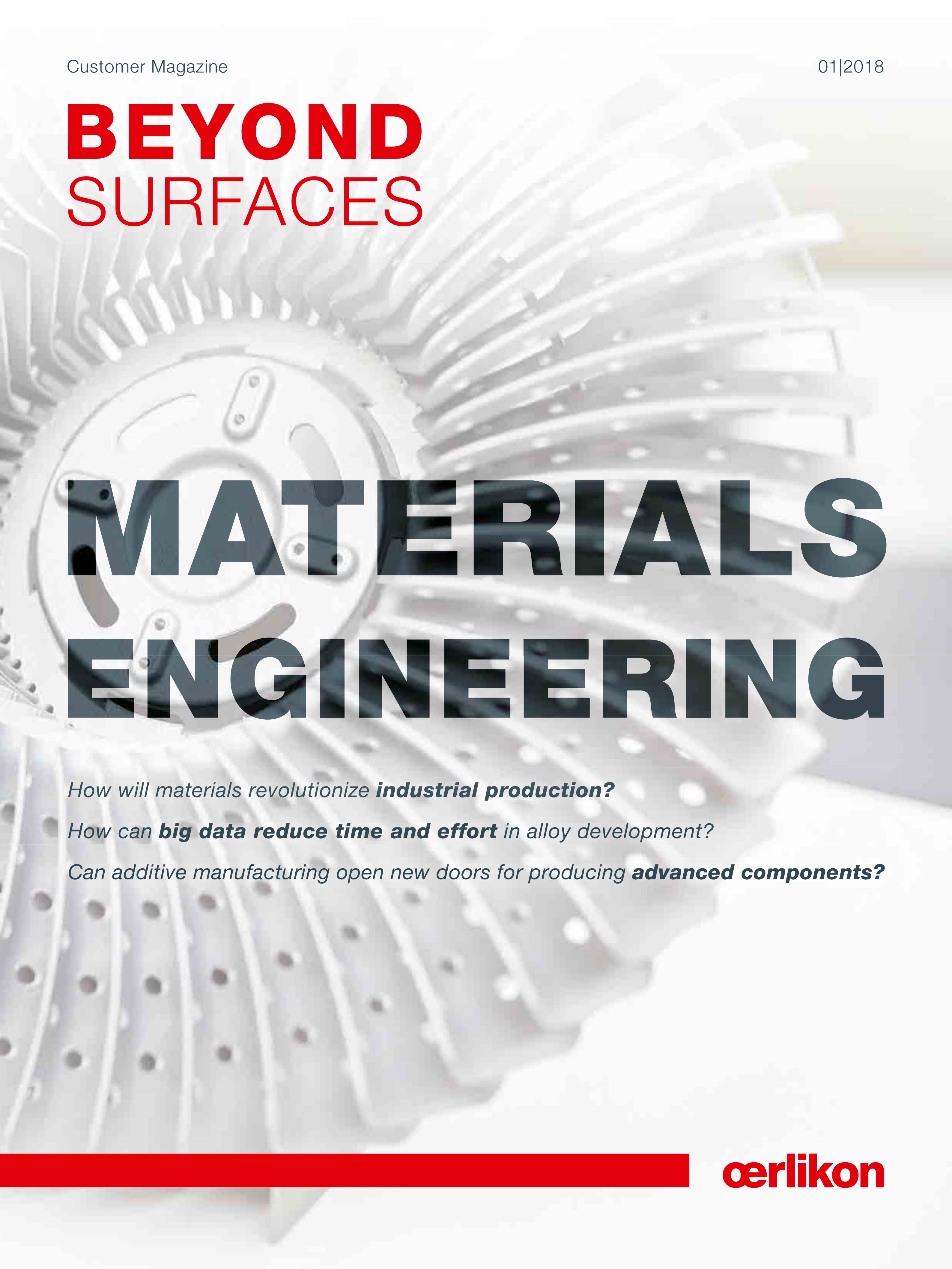
Customer Magazine

01|2018

# BEYOND SURFACES



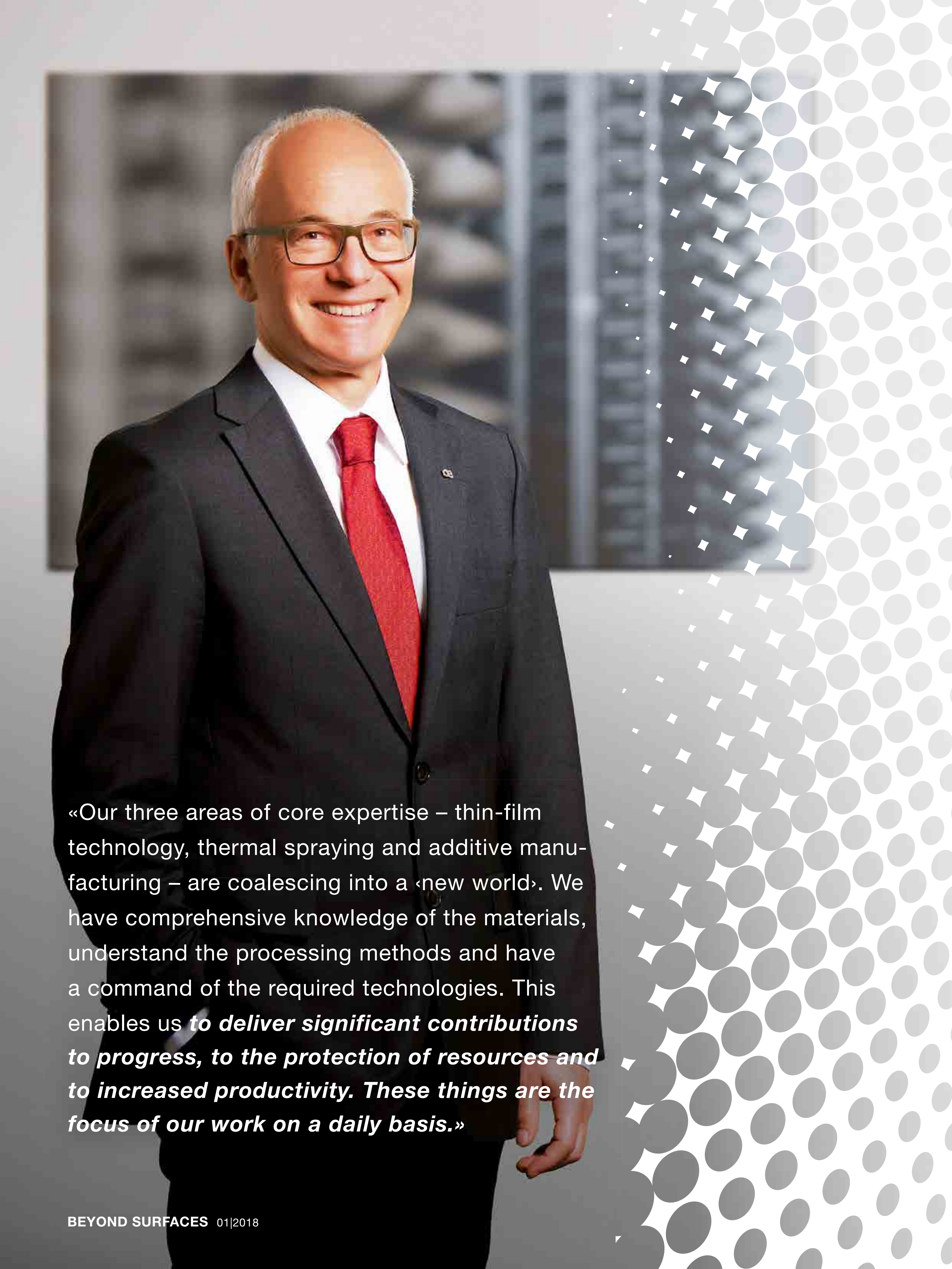
# MATERIALS ENGINEERING

*How will materials revolutionize **industrial production?***

*How can **big data reduce time and effort** in alloy development?*

*Can additive manufacturing open new doors for producing **advanced components?***

oerlikon



«Our three areas of core expertise – thin-film technology, thermal spraying and additive manufacturing – are coalescing into a ‹new world›. We have comprehensive knowledge of the materials, understand the processing methods and have a command of the required technologies. This enables us ***to deliver significant contributions to progress, to the protection of resources and to increased productivity. These things are the focus of our work on a daily basis.»***

A personal insight

# NEW DIMENSIONS IN THE WORLD OF MATERIALS

Surfaces have fascinated me since my time as a student: They represent the interface of a body with the outside world. When we make contact with a body, it is always by way of its surface, which is subject to many external influences. But this also means that the surface is vulnerable. Human skin is a good example here. Significant Oerlikon business segments pursue an important objective: to reduce or eliminate this vulnerability. This can be accomplished successfully, for example, by simply applying a suitable coating – sometimes in combination with other surface technologies. What fascinates me here is that coatings of this nature, though often much thinner than a human hair, are able to effectively protect the surface and thereby the body as well. That is truly amazing.

The effectiveness of these protective coatings is gauged by, for example – their ability to make a body more resistant to wear or reduce its friction. These capabilities are dependent not only on the choice of the material but also on the exact design and microstructure, which must be understood in detail. This makes for a very complex set of circumstances.

Many factors must come together so that the desired material can be created: knowledge of the application and, of course, understanding of the materials involved. But that comprehension of the material must have greater depth and breadth, so that it extends to the manufacturing process and the technology that makes this process possible. Oerlikon's know-how has successfully combined these factors for decades.

Rising productivity demands, considerations concerning how new materials can contribute to ecological sustainability and, always a factor, questions dealing with the economic usefulness of measures, drive us forward. They motivate us to develop new and continually improved materials, thereby making the previously unthinkable possible.

This sort of material development process often used to take years. With Scoperta, one of the newest members of our Oerlikon Group, we are now able to reduce it to a matter of a few weeks. The "Rapid Alloy Development" approach enables us to combine the findings resulting from thousands of man-years of materials science with a materials database that is growing non-stop. Consequently, within a very short time, we are able to develop new material compositions that align with our customers' needs. In our article starting on page 22, our specialists at Scoperta explain how we manage this.

With additive manufacturing (AM), an entirely new dimension is now arising in the world of materials: We not only select the material itself, in accordance with the requirements of the process, but we also define the design of the component so that it can fulfill its intended function. AM is truly unique in this respect because it makes component geometries possible that could not be realized using prevailing, conventional manufacturing technologies. Moreover, the use of AM (and, consequently, the omission of the mold) allows a reduction of development times and costs because the prototypes are available and can be tested very quickly. A successful example of collaboration by the founders of the startup Urwahn Engineering in Germany is described starting on page 18. Or consider the students at the Delft University of Technology, who seek to use materials from Oerlikon Metco to conquer outer space. Read their story starting on page 37.

The coalescence of our three areas of core expertise – thin-film technology, thermal spraying and additive manufacturing – will create an entirely new world of materials. I am convinced of this. Materials are given very specific functions, entirely by design. This is because what were until now the known limits of producibility are disappearing while new doors are opening for developers and design engineers.

With this new issue of our magazine BEYOND SURFACES, we want to take you along on this journey and attempt to gain insights together into new perspectives in consultation with a few experts. I hope you will become enthused by the new world of materials and their applications, as I am.

I wish you exciting reading.

Cordially yours,

Dr Helmut Rudigier
Chief Technology Officer, Oerlikon Group

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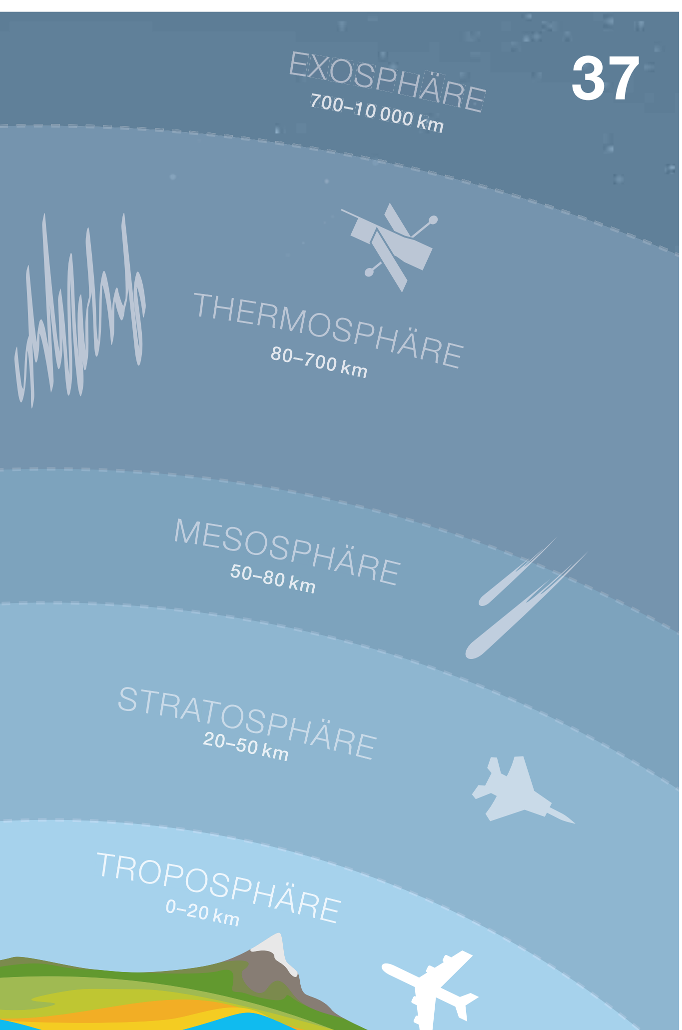

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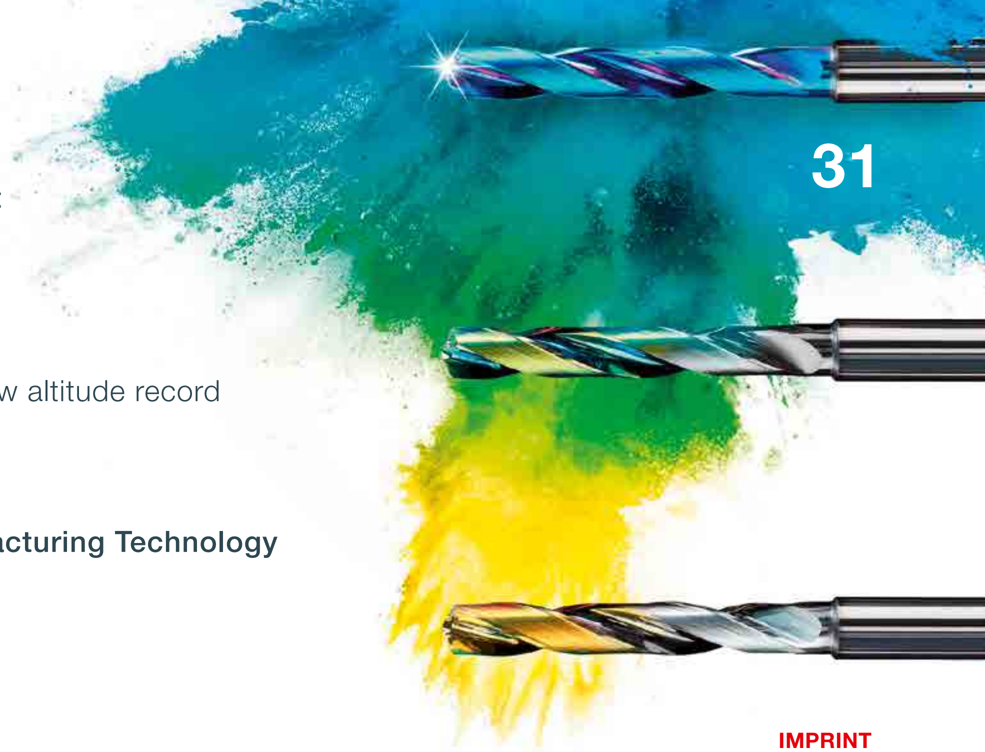
EXOSPHÄRE
700–10 000 km
THERMOSPHÄRE
80–700 km
MESOSPHÄRE
50–80 km
STRATOSPHÄRE
20–50 km
TROPOSPHÄRE
0–20 km


40





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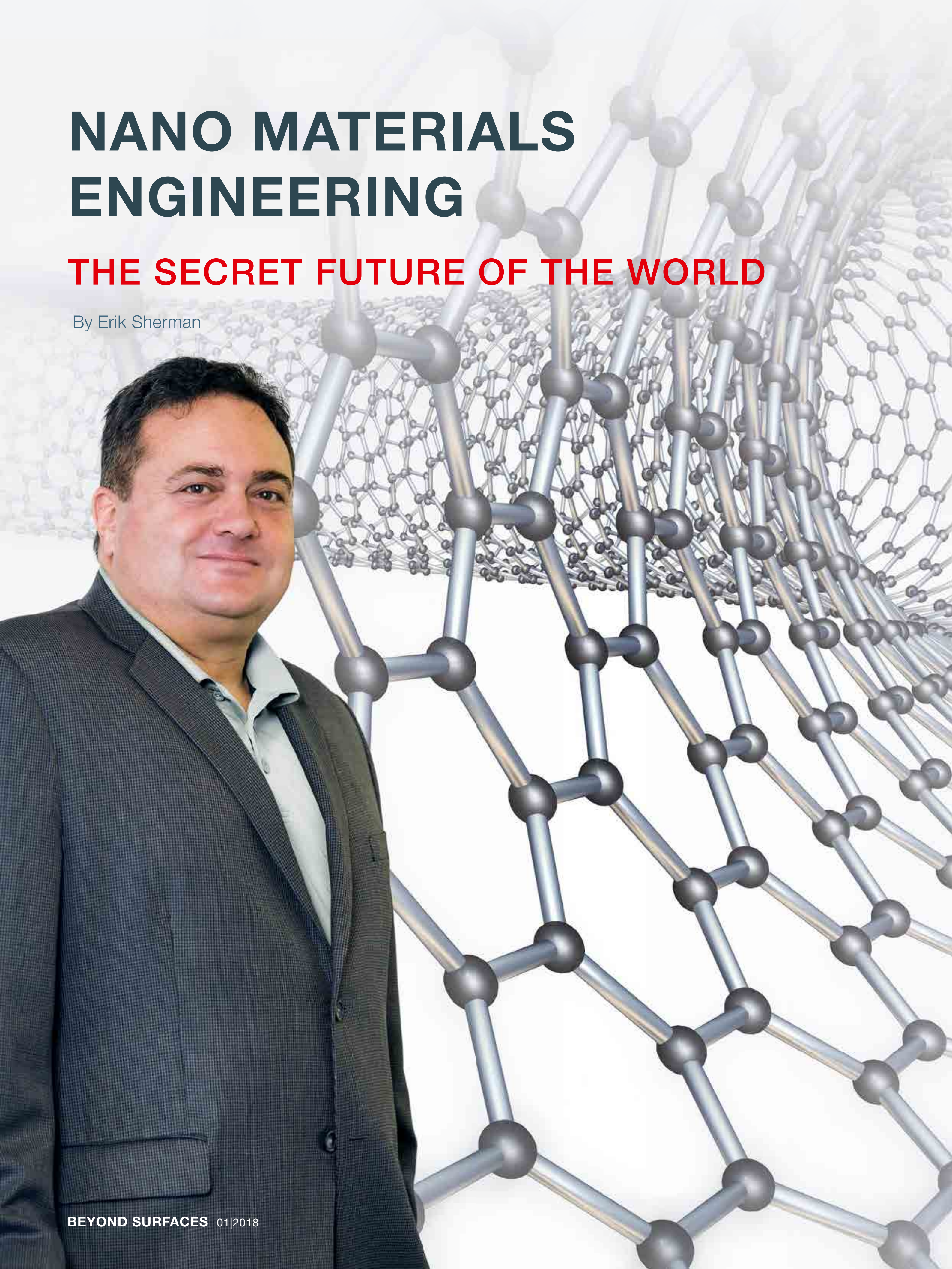
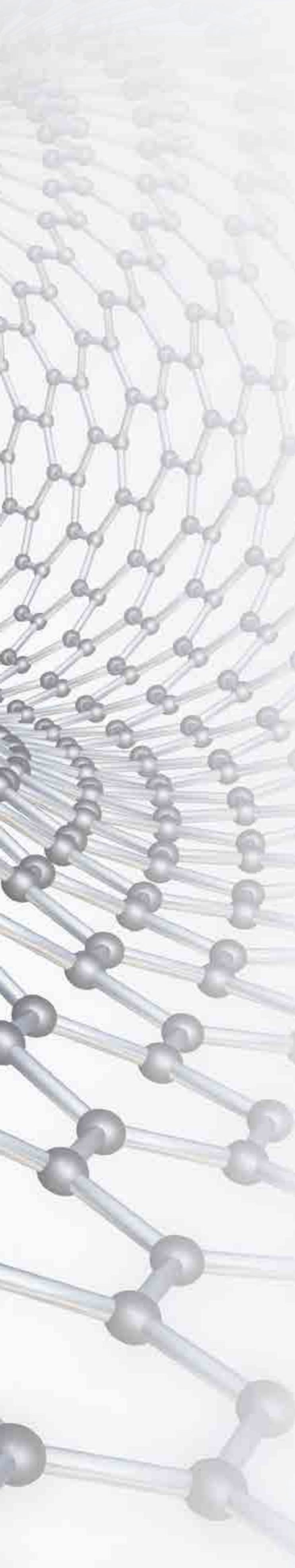
# NANO MATERIALS ENGINEERING

## THE SECRET FUTURE OF THE WORLD

By Erik Sherman





Materials science is responsible for amazing advances, whether chips that make consumer electronics work or steel that avoids corrosion in modern cars. **Professor of Materials Engineering Kenneth Vecchio** at the University of California, San Diego, is the Founding Chair of the school's Department of NanoEngineering and Director of the NanoEngineering's Materials Research Center. In an interview for BEYOND SURFACES, he discusses the **breathtaking future new materials research will bring to many areas, even medicine.**

**People often take materials for granted, but aren't many advances due to materials science?**

When I was a kid, it was not uncommon to see cars rusting through. Nowadays, you rarely see that happen. That's all through metallurgical advances in the making and processing of steels. The entire consumer electronics world is actually a result of successes in the materials science world, going back to the development of semiconducting devices. People have materials science successes in their hand every time they pick up a cell phone, but they don't recognize them as being materials science-based innovations. They think of it as electrical engineering or computer science successes.

**How did you become interested in the field?**

I grew up in a household where materials were the focus of the business that my father was involved in, a failure analysis company that did structural analysis and investigations into structural failures. His father, my grandfather, was in the scrap metal business. It was an engineering environment we were exposed to at a very young age that influenced at least two of our father's five children.

**How did your studies affect your thoughts about materials?**

In graduate school, I worked on research projects that were both related to understanding the mechanisms that lead to failure as well as the design of materials. As I got further in my education, I became more interested in the ability to develop materials that would avoid those failure mechanisms. Nowadays, my work has gone in the direction of developing materials that enable functionalities: new things that materials can do that weren't available in existing materials. You start looking at a problem as a reason to get into studying a particular material. And then, as you learn to understand the underlying fundamentals of why that happens, you look at whether you could design a material where that mechanism or that process wouldn't happen.

**What are your current research interests?**

My major research interests lie in three interrelated activities. My strongest interest is in materials that we refer to as multi-functional: a material designed to do more than one primary thing. Rather than just being a strong material that carries loads, maybe it has another property that is also able to be optimized. For example, in addition to strength, maybe thermal conductivity, something that can dissipate heat at a very rapid rate are both maximized, or perhaps a certain level of stiffness or strength in the material that interacts with electromagnetic fields in a certain way.

Another area we refer to as uniquely functional materials. You're trying to create a performance or function in the material that isn't common in other materials. As an example, a typical metal can be stretched like a spring. It will keep coming back to its original size, but the amount you can stretch it is very limited, about 1% of the material's length. There's a whole group of materials that have been developed where the elastic behavior can be extended out to 13 times the same extension, and so they behave sort of like super springs. We then try to develop an understanding →

of how would you go about making another material that perhaps would exhibit that property as well, but maybe at a lower cost or maybe you can find another material where the process to achieve that behavior is simpler, less costly.

**And what about your other two research focuses?**

The second focus of my research is new material discovery. It used to take decades or more to develop a new material and go from the lab to commercial use. We refer to it as an empirical approach – a sort of trial and error: make an alloy, measure its properties, characterize it, go in the lab and make a slightly different alloy, measure its properties. We now use models that run on computers to avoid doing some of the experiments and find materials systems that would work in the application. It's possible to go from what used to be a decade or more down to maybe two or three years from the lab to commercial application. This doesn't mean we don't still employ a lot of experiments, but the experiments become significantly more focused, fewer in number. Using the computer tools, we can avoid making materials that we can calculate will not work.

The third part of my research is to look at how to develop a processing method that enables the development of the [desired] functionality. Oftentimes, these mechanisms rely on the material being produced in an unconventional path: maybe cooled at a uniquely faster rate than typically or a series of heating and deforming steps that are necessary to create the functionality.

**The Department of NanoEngineering that you founded has a focus on nano-materials and processes. Why is the nano-focus important?**

Materials science has always been about exploiting materials at the nano-scale. Many of the structural materials that we use in everyday engineering systems and products people interact with are made possible by manipulating materials at the nano-scale. Materials have different properties at that scale that actually enable new functionalities.

As materials scientists, we basically have the periodic table as our list of ingredients. It's a two-dimensional array of material options. You can pick and choose from different elements, mix them together, and produce new materials. In nano-engineering, we turn the periodic table into a three-dimensional table. The third dimension is the scale of the materials. This dimension becomes a whole new set of properties for the individual elements that are not necessarily associated with where they lie on the periodic table alone but what happens when we put several of them together on the nanometer scale.

**Can you illustrate this with an example?**

If you have a gold ring, you see the color we refer to as gold. If I could make the gold ring a few nanometers [in size], it would be red rather than gold in color. The color is a property change that occurs only because of the scale of the material rather than the elements that make up the material. Many other material properties change with scale as well. It opens the possibility of the material to do something different just because of the scale of the material itself.

Nano-scale particles, for example, can assemble themselves inside cells. Their special properties can sometimes provide better diagnostics of diseases and even therapeutic results [than traditional techniques]. A third or more of our department is doing nano-materials research in the field of nano-medicine. That would not be an area of research in a typical materials science and engineering department, but is a major component of our department because materials on the nano-scale are able to interact with biological materials.

We're also making significant progress in the implementation of nano-scale materials and phenomena to improve different energy systems, whether improvements in battery technologies or in photovoltaics – solar energy areas.

We expect many of the technologies from our research to have a big impact over the next decade. People will start to see those effects in their daily lives.

«Many of the structural materials that we use in everyday products ***are made possible by manipulating materials at the nano-scale.»***


**Prof. Kenneth S. Vecchio**
Kenneth S. Vecchio received his Ph. D. in Materials Science and Engineering from Lehigh in 1988 and joined the faculty of the University of California San Diego later that year. He created the Department of NanoEngineering in 2007 and served as Founding Department Chair until 2014. From 2014 until the present he has been Director of the NanoEngineering's Materials Research Center.

Prof. Vecchio received the Irene Payne Award from the Microbeam Analysis Society (MAS) in both 1986 and 1987. He was awarded first prize at the Materials Research Center Review Seminar and received the George P. Conard II Award for Outstanding Graduate Achievement during 1987. Prof. Vecchio won the Marcus A. Grossman Young Author Award in 2000 and was made a Fellow of the American Society for Metals (ASM International) in 2009. Since 1988, he has worked as a consultant and expert witness and, in 2008, co-founded Scoperta Inc., a company that focused on computational materials science-based alloy development, which was acquired by Oerlikon in 2017.

Find more information on UCSD at:
**nanoengineering.ucsd.edu**

For more information on Scoperta read the article on page 22 or visit their website:
**www.scopertainc.com**

A workpiece is only as good as the **grade of its material and the quality and intelligence with which it is processed.** With more than 80 years of experience, Oerlikon’s expertise is virtually unmatched in this field.

# MATER

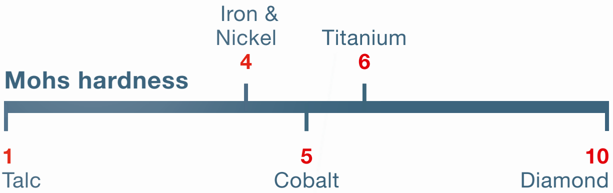
## From raw material to pro

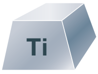
Materials are refined through the introduction of additional elements, and properties such as **resistance to fracturing, hardness, heat resistance, etc.** can thereby be controlled with precision.

For example, the metal iron (Fe) has a Mohs hardness of 4. When it is alloyed with carbon (C) and additional metals, then, depending on the composition,

a hardness of up to **6.4**

can be achieved.

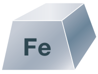





Titanium is characterized by its low weight of only

**4.5 g/cm³**

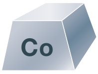
with very high durability and biocompatibility. Consequently, it is used most commonly in the aerospace and shipping industries as well as in medical technology.



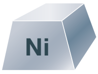

Iron is the main component in steel, and with an annual volume of

**2 800 000 000 t**

it is the most commonly used metal in the world.




Cobalt is a very tough heavy metal with good current and heat conduction properties. As a result, it is used predominantly as a component in alloys, in batteries and in medical technology applications, but also as a pigment.




Nickel is an important alloying constituent for steel processing and in the manufacture of jet engines and gas turbines.

Findings confirm that it was already in use in

**3500 B. C.**

in the form of a nickel-iron alloy.

**Sentinel satellite antenna bracket:** A collaborative project of RUAG, citim (a member of the Oerlikon Group), eos, and Altair.

# MATERIAL

## From raw material to processing

### Superalloys

are metal materials with a complex composition that offer a series of desirable properties for high-temperature applications (engines, turbines and jet engines). Among other things, they are characterized by **mechanical robustness, thermal stability and resistance to corrosion and oxidation.**

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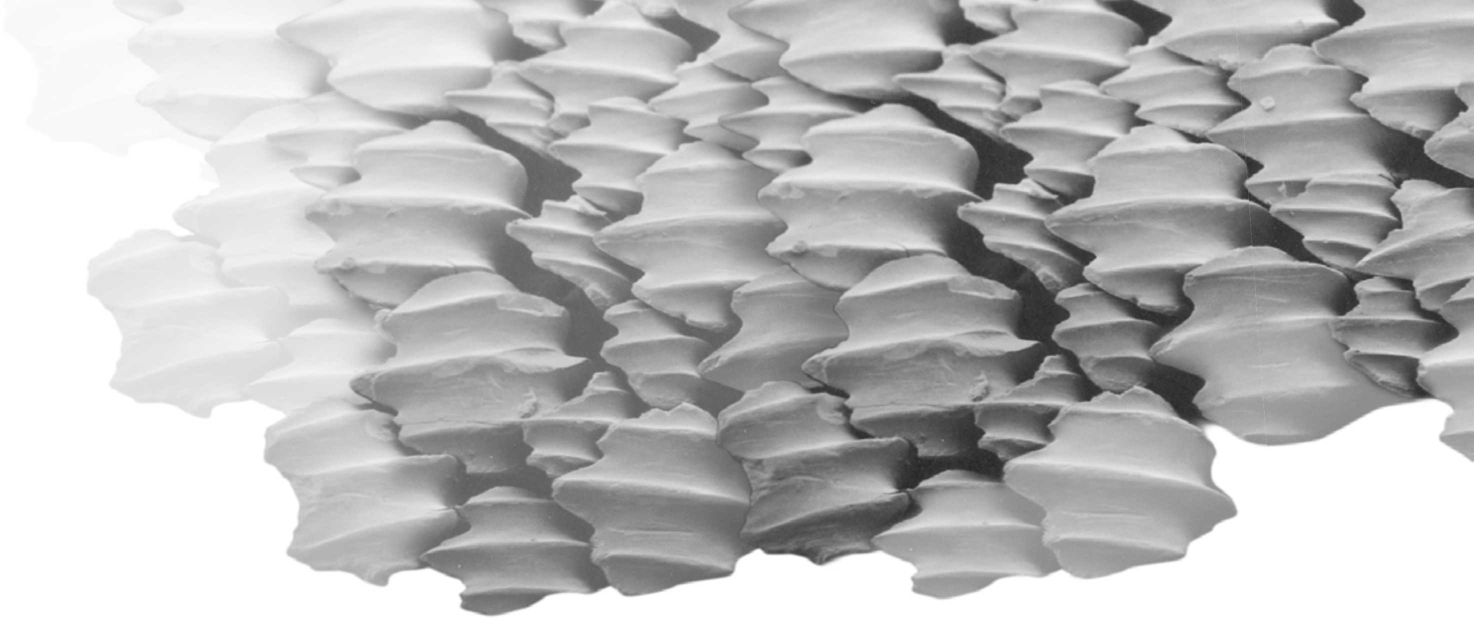
Coatings can also be used to achieve greater resistance to higher temperatures. A common application is aircraft engines, which can reach an internal temperature of more than

**2 000 °C.**



The scalation of some shark species reduces their water resistance by up to

**80%.**

As a result, mako sharks can achieve speeds over short distances of

**50–70 km/h.**

This effect is implemented in the shipping industry as well as in aviation and space travel by means of coatings patterned after the shark's skin which are designed to save fuel.

The adhesion of algae and barnacles on the hulls of ships can also be reduced by up to

**70%** using similar coatings.

This is referred to as "anti-fouling effect". Until now, poisonous paints were used that inhibit the growth of algae and barnacles, but also harm the environment.

# A QUESTION OF *PASSION*

**Shawn Kelly** encountered a 3D printer for the first time while a student. Since then, the topic of **additive manufacturing** has fascinated him. Anyone who meets the Head of Oerlikon's AM Research and Development department in North Carolina will understand why.

By Gerhard Waldherr

«AM is able to create bionic structures ***with which nature's phenomena can be transferred to technology.»***

He had gotten off the bus that brought him from Munich to the AM Technology & Innovation Center in Feldkirchen only a moment before. Now Shawn Kelly shoved a piece of pizza into the microwave and poked his head through the door to ask if it would be all right if he were fifteen minutes late for the interview. There's been a lot going on. No time for lunch. "I'll just have a quick bite to eat and then I'll be right with you, okay?"

No problem. Kelly has behind him an overseas flight, jet lag and two hectic days at Oerlikon's 1st Munich Technology Conference, at which the future of additive manufacturing (AM) was discussed. Representatives of industry, science and government met for this event at the Technical University of Munich. Roland Fischer, CEO of Oerlikon, was there, as were Mohammad Ehteshami from GE Additive; professors Akhatov, Todd and Schleifenbaum from Moscow, Sheffield and Aachen; and representatives from Audi, MTU Aero Engines and 3D printer manufacturer Trumpf, as well. In short: Exciting lectures, interesting talks in between and not much time for sleep.

Kelly was much in demand, too. After all, he plays a central role in Oerlikon's ambitions concerning the new AM business unit, in which a total of 300 million Swiss francs are to be invested. Kelly works in Charlotte in the US state of North Carolina, where a research and development center with production capacity encompassing 40 printers is being established. There, he heads the AM Research & Development department, which also employs seven engineers and four technicians.

## Printing is not enough

His break over, he is ready for the interview to begin. What one notices first is the calm competence he projects. This is a man who considers carefully what he says and also makes sure that what he's said is understood. A man one trusts instinctively, especially when he says right at the outset: "It doesn't matter whether you're talking about additive manufacturing, laser sintering or 3D printing: Don't be taken in by the hype – I've already experienced the cycle of a rise, fall and renewed rise of this whole topic."

At the moment, AM is considered to be the next industrial revolution. It appears that the elements for this are in place – or what does Kelly think? He leans back, gently shakes his head and says: "It's not just about printers and powders, it's also about efficiency, reliability and quality. It's about completely new process modalities. And there is a long way to go before we get there. Printing is easy. In the end, you have a part for a jet engine that looks like a part for a jet engine. But the question is, does it work, too?"

The aerospace sector is a good example. Here, in particular, AM is able to replace conventional production, especially of parts that need to be unusually light, are produced in low quantities and are therefore extremely expensive. "At the same time," says Kelly, "we have been able to create completely new parts thanks to AM." 3D printers are able to create bionic structures with which nature's phenomena can be transferred to technology. In doing so, engineers face no creative limitations; they are able to focus entirely on the functionality. Kelly states: "AM offers massive advantages here as compared to classic, industrial manufacturing."

## From childhood dream to Oerlikon career

He grew up in Baltimore. As a child, he liked playing with Legos. Everything he was able to build with his own hands was fun. At that time, the NASA space shuttle was making regular trips into space. Kelly says: "I was a great fan; even in kindergarten, I already had the dream of working for NASA in a lab. It was clear to me very early on that I was going to be an engineer."

In 1995, he began his studies in materials science and engineering at Virginia Tech. The investigation of the structures and properties of metals, plastics, ceramics and glass was not considered hip at the time. Nonetheless, Kelly says: "I have never regretted the decision. Materials, especially metals, are a fascinating field and few people understand what drives their performance." →

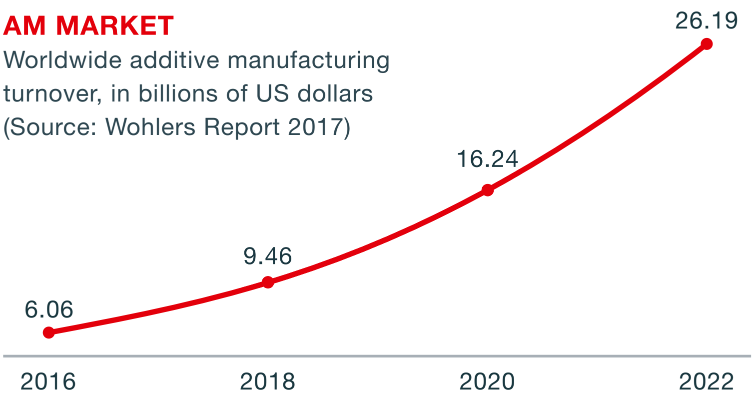
Additively manufactured double nozzle for aerospace applications.

«When the microstructure is understood, ***the properties of the material can be modified and employed advantageously.»***

During college, his kindergarten dream came true. Kelly was able to spend one practicum semester in the NASA Goddard Space Flight Center. There, he researched adhesives and connecting pieces for the Cassini space probe, which was to crash into Saturn 20 years later. Kelly, once again: “The time I spent at NASA was exciting, but afterward, it was clear to me: I don’t want to spend the rest of my life just testing materials, I want to understand these things better and at greater depth.”

One day, a professor suggested a research project to him that was initiated by Boeing and dealt with titanium from a 3D printer. Kelly had no knowledge of the processes with which the material was created. “Consequently, I had to investigate what took place thermally. Some microstructures are changed by heat, and some are not. It was only as a result of my investigations of the microstructures that I was able to understand how the material was put together.” Kelly turned the project into a doctoral thesis. The fascination with 3D printing has never left him since.

**AM MARKET**
Worldwide additive manufacturing turnover, in billions of US dollars (Source: Wohlers Report 2017)




After completing his doctorate and two engagements as an assistant at universities, Kelly landed at EWI in Columbus, Ohio, one of the leading companies for the development and deployment of new technologies. In 2015, Kelly was the head engineer in the area of AM when Oerlikon contacted him to ask if he could imagine setting up a competence center for additive manufacturing on Long Island, in the New York City suburbs. “It sounded interesting,” says Kelly, “but I liked my job, I enjoyed being in Ohio, and my wife and I couldn’t really picture ourselves on the east coast at that time; Long Island was not a good fit for our plans.” Kelly declined and recommended his college friend, Jeff Schultz.

A few months later, the phone rang again. This time it was Schultz who was calling. He had gotten the job at Oerlikon and was thrilled: “We want to industrialize AM. Maybe you could come after all?” Kelly met Florian Mauerer, who set up the AM area at Oerlikon. He also met further representatives from management. He discovered, “They all had an understanding of the technology and were committed to the concept.” Moreover, as a manufacturer of metal powders for 3D printers, Oerlikon is well acquainted with the subject. Establishing AM as a comprehensive business unit was a completely logical move. He had found his sweet spot: “I knew what it would take to get things up and running, and I knew that at Oerlikon, I could implement my ideas and make a difference.”

## The playing field of microstructures

Given that AM has already proven its utility in gas turbines, Kelly sees immediate potential for its application in the aerospace and energy sectors. “Everything else is possible as well, but we need to be patient.”

In response to reports of success using huge, multi-million-dollar machines to print cars, concrete parts for bridges or pavilions made of carbon rods, he offers a different perspective. “We can print the craziest structures,” says Kelly, “but what many overlook is that we can not only create shapes with AM, but also materials which could never be produced using conventional methods. The really exciting thing is that we can virtually create our own microstructures, which are of decisive importance for the properties of a material.”

When the microstructure is understood, the properties of the material can be modified and employed advantageously, he explains. “We can also use this approach to offer the customer new possibilities or suggestions for solutions for better, more efficient production. That’s exactly what Oerlikon is all about, and that’s what we want to research and learn about so that we can make even greater, more daring and innovative decisions in the future.”

Before Kelly came to Oerlikon, he had never been outside of the USA. Now he regularly commutes between Charlotte, the rest of the US, Zurich, Feldkirchen and Magdeburg. As he does so, he remains in virtually non-stop contact with his colleagues, an eclectic mix of people from every country imaginable.

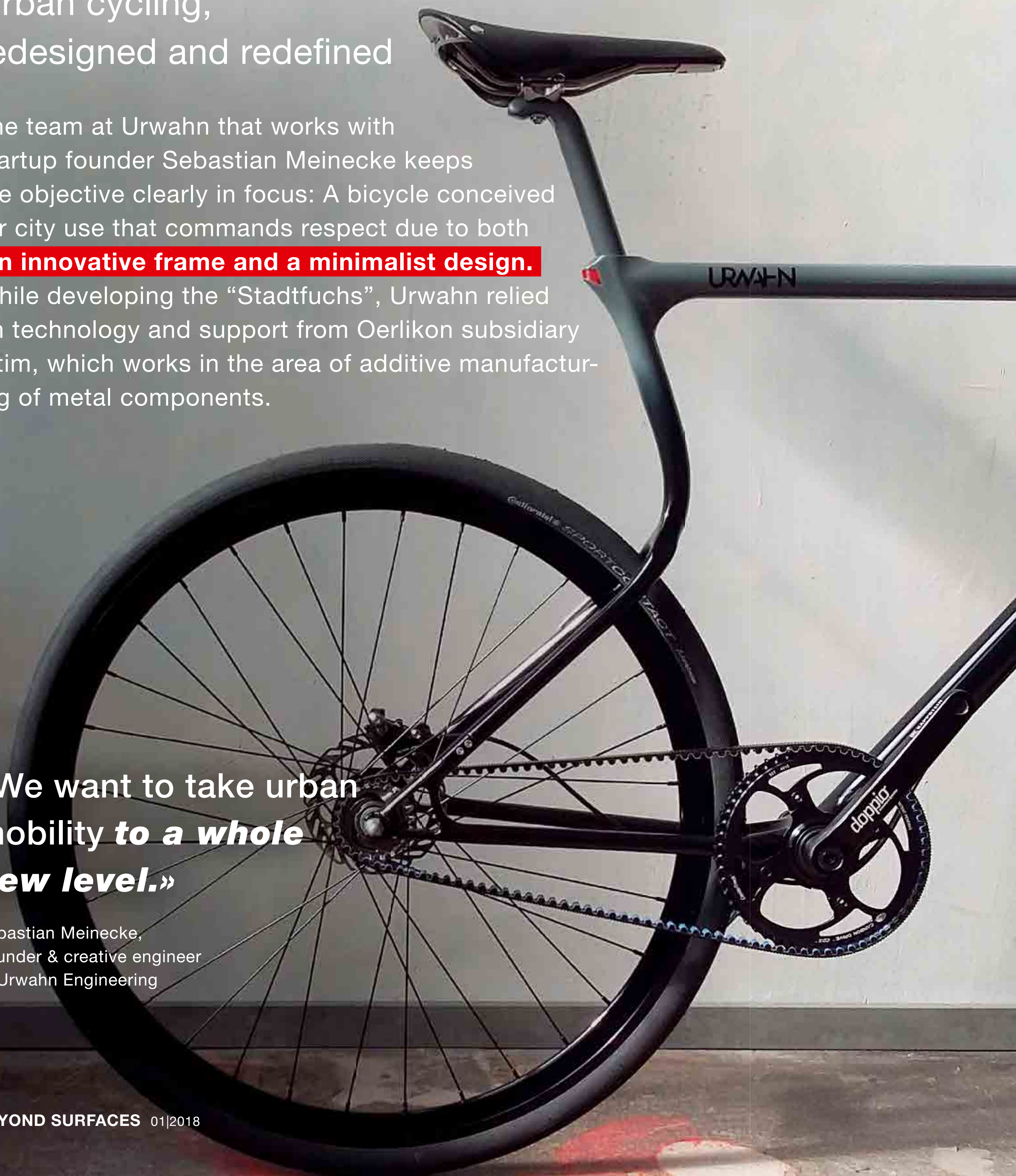
The professional demands come at certain costs to his personal time, but he has found his calling. “Do you know why I do all this? It is totally fascinating to have the privilege of developing something significant with a team of young and passionate people,” he says. “I don’t want it to sound overblown, but this is a once in a lifetime opportunity for the team and for Oerlikon.”

«It is totally fascinating ***to have the privilege of developing something significant with a team of young and passionate people.***»

# *ELEGANCE AND FUNCTIONALITY*

## Urban cycling, redesigned and redefined

The team at Urwahn that works with startup founder Sebastian Meinecke keeps the objective clearly in focus: A bicycle conceived for city use that commands respect due to both **an innovative frame and a minimalist design.** While developing the “Stadtfuchs”, Urwahn relied on technology and support from Oerlikon subsidiary citim, which works in the area of additive manufacturing of metal components.




«We want to take urban mobility ***to a whole new level.»***

Sebastian Meinecke,
Founder & creative engineer
at Urwahn Engineering

**Perfectionists:** The Urwahn Engineering team with Konrad Jörß, Sebastian Meinecke and Ramon Thomas (from left).

Sebastian Meinecke is a sports engineer, product designer and enthusiastic bicyclist. He financed his education by establishing his own production facility, in which he built truly distinctive bicycles. Even then, he was already passionately involved in the areas of design, functionality and integration. Nonetheless, he wanted more: "My dream was to develop a bicycle on my own that elegantly unified design and functionality, was specifically adapted to suit the everyday circumstances of the city and thereby to take urban mobility to a whole new level."

The idea simply never let him go, and his enthusiasm proved contagious. He persuaded Konrad Jörß and Ramon Thomas, members of the scientific staff at the Otto-von-Guericke University Magdeburg, to join him in the development of a new type of bicycle. Soon they registered a patent and founded the startup "Urwahn Engineering". The term "Ur-wahn" is a coinage which, in German, clearly underscores the young founders' objective: Urban (ur) engineering connected with the passion, even obsession, and the committed determination (wahn) to create new, innovative and perhaps previously unimagined products.

## Elegant appearance, outstanding functionality

Motivated and driven by the interdisciplinary model of "Integrated Design Engineering," Urwahn places humans and their needs at the focus of their bicycle conceptualization. The central innovation that arose in this connection is a completely new type of bicycle frame whose design is a complete departure from the well-known trapezoidal shape. Employing a comprehensive form closure of the front and rear parts, they succeeded in giving the rear wheel an elastic suspension. This helps absorb shocks on rough terrain. By eliminating typical commercially available spring suspension systems, they reduced weight while retaining a comfortable ride. Further innovative details, such as powerful LED lighting and a GPS tracking system that serves as a theft deterrent, are fully integrated in the frame and make the bicycle truly unique. "Our constant focus at every turn was a reduction to the most basic elements, which is the source of the bicycle's delicate and elegant appearance," describes Sebastian Meinecke.

## "3D printing" for a unique result

The frame of the "Stadtfuchs V2" ("City Fox V2") was fabricated in Barleben, Germany, by citim GmbH, which is part of the Oerlikon Group. It is made of 1.4404 stainless steel, a very highly corrosion resistant chrome-nickel-molybdenum steel, which was shaped by means of additive manufacturing. Using the process of Selective Laser Melting (SLM), the powdered material was applied and melted layer by layer, which results in the creation of a three-dimensional object. This manufacturing process opens up completely new shaping and forming possibilities and thus the production of component geometries which would be unthinkable with other production processes.

Founded in 1996 as a spin-off (as was Urwahn itself) of the Otto-von-Guericke University in Magdeburg, citim specializes in additive manufacturing of metal components. This process eliminates the costly and time-intensive mold-making procedure and thus →

«We chose the AM process because it ***eliminates the costly and time-intensive mold-making procedure and thus makes it possible to create prototypes in a short time.»***

makes it possible to create prototypes in a short time. The component can be modified quickly and without complications during the development process. “Our collaboration with citim was fantastic,” states Sebastian Meinecke. “We were assisted by the citim team in every respect, both in the selection of the most suitable manufacturing process as well as in the design of the frame and ultimately, even in the perfecting of the frame’s surface finish.”

In the context of the ego.-Gründungstransfer program, their project received funding from the European Regional Development Fund via the Saxony-Anhalt Investment Bank. Because the subsidies were approved for only a limited time period, the team was under tremendous deadline pressure. “Together with citim, we were nonetheless able to produce a fully functional prototype within a matter of only a few weeks,” explains the product designer.

## Internationally successful, anchored in the region

The “Stadtfuchs” has engendered international excitement since its unveiling. “Of course, we’re very pleased about this. Of almost greater importance for us, however, is that we have developed a product that is strongly anchored in the region,” Sebastian Meinecke notes enthusiastically. “We not only use sustainable processes and materials for production, but are also creating jobs at the same time.”

The “Stadtfuchs” will soon be available on the market. The Urwahn team is already brewing up new ideas. We are looking forward to further surprises.

Urwahn Engineering is a startup launched in 2016 and located in Magdeburg, Germany. Driven by the idea of taking urban mobility to a whole new level, the company designed an innovative bike especially suited to deal with the everyday circumstances faced in the city.

**www.urwahnbikes.de**

Making of the ‘Stadtfuchs’:
**www.vimeo.com/195801484**


AM production in Barleben.

For over 20 years, citim GmbH is specialized in additive manufacturing and covers the whole production chain: from part conception to assembly completion. The company was founded in 1996 as a spin-off of Otto-von-Guericke University Magdeburg. Now, with 21 up-to-date machines operating in Barleben, Germany, and at the company’s second site in Kennesaw, USA, citim is a leading supplier for additively manufactured metal parts. Customers from the automotive, aerospace and consumer goods industries benefit from the company’s manufacturing experience and expertise. Since January 2017 citim is part of the Oerlikon Group.

For more information on services of Oerlikon and citim please visit:
**www.oerlikon.com/am**
**www.citim.de**

# OERLIKON IN WORLD'S FIRST 3D PRINTING MUSEUM

Additive manufacturing is recognized worldwide for its impact on industry. But China has become the first country to test its value for tourism, as well. The world's first Museum of 3D Printing opened in Baoshan, Shanghai in July 2017. Visitors explored the 5000 square meter space and its displays of a multitude of 3D printing technologies and products. Exhibits of 3D printed works included metal art objects, furniture made of nylon, ceramics and dazzling pieces of jewelry.

The museum, whose mission extends to an educational objective, is home to a center for scientific research, a lecture hall, and a library of materials employed in additive manufacturing. Three types of metal powder developed by Oerlikon Metco – MetcoAdd C300-A, MetcoAdd 316L-A and MetcoAdd 78A – have proven themselves in customers' additive manufacturing processes in the past. These products are included in the library collection.

Lacey Li (Oerlikon) with the museum curator Julie Zhu in front of the shelf where the Metco AM powders are displayed.

## REPEAT PERFORMANCE

The University of Stuttgart racing team (Rennteam Uni Stuttgart) is looking back on a very successful 2017. For the second consecutive year, the team won first place for internal combustion engines in the Formula Student. As reported extensively in our 2/2016 issue, student teams race their cars in the Formula Student competition. In addition to speed, factors that contribute to winning include energy efficiency and engineering design. The University of Stuttgart team relies on the proven Oerlikon surface technologies SUMEBore and BALINIT DLC in their race car. These innovative engine coatings reduce friction and increase power. This not only lowers oil and fuel consumption, but also provides decreased wear.

# THE ART OF DISCOVERING

*How the smallest discoveries are having massive impact*

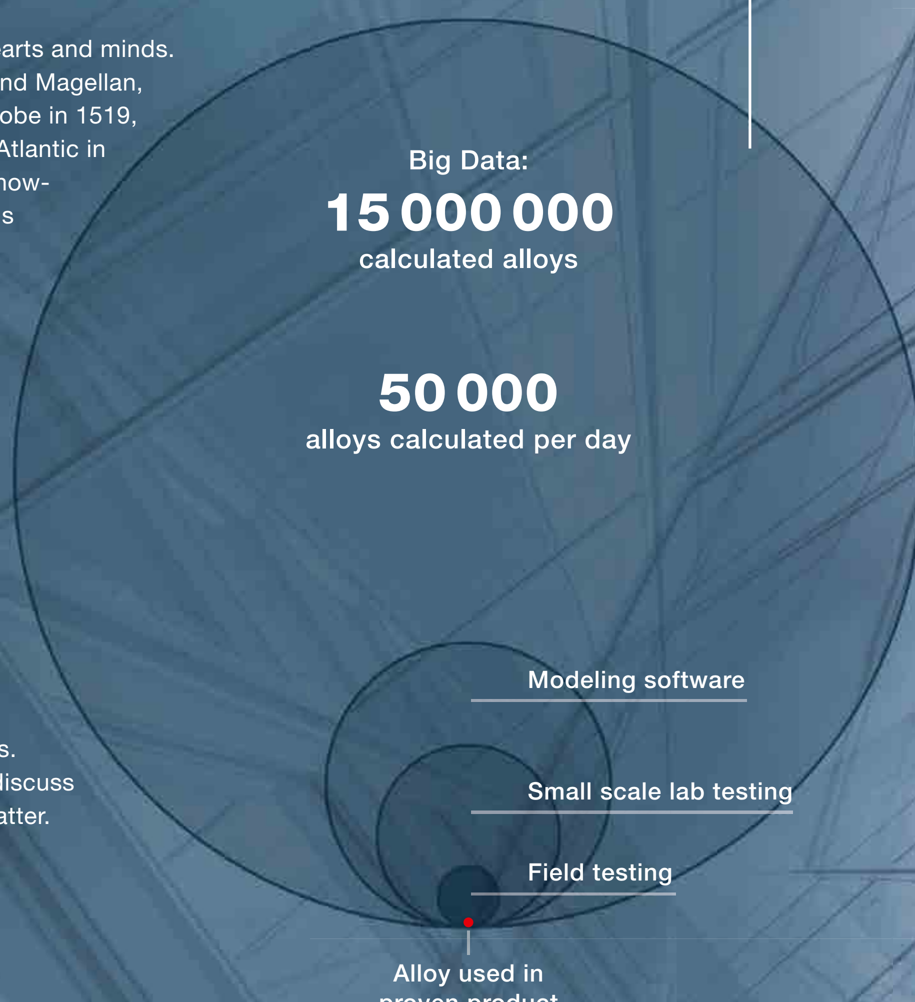
Big data is the secret behind the company Scoperta's amazing ability to **develop new materials in weeks instead of years.**

Explorers have always captured people's hearts and minds. People like the Portuguese explorer Ferdinand Magellan, who embarked on his first trip around the globe in 1519, or John Cabot, who traversed the northern Atlantic in the 1497. Such adventurers returned with knowledge, discoveries, and goods from the lands they found, and created new trade routes.

Modern "explorers" – instead – are making remarkable discoveries at the nanoparticle level, revolutionizing the way new materials are developed, as well as the properties and attributes they have.

Companies like Scoperta – which is the Italian word for "discovery" – are changing the game when it comes to materials development. One of the newest members of the Oerlikon family, Scoperta uses rapid alloy development (RAD), a multi-staged process driven by its proprietary software, to create innovative products to meet customer needs. Here, three of Scoperta's senior managers discuss the company's advantages and why they matter.

This is how Scoperta's rapid alloy development platform works.



# «*We quickly deliver break-through materials performance* to improve customers' products at the lowest possible cost.»

**John Madok, CEO**

"Customers need specific attributes in various materials. Sometimes, their needs are complex and can seem diametrically opposed. For example, they may want a hard, durable material that still behaves or performs as if it were soft.

The traditional way of developing a new material is labor-intensive and based on trial-and-error tactics. Even incremental improvements in materials properties can take years to achieve, as each iteration is created and tested. Scoperta's technology is uniquely suited to find compositions that result in materials microstructures that meet the needs of customers, even displaying opposing attributes.

Our proprietary algorithms analyze hundreds of thousands of possible compositions each day. We use sophisticated data mining techniques to sort the best candidates, identifying material improvements and testing them on actual customer components within weeks instead of years. This saves customers an enormous amount of time, money, and effort, and provides them with significant competitive advantages in their businesses.

Our promise to our customers is simple: We quickly deliver breakthrough materials performance to improve their products at the lowest possible cost. In short, we set out to, and we succeeded in, revolutionizing materials design with technology."

**Justin Cheney,**
**Chief Technology Officer**
"Sometimes, bridging the gap between our scientific developments and what is important to customers can be a big challenge. I recall the first 'commercial' material I developed with the RAD software tool I wrote in graduate school was an iron-based amorphous alloy. I was on my first business trip, traveling to a thermal spray shop in Seattle. As I spoke to the customer, I proudly discussed the high ultimate tensile strength of the amorphous alloy I invented. I was oblivious to the fact that the customer I was trying to persuade had no idea what 'ultimate tensile strength' or what the term 'amorphous alloy' meant.

It was a valuable lesson: Innovative companies need to be able to translate complex scientific discoveries into what that means for the customer, whether it's a thermal spray shop in the western United States or a coal mine in Indonesia. Even after I became CTO, it took years and a lot of help along the way for me to be able to do that. It is still something I think a lot about today.

At Scoperta, we have a strong culture of innovation, and independent drive to accomplish great things. Because we innovate at such a fast pace, we are able to work with our customers to design customized solutions within months. Our RAD method lets us immediately answer questions such as, 'What is the effect if I change the elemental composition?' or 'What is the best microstructure for the job?' Objective and fast, this method lets us target the best solution for our customers quicker than ever before.

Google transformed how people find information and connect, essentially making the once-iconic Yellow Pages unnecessary. Similarly, by harnessing the power of big data, Scoperta is disrupting materials development in a way that makes former methods obsolete. Best of all, our customers and prospects easily understand the benefits that holds for them."

«Innovative companies need to be able to translate complex scientific discoveries into ***what that means for the customer.»***


Once computed, hundreds of thousands of alloys (each dot representing one alloy) can be evaluated simultaneously to discover new materials with useful properties.

«Our RAD technology has allowed us to help several industries ***move performance metrics to significantly higher levels.***»

**Adolfo Castells,**
**Vice President Business Development**

“We all like to work with people who raise our game and make us better. Oerlikon / Scoperta’s RAD technology has allowed us to help several industries move performance metrics to significantly higher levels. Being able to microstructurally examine and analyze millions of potential compositions simultaneously affords us the opportunity to make real changes in our customers’ businesses. This proven approach to developing new disruptive solutions strengthens our existing relationships and wins new ones.

There are times in your work life that are rewarding, and times when you feel unduly challenged. The Scoperta team has made working rewarding beyond measure. Our team’s total commitment to solving customers’ problems using our innovative technology has been both exciting and fulfilling, while making the challenging times less so.

We joined the Oerlikon family because our organizations have a joint vision for the future — a vision for innovation the industry has not seen since its early years. We each understand that true innovation will face obstacles, just as any explorer, inventor or innovator has. However, together, our goal is to find our way, discovering new approaches and breakthrough solutions that will change our customers’ businesses for the better and bring our industry into a new world of possibilities through technology and revolutionary new materials.”

Originally developed at the University of California, San Diego, as part of Justin Cheney’s doctoral work, Scoperta has transformed the software platform from a simple predictor of certain microstructures to a fully digitized materials design platform. Harnessing thousands of human years’ worth of materials science knowledge combined with Scoperta’s ever-expanding materials database, the technology can quickly zero in on the optimal solution for a next-generation material.

Learn more about how Scoperta can help you with the development of new materials:

**www.scopertainc.com**

www.oerlikon.com/metco/en/products-services/rapid-alloy-development/

# The MAGIC of molecules

By Gerhard Waldherr

What makes a young woman get involved in **materials science? Cristina Mercandetti** is already familiar with that question, which she hears often. So, she simply starts telling her story – a beautiful tale with a perfectly logical ending. A story in which someone happened to be at the right place at the right time – as is so often the case in life.

Mercandetti is born in Italy in 1992, and when she is three, her family moves to a small Swiss village close to Zug. The father, a chemical engineer, has a professional interest in nature sciences, and his enthusiasm seems to capture little Cristina's imagination. The child becomes adept and solving mathematical riddles. She plays with a chemistry set, mixes water with mysterious powders to create fantastic colors and falls completely under the spell of the magic of atoms and molecules. At school, she is fascinated by subjects like chemistry, physics, mathematics and biology. She knows she wants to study. But what?

One year before her "Matura" (pre-graduation examination), Mercandetti visits an information event at the Eidgenössische Technische Hochschule (ETH) in Zurich. There, she learns that one degree program combines practically all nature sciences – and thus covers all her interests. "A subject which has a bit of everything," says Mercandetti. "I thought that was cool."

Cristina Mercandetti in one of the laboratories of the ETH Zurich.

## From tennis racket to aerospace

Discovering materials sciences changes her life. All of a sudden, Mercandetti thinks about the products she uses. As an amateur tennis player, she asks herself why a new racket model is hyped – and finds out which plastic alloys this may be attributed to. She analyzes the components of her smartphone and finds out that its function depends on extremely rare raw materials. A particularly illustrative example is her mountain bike. In earlier times, bicycles were made of iron, and later on from aluminum; today, they consist of ultralight extremely solid carbon fibers.

Mercandetti says: "Materials are central elements in all industries, no matter whether in the automotive sector, in the aerospace industry, for medical devices or in electronics. The better materials are, the better is the performance of the products. Materials science has a significant influence on our lives."

## Proving in practice

On completing her bachelor's degree at ETH, Mercandetti embarks on several internships. One is at an aerospace company where the material and process team occupies itself with the manufacture of satellites. "A fantastic experience," as she puts it. After three years of study, the recent graduate was finally able to prove her know-how in practice. "I am a huge fan of everything which has somehow to do with space as the materials simply must resist even the most extreme conditions. Heat, cold or pressure would enormously accelerate wear otherwise. The mere thought that the products you are working on might be sent into space is simply fascinating."

## Magical materials

Of course, this is not everything. The field of materials science is vast and covers many disciplines and areas of focus. Among Mercandetti's favorites, one stands out as "magic" for her: Shape Memory Alloys that remember and can restore their original shape after being subjected to heavy deformation. Stents, braces, glasses frames as well as wings and winglets of aircrafts are examples of how this works.

Another innovation she finds exciting is the capacity of Self Healing Coatings to repair surface damage on their own, an ability developed for, among other things, paintwork damage to cars. Mercandetti also immerses herself in the field of microfluidics, dealing with the behavior of fluids and gases within the smallest space. "This is, for instance, important in laboratory medicine where one often has extremely little blood or urine available for tests," she says. Work in this field becomes the theme of her master's thesis.

"I believe that materials science will significantly increase in importance in the near future," Mercandetti says, "in view of the also increasing environmental awareness and the need for sustainability." Where her professional career will take her next after completing her master's degree remains to be seen. Before she makes a decision about where and in which sector to work, she intends to complete another internship abroad. But there is one thing that Cristina Mercandetti has long known: "I want to work at something which helps solve problems, at something which is good for mankind. For that, materials are the lynchpin."

**Watch the complete video of the interview at:**

**www.oerlikon.com/stories/passion-for-materials**

### ETH zürich

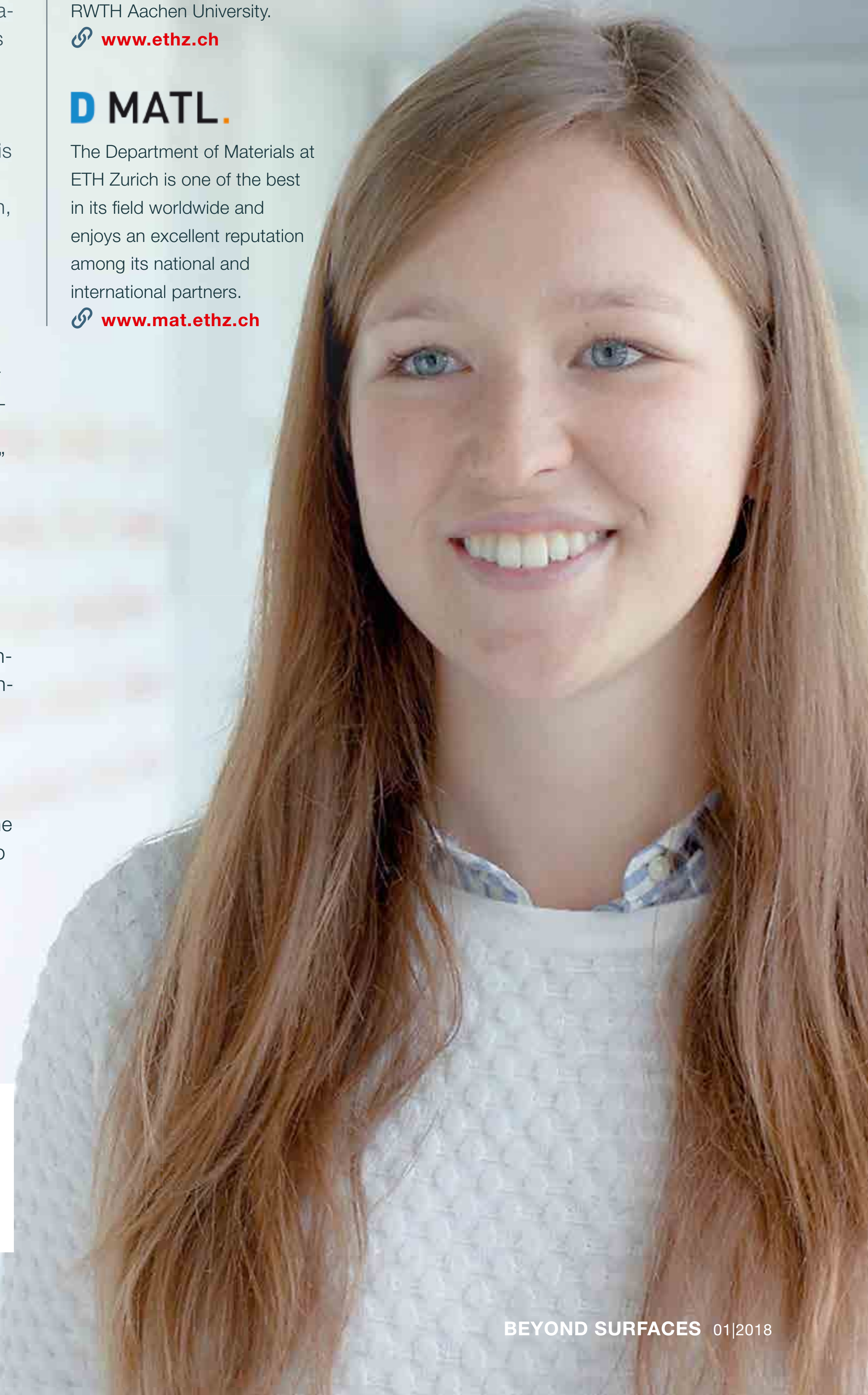
The ETH Zurich (Swiss Federal Institute of Technology in Zurich) was established in 1855 and is ranked among the top ten universities in the world. So far, 21 Nobel Prizes have been awarded to researchers who have or had a connection with ETH Zurich. Oerlikon has research partnerships with the ETH Zurich and with around 50 other academic institutions such as the Technical University of Munich, Skoltech and RWTH Aachen University.

**www.ethz.ch**

### D MATL.

The Department of Materials at ETH Zurich is one of the best in its field worldwide and enjoys an excellent reputation among its national and international partners.

**www.mat.ethz.ch**




**1st munich technology conference**
11–12 October 2017
TU Munich / Germany

mtc 1

# THE FUTURE OF THE INDUSTRY

**Some 600 visionaries, technologists and users discussed the future of additive manufacturing at the 1st Munich Technology Conference (MTC[1]).**

An apocryphal story claims that when asked how he created David, Michelangelo replied that he simply chipped away from a marble block everything that didn't look like the statue. From the dawn of primitive tools to the machine age, that was the approach to manufacturing: a process known as chipping was used to cut shapes from stone or metal. Additive manufacturing (3D printing) represents a reversal of this process in industrial manufacturing. "Instead of cutting away material, metal powder is melted with a laser and then deposited in the desired form," explains Professor Dr Michael Süß, Chairman of the Oerlikon Board of Directors. As a result, engineers can now build – or rather, generate – new components in any shape they want. They are no longer limited to certain geometries. For

«The opportunities afforded by additive manufacturing concern economic variables, time savings and the handling of complexity at a level never seen before. And, there is one more important point: ***Additive manufacturing is an ‹enabler› for existing methods: it make these more efficient and better.»***

Professor Dr Dr h. c. mult. Horst Wildemann, TUM

«This was a fantastic conference because it collected ***hundreds of additive manufacturing enthusiasts*** who shared their vision for where additive is and where it will go. It was a great opportunity for me to see ***where other people are thinking AM might go,*** and to exchange views with industry colleagues. I also had an opportunity to showcase how far GE has come with additive manufacturing.»

**Mohammad Ehteshami,**
**Vice President & General Manager GE Additive**

the first time, we can now virtually replicate nature in the manufacture of objects.

**A conference in the interest of a shared commitment**
With the objective of promoting dialog and partnerships, Oerlikon organized the 1st Munich Technology Conference (MTC[1]) on the topic of additive manufacturing in cooperation with the Technical University of Munich (TUM). For two days in October 2017, more than 600 experts from industry, research, government and associations gathered at the conference to exchange ideas concerning the future and the possibilities of this technology. Participants agreed that additive manufacturing will revolutionize industrial production processes by allowing ideas to be implemented more quickly and industrial components to be made lighter due to bionic structures. Moreover, all this can all be accomplished with a reduced consumption of resources.

**The leap to large-scale industrialization**
Additive manufacturing has already been employed industrially for some time now, especially in the aerospace and medical technology sectors. Their pioneering use of this advance is logical, as it is well suited to uses in which small production runs with individualized shapes are required. Jet engine parts are one example, as are prosthetics that can be adapted to provide each patient with a perfect fit. However, increasingly, other sectors are also recognizing the potential associated with additive manufacturing. →

«There is a good deal for us to do before the industrialization of additive manufacturing becomes fully established. ***Nonetheless, it is not a question of ‹if›, but of ‹when›.*** And when that time comes, it will bring tremendous changes to industry.»

**Dr Roland Fischer, CEO Oerlikon**

«Additive manufacturing makes lighter components possible due to bionic structures. A bracket for a flight attendant to hold onto in an A350 can now be manufactured additively using titanium as a basis and it ***weighs 500 g less***. Extrapolated over the 30-year life of an aircraft, this leads to a ***reduction of 300 000 tonnes of $CO_2$.***»

**Michael Schreyögg,**
**Chief Program Officer, MTU Aero Engines AG**


According to a 2016 study by EY, three fourths of the companies in the automotive industry are already using 3D printers or have plans to do so.[1] In the energy sector as well, parts for gas turbines, for instance, are today being produced using the additive manufacturing method.

Nonetheless, there is still a long way to go until large-scale industrialization becomes a reality. Conventional manufacturing processes will remain with us for some time yet. In the near future, the focus of this technology will especially be on cost reduction and the stabilization of processes. The training of specialized engineers must also be promoted, because additive manufacturing requires completely new skills and ways of thinking.

**"Additive manufacturing will be the key to the future competitiveness of European industry," says Professor Dr Michael Süß. "The utilization of the technology's full potential will require the cooperation of the best thinkers."** The 1st Munich Technology Conference succeeded in bringing these together.

The video on the conference and the presentations by the speakers can be viewed and downloaded on our website:
**www.oerlikon.com/am**

**Save the date of the 2nd Munich Technology Conference: October 10–11, 2018**

[1] EY's Global 3D Printing Report 2016

«The beauty of additive manufacturing is that ***you can translate ideas directly into reality.*** This makes it possible for engineers to be more creative and conceive completely new things.»

**Professor Dr Johannes Schleiffenbaum,**
**RWTH Aachen University**

# BE UNIQUE
## BALIQ UNIQUE AND INLENIA

Oerlikon Balzers presented BALIQ UNIQUE, which introduces brilliant colors into the previously gray world of wear protection for tools, in September 2017 at the EMO in Hanover. The BALIQ family of coatings, based on the S3p technology launched in 2011, enables trouble-free chip transport and eliminates the need for mechanical reworking.

Gleaming colors are more than just pleasing to the eye; they also meet the demands of tool manufacturers that need to differentiate, classify and visualize their products. This newest development allows them to assign specific colors to their tool types or groups, select colors appropriate for particular applications and even determine the degree of abrasion based on the color. The result is that manufacturers in the tool market are now able to design their own unique color combinations for their range of tools – all with the revolutionary performance BALIQ delivers.

Moreover, the new INLENIA pica and INLENIA kila systems expand the Oerlikon Balzers range of machines that are able to process BALIQ coatings. While the extremely quick coating times make the INLENIA pica ideal for ramping up smaller batches, the INLENIA kila represents the logical next step for high-volume production runs.

At Hitachi, enthusiasm is running high. Kazuyuki Kubota, Head of Manufacture Department and Head of Coating Technology:

“We are working for more than 20 years with Oerlikon Balzers and are always on the leading edge of coating technology. With the new INLENIA coating system, ***we are completely free in customizing coatings to our needs and creating our own, individual coating portfolio.*** The system exceeds our high requirements on precision, surface quality and performance of our applications.”

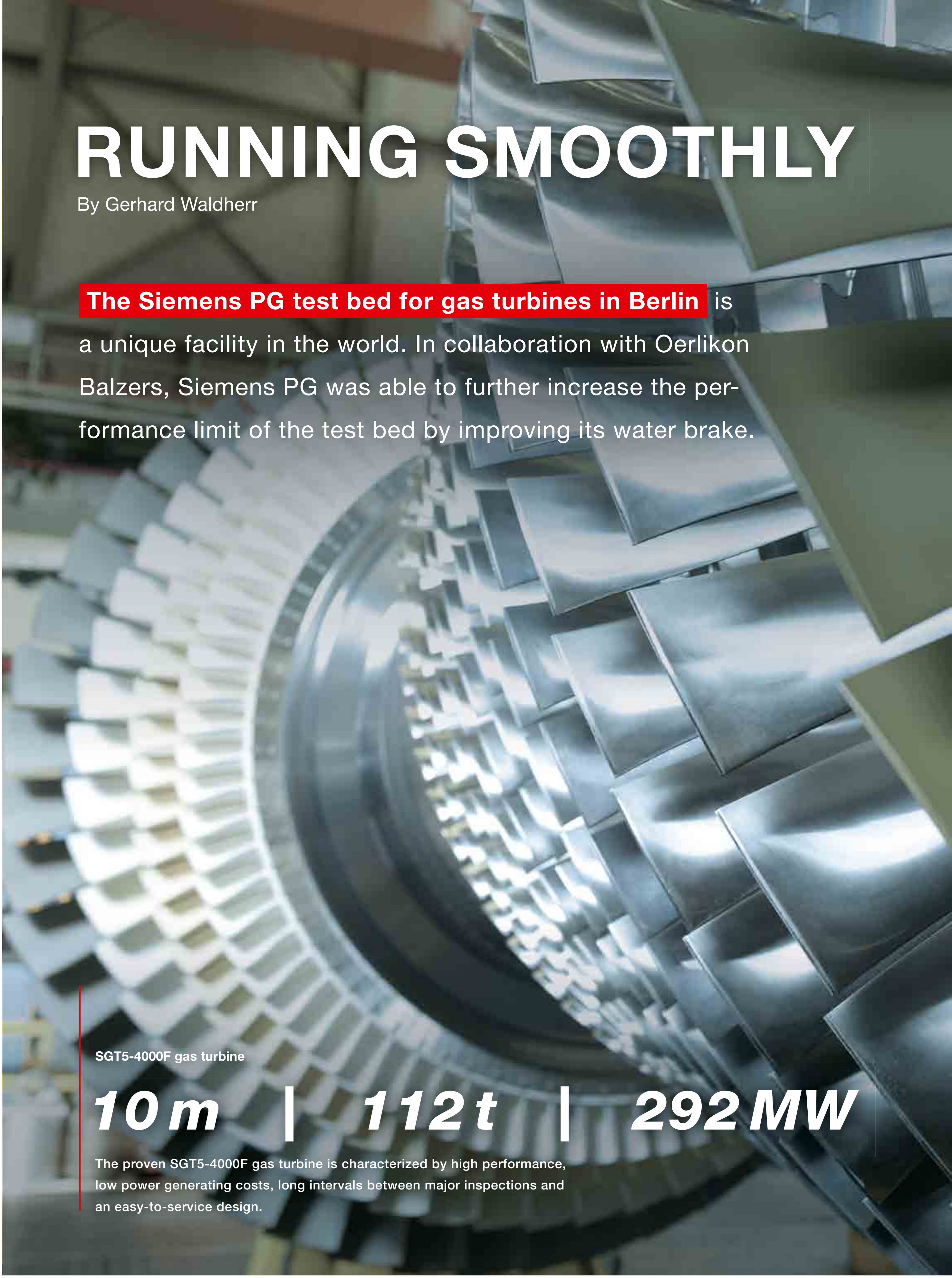
**Learn more at**

- www.oerlikon.com/balzers/com/en/portfolio/equipment/inlenia
- www.oerlikon.com/baliq-unique

From left: Kazuyuki Kubota, Head of Manufacture Department and Head of Coating Technology, and Tomoya Sasaki, Assistant Manager, Production Department from Hitachi in front of an INLENIA kila.

# RUNNING SMOOTHLY

By Gerhard Waldherr



**The Siemens PG test bed for gas turbines in Berlin** is a unique facility in the world. In collaboration with Oerlikon Balzers, Siemens PG was able to further increase the performance limit of the test bed by improving its water brake.

SGT5-4000F gas turbine

***10 m | 112 t | 292 MW***

The proven SGT5-4000F gas turbine is characterized by high performance, low power generating costs, long intervals between major inspections and an easy-to-service design.

«I believe that in the future we can ***aim to increase the lifespan of the wheel discs*** by two or three times, ideally even more.»

**Ayhan Cetin, Research Engineer, Siemens**

Moabit, Berlin. The legendary gas turbine plant at Huttenstraße. Ayhan Cetin walks through the final assembly hall. In the middle of the hall, an order is being completed for an SGT5-4000F turbine. In a few weeks' time, this mighty, high-performance machine will be shipped from nearby Westhafen to the Middle East.

Research engineer Cetin now walks up the stairs to a gallery. From here, we see an area at the rear of the hall surrounded by white sound barriers. This is the gas turbine test bed. This, says Cetin, is where current products and new technologies are "put through their paces." Several thousand measuring points provide information about performance, efficiency, effectiveness, emission levels and much more. Outsiders can only guess at what goes on behind these sound barriers. What we learn from Cetin is that the facility's water brake plays a vital role.

**Extreme pressure creates challenges**

The water brake consists of a steel case that contains a rotor comprising multiple wheel discs. The material: a low-alloy steel. Cetin can talk about the water brake for hours, although his explanations are more suited to the experts – just as when he waxes lyrical about the theory of boundary layer friction in turbulent flow. Put simply, high shear and friction forces cause thermal energy to be produced and extracted from the heat transfer medium (water). Depending on the regulatable flow rate and the effective frictional surface, a torque is created that works against the gas turbine that's being tested and thus absorbs the energy produced.

In 2010, Cetin was appointed system supervisor of the water brake system at the Berlin gas turbine test bed, the largest of its kind in the world. The challenges associated with a facility of this size are huge. The water brake, in particular, is subject to extreme stress and must be inspected constantly to ensure uninterrupted operation. Cetin is therefore all the more delighted to have recently succeeded in optimizing the water brake in collaboration with Oerlikon Balzers. This involved making the wheel discs more hard-wearing. The process: plasma nitriding. The product: BALITHERM IONIT. The result: longer inspection intervals. But let's go back to the beginning.

Siemens is one of the world's leading companies in the field of power generation, and gas and steam turbines form the core business of the technology group. To define its portfolio, it is testing prototypes of new products and technologies. Development times and costs are deciding factors when it comes to the profitability of any company, and the high availability of the gas turbine test bay is therefore essential for Siemens PG.

In a conventional gas turbine power plant, the energy created is absorbed by the generator. In the Berlin gas turbine test bed, however, this is not the case. Here, no continuous power generation can be guaranteed, and thus it cannot be fed into the grid. The mechanical output of the gas turbine is therefore converted into waste heat via the water brake, which in effect replaces the generator and absorbs the energy produced. →

**Size comparison between human and machine.** The horizontally-placed rotor with turbine exhaust casing is 10 meters long and weighs circa 112 tons. The picture shows the SGT5-4000F gas turbine which has an output of 292 megawatts.

## What can protect against corrosion and cavitation?

The Berlin gas turbine test bed was built in 1972, with the water brake following in 1975. Over the decades, however, the demands placed on the facility increased constantly. While 100 megawatts were originally marked as the maximum total output for the test bay, this has since increased to 360 megawatts. Nowhere else in the world other than at Siemens in Berlin are these values achieved.

For a long time, the greatest challenge was presented by the functionality of the wheel discs of the water brake. The wheel discs' material is susceptible to corrosion, which is triggered as soon as contact with moisture occurs. Rust, for its part, results in the creation of cavitation, which can significantly damage the wheel discs. Cetin mentions centrifugal and coriolis forces and talks about tremendous turbulence in the system. "In many cases," he says, "cavitation is caused as a result of high flow rates. As the rate increases, the static pressure of the liquid falls. If it falls to below vapor pressure, vapor bubbles are formed that are carried along in the flow and can suddenly implode. This results in the formation of microjets that cause material damage with their high speed and extreme pressure load."

Cavitation leads to vibration problems, imbalances that can impair the function of the water brake. Should several wheel discs fail, for example, the brake can no longer be operated, and the gas turbine test bed is out of action. While the discs can be mechanically reworked or exchanged if necessary, this would result in frequent inspections and high maintenance costs. There were times, says Cetin, when the wheel discs were unusable after relatively few hours of operation.

## Siemens PG and Oerlikon: Solving it hand-in-hand

The preliminary discussions between Siemens PG and Oerlikon were held in autumn 2014. Oerlikon Balzers' Martin Fromme says: "The economic objective was to significantly increase the lifespan of the wheels." The first tests and basic analysis were carried out at the Clausthal University of Technology in 2015, and the first samples were prepared in 2016. Plasma nitriding with BALITHERM IONIT involves diffusing

**«We are able to save time and money, and to improve the performance of the test bay.** We couldn't ask for more.»

Ayhan Cetin, Research Engineer, Siemens

**Ayhan Cetin,** born 1977, studied mechanical engineering at the Technical University of Berlin, where he specialized in design technology. He joined Siemens in January 2008 and has been responsible for the water brake in the gas turbine test bed since 2010.

nitrogen 0.2 millimeters into the steel. In the test phase, the nitrided brake discs showed no corrosion or cavitation after 25% more hours of operation. "The discs looked almost the same as they did on the first day," says Cetin. The first series went into production at the beginning of 2017.

### We couldn't ask for more

Now, nine months later, Ayhan Cetin still has no cause for complaint. On the contrary. Recently, a gas turbine was tested at 50 hertz. The result: no cavitation, not even any corrosion. "However," says Cetin, "we have not yet reached the wear limit. I believe that in the future we can even aim to increase the lifespan of the wheel discs by two or three times, ideally even more." Cetin is also confident about the turbine currently in the test bed: "I do not anticipate any significant maintenance, or that the brake discs will need to be replaced." So, does this mean that everything ran smoothly with the collaboration between Siemens PG and Oerlikon? "We are able to save time and money, and to improve the performance of the test bay," says Cetin. "We couldn't ask for more."

**A German industrial monument**

The factory in the Moabit area of Berlin, in particular the gas turbine hall that was completed in 1909, is an internationally renowned monument of industrial architecture. The leading architect Peter Behrens was commissioned to give the building an aesthetic and unmistakable appearance without concealing its industrial significance. The result was one of clear elegance, despite the vastness of the building. It is also extremely rare for a factory building to have served its original purpose for over 100 years. The thousandth gas turbine was produced in 2016.

# THE FUTURE OF ADDITIVE MANUFACTURING

## THE STARTUP CHALLENGE REVEALS GREAT POTENTIAL FOR INNOVATION

Together with the Russian Skolkovo Foundation, Oerlikon initiated the first “AM Startup Challenge.” Its objective is to promote innovative ideas and technologies in the booming market of additive manufacturing (AM). In October 2017, the winners were selected from among 18 entries.

The “Digital Economy” was the focus of this year’s “Open Innovations Forum” in the Russian Skolkovo Innovation Center near Moscow. More than 18 000 participants from all over the world – business people, researchers, engineers and politicians – exchanged their ideas and perspectives on this occasion. AM is considered one of the pioneering technologies that are revolutionizing the future of industrial manufacturing.

Held concurrent with the forum, Oerlikon’s “AM Startup Challenge” provided young scientists and business people with a platform designed to promote the exchange of knowledge and to present innovative AM solutions.

The Skolkovo Foundation (Foundation for the Development of the Innograd Skolkovo) and Oerlikon view the competition as a decisive contribution to the development of their partnership and to the promotion of the AM market. They both have a clear objective: To bring together startups and leading international industrial enterprises in Skolkovo in the coming years. Thus, the Russian Innovation Center is to become an incubator for the development of new materials, technologies and applications in the area of additive manufacturing.

The winners of the “Skolkovo-Oerlikon Startup Challenge”. Shulunov Vyacheslav Rubinovich, Shvarts Dmitry Rihardovich, Mazalov Aleksey Borisovich. The first prize went to Shulunov Vyacheslav Rubinovich (3rd fm. left) for his contribution on “Roll Powder Sintering (RPS)” technology, a new type of 3D printing with which especially rotationally symmetrical parts can be manufactured more quickly than with familiar conventional methods.

# OFF INTO **SPACE**

## Delft students are aiming for a new altitude record with their rocket

**Delft Aerospace Rocket Engineering (DARE)** is one of the world’s most ambitious amateur rocket-building clubs. Based at the technical university in Delft, The Netherlands, its 130 members share a big dream: **to reach outer space.** Using materials and technologies from Oerlikon Metco, they have moved a significant step closer to their lofty goal.

Until 2016, the students from Delft held the European altitude record for a rocket built by students. That year, the record was snatched from them by the team at the University of Stuttgart, Germany. With the Stratos III, DARE’s largest project, they hope to bring the record back to The Netherlands – and build on the momentum generated by the Stratos I and Stratos II+ rockets’ success. A flight altitude of 32 300 meters will achieve this goal. However, the group working with Felix Lindemann, the Stratos III team leader, is aiming for a good deal more: “If everything works right, then our rocket will achieve a flight altitude of 60 to 80 km,” he explains.

**The engine as an influencing variable**
He notes that “a prognosis like this is always a bit risky.” That’s because flight altitude potential depends on quite a few considerations. The air density at the launch site and the wind conditions in the atmosphere are just two of the variables. Each has considerable influence but can be calculated with only limited accuracy.

What can be controlled by the rocket builders (and is therefore of decisive importance) is combustion time: how long the engine burns. It must generate the necessary thrust, and every tenth of a second of combustion time results in more meters in altitude. For this reason, the engine is being thoroughly tested during the development phase, Lindemann explains: “At the moment, we have achieved a combustion time of 15 seconds for the rocket engine. Our goal is to increase this to 28 seconds.” →

**Height comparison:**
The Stratos III is approximately 8 m long.


«Oerlikon supplied a highly temperature-resistant titanium alloy powder for the manufacturing of the nozzle outlet using the AM technology. ***To further reduce the thermal load, they coated the component with their proven thermal barrier coatings.»***

Part of the Stratos III team after the successful first test of the rocket engine.

**Hot nozzle**

However, a longer combustion time also means higher temperatures at the nozzle. The flame in the combustion chamber is about 3 000 K hot, or somewhat more than 2 700 degrees Celsius. At the outlet of the nozzle, the temperature is still about 2 000 K. “This temperature is influenced by the shape of the nozzle, which, in turn, is also a significant factor for the thrust,” says Felix Lindemann. “The nozzle must not become deformed under any circumstances, even when subject to such a high thermal load.”

In order to optimize the engine and the ignition sequence, test nozzles made of graphite are being manufactured first. This material provides sufficient thermal stability, but is too heavy for later use in the actual rocket. Consequently, Lindemann’s team is working with a hybrid structure for these components in which only the parts that are subject to the greatest thermal loading are made of graphite. However, the calculations are turning out to be a challenge: “It’s important to understand that we are working at the very limits of what is technically possible as to whether and how many components in the nozzle can be replaced – and whether this will prove worthwhile in the end,” he says.

**Material and technology from Oerlikon**

Oerlikon Metco is providing the young researchers with support in the development work. The company is supplying a highly temperature-resistant titanium alloy powder to DARE project corporate partner 3D Systems, which is building the nozzle outlet using the additive manufacturing process with laser melding. The demands for temperature stability would not be met by titanium alone: “In order to reduce the thermal load, Oerlikon Metco had the idea of additionally coating the component with yttrium-stabilized zirconium oxide at their Swiss location,” says Felix Lindemann. And he is pleased at the current status of the development work: “Two nozzles have already been tested and the results are very promising: At least the two last centimeters of the so-called ‘divergent section’, meaning the outermost part of the outlet, can be replaced with this material.”

**End spurt**

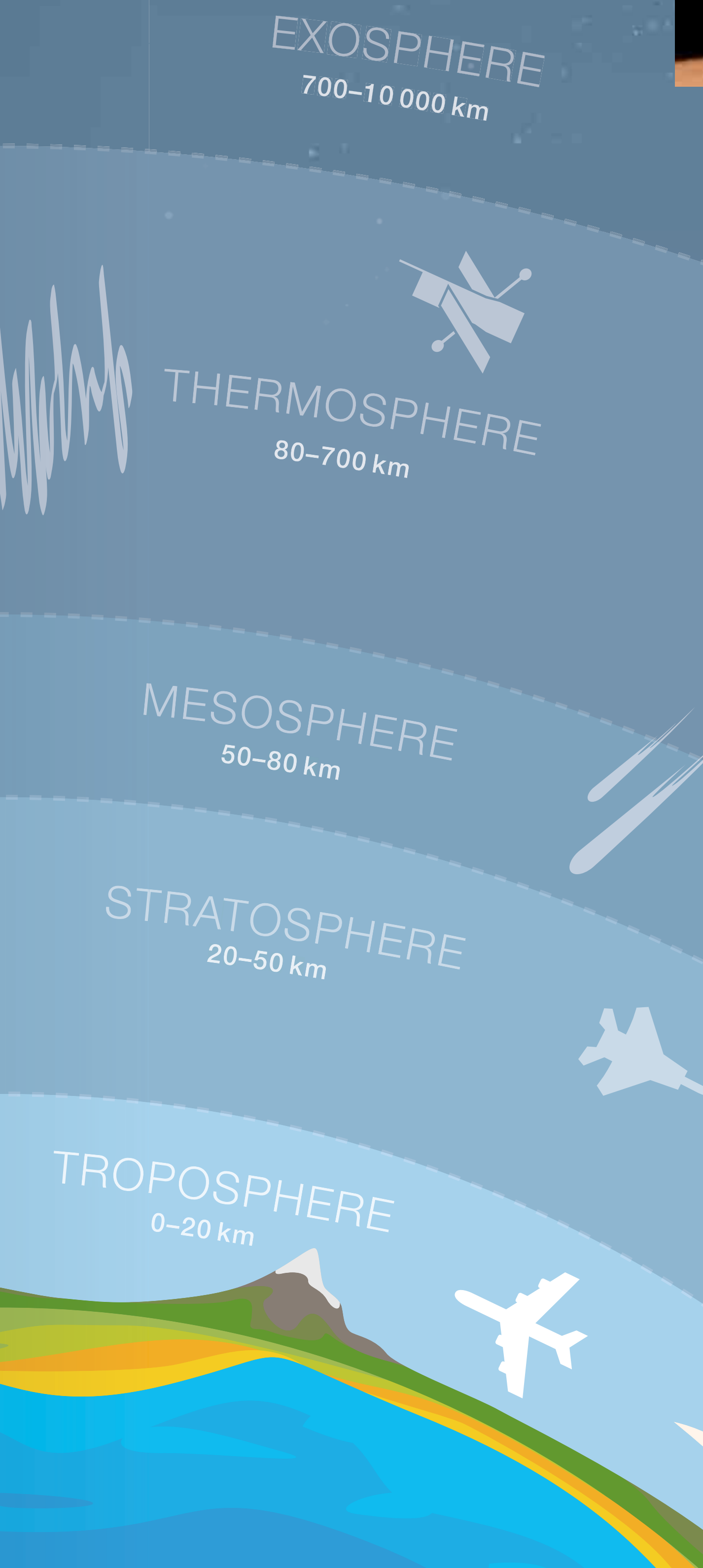
The rocket is not yet ready for launch. Many tests are still pending before the exact launch date can be determined. As things stand today, though, all should be ready by the early part of 2018. Until then, Lindemann says, the students have a good deal to do, as “70 hours per week and sometimes more is the standard for members of the core team.”

DARE is no “extra-curricular” activity. Semester breaks are being sacrificed and semesters on leave invested. But as an enthusiastic student member he says it is worthwhile: “We love what we are doing here. We have a great deal of freedom in the project and are able to develop and make decisions ourselves. That includes from the start to the finish – in fact, from the design of the individual components on to the testing.”

And what about the competition with the other student teams? “Oh, that shouldn’t be taken too seriously. We exchange information and now and then there are team members who worked in a team from a different country just as enthusiastically – as I did as well.” Felix Lindemann smiles slyly: “But we’ve made great progress in Delft. With the Stratos III we’re going to get the record back.”

# «We're going to ***get the record back.***»

**Material and technology from Oerlikon Metco:** Outlet of the Stratos III nozzle, additively manufactured with a titanium alloy powder and treated with a heat-protecting coating made of zirconium oxide.




**DARE and Stratos III**

Delft Aerospace Rocket Engineering (DARE) was founded in 2001 at the Delft University of Technology, the Netherlands, and today has about 130 student members. With numerous projects, DARE offers students the opportunity to gather practical experience in the development and the construction of rockets as of the first year of studies. Stratos III is the largest of the more than 100 rockets which have been launched into space since the founding of DARE.

**Thermal Barrier Coatings (TBC)**

Thermal Barrier Coatings (TBC) reduce the transfer of heat and isolate the substrate. The low thermal conductivity and the high thermal coefficients of expansion of Oerlikon Metco's coating solutions offer decided advantages: Longer service life of the components at the permissible, higher temperatures and a significantly improved degree of thermal efficiency.

Find out more about our materials, which have been developed specially for additive manufacturing and our coatings for highly effective thermal insulation:

**www.oerlikon.com/3dmaterials**
**www.oerlikon.com/thermalprotection**

## Opening of the

# ADDITIVE MANUFACTURING

## TECHNOLOGY AND INNOVATION CENTER


The 1st Munich Technology Conference marked the opening of the Oerlikon Additive Manufacturing Technology & Innovation Center in Munich on October 11, 2017. The Center allows Oerlikon's customers to see and experience first-hand the manufacturing of metal components using 3D printers along the process chain, from design to production and on to post processing. The Center leverages its partnership with the Technical University of Munich and its proximity to leading global industrial companies in the aerospace, automotive, power generation and medical devices sectors in the Munich region to drive research and innovation advances in additive manufacturing (AM). More than 50 AM engineers, specialists and technicians will be active in the center.

Florian Mauerer, Head of the Additive Manufacturing Business Unit at Oerlikon, stated: ***"In the ongoing industrialization of AM, we are focusing on the task of gathering all the important steps in the AM value-added chain under one roof to provide our customers with comprehensive, fully integrated AM services. The Munich Center uniquely connects the dots between our material science, component design, production and post processing capabilities."***



Oerlikon's Additive Manufacturing Technology and Innovation Center.


The ceremonial opening tape was cut by (from left to right) Dr Bernhard Schwab (Head of the Bavarian Ministry of Economic Affairs and Media, Energy and Technology), Dr Roland Fischer (CEO Oerlikon), Professor Dr Michael Süß (Chairman of the Board of Directors at Oerlikon) and Florian Mauerer (Head Business Unit Additive Manufacturing).


Additively manufactured heat sink.

Additively manufactured distributor housing.

## NEW U. S. SITE FOR
# AUTOMOTIVE CUSTOMERS

In order to facilitate increased growth, Oerlikon opened a new facility in Rock Hill, South Carolina. The site is designed specifically to cater to the needs of the automotive sector. Under the brand Oerlikon Balzers, the company offers product development and thin film coating services for automotive components. Surface technologies are used for automotive parts to increase their reliability, durability and performance.

With this new site, Oerlikon can serve automotive customers in South Carolina, such as Cummins, Pure Power Technologies, Bosch, Hitachi and Burgess Norton, right at their doorstep. The new plant complements Oerlikon Balzers' existing facility in Rock Hill, which opened in 1989 and focuses on serving the tooling business.

**www.oerlikon.com/balzers/us/en/markets/automotive-and-transportation**


Steve Ferdon, Director of Engineering Technology at Cummins, presents the award to Dr Jörg Jorzick, Head of New Acquisitions Automotive Solutions at Oerlikon Balzers, in Columbus.

# VALUED AS A PARTNER

Oerlikon Balzers has been honored with the "Category Partner Supplier Award" by Cummins Inc., which develops engines for special purpose vehicles. Heavy-duty trucks, mining vehicles, fire engines and industrial generators are subject to strict emissions and efficiency regulations. BALINIT coatings for sensitive components in diesel fuel injection systems and pumps make it possible to meet these requirements. The award commends the outstanding cooperation Cummins enjoys with Oerlikon and the know-how, experience and technical support the coating specialist provided during the market launch of a new component.


Top: The winning team of the first AM hackathon with Matt Donovan, Application Engineer at Oerlikon Additive Manufacturing.
Right: Additively manufactured medal for the winning team.

# #CREATIVEDISRUPTION

## THE OERLIKON AM HACKATHON SERIES STARTED

Take one real-world challenge: use metal additive manufacturing to design a lightweight compact wheel for the Mars rover that NASA plans to launch in 2020. Then add a few twists. First, the design must be completed in 24 hours. Second, it must be presented in the form of a CAD model. And finally, the teams competing for the winning design would be composed entirely of students.

That was the idea behind the first annual “hackathon”, an event launched by Oerlikon in partnership with North Carolina State University. Held October 20–21, 2017, this “hack marathon” attracted more than 40 students who participated on teams of three to four people. Equal parts innovation incubator and endurance race, the event culminated in the presentation of final designs to a panel of judges drawn from additive manufacturing industry professionals and academics. All the students came up with innovative design solutions, but the first prize was awarded to team MAM+ (which stands for Metal Additive Manufacturing+). The four students on the winning team were commended for the quality of their presentation and for developing a concept that was cost-efficient, put AM solutions at the forefront, used sound engineering and was durable.

The event was an opportunity for students to be part of the new industrial revolution sparked by additive manufacturing and to get hands-on experience using tools that are transforming the production of advanced components. At the same time, it was an opportunity for industry veterans to see how emerging talent will make use of – and add to the capabilities of – this industrial change.

# OERLIKON EXPANDS PRESENCE THE USA

## IN-HOUSE COATING CENTER OPENED IN OHIO

At the beginning of 2017, Oerlikon celebrated the inauguration of its fourth in-house coating center in the USA. The new center is located in Perrysburg, Ohio, at the IMCO Carbide Tool plant. Founded in 1977, IMCO is a prestigious manufacturer of high-performance cutting tools, such as drills, end mill cutters and reamers. The establishment of the in-house coating center reflects both companies’ long-term strategy of providing their customers with the best technologies and products. This step has strengthened Oerlikon Balzers’ presence in the Midwest region and impressively underscores its technological leadership in the area of high-quality PVD coating solutions.

In addition to in-house coating centers in Perrysburg and Dover, Ohio, as well as Alma and Tawas, Michigan, Oerlikon Balzers is represented at 13 further strategic locations in the USA for optimal proximity to customers. Nathan Olds, Oerlikon Balzers Regional Executive for the American Region, notes the further importance of these centers: “We are creating jobs and also always endeavor to have a positive influence on the quality of life in the geographical areas in which we are active. This is not only a plus for us as a company, but it also strengthens the relationships to our customers, employees and suppliers.”

Marc Desrayaud, Head Business Unit Balzers Industrial Solutions, and Perry Osburn, President of IMCO Carbide Tool, signing the contract.

# Expanding our expertise

Oerlikon expanded its portfolio with the addition of **promising technologies and expertise in the areas of advanced materials and surface solutions** through its fall 2017 acquisition of three companies and entered into a partnership with LENA Space.

**DiaPac** is an internationally recognized leader in the production of high-performance powered metals, wear resistant surface coatings and cemented carbides for use in oil and gas, mining, construction, agriculture and manufacturing operations.

**Diamond Recovery Services (DRS)** specializes in providing hard materials and environmentally complementary reclamation services.

**Primateria** is a provider of surface engineering services and specializes in pre- and post-treatment solutions for tool optimization. With the acquisition, Oerlikon is strengthening its foothold in the gear cutting tools market, especially in Sweden, and will be able to provide even greater know-how and a broader portfolio of surface treatments to its customers worldwide.

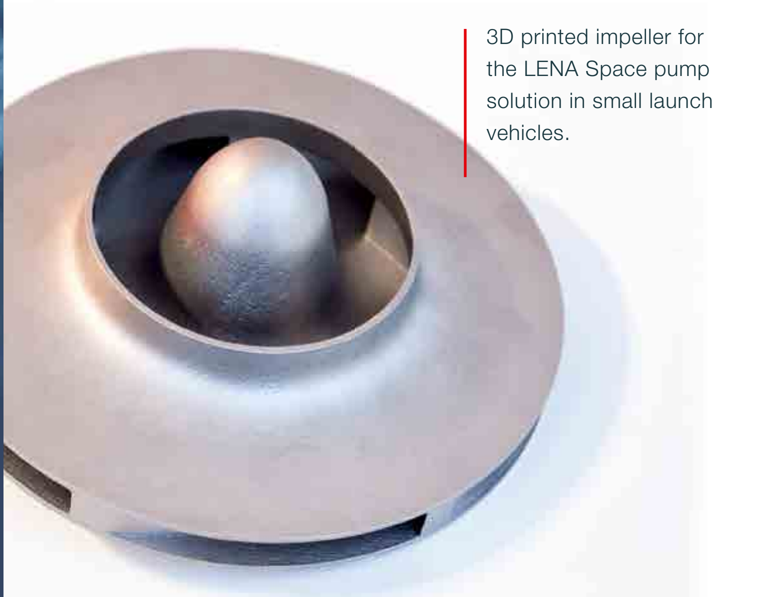
Dr Roland Fischer, CEO of the Oerlikon Group, said: "Because a clearly growing demand for surface technologies can be discerned in many of our end markets, we are expanding our range of technologies and services offered so as to adequately meet the needs of our customers both today and in the future."

**Advanced manufacturing for space launch technology**

Oerlikon has agreed a partnership with LENA Space, a disruptive propulsion startup in the UK, to develop optimized additively manufactured components for low earth orbit small launch vehicle propulsion systems.

LENA Space designs and develops turbines, impellers, pumps, combustion chambers, regenerative cooling systems and more. Collaborating with Oerlikon's additive manufacturing business provides an opportunity to unlock new designs with next generation materials to produce highly functional parts that offer breakthrough performance.

The partnership combines LENA's experience and vision for fast-to-market, high-performance, low-cost launch propulsion technology with Oerlikon's end-to-end value proposition in additive manufacturing to drive wider adoption of additive manufacturing in the space industry. Dan Johns, Global Head of R&D-Additive Manufacturing at Oerlikon, said: "This collaboration provides a fantastic opportunity to exploit four of Oerlikon's differentiating capabilities, including design for additive engineering, Rapid Alloy Development (RAD), additive process knowledge to create high quality, repeatable components, and our advanced coatings to expand the operational envelope."



3D printed impeller for the LENA Space pump solution in small launch vehicles.

# 2018 Trade show dates

Oerlikon will again be represented at the important surface solutions and additive manufacturing trade shows. We look forward to your visit!

## Europe

**16–18 Jan** **Euroguss**
Nuremberg, Germany

**7–8 Feb** **MNE 2018**
Kortrijk, Belgium

**27–28 Feb** **Intl. Engine Congress**
Baden-Baden, Germany

**14–15 Mar** **Plastics in Automotive Engineering 2018**
Mannheim, Germany

**14–17 Mar** **Grindtec**
Augsburg, Germany

**20–23 Mar** **Esef 2018**
Utrecht, The Netherlands

**25–27 Apr** **Turbine Forum**
Nice, France

**15–18 May** **Intertool**
Vienna, Austria

**5–6 June** **Cylinder Linings, Pistons, Connecting Rods**
Baden-Baden, Germany

**5–7 June** **automotive interiors EXPO2018**
Stuttgart, Germany

**5–7 June** **RapidTech**
Erfurt, Germany

**5–7 June** **Engine Expo**
Stuttgart Trade Fair, Germany

**11–15 June** **Eurosatory**
Paris, France

**12–15 June** **EPJH Trade Fair**
Geneva, Switzerland

## America

**27–28 Mar** **AeroDef**
Long Beach, CA, USA

**8–12 Apr** **AMUG**
St. Louis, MO, USA

**16–19 Apr** **Space Symposium**
Colorado Springs, CO, USA

**23–26 Apr** **RAPID**
Fort Worth, TX, USA

**7–11 May** **NPE Plastics Show**
Orlando, FL, USA

**12–14 June** **OMTEC**
Chicago, IL, USA

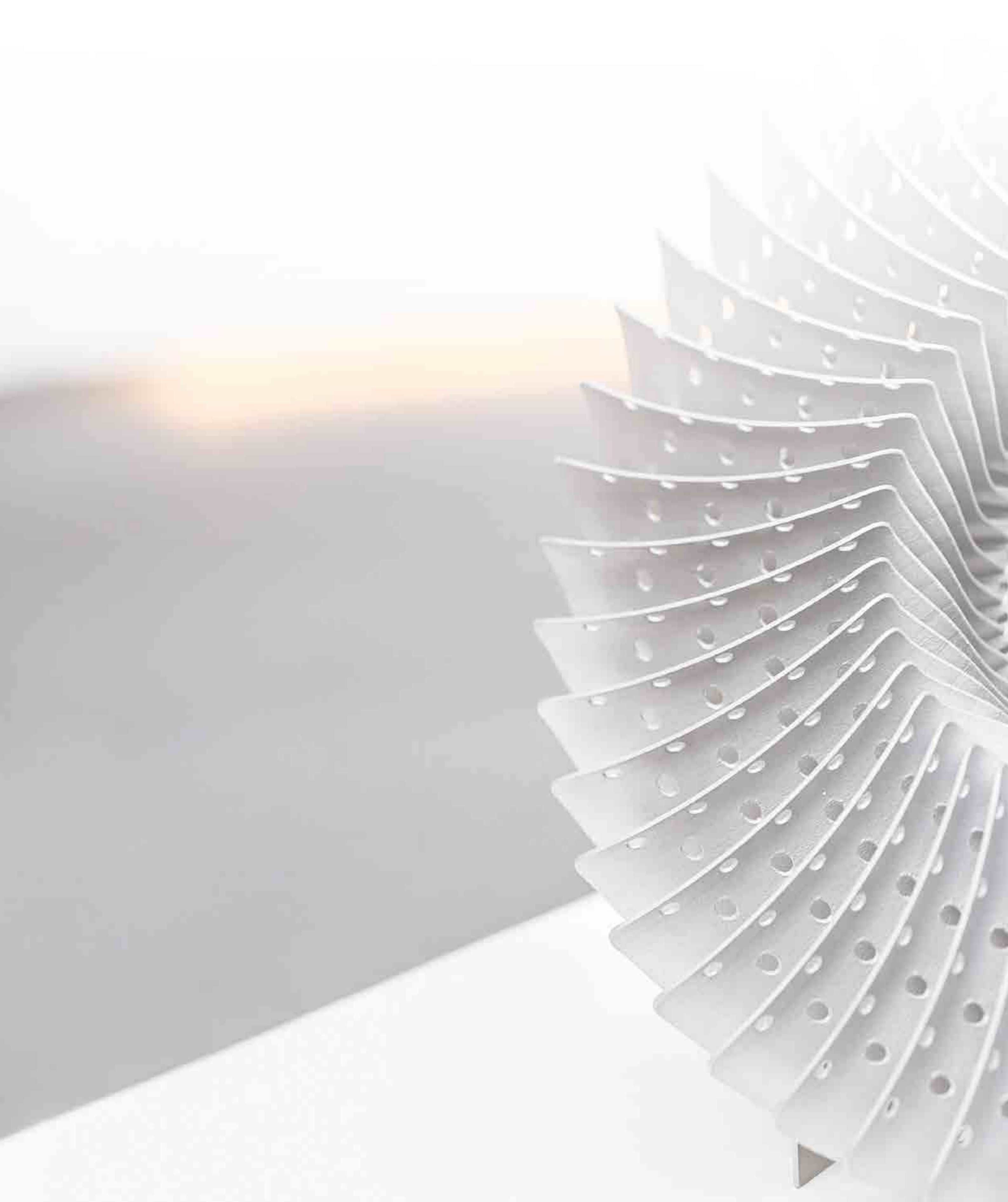
## Asia

**1–3 Mar** **TCT Asia**
Shanghai, China

**3–7 Apr** **SIMTOS 2018**
Ilsan (Seoul), Korea

**13–16 June** **INTERMOLD Nagoya 2018**
Nagoya, Japan

**20–22 June** **M-Tech**
Mechanical Components & Materials Technology Expo 2018
Tokyo, Japan



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