve this, we are continually filling and expanding our 'toolbox,' with the help of 'Material Informatics' – the data-based design of new materials, for example, or through the targeted use of Artificial Intelligence to optimize tank technologies and downstream processes. We work at the forefront of laser technologies (p. 24). We also look beyond the "glassy" horizon and evaluate so-called 'adjacencies.' 'Adjacent' materials and technologies can perfectly complement our portfolio. And, today more importantly, we want to make the production of glass climate-neutral – a huge challenge! We rely on external partners in areas where we are not that strong. In the future, we will benefit significantly from the further expansion of multidisciplinarity, internationality, diversity, and networks.

What challenges do glass and its manufacturing processes face?
With increasing globalization, the markets are shifting, especially to Asia, where we see significant opportunities for further growth with glass, but where new competition is also on the rise. The availability and scarcity of raw materials, such as lithium, is also an issue. And digitalization will continue to change our private and professional lives dramatically. This requires new skills, but it also opens up opportunities: every software needs hardware, and therefore also high-performance materials such as glass. This also applies to modern energy and mobility concepts (*solutions 1/19*). And, as I mentioned, we see a huge challenge due to the energy-intensive production of glass. We want to take responsibility for ensuring that this becomes climate-neutral within the next decade against the backdrop of climate change. And I am committed to jointly making SCHOTT the first manufacturer in the glass industry worldwide to become CO_2 neutral. ●

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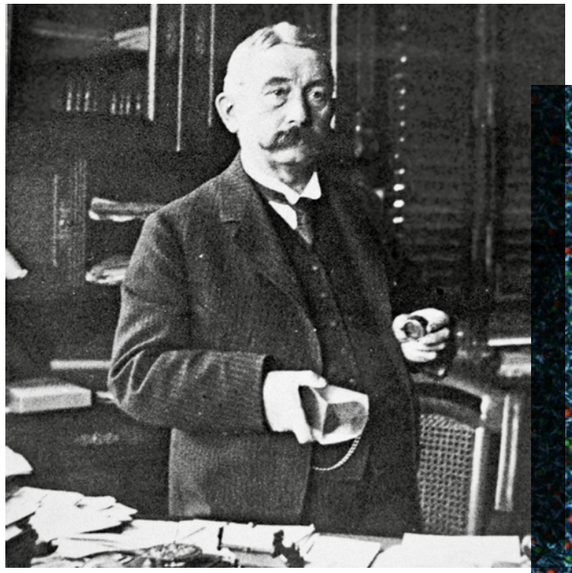
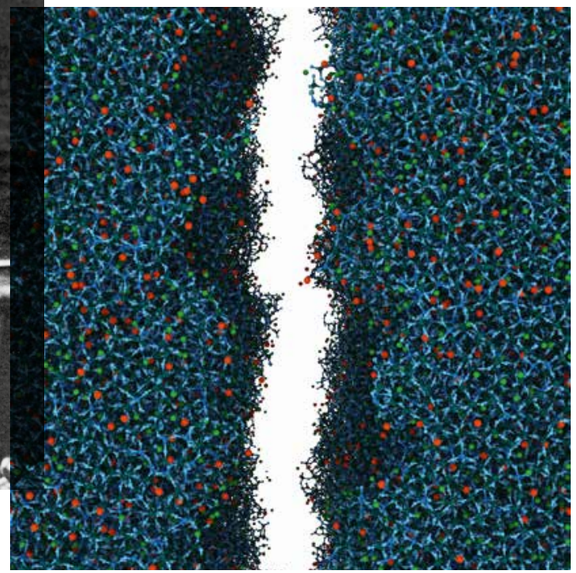


Otto Schott is regarded as the inventor of specialty glass. He pioneered the development of glass with precisely defined properties.



Materials research today: Simulations help us answer key questions, such as why cracks occur in borosilicate glass.

Decoding the glass genome

Materials informatics provides efficient tools that can predict glass properties with increasing accuracy. SCHOTT experts are lifting the scientific methodology of glass development, founded by the ‘glass doctor’ Otto Schott in the 19th century, to the next level.

TEXT: THILO HORVATITSCH

Even as a young boy, Otto Schott was fascinated by his father’s glassmaking business. In 1879, the chemist began to study chemical elements as suitable ingredients for the fabrication of glass. Through his laboratory experiments, he discovered how the right chemical compound could be used to obtain desired glass properties. He discovered chemical relationships: his law of mixing was the first to quantitatively predict future glass properties such as refraction and thermal expansion from its chemical composition.

This milestone was the starting point of modern glass science. For thousands of years, the production of glass had depended solely on the experience and experimental skills of the glass maker. Otto Schott forged ahead with his theories on the properties of glasses. Thus, within a period of time, he did not only develop innovative glasses (see info box) and fabrication processes, but also established specialty glass as a new industrial sector, turning SCHOTT into a global company.

“Contemporaries claimed that Otto Schott could look right into the heart of the glass. However, he was also the first to develop glasses by data processing. Today, with the rising performance of materials informatics, we can delve even deeper into his legacy, by looking into the genome of a material, you might say,” explains Senior Principal Scientist Dr. Ulrich Fotheringham. The physicist is engaged in material development and has been working at SCHOTT for more than 30 years, since the beginning of the 1990s when he initiated the collaboration with the Faculty of Physics at the Johannes Gutenberg University in Mainz on computer-assisted glass development.

Mathematical modeling and simulation enable on-screen experiments in order to obtain insights into a real system or to make predictions. This accelerates and improves the material development process, aimed at shorter development times and innovation cycles. SCHOTT uses these methods in the optimization and development of almost all of its technological processes and products.

“Thanks to mathematical simulation, in modern glass-ceramic fabrication, crucial properties such as zero thermal expansion or color impression, can be precisely adjusted to the desired values.” Dr. Fotheringham explains.

The development of innovative materials with surprising qualities is also promoted. A ‘hot’ example is a new borosilicate glass, which is ideal as a fire protection safety glass. However, to achieve this quality, it must first be thermally toughened, a complex physicochemical process, the result of which largely hinges on the ’hidden parameters’ of the glass. “For the first time, we were able to determine these parameters through simulation, rather than painstaking experimentation, significantly reducing development time and cost,” continues Dr. Fotheringham.

In addition, the development of specialty glass ceramic powders for the next generation of battery technologies offers impressive potential for success in this attractive future market. The material is key to the production of innovative solid-state batteries, which are aimed at increasing the range of electric vehicles.

As these examples underline, the development of new products often hinges on new materials with improved properties. It is estimated that new materials are currently pivotal to around two out of three innovations. Materials informatics can quite literally act as a turbo effect. This emerging discipline has recently begun to draw on artificial intelligence, machine learning and automated analysis processes in data processing. Such concepts already support successful applications in other areas such as autonomous driving, speech recognition on mobile phones and the utilization of Internet data for user profiles and customized marketing. This involves powerful computers processing reams of data based on self-learning algorithms.

“With the help of machine learning, patterns and relationships can be extracted and predictions made – which is exactly what we are aiming for. However, such data volumes are not available to us in glass development,” says Dr. Benedikt Ziebarth, Principal Scientist Materials Informatics. While the Internet basically generates billions of data for free, a single datapoint in the field of materials science may well be the result of a measurement that has cost thousands of euros. “We therefore develop hybrid models that combine the small amount of material data with domain knowledge. This domain knowledge is present in the extensive toolbox of mathematical simulations and modeling already available at SCHOTT. We are also involved in relevant consortium projects,” adds Ziebarth. SCHOTT thus maintains a lively exchange with institutes and companies on the digitalization of material development. This shows that besides artificial intelligence, human intelligence is still a necessary part of the equation. SCHOTT is thus set to remain a prime address for upcoming generations of ‘glass doctors,’ true to the spirit of its founder, Otto Schott. ●

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NEW GLASSES FOR THE WORLD

Otto Schott (1851–1935) was a pioneer of industrial glass fabrication who sparked a plethora of outstanding glass developments and applications in the 19th century. Here are just a few examples:

1884
Optical glasses for improved microscopes

1884
Glass tubing for thermometer and water gauge glasses

1887/1893
Invention of chemically resistant, heat- and temperature-change resistant borosilicate glass

1891
Borosilicate glass tubing for thermometers

1893
Laboratory glassware made of borosilicate glass

1894
Borosilicate glass cylinder for gas lighting

1894
Optical glasses (up to 140 cm in diameter) for refracting telescopes

Long live lasers

A laser is a miraculous tool that generates a lot of interest in the area of glass processing. And SCHOTT is constantly developing its process know-how. This enables high-precision, customized product solutions that help drive trends, particularly in the area of digitalization.

TEXT: CHRISTINE FUHR

Laser-based processes create new glass functionalities that would be impossible without lasers.

Fans of the blockbuster movie *Star Wars* immediately think of one thing when they hear the word laser: the lightsaber swung by Darth Vader & Co. What fascinates us in fiction has also become a popular constructive tool in the industrial sector. Even while George Lucas was producing his space adventure in the mid-1970s, laser tools had long since become industrial reality: improved CO_2 lasers and the development of new types of lasers enabled the first applications in metalworking, especially in the automotive and aircraft industries.

"It took a while for lasers to be used in glass processing," explains Bernd Hoppe, Head of the Competence Field Laser and Post Processing at SCHOTT. "In the meantime, they have become robust, reliable and economical. When it comes to specialty glasses, they do an extremely good job, with highly reproducible results in 24/7 use, high flexibility and no wear and tear." The process engineer knows what he is talking about. He has been working intensively on glass-based laser processes for over two decades and is a stakeholder in over 75 patents on novel glass processing technologies. His 15-member team of experts works on development projects that involve the use of lasers – from the initial process idea to the successful transfer for use in serial production.

With the laser, glass can be precisely and individually structured.

The infrastructure in the so-called experiment hall of the research center is always kept up-to-date. For the last few months, it has also housed a glass processing facility with the most powerful commercially available ultrashort pulse laser for industrial applications. This is used to develop particle-free cutting processes, flexible structuring processes and innovative optical concepts for glass processing. The processing area of the system is 600 x 1,200 mm. "We achieve extreme specifications with the new tool. More specifically, tolerances of ten micrometers or less," explains Michael Kluge, the person responsible for the facility and Project Manager for Post Processing. His job is to make the production technology of the laser tools that are available on the market accessible to SCHOTT for use in glass processing, to develop it further and ensure that it is ready for use in development projects.

LASER – GLASS INTERACTION

Conventional cutting and scribing of glass cause splinters and particles, while breaking causes chipping along the edges. The diamond tools used wear down and then have to be replaced. Furthermore, customized products require a complex and time-consuming process sequence. Laser processes, on the other hand, offer many advantages: Complex geometries can be realized in a short period of time simply by reading the design drawing directly into the machine. The non-contact tool works without leaving any particles behind, is dry and requires no additional aids. During cutting, the glass is first perforated or 'damaged' locally and then separated by way of thermal cleaving. SCHOTT has several high-performance ultrashort pulse lasers as well as CO_2 lasers of various power classes that are used not only for cutting, but also for structuring, marking, decorating, forming and bonding.

314

laser light projectors were used in 2017 at the world's largest laser show. The demonstration in Las Vegas lasted 30 minutes and secured the creators an entry in the Guinness Book of Records.

There is no universal recipe for the optimal interaction of glass and lasers for all glass types, however. What counts is experience coupled with specific technological and material know-how. "With laser-based processes, we achieve new, improved glass functionalities and properties that would be completely unthinkable without lasers. We are thus exceeding the technological limits of conventional processes," explains Bernd Hoppe. "Our unique selling point is our continuously optimized process know- ▸

The structured glass wafers achieve tolerances of 10 micrometers thanks to laser processing.

how for a broad portfolio of specialty glasses. And customers benefit from this."

REVOLUTIONARY SOLUTIONS

Besides dead-front effects for special light displays in cooktops that are created by structuring, the forming of light conductors for dental applications, glass plates with precise laser-drilled holes for shower heads, sophisticated structured flat, thin and ultra-thin glass wafers with tolerances of less than 10 micrometers and high edge qualities are particular highlights of the laser processing that SCHOTT performs. They are suited for innovative electronic, semiconductor, diagnostic and medical glass solutions. The pharmaceutical industry also benefits from SCHOTT's know-how. The introduction of Smart Containers makes it possible to tap into the power of machine vision and mass data analysis on pharmaceutical filling lines. Each Smart Container is marked by laser with a unique identifier to enable the first time complete traceability throughout the entire manufacturing process. The data matrix code is as small as 1 x 1 mm. The technology can be used to improve line clearance, reduce the risk of mix-ups, and reduce targeted container-based recalls. "We are ushering in a new era of digitalized pharmaceutical production that focuses on real-time approvals and utilizes the latest developments in machine vision and data science," comments Diana Löber, Global Product Manager for Vials.

Ultrashort pulse lasers also offer new possibilities for the joining of glass wafers without the use of any adhesives. This enables hermetic sealing with new material combinations. "With glass micro bonding, we have a pinpoint sealing area with minimal thermal load of just a few microns. We can create a hermetic seal without subjecting the component or electronics to be encapsulated to potentially damaging heat, and without the need for any additional materials," explains Ville Hevonkorpi, the Finnish Managing Director of SCHOTT Primoceler Oy. Glass micro bonding technology enables room temperature processing without warpage or outgassing. "The benefits of our laser welding process are multiplied when using thinner materials and bigger wafers, which is well aligned with current development trends," Hevonkorpi adds. The process is suited for near-perfect gap control in microfluidics, glass-based hermetic lens positioning in micro-optics, VCSEL arrays in aerospace, and 3D chip packages for semiconductors. In combination with biocompatible glasses, solid glass housings make it possible to realize highly miniaturized medical implants – many of which are orders of magnitude smaller than current implants and enable entirely new medical applications (p. 39).

5

letters, one shortcut. The word laser stands for light amplification by stimulated emission of radiation.

Using the ultrashort pulse lasers, SCHOTT is perfectly prepared for the next technology leap: high rate structuring.

Already in

1933

the lightsaber is mentioned in science fiction literature, long before *Star Wars*, namely in Edmond Hamilton's *Kaldar, World of Antares*.

1960

On May 16, the American physicist Theodore Maiman built the first working laser – a ruby laser.

HIGH RATE STRUCTURING

The high performance levels now available prepare the laser for the next leap: ultra-fast processing of large surfaces. This is achieved by special beam shaping and parallel laser beams with only one laser source. By using large format optics, square-meter-sized glass plates can then be processed and structured in seconds. This opens up new functionalities, faster structuring processes and decorative applications. As Hoppe puts it: "High rate structuring is a trend and currently one of our new focus topics. We are at the forefront of technological evaluation and maintain a large network with external partners in order to implement the technology as quickly as possible." In the new star saga by film producer J.J. Abrams as well, the lightsabers have not only developed in terms of color, but also technologically, after 42 years: In the latest *Star Wars* episode 9, a folding red double lightsaber was even used for the first time. And at the University of Würzburg in 2018, Professor Dr. Tobias Brixner and his 'Femto Stars' from the Faculty of Physical and Theoretical Chemistry, took a closer look at the fictitious fencing weapon and realized a lightsaber based on femtosecond laser pulses. ●

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Inkjet printers enable high design flexibility. SCHOTT's know-how lies in the chemistry of ceramic inks.

Sophisticated surfaces

Glass that doesn't go blind in sandstorms or change color when viewed from different angles is fascinating. This is made possible by coatings and surface modifications that result in stable processes for innovative customer solutions.

TEXT: CHRISTINE FUHR

Our motivation is to develop new properties and solve puzzles," says Dr. Eveline Rudigier-Voigt. This is not so much about conventional puzzles as it is about scientific and technical issues: how can glass that is exposed to stresses such as corrosion, wear and tear, and many other effects be improved by altering its surfaces? How can glass surfaces in particular be manipulated in such a way, for example, that light reflects differently or not at all? What processes can be used for this and how can stable and economical processes be achieved in addition to new properties? This is precisely what interests the team in the Coating and Surface Modification competence area.

In order to solve such challenges and to modify surfaces to precisely meet customer requirements, the experts at SCHOTT Research have a toolbox at their disposal for implementing various property profiles. "Our 'superficial' approach requires a deep and detailed understanding of the materials of glass and glass-ceramics," explains Dr. Rudigier-Voigt who has been at SCHOTT for 12 years. After all, layers must not only adhere to glass optimally, but also be able to survive temperature cycles or sterilization processes, for example, without damage depending on the subsequent application. Besides the traditional coatings, surfaces can also be modified in a targeted manner by doping, activating or leaching, for example. These types of functionalizations often need to fulfill not only one property or requirement, but must also combine several of them.

INNOVATIVE PROCESSES FOR DIFFERENT (LAYER) DESIGNS

The traditional methods of enhancing glass surfaces are no secret: here, a distinction is made between plasma-assisted and direct gas phase technology, as well as liquid coating technologies. These technologies are then adapted and optimized for a wide variety of glasses or glass-ceramics.

Key technologies for gas phase coating include PVD (physical vapor deposition) and CVD (chemical vapor deposition), in which the coating materials are applied by the gas phase. The advantages of such vacuum processes are high precision and the deposition of extremely thin layers, from a few micrometers to a few 10 nanometers. These technologies are constantly being questioned, optimized and adapted with regard to their future viability and competitiveness. With plasma-assisted chemical vapor deposition processes, such as PICVD (Plasma Impulsed Chemical Vapor Deposition), a plasma pulsed in a few µs ensures a homogeneous special coating of complex 3D geometries, for the inside of pharmaceutical containers, for example.

Typical liquid coating technologies that SCHOTT uses include screen printing, inkjet and dipping processes, which can be used to apply a wide variety of coating materials – also available in structured form. As a comparatively new technology for glass and glass-ceramic coating, inkjet combines the advantages of high design flexibility with the possibility of economically realizing small batch sizes up to batch size one, making it an important component for future product developments, in the home appliance area, for example. The glass can be of various shapes and geometries: from flat and ultra-thin glass to tubes and formed pharmaceutical containers.

The main components for the respective functionality are the coating materials that are produced and applied using the previously mentioned processes. The process and synthesis go hand in hand. These materials can be organic, hybrid or inorganic. The layer design, on the other hand, can consist of a single material, a gradient, a nanocomposite or several layers (multilayers) depending on the functionality needed. Processes that achieve a change in the glass surface without direct coating are yet another component of realizing functionalities. The main emphasis is on developing wet chemical processes, from cleaning to etching. Experts on the team of Dr. Markus Kuhr, Head of Analytics, are responsible for this. Recently, however, the coating experts have also started researching modification processes that can be realized via the gas phase and especially through plasma processes.

TOOLBOX FOR EVERY REQUIREMENT

The easiest way to describe an overview of the functionalities that can be achieved by coating and surface ▸

First product tests are carried out on prototype systems. With the inkjet printer, different geometries – from flat glass to thin glass up to pharmaceutical containers – can be individually printed.

In the multi-process plant, functional coating materials with nanometer-sized particles can be produced.

modification (see graphic for examples) is to use a toolbox system. For example, coatings can be used to achieve optical, decorative, scratch-resistant, protective, tribological, electrically conductive or switchable properties, as well as surfaces with bio-relevant functionality such as protein-repellent properties.

The respective SCHOTT products range from optical glasses and filters, decorative flat glasses and glass-ceramic cooktop panels to pharmaceutical packaging and diagnostic slides. "There are always a number of fascinating question for us: What is the best way to meet the customer's requirements? What is really needed and how can the target functionality be best described? Are familiar solutions already sufficient or do we have to tinker around and develop something new?"says Dr. Rudigier-Voigt.

TOP COATING INNOVATIONS

The coating team recently broke its own functionality records with an innovation. Together with the Home Tech Business Unit, they developed the world's first and only scratch-resistant glass-ceramic cooktop panel. The surface of CERAN Miradur® has a degree of hardness close to that of a diamond! Practically speaking, this means 95 percent fewer scratches from sand and 70 percent fewer scratches from abrasive sponges. The special coating meets all of the respective thermal, mechanical and chemical requirements and can be used with various heating technologies. The innovative lighting solutions of CERAN EXCITE®, which are also implemented by means of underside coatings, allow for new design options, by replacing the decor with light, for example – and at the same time increase user comfort through precise, visual feedback (p. 18).

Microscopically thin double-sided Low-E coatings enable the oven doors of pyrolytic baking ovens to remain below 70° Celsius on the outside - and this during pyrolysis processes lasting up to five hours at temperatures of up to 400° Celsius. This is ensured by specially developed, highly efficient heat-reflective coatings that also shorten the heating up phase for the self-cleaning process.

With their innovative coating on the outer surface, EVERIC™ smooth pharmaceutical vials help eliminate a problem in filling pharmaceuticals: the outer glass surface is protected by this layer, which means that during processing on a filling line, the vials can be additionally protected against defects such as scratches. The transparent coating on the outer wall of the vials creates a low-friction surface while maintaining the optimized container strength. The result: an 80 percent improvement in the coefficient of friction for a smooth filling process. Side effect: cosmetic defects can be reduced by up to 95 percent (p. 44).

WHAT DOES THE FUTURE HOLD FOR COATINGS?

Comprehensive material know-how, a detailed overview of the portfolio, internal synergies, analyses and product tests, from which we learn time and again, coupled with the observation of worldwide technological trends, enable the experts at SCHOTT's central research center to develop perfect and customized solutions for customers.

Other challenging puzzles that need to be solved are currently in the development of magnetic layers in the context of quantum sensor technology and glass as a functional (sensory) component. In addition, coated glass plays an important role in digitalized processes and products: glass can 'communicate,' for example, through functionalization with RFIDs or sensor elements that can register surface changes. Current trends such as sustainability, health and environmental protection are also increasingly important for the development of new surface functionalities. For example, future coatings will have to meet increasingly stringent requirements in terms of performance and service life, as well as regulatory guidelines. Researchers are committed to the creative design of surfaces and evaluate, among other things, the applicability of self-healing layers, functional layers with a defined morphology, or biomimetic surfaces for our SCHOTT products. No wonder that the puzzle-cracking among the coating experts is so successful and effective. ●

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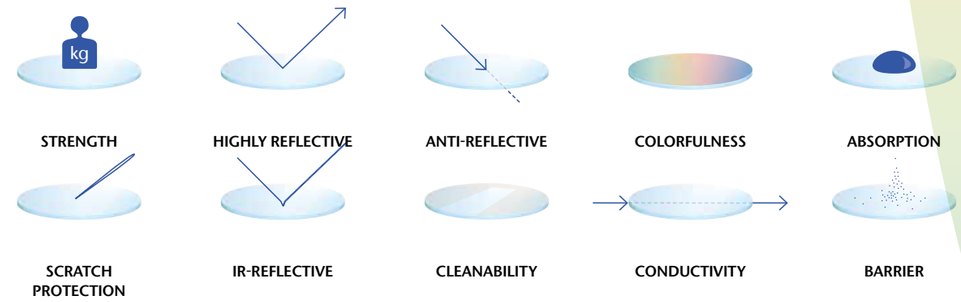
"I FIND IT FASCINATING THAT THE ARCHAIC MATERIAL OF GLASS CAN BE GIVEN COMPLETELY NEW FUNCTIONALITIES THROUGH A SURFACE TREATMENT. THERE IS STILL A LOT OF ROOM FOR SURPRISING INNOVATIONS HERE."

Dr. Eveline Rudigier-Voigt, Director Cold Processes SCHOTT

A PICVD inner coating enables highly efficient, transparent barrier layers for pharmaceutical packaging.

WIDE RANGE OF FUNCTIONALITIES

Which surface properties are required?
Properties are defined according to a modular principle and combined according to specific requirements.



Magic material

Ceramic converters for laser-pumped phosphor light sources pave the way to laser light technology with the highest luminance in the smallest spaces.

TEXT: THILO HORVATITSCH

Zap! When laser high beam light is emitted from a car headlight, it shines twice as far into the night as its LED counterpart. The laser-pumped phosphor light sources used for this purpose can generate light of the highest intensity on a few tenths of a square millimeter. Installed in state-of-the-art digital projectors, these light sources illuminate cinema screens with a diagonal of 20 meters and more. The lighting technology is considered to be trend-setting in research and industry. Its trump card: maximum luminance in the smallest spaces.

Luminance indicates how brightly the eye perceives luminous surfaces. It is measured in candela per square meter (cd/m²), the intensity of a surface per unit area. A clear 100-watt bulb reaches 10 million cd/m², the glaring midday sun around 1.6 billion. Modern laser-phosphor light sources can achieve significantly higher values today. This makes them ideal for concentrated illumination of limited areas – ideal not only for search or stage lights and projectors, but also for machine vision applications, microscopes or fiber optic devices such as endoscopes.

The trend is headed towards ever higher luminance levels with miniaturized technology. SCHOTT is accelerating this journey with an advanced material: fluorescent ceramics. What do they achieve when used for laser-pumped phosphor light sources? This light technology requires the conversion of laser light. It hits a phosphor and stimulates it to glow. For example, blue laser light is converted into yellow light. SCHOTT uses the same kind of doped crystalline phosphor that every LED light source contains for this purpose. "But unlike the conventional organically embedded phosphor powders, our material is prepared as completely inorganic fluorescent ceramics," explains Dr. Volker Hagemann, Senior Manager Applications at SCHOTT Advanced Optics. "It is more resistant to aging, allows more light to be generated in a minimal amount of space and enables even higher luminance levels with the best heat management."

Thanks to the bulk of the converter being made of solid ceramic, it can withstand temperatures of over 1,000 degrees Celsius, while phosphors in organic bonds such as silicone can only withstand temperatures of under 160 degrees Celsius. This and the excellent thermal conductivity are decisive factors in increasing performance because higher and higher luminance also leads to higher and higher temperatures.

SCHOTT has developed converter materials for yellow and green light on this basis, especially for laser-phosphor wheels in digital projectors. Here, the converted laser light is color-filtered to cover the entire color space of digital projection. The rotation of the phosphor wheels ensures their cooling and enables luminances of over 2.5 billion cd/m². The wheels can thus withstand more than 500 watts of laser light.

Static converters that enable extremely compact designs are the latest SCHOTT innovation. The ceramic material is soldered onto a heat spreader in order to dissipate the heat sustainably and to achieve the highest efficiency and reliability. The front and back of the ceramics are given special anti-reflective and metal coatings for optimal light control and heat dissipation. The converter components withstand a high permanent irradiance of more than 50 watts per square millimeter and enable luminances of up to 1.5 billion cd/m². The latter applies to hair-thin material thicknesses of 100 micrometers, which enable particularly good heat dissipation.

Material and process developers have refined a sophisticated industrial production process from nanopowder to sintered ceramics. Today, we can manufacture tailor-made products for various laser applications," says Dr. Hagemann. SCHOTT has been working on tapping into this new class of materials and its applications for years – and it remains exciting. "We are constantly working on increasing customer benefits, whether through thinner converter plates, new geometries, coatings or new classes of materials." ●

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SCHOTT manufactures both dynamic (left) and static converters (below).

Dr. Volker Hagemann, Senior Manager Application Ceramic Converters

ADJACENCIES

Exceeding performance limits

SCHOTT has been supporting the disruptive change in lighting for more than 100 years.

How did the development projects become a product?
We were able to draw on outstanding expertise in powder processing, hot forming, coating and optical measurement technology at SCHOTT and combine it with our ceramics and optical know-how in a new project. This allowed us to quickly adapt the ceramics to the requirement profiles of the first customers and to provide samples very quickly for the development of the first laser-phosphor light sources. Product development and the transition to mass production was then achieved in close cooperation with our customers.

What fascinates you about converter ceramics?
Their application potential. Ceramics can withstand several 100 watts of laser power. They help generate light that is actually brighter than the sun. It is precisely because of such outstanding performance that we look beyond the boundaries of our glass materials group – and deal with adjacent materials, so-called 'adjacencies.'

Why does a glass manufacturer even deal with ceramics?
We always keep an eye on market requirements and want to expand performance limits. Glass is naturally in competition with other materials. Already more than ten years ago, SCHOTT was interested in ceramics as an optical, transparent material because it can complement the range of properties of glass and glass-ceramics in terms of strength, its refractive index and dispersion.

Ceramic light converters are quite popular due to their other properties, however.
Even back then, development projects were already revealing the qualities of ceramics as light converters. The material impressed us with its good conversion efficiency and its thermal properties. This was also of interest to us because

Next stop: Polymer and hybrids

Borosilicate glass is considered the gold standard in the health industry. Yet, polymers are also gaining interest. It's not a question which material is better, but which offers the perfect fit for an application – or if a hybrid is the right solution.

TEXT: JOANA KORNBLUM

While the invention of borosilicate glass by Otto Schott opened the doors for numerous new technology applications, polymers are seen as modern game-changers for specific solutions. Particularly the pharmaceutical packaging and diagnostics markets have found ways to incorporate the material and build on its advantages.

Thanks to its characteristics, including its glass-like transparency and its flexibility in design, high-quality polymer and precisely Cyclic Olefin Copolymer (COC) has won itself an increasing share in the market of pre-filled pharmaceutical containers. "We have been producing polymer syringes for over 20 years to meet the industry's need for both glass and polymer pharma packaging," notes Mario Haas, Head of the Polymer Solutions division at SCHOTT's Pharmaceutical Systems Business Unit. "Pharma companies can therefore find the right container for various patient, drug and device requirements without being limited by choice of material."

As an attractive alternative for pharmaceutical packaging, polymer must meet the highest quality standards. Manufactured in a fully automated production process, polymer containers do not feature any tungsten or adhesives to protect the drug from possible interactions.

Pre-fillable polymer packaging is used in a variety of therapeutic areas within the clinical setting. The material's high break-resistance and design flexibility, among others, makes it suitable for administering drugs in hospital surroundings, such as in emergency situations or when administering pain medication, anesthetics or cardiovascular medications. Designed as an optimal fit with pump systems and connectors, polymer syringes can also be used in infusion therapy. "Our polymer pre-filled syringes have actually helped to bring blockbuster drugs to market," Haas proudly adds. Even in the field of compounding, a trend toward using a high-quality polymer packaging solution can be observed.

Yet the use of polymer also extends into other application fields including the cosmetic area, where particularly highly viscous drugs such as hyaluronic acid come into play. Here, an optimized injection force and robust syringe system ensure a safe and comfortable process for the patient. Moreover, its compatibility with numerous devices and wearables plays an important role in the trend of moving the administration of medications, e.g. biologic drugs, from a clinical to a home care setting.

HYBRID ON THE HORIZON

Similarly to the pharma industry, the use of glass significantly predates that of polymer in the diagnostics industry. Yet polymers including COC and other cyclic olefins now play a significant role in the diagnostics industry due to their excellent microfeature replication, biocompatibility, low fluorescence, and high-temperature resistance.

SCHOTT's recent acquisition of MINIFAB complements its existing portfolio of glass substrates used for research, diagnostics and many other life science applications. The Australian company specializes in the development and contract manufacturing of microfluidics-based diagnostic and life science products based on polymers. "By acquiring MINIFAB, we have expanded our internationally renowned glass development and technology expertise to include a comprehensive polymer technology and application engineering suite to enhance our portfolio in the diagnostics market," emphasizes Dr. Heinz Kaiser, the member of the SCHOTT Board of Management responsible for the diagnostics business.

SCHOTT is strengthening its diagnostics business by acquiring MINIFAB.

Break resistant, lightweight and transparent: SCHOTT TOPPAC® polymer syringes

Polymer materials are quite compelling as they come at a relatively low cost and can be manufactured using faster and more conventional methods like injection molding and lamination. Yet new applications start to challenge the inherent properties and require the industry to consider various material combinations. "This opens the door for hybrid solutions," explains Greg Wolters, Head of the Diagnostics group at SCHOTT. "By integrating glass components into a polymer device, a balance can be achieved between cost and performance and we see some interesting options there."

Therefore, it's not neccessarily a discussion on which material is the better choice, but rather which requirements it needs to fulfil and whether glass or polymer or a combination of both offer a suitable solution for customers. ●

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Flexible cover glasses are revolutionizing the smartphone market and opening up completely new possibilities for developers.

‘Ultra’ in every sense

Smartphones should be robust and even foldable. This is made possible by the extreme properties of glass at the limit of what is technically feasible. Examples include ultra-stable and ultra-flexible cover glasses.

TEXT: MICHAEL MÜLLER

When Apple introduced the first generation of its iPhone back in 2007, a glass cover protected the novel touch display from the daily challenges of life for the first time. Where protective plastic covers were once used, glass now fills users with pride. But why glass? Transparent polymer covers that were used in the many smartphone predecessors of well-known brands such as Nokia, Palm and BlackBerry were inappropriate for bare-finger navigation and made the use of tactile input aids, such as the stylus, necessary. The displays also proved to be very susceptible to scratches. Glass, which is brittle and not shatterproof by any means, offered clear advantages over polymers in terms of brilliance, transparency and scratch resistance – especially with regard to the high quality standards in the premium segment.

The first generation of the iPhone was followed by new smartphones, hardware and software approaches from other players – in 2008, for example, with the now omnipresent Google Android. As the industry flourished, SCHOTT also invested in the development of modern cover glass materials. Between 2010 and 2012, the company introduced several cover glass types, marketed under the Xensation® brand. The 0.5 to 2-millimeter-thick aluminosilicate glass (AS) was manufactured in Jena, Germany, using the microfloat process and met the industry’s requirements. It was brilliant, thin, strong and scratch-resistant. Due to its high share of aluminum and sodium, it perfectly met the requirements of chemical strengthening – a process that makes the glass extremely strong.

Microfloat

In glass production using the microfloat process, the molten mixture is guided onto liquid tin so it floats on the surface. The glass ribbon is cooled under control while it floats on the tin and is cut into large glass plates at the end of a cooling section.

The combination of aluminum and sodium allows for a highly effective ion exchange. The raw glass is immersed in a salt bath, whereby smaller sodium ions are exchanged with larger potassium ions. This post-processing gives the glass increased resistance to impact, bending and scratching.

Shortly after the introduction of the first Xensation® generation, SCHOTT was the first glass manufacturer in the world to develop an aluminosilicate-based cover glass that added lithium, a lithium aluminosilicate (LAS) glass. This type of glass allows for even deeper strengthening thanks to multi-ion exchange and, as a result, increases the breaking strength of the glass when it is dropped onto rough, hard surfaces.

RIGHT COVER GLASS FOR EVERY TREND

SCHOTT addressed current market trends with the first generation of LAS glasses. Over time, smartphone designs showed fewer and fewer frames – the display surface dominated. A full-surface, seamlessly integrated touchscreen posed new challenges. After all, the display could now bounce against the floor without any protective casing. Based on positive experiences regarding cover glass development, the next evolutionary leap followed with Xensation® Up. a further developed high-performance LAS glass.

“With Xensation® Up., we have been selling large quantities in the premium segment since 2018 and are involved in various high-end devices from the Chinese manufacturer vivo,” Dr. Lutz Klippe, Product Group Manager for Cover Glass at SCHOTT, is delighted to report. “Its breaking strength under real conditions is a major advantage of LAS glass. The device drop test is thus the measure of all things, as it comes much closer to everyday life than laboratory tests. Xensation® Up. is ten times more resistant to a fall than AS glass.”

FLEXIBLE ULTRA-THIN GLASS FOR FOLDABLE PHONES

Cover glasses do not always have to be as break-resistant as possible, however. New trends and designs of foldable smartphones – “foldables” or “flip phones” – rather demand cover glasses that are flexible and offer a very small bending ▸

HIGHER BREAKING RESISTANCE

What is so special about LAS glass? The composition of the ingredients enables much deeper chemical strengthening. Temperature, time and the composition of the glass have a direct influence on the depth strength. The ion exchange takes place at a temperature that is considerably lower than the glass transition temperature (Tg), so the original network structure of the glass is preserved. Potassium ions, which are about 1.3 times larger than sodium ions, take the place of the sodium ions and cause a “stuffing effect.” This creates compressive stress in the surface of the glass, with the positive effect of higher breaking resistance. The tempering depth for AS glass is about 40 µm, whereas it is up to 200 µm for LAS glass, facilitated by a two-stage strengthening process.

LAS glass is an important factor on the journey to indestructible glass: “We are currently already working on the next cover glass generation. Our research makes us confident that we are a big step closer to our vision of unbreakable glass,” Klippe adds.

radius. Here too, SCHOTT is presenting a groundbreaking product in this area. Xensation® Flex is the first ultra-thin cover glass on the market that enables a bending radius of less than two millimeters after processing and chemical strengthening.

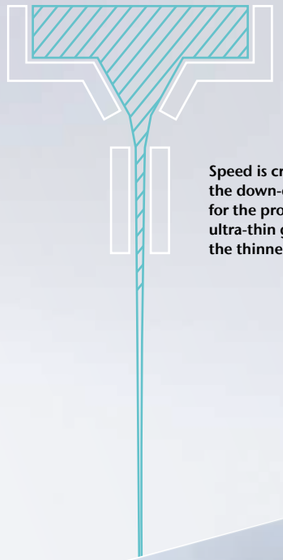
In the spring of 2020, Samsung introduced the first foldable smartphone with a display cover window that features foldable ultra-thin glass. High-tech glass from SCHOTT was part of the success story. “We are proud that Xensation® Flex is used in a new generation of foldable smartphones,” says Dr. Jack Ju, Product Group Manager for UTG Cover Glass at SCHOTT. “Our technology helps premium foldable displays achieve unprecedented quality.”

SCHOTT has produced UTG since the 1990s using a down-draw production process. There are several different types of ultra-thin glass. With continuous development, a UTG thickness of 16 µm has already been achieved in the laboratory. By comparison, one red blood cell is 8 µm thick!

Jack Ju: “With UTG, we are working at the edge of what is physically possible, with thicknesses and bending radii that leave you speechless. It gives us great pleasure to be on the market with Xensation® Flex in real products and to actively shape consumer tech innovation.” ●

Down-Draw

With the down-draw process, a glass ribbon is simply pulled down. The rule here is the faster the glass ribbon is drawn, the thinner the end product – and the more challenging the production. In addition to seamless adjustment of the thickness, the process offers an advantage in that the glass does not need secondary slimming, thus eliminating downstream etching processes that are harmful to the environment. Glass produced by the down-draw process also shines with a low thickness variation and a flawless surface (surface roughness ~1 nm).



Speed is crucial in the down-draw process for the production of ultra-thin glass: the faster, the thinner.

The surface of glass produced by the down-draw process is flawless.

CHEMICAL PRELOAD

Chemical strengthening involves the transfer of ions. In AS glasses, the non-crystalline network structure is modified in such a way that smaller sodium (Na+) ions are exchanged by larger potassium (K+) ions. This is made possible by immersing the glass in a potassium nitrate bath (KNO_3). Due to their chemical composition, LAS glasses allow for a two-stage strengthening process. In the first step, sodium ions are exchanged by lithium ions; in the second step, sodium ions are exchanged by potassium ions. This creates compressive stress in the surface of the glass, and an opposite tensile stress as a counterforce inside the material. The special feature of LAS glass is that high compressive stress on the immediate surface can be combined with deeply located compressive stress, which creates an additional mechanism that increases the breaking strength when hitting rough, hard surfaces.

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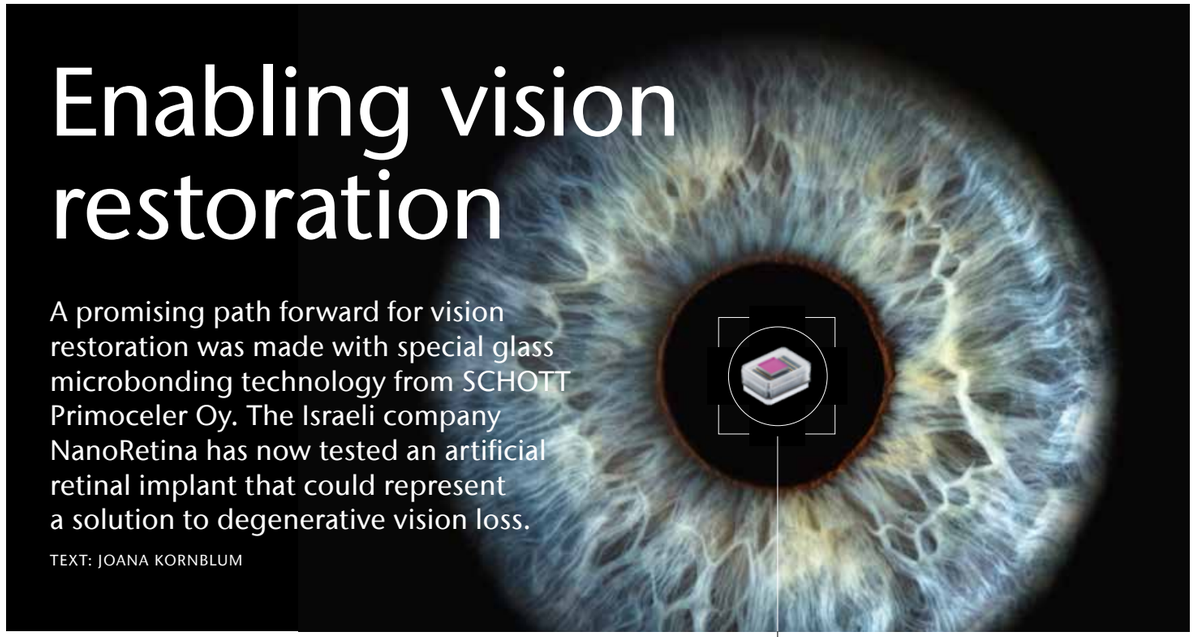
Enabling vision restoration



A promising path forward for vision restoration was made with special glass microbonding technology from SCHOTT Primoceler Oy. The Israeli company NanoRetina has now tested an artificial retinal implant that could represent a solution to degenerative vision loss.

TEXT: JOANA KORNBLUM

Microelectronics is regarded as one of the key technologies for innovative products. Miniaturized electronic components even have their place in the human body and have done so for decades. The cardiac pacemaker is a classic example. The pulse generator in the case of cardiac dysrhythmia is now available in miniature format; it can be pushed into the heart via the groin through a vein by using a catheter. Implanted long-term sensors make it easier for diabetics to measure their blood sugar levels, and an insulin pump coupled via app makes it much easier to manage the disease. What they all have in common is that the smart helpers operate in a safety-critical area. The priority is clear: They must function reliably inside the human body. It is important that the highly sensitive microelectronics are perfectly protected against external influences. Glass is the material of choice for encapsulation, as it is biocompatible, chemically resistant, corrosion resistant, durable and does not emit any particles.

A special laser microbonding technology (see also article on p. 24) has recently made it possible to produce all-glass housings at room temperature. This opens up new prospects for highly sensitive medical mini-implants. A new development by NanoRetina is just one example.

The Israeli company has taken a decisive step closer to its ambitious goal of restoring blind people’s vision through advanced nanotechnology by successfully testing its artificial retinal implant “NR600.” The first human trials that started in early 2020 have produced exceptional results. “The device was activated for the first time, and the result was amazing: this patient had been completely in the dark for 5 years and immediately reported seeing an image in the center of her visual field when the device was activated, and was able to show the size of the image she saw with her hands. I am very impressed by this experience. This is the first time I witnessed a completely blind patient being given back visual perception,” explained Professor Peter Stalmans, one of Europe’s leading retinal specialists.

The challenge is to manufacture a hermetically sealed implant

SCHOTT Primoceler and NanoRetina have a longstanding partnership dating back seven years to the beginning of this project. The direct laser bonding method enables extreme miniaturization – for NanoRetina an absolute requirement for this implant that is placed inside the human eye. Hermetically sealed glass encapsulation is critical for the NR600 implant, as transparency is a must for precise optical performance. Furthermore, the implant is made of extremely small and complex electronic components. Exposing these to nearly any amount of heat could damage them. The glass wafer bonding process from SCHOTT Primoceler Oy creates only a minimal heat-affected zone during the laser joining process with NanoRetina’s device. “SCHOTT Primoceler’s unique technology enabled the realization of the NR600 miniature implant,” explains Ran Mendelewicz, NanoRetina’s Vice President of R&D. “The team in Finland has repeatedly proven that it is up to our challenges, and with their ‘can do’ approach, NanoRetina completed the development of a small, biocompatible, and hermetic implant.” Ville Hevonkorpi, Managing Director of SCHOTT Primoceler Oy, adds: “It has been a pleasure to see this transformative device move forward to become a reality for the treatment of vision.” ●

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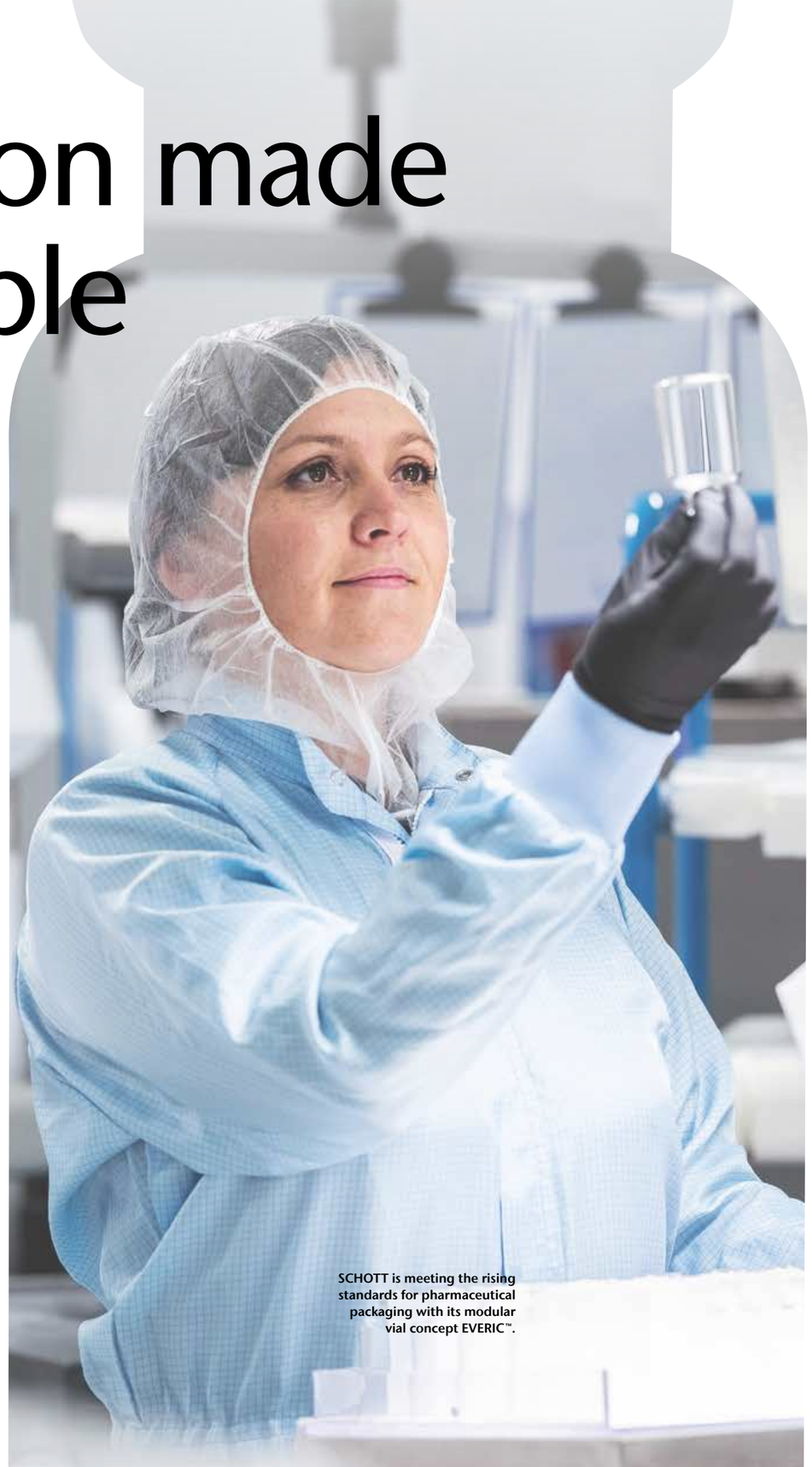
Perfection made for people

Pharmaceutical packaging that is filled on conventional filling lines is often exposed to mechanical stress that can cause small scratches or cracks. The possible consequence: glass breakage. SCHOTT developers offer a solution with optimized borosilicate glass vials.

TEXT: JOANA KORNBLUM



SCHOTT is meeting the rising standards for pharmaceutical packaging with its modular vial concept EVERIC™.

Constantly rising quality standards for improved patient safety present the pharmaceutical industry with major challenges. Furthermore, new drugs must be packaged in the best possible way. This is particularly true for the packaging of high-value medicines that must meet precise requirements. What is needed is a container that meets all qualitative criteria and at the same time enables a smooth filling process.

Traditional fill and finish operations for drugs rely on bulk filling processes, which allow for a high throughput in a short period of time. Yet, a critical factor here is that the glass-to-glass contact and the mechanical stress on the containers can create small glass particles that can get inside and contaminate the medication. In addition, containers may be damaged or even broken. This is particularly problematic when highly potent drugs such as biopharmaceuticals are involved. Here, it is all the more important to avoid glass breakage during filling.

Borosilicate glass that is used for pharmaceutical packaging and has proven itself for many decades offers many advantages: It is chemically very resistant, neutral, dense and, like glass in general, is remarkably strong. But what can be done to also protect the containers from the axial and lateral pressure on the filling lines and consequently protect them from breaking?

OPTIMIZING GLASS STRENGTH

SCHOTT researchers are constantly working on further developing glasses in order to meet customers' increasingly complex requirements and offer suitable solutions. With SCHOTT EVERIC™, the company has now developed a modular concept for a new generation of pharmaceutical vials. The idea: Pharma companies can combine different features depending on their needs for the drug.

The module option EVERIC™ strong stands for the improved strength of the container. "The prerequisite for this is an enhanced surface of the glass – in combination with an optimized geometry of the vials that deflects mechanical stress that is applied from the outside," says Dr. Florian Maurer, Senior Scientist Strength, Reliability and Life Time in Material Analysis at SCHOTT. "After all, glass breakage is the result of a too high physical interaction between a glass defect and a mechanical tensile load applied on the defect." The EVERIC™ strong containers focus on preventing flaws in the vial's heel area at the bottom of the side wall. "This is because precisely this area of the vial has proven to be particularly critical for breakage. Nevertheless, the geometries are still within the ISO standards," the expert explains.

Essential for this new development is that the typical stress situations during filling, transport or handling of the vials in the pharmaceutical industry are known. With the help of computer simulation, the SCHOTT researchers transfered the detailed information about which mechanical stresses, in what strength and where, act on the vials to mathematical models of containers with different geometric properties. Dr. Maurer: "EVERIC™ strong is therefore not an artificially hardened vial. Neither the composition of the glass nor its structure are changed. The idea is to maintain the original strength by simply avoiding glass defects." Expressed in one figure: Hot manufacturing and computer simulation know-how from SCHOTT achieved an increased axial strength by a factor of four compared to the market standard. EVERIC™ strong and the experts' knowledge of glass is therefore "real strong." ●

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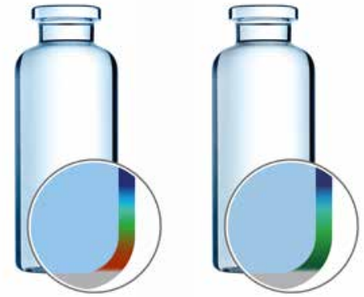

Standard borosilicate glass vial

EVERIC™ strong

IMPROVED BOROSILICATE GLASS FOR EVERIC™

Proven FIOLAX® borosilicate glass that has been considered the gold standard in the pharmaceutical packaging industry since it was first developed in 1911 is the starting material for the new generation of vials from SCHOTT.

SCHOTT manufactures its EVERIC™ pure vials using the proven DC forming process (delamination controlled) to ensure drug stability while keeping delamination under control. Here, SCHOTT uses an optimized borosilicate glass with an improved hydrolytic resistance of the inner surface, namely FIOLAX® CHR (Controlled Hydrolytic Resistance). The ultra-pure containers are extremely chemically stable and have a homogeneous surface. This predestines them as a packaging solution, especially for highly sensitive biopharmaceuticals with low filling volumes, avoiding leachables and thus ensuring optimized drug stability.

EVERIC™ smooth offers two outer coatings to choose from that protect the glass surface from additional flaws during the entire process. Cosmetic defects can be reduced by up to 98 %. At the same time, the transparent coating creates a low-friction surface while maintaining the same optimized container strength. The result is an 56% improvement in the coefficient of friction (CoF) for a smooth filling process.

High-quality glass optical fibers from SCHOTT can transport light and images.

The finest of fibers

Glass optical fibers many times thinner than a strand of human hair are masters of virtually loss-free light transmission. Precisely arranged, many thousands of these fibers can even be used to transmit images. Thanks to its light and glass expertise, SCHOTT is now providing innovative new light guides for single-use endoscopes and extremely thin fibers for high-quality image guides.

TEXT: BERNHARD GERL

Imagine a window pane was several centimeters thick. "Everything would have a distinct color gradation, and you would have trouble seeing through it," explains fiber optics expert Lothar Willmes, Head of Product and Technology Development Fiber Optics at SCHOTT Lighting and Imaging. "The reason for this is that the soda-lime glass used to make most windows isn't very high quality, and so the light quickly degrades while traveling through it."

In contrast, high-quality glass optical fibers can transmit white light over 10 to 15 meters with almost no loss and little degradation in quality. High-quality light transmission is critical for many applications, including the light guides in endoscopes used for tissue analysis. For a precise diagnosis, it is extremely important that tissue color be reproduced with as little distortion as possible.

This is where PURAVIS® glass fibers come into play. These widely-known fibers have a typical structure consisting of a glass cladding only micrometers thick surrounding a solid optical core with a distinctly altered refractive index. Where these two glasses meet, the light is entirely internally reflected and thus transmitted down the fiber with barely any loss. The high-tech, in-house glass used in SCHOTT's fibers allows the cladding and core to be finely calibrated to each other. The characteristics of the two glasses can be precisely optimized to create specific optical properties, such as certain light entry and exit angles.

Most of these fibers start as a rod several centimeters thick and one meter long. They are installed on the second floor of the multiple fiber line draw tower used to carry out SCHOTT's completely unique multiple fiber drawing process. The process begins by simultaneously heating many rods in a patented, precisely controlled furnace. Once hot, the glass is drawn downwards by gravity until a bundle of exceptionally fine glass fibers is formed. The fall distance over two floors allows fibers with diameters of just 30, 50 or 70 micrometers to cool and set before being wound up.

Willmes stands on the ground floor next to the precision winder that rolls the filigree fiber bundle onto spools. He has been involved and significantly shaped the company's glass fiber production over the last 35 years. This precise winding technology, developed and patented in-house, allows several hundred meters of glass fibers to be wound onto a spool at high speeds without any breakage. On these spools, fibers can be handled efficiently – a prerequisite for their cost-efficient further processing. It also allows SCHOTT to supply customers with single fibers, fiber bundles or extruded bundles enclosed in an elastic plastic sheath according to individual specifications.

60 to 80
micrometer is the average thickness of a human hair. The thinnest glass fibers for light transport are about half as thick.

The tightly regulated medical technology industry and environmental protection requirements both place high demands on glass. For one, it must be free of toxic lead. "Normally, additives such as lead are used to raise the quality of glass and glass fiber production – the main reasons being that they can be used to adjust optical properties and also remove any flaws such as air bubbles during the so-called refining process," says Willmes. "Thanks to extensive research and development work, we have created a process that doesn't use these types of undesirable materials." SCHOTT has developed and patented its refining technology with more than 30 patents that protect the production of PURAVIS® fibers.

After more than 35 years, Willmes says he still isn't bored studying glass fibers. "Customers keep coming back with new, special requests and suggestions," he says. "For example, these fibers are now being used in the first single-use endoscopes, which are just now entering the market." Close internal networking enables SCHOTT to offer customers services ranging from customized solutions to industrial mass production. ●

schott.com/fiberoptics
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SCHOTT uses a globally unique multiple drawing process to manufacture the glass fibers.

TECHNOLOGICALLY DEMANDING

SCHOTT is one of the leading manufacturers of image guides that use flexible glass fibers to transmit an image from an area being examined directly to the observer's eye. To optimize resolution, SCHOTT has reduced the fiber thickness from 6.7 to just 4.7 micrometers. Now, up to 18,000 individual fibers can fit into a bundle that is just 0.5 to 1.2 millimeters thick. Producing these fibers is a technological breakthrough because despite being flexible, the arrangement of individual fibers at the entry and exit points must be identical, and no more than two fibers can be defective.

Award-winning glass researchers

Original, productive and of high quality – this is how the laudator describes the work of the two winners at the 16th Otto Schott Research Award ceremony. In a virtual ceremony, Professors Sabyasachi Sen (right) and Josef Zwanziger received the 25,000 euro prize for their outstanding achievements in glass and glass-ceramic research. Sen from the University of California was honored for his research on oxidic and non-oxidic glasses. Zwanziger from Dalhousie University in Canada has made significant contributions to the understanding of glasses that contain boron.

New production started in China

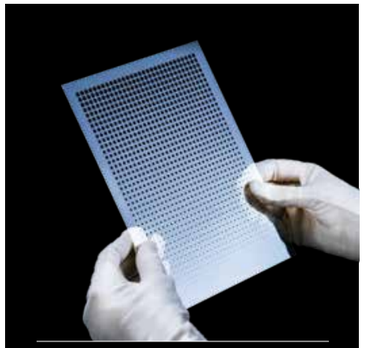
"WE WANT TO CONTRIBUTE TO MAKING THE CHINESE INITIATIVE 'HEALTHY CHINA 2030' A REALITY WITH OUR NEW PLANT AND OUR EXPERIENCE."

Dr. Patrick Markschläger,
Head of the Tubing Business Unit

Production of special glass tubing under the brand name FIOLAX® was put into operation on schedule at the new SCHOTT site in Jinyun, China, at the end of 2020. With an annual capacity of 20,000 tons in a first step, it is intended to serve the rapidly growing domestic demand for high-quality pharmaceutical glass as a starting material in China. The plant has one of the most modern manufacturing facilities in the industry worldwide; in addition, the SCHOTT perfeXion® quality process is used to ensure that every single glass tube is inspected. SCHOTT wants to support China on its way to becoming an innovative global player and in its "Healthy China 2030" initiative, which is aimed at renewing the healthcare system and, among other things, developing more new medicines.

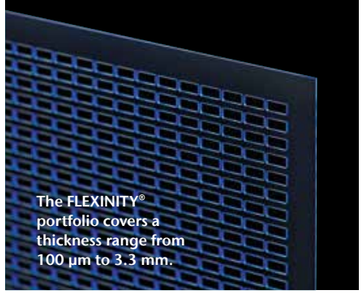
Neuschwanstein newly glazed

The Singers' Hall of Neuschwanstein Castle has been renovated for the last two years. SCHOTT has added the finishing touches to the historic lead glass windows: Thanks to AMIRAN® Heritage Protect anti-reflective exterior protective glazing, they are protected from the weather and can be viewed without any annoying reflections.



Mass production more precise than ever

SCHOTT has consistently further developed its FLEXINITY® portfolio of structured glass wafers and now offers a thickness range from 100 µm to 3.3 mm with a maximum format width of up to 600 mm. The structuring tolerances have been reduced to less than 20 µm (± 10 µm). This makes the glass wafers more precise than ever. They are used in a wide variety of sectors, such as semiconductors & sensor technology, camera imaging, optoelectronic and RF/IC packaging, biotechnology & diagnostics and sustainable energy. Together with the new production line in Penang, Malaysia, where mass production has now begun on solid footing, SCHOTT now offers its partners a comprehensive range of products with FLEXINITY® – from design to development and production.



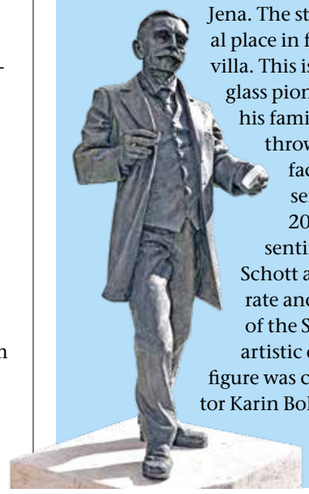
The FLEXINITY® portfolio covers a thickness range from 100 µm to 3.3 mm.

Safe sensors

The development of vaccines is more important now than ever before. An absolutely sterile atmosphere is necessary for this. With the new SCHOTT ViewPort™ PAT components with highly transmissive optical windows, the processes in the bioreactors can be monitored from the outside without having to open them and thus impair the sterile barrier. This significantly minimizes the risk of contamination.

A monument to Otto Schott

SCHOTT has created a life-size bronze statue as a worthy memorial to its company founder Otto Schott (1851 – 1935) at the founding site in Jena. The statue stands in an ideal place in front of the SCHOTT villa. This is where the specialty glass pioneer once lived with his family, just a stone's throw away from his glass factory. The villa has served as a museum for 20 years now, presenting the work of Otto Schott as well as the corporate and innovation history of the SCHOTT Group. The artistic design of the bronze figure was created by the sculptor Karin Bohrmann-Roth from Grebenstein near Kassel, Germany.



Müllheim: A strong site

October 1, 2020, marked the 50th anniversary of the day on which SCHOTT became a partner in the former Max Geiss KG in Müllheim. SCHOTT became the sole owner in 1980 and the site has been a direct part of SCHOTT AG since 2004. The Müllheim site has developed very successfully since then and particularly over the past ten years.

As the Group-wide competence center for pharmaceutical vials, the only manufacturing site for coated vials and the lead site for so-called Big Vials, SCHOTT in Müllheim has important unique selling points in the Pharmaceutical Systems Business Unit's global manufacturing network. Besides vial production, a completely new plant for polymer syringes will be added on site in 2022 as a second mainstay. The corona pandemic has given SCHOTT's position as a leading pharmaceutical packaging manufacturer special significance (see article on page 8). And as soon as a vaccine is available, it will be filled in vials from Müllheim, among other places.

The Receptionist – a true glass lover

With the online mini-series ‘The Receptionist,’ SCHOTT is following a bold and humorous path on social media platforms such as YouTube, LinkedIn, and WeChat.

SCHOTT has created a series of short videos as part of its #glasslovers campaign, revealing why glass is so appealing to the company’s customers and employees. Entitled ‘The Receptionist,’ the videos feature the fictional character Fritz Klein, who experiences a number of charming and funny situations in the world of SCHOTT.

The role of The Receptionist is played by German comedian and actor Michael Kessler, and through him, Fritz becomes a likeable ambassador who lets us experience what makes glass so unique and lovable. Created in the style of a Netflix Original, The Receptionist aims to amaze and amuse, while encouraging everyone to find out more about specialty glass.

Under the keyword #glasslovers, this new SCHOTT campaign demonstrates not only how we constantly push the boundaries of what is technically feasible, but also innovate in terms of customer communication. Otto Schott would be proud. ●

You can see and experience #glasslovers on social media and at

schott.com/glasslovers

stories@schott.com

Like, share and be part of it: SCHOTT is looking for committed #glasslovers. One of them is actor and comedian Michael Kessler, who slips into the role of the quirky SCHOTT Receptionist Fritz Klein in the video series.

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