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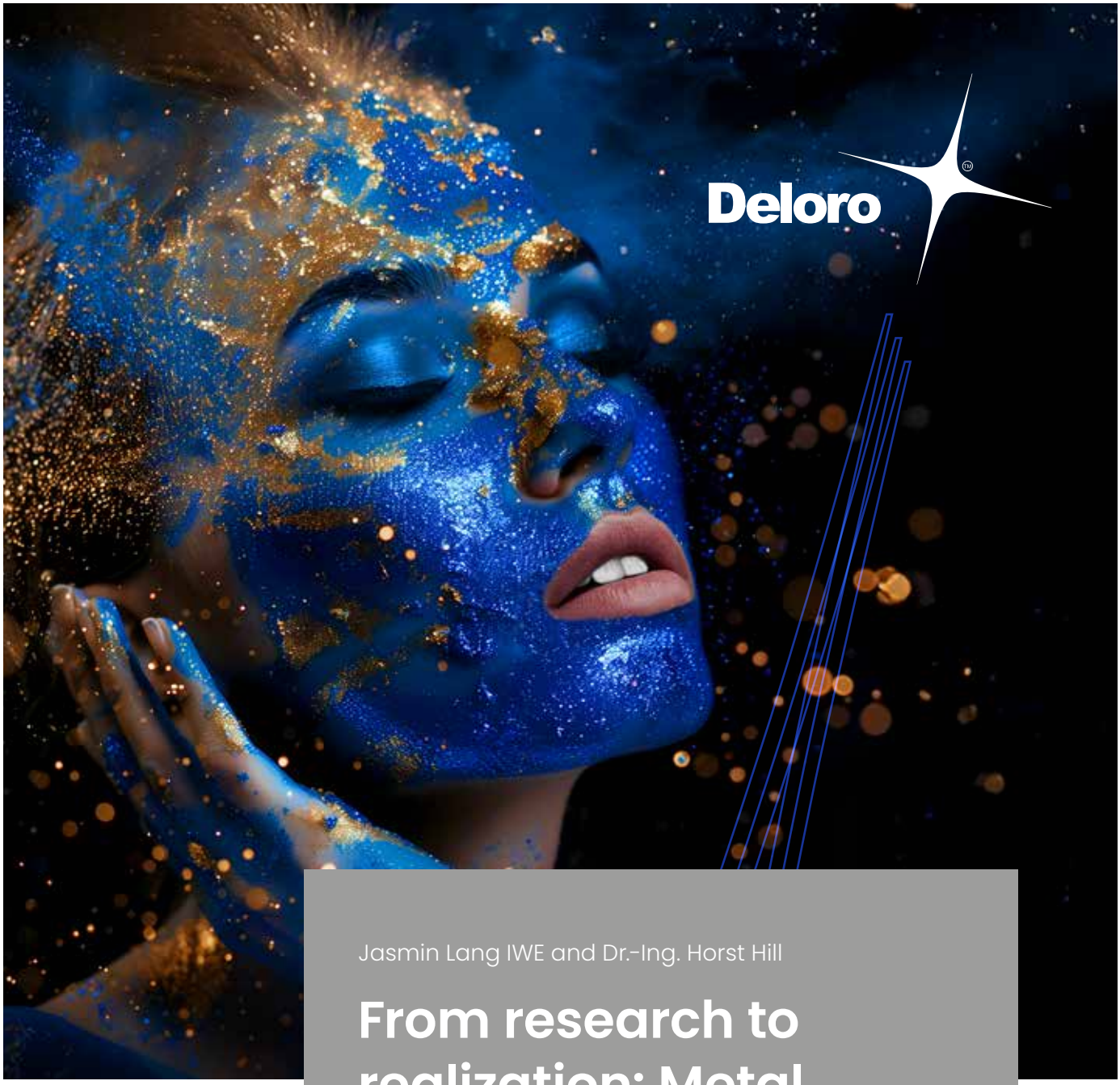


Jasmin Lang IWE and Dr.-Ing. Horst Hill

# From research to realization: Metal powders in industrial applications

Powder solutions at the nexus of research, manufacturing, and function.

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# Editorial

Dear Readers.

Whether 3D-printed implants, valves for energy generation or wear resistant components that must prove themselves under extreme conditions: Metal powders form the basis of modern metal manufacturing and are at the core of numerous important parts and components. They ensure wear and corrosion protection as well as longevity.

With the right partner, any idea can be realized. However, the perfect powder does not happen by chance. It requires experience, precision and in-depth understanding of material behavior, processes, and applications. At Deloro, we stand for thoughtfully designed and reasonable material solutions: from customized powder development and analysis to process support and consulting on standards and certifications.

Our 360° expertise and our own user experience establish us not just as a powder supplier, but as a strategic partner for all those who demand the highest performance and safety standards while driving innovation.

This white paper illustrates the quality criteria, testing methods, and technologies that make modern powder solutions reliable building blocks in industrial manufacturing. This is particularly evident in dental technology, where the importance of purity, particle morphology, and expert consultation for achieving a safe and durable final product is crucial.

We hope you enjoy the read.

**Dr.-Ing. Horst Hill**
Head of R&D Materials

**Jasmin Lang**
Director Welding Equipment, Materials and Marketing

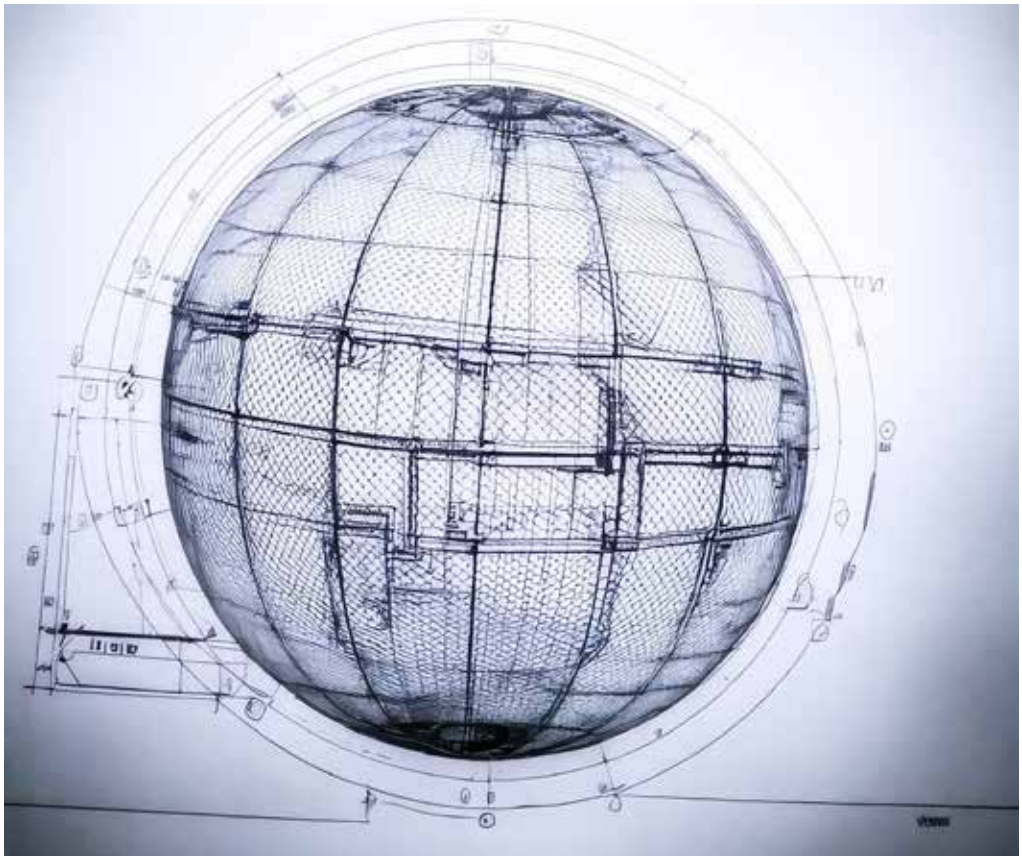
Deloro powder

# Powder enabling technological diversity

Powder materials are fine, mostly spherical metal particles that play a crucial role in modern manufacturing technologies. The reproducible properties of powder metallurgy processes and high material quality enable solutions for a wide variety of applications. Powder materials thus form the basis of numerous processes – from additive manufacturing and thermal spraying to plasma or laser cladding. The result is (custom) components with high strength, corrosion resistance, and temperature stability – properties that are indispensable in demanding fields such as medical and healthcare technology, aerospace, and energy production.

A broad spectrum of materials and in-depth metallurgical expertise are key to reliably serving this diverse range of applications – and this is where Deloro Wear Solutions comes in. As experts in metallic wear protection and powder solutions, we offer over 200 off-the-shelf alloys that meet a wide range of customer requirements out of the box. These proven cobalt-, nickel-, and iron-based alloys are ready for direct use in many applications, providing a fast, reliable solution without lengthy development phases.

For specific requirements, Deloro also develops customized powder materials that are precisely tailored to the distinct process conditions and performance requirements. This enables us to combine a broad, tried-and-tested powder portfolio for various applications with the know-how and capability to implement customized solutions for demanding applications. This development and manufacturing expertise is based on a clear commitment: to always develop and produce powder solutions that meet the highest quality standards, from alloy design to powder testing.



Deloro provides a comprehensive characterization of powder materials.

# Determinants of metallic powder quality

To achieve optimal results in welding and coating processes and powder metallurgical manufacturing processes, powders as base materials must fulfill certain key properties.

## Chemical composition and powder particle distribution

The chemical composition of a powder is fundamental to its suitability for subsequent use. Even with good processability, an alloy can fail if its composition does not meet the required specifications. Deviations from customer-defined requirements or – in the case of standardized materials – from the threshold values of relevant standards are considered „incorrect." For example, DIN EN ISO 22674 specifies maximum levels of 0.02% each for lead (Pb), cadmium (Cd), and beryllium (Be) in dental alloys.

Particle distribution is also essential: it influences the flowability as well as the bulk and tap density of the powder, which in turn determines its processability. In plasma powder deposition welding (PTA), for instance, particle sizes in the range of 50 to 150 micrometers are frequently used. A precise and, above all, reproducible particle distribution ensures that the powder can be melted uniformly throughout the process, as this is the only way to ensure a controlled feed to the nozzle.

## Morphology and process behavior

Besides chemical composition and particle distribution, density and particle shape also significantly influence the quality of metallic pow-

ders. These parameters determine how well a powder can be metered, conveyed, and melted in the respective process – for example, in additive manufacturing, thermal spraying or PTA welding.

Uniform particle shape and homogeneous powder density contribute significantly to stable feed rates and uniform energy input in the melting zone. Ideally, the particles exhibit a spherical morphology, as this promotes consistent flow properties and a reproducible bulk density.

At Deloro, this is achieved, among other methods, through gas atomization in a protective gas atmosphere – a process that ensures high particle sphericity, good flowability, and simultaneously low oxygen content.

Another important aspect is apparent density or tap density, i.e., how compact the powder is within a given volume – both loose and after mechanical compaction. These values are particularly important in sintering processes or hot isostatic pressing (HIP), as a higher density reduces material distortion and improves the mechanical properties of the components.

## Oxygen content

Another crucial factor for metallic powders is their oxygen content. Due to the large specific surface area of atomized particles, powders already exhibit significantly higher oxygen contents than comparable cast materials after production; in some cases, up to ten times higher. If the powder is processed under unsuitable conditions, such as lacking a sufficient protective gas atmosphere, the oxygen content can increase even further. This negatively impacts on the mechanical properties, as oxygen leads to the formation of hard oxides. These reduce the material's toughness and thus impair the result.

## Minor elements of the alloys

In addition to oxygen, minor elements such as phosphorus, sulfur and boron also play a role. They increase the tendency for hot cracking, thus complicating processing and potentially impairing material performance, leading to unwanted cracks during processing. Therefore, appropriate monitoring for contamination is essential throughout the complete process.

### Powders irregular by design?

Not all powders need to be perfectly spherical to deliver optimal results. For certain applications, Deloro also offers water-atomized powders whose irregular particle shape is deliberately used to adapt the processing properties to specific process requirements; for example, where higher surface contact or a modified melting characteristic is desired.

The Deloro laboratory offers a wide range of testing options in the field of metallurgy.

# Testing procedures to ensure powder quality

To reliably use powders in processes such as additive manufacturing, thermal spraying or cladding, several essential factors must be taken into account:

- ✓ **Chemical composition**
  The basis for generating the material's fundamental properties
- ✓ **Particle distribution**
  This influences processability and significantly impacts the required process energy.
- ✓ **Flowability and density**
  These determine how well the powder can be dosed and processed.
- ✓ **Oxygen content and other trace elements**
  These must remain below the limit values to avoid negatively affecting the material properties.

How can we ensure that all these factors remain constant, thus preserving quality? The answer lies in precise and comprehensive testing procedures implemented at every stage of powder manufacturing.

To reliably assess the physical quality of the powders, optical measurement methods or microscopic analyses are used. Special measuring devices record the shape and surface of the particles.

Potential interfering factors such as satellite attachments or irregular shapes, which can negatively affect flow properties and density, are thus reliably detected.

Deloro puts such a distinct quality concept into practice every day; relying on a multi-stage quality assurance system that covers every step, from raw material testing to final inspection of the powder batches. This quality concept involves documentation of the physical and the chemical properties of the powders – consistently rendered for every single batch.

Key methods include sieve analysis (also known as granulometric analysis), flow velocity determination using a Hall flow meter and bulk density analysis. This is complemented by optical particle distribution measurement, which enables a particularly detailed analysis of particle distribution and morphology. Especially with exceptionally fine powders, such as those required for additive manufacturing, measuring powder parameters is indispensable.

Quality assurance, however, does not begin with powder analysis, but rather with the selection and the supplier of the very raw materials. For critical applications in fields such as medical technology and aerospace, Deloro ensures the highest standards by sourcing ultra-pure cobalt and applying stringent incoming inspections to batches delivered. These standards apply to all primary forming processes at Deloro.

Another key component of all manufacturing processes is the analysis of the chemical composition.

Deloro's laboratory provides various analytical methods to precisely determine the chemical composition of its powders. Spark spectroscopy is commonly used at Deloro to identify the full spectrum of metallic elements and alloying components, while combustion analyses and hot gas extraction are specifically employed to measure lighter elements such as carbon, sulfur, oxygen, nitrogen, and hydrogen. This combination of carefully selected raw materials, continuous process monitoring, and precise final inspection ensures that every metal powder is not only process-ready but also perfectly suited to its specific application.

To ensure all the key factors for high-quality powders, Deloro manufactures its powders under tight control and within strictly defined specifications – both according to internal standards based on years of materials expertise and according to customer-specific requirements. Furthermore, international standards regulating chemical purity are applied. For certain applications, such as products with end-use in dental technology, standards like DIN EN ISO 22674 are pivotal, as they set clear limits for critical elements and thus ensure the highest material purity.

Compliance with these standards is a matter of course for Deloro – it forms the basis for **quality, safety, and trust.**

In medical products the need for quality, safety and trust comes together.

Deloro maintains very high quality standards which are continuously reviewed.

# Standards and certificates: Insights into the world of Deloro's quality assurance

Safety and quality are top priorities for powder materials – especially in sensitive application areas such as medical technology, aerospace, or nuclear technology. Here, not only product safety and legal requirements are crucial, but also compliance with international standards and certifications.

At Deloro, handling such standards is daily business: In addition to monitoring the chemical composition of the alloy itself, minor elements and oxygen content are also regularly tested. Certificates such as ISO 13485 for medical devices demonstrate compliance with the standards, being verified by regular audits. For safety-critical applications, such as in the nuclear sector, individual samples are also analyzed to unequivocally prove the mechanical properties and material quality of the final product.

Find relevant certificates at our website deloro.com

The following overview shows which specific standards and certifications applicable in this context.

## ISO 13485: For the highest standards in medical technology

ISO 13485 is the international standard for quality management systems for medical devices. It provides tools to ensure that products intended for medical application meet the highest demands.

## ISO 19443: Safety in nuclear technology

ISO 19443 is a standard that ensures suppliers of materials for the nuclear industry meet the relevant requirements. It builds upon the principles of ISO 9001 and supplements them with requirements essential for nuclear safety. The goal is to guarantee the quality and safety of products and services throughout the entire nuclear supply chain and to foster a strong safety culture. This certification is mandatory because, in nuclear technology, there can be no compromise when it comes to the quality of the materials used.

## The 3.1 certification: Trust seal for the customer

A 3.1 certification is an acceptance test certificate according to the European standard EN 10204. It certifies the chemical composition and mechanical properties of a material. This certification assures customers that the powder possesses the guaranteed properties and is suitable for its intended application. Particularly in highly regulated sectors such as medical technology or aerospace, it is indispensable that every powder material is delivered with the correct properties – and this is verified by the 3.1 certification.

## Welding certificates according to the 3834 standard: When powder becomes components

It is not just the powder itself that needs to be certified. The process by which the powder is further processed is also subject to specific standards. One example is standard 3834 for welding technology. When metal powder is used in welding, the welding process itself must meet the highest quality requirements. This certification ensures that the powders used for welding applications do not compromise on quality during processing.

# Powders in action: Added value industrial applications

Besides off-the-shelf powder solutions, Deloro develops and supplies customized powder solutions used in a wide variety of industries to protect against wear and in diverse applications. Whether in medical application, energy generation, or valve manufacturing, users benefit from powders that meet the highest standards of purity, particle distribution, and process reliability.

A key advantage for Deloro's customers lies in the combination of experience, diversity, and flexibility. Where standard solutions reach their limits, Deloro's experts develop customized powders and alloys precisely tailored to process conditions, material properties, and – last but not least – application scenarios.

This added value is particularly evident in additive manufacturing, which plays an increasingly significant role when it comes to powdered materials opening up completely new possibilities for complex challenges: from rapid prototype manufacturing to mass production of complex components.

## Integration of powder technologies into additive manufacturing

Powder materials play a vital role in additive manufacturing, as they form the basis for the entire manufacturing process. In processes such as laser powder bed fusion (LPBF) or electron beam melting (EBM), the finest metal or alloy powders are melted and built up – layer by layer – to create complex components with high precision, delicate structures

and – yet – strength. Since particle size, morphology, flowability, and bulk density have a decisive influence on print quality and process stability, these parameters are specifically adapted for each application.

For example, the LPBF process uses powders with particle sizes of 10–30 µm or 15–45 µm, while the EBM process requires coarser fractions up to 150 µm. The chemical composition is also specifically tailored to the process. In LPBF, for instance, rapid heating and cooling cycles can lead to thermal stresses—with the risk of cracking. By specifically adjusting the carbon content, the hardness can be reduced, processing facilitated, and a fine-grained, solid microstructure maintained.

## Thinking ahead: Consulting as part of the product

Providing metallic powders alone is not enough. Not every challenge can be solved with a standard product. The correct combination of material, process, and expertise is always essential. Deloro, therefore, sees itself not only as a manufacturer of powders but as a strategic development partner for its customers.

With over 115 years of expertise in materials and material design, in-house application experience, and a deep-rooted knowledge of industrial processes, the company supports projects from material selection and alloy development to the process-specific adaptation of the powder.

Consulting on a project

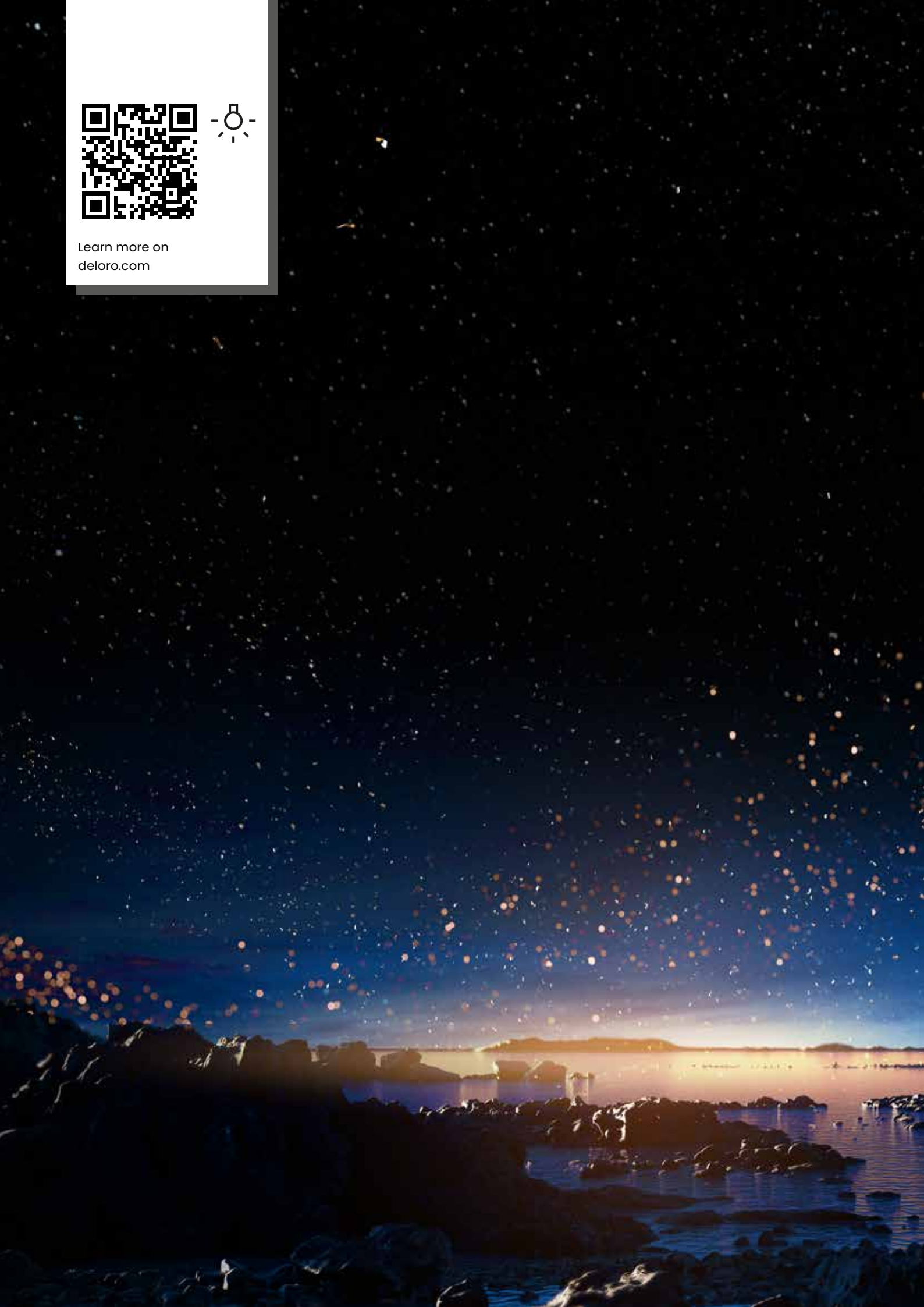
The result is solution-oriented powder materials that not only meet the highest technical requirements but also make the entire manufacturing process safer, more efficient, and more sustainable.

# Research & development: Powder for tomorrow's requirements

The demands imposed on modern materials are constantly increasing. Components are expected to be lighter, more efficient, and more durable. At the same time working conditions are becoming more and more challenging. Metal powders play a key role in the ongoing technological transformation: Powders that form the basis for technologies that are fundamentally changing industrial manufacturing – from additive manufacturing, PTA, and laser cladding to thermal spraying.

In order to keep pace with these developments, continuous research and development are essential when it comes to materials. This allows powders to be precisely tailored to specific applications, processes, and environments, thus creating technical and economically sound solutions. This is how Deloro paves the way for innovative technologies. For 115 years.

Director of R'n'D Jörn Stermsek is checking a sample.



Learn more on
deloro.com

# Research focus areas in powder technology

## New alloys and material systems

In addition to new Co- and Ni-based materials, the portfolio is also being expanded to include Fe-based materials. Another focus area is optimizing materials specifically for hydrogen or ammonia environments.

## Process and material-based optimization

Frequent analysis is conducted to determine how powder changes during use in the Additive Manufacturing process. Also powder analyzed during repeated use and how this affects the final product.

## Powder manufacturing and characterization

Technical advances in gas atomization, particle fractionation, and optical and chemical analysis help to develop even more specific powders for complex applications.

The demands imposed on modern materials are constantly increasing. Components are expected to be lighter, more efficient, and more durable. At the same time working conditions are becoming more and more challenging. Metal powders play a key role in the ongoing technological transformation: Powders that form the basis for technologies that are fundamentally changing industrial manufacturing – from additive manufacturing, PTA, and laser cladding to thermal spraying.

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## Deloro's constant contribution to powder research

Deloro is actively driving innovation in powder metallurgy. One example is the development of iron-based alloys with 15% vanadium which are specifically optimized for PTA and laser welding. Furthermore, the so-called TriboDel powders* have been used to design materials for use in motors and pumps under hydrogen or ammonia atmospheres.

Such developments show how closely materials science, materials development, and application engineering are connected today. Powders are no longer considered mere raw materials, but rather strategic drivers of innovation. They allow for customized solutions, shorten development cycles, and expand the boundaries of what is technically feasible – from highly stressed turbine components to individualized dentures.

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# *TriboDel Pro: Powder metallurgical solution for demanding applications

The TriboDel Pro alloy, newly developed by Deloro, is an example of current developments in the field of powder metallurgical materials.

It is based on Tribaloy® technology and was designed using the High-Entropy Alloys (HEA) principle – a class of materials in which several elements are combined in equal proportions to specifically influence the mechanical and chemical properties.

TriboDel Pro is characterized by its high wear and corrosion resistance as well as its good temperature stability. In an initial application involving the manufacture of valve seat rings for biogas engines, the formation of stable oxide layers at temperatures up to 1,000 °C significantly enhanced component durability and extended maintenance intervals.

Designed for use under extreme thermal and chemical conditions, the material is also suitable for future applications, such as hydrogen or ammonia engines.

This development shows how targeted material modification via powder metallurgy processes can contribute to adapting to changing industrial requirements – especially in areas where conventional materials reach their limits.

More information, data and figures: deloro.com/tribodelpro

Heavy Duty Engine in the field of biogas energy production

## Adapting to future raw material markets

Considering the dynamic developments in the raw materials markets, research, and development department at Deloro, for example, is also focusing on adapting to future mercantile challenges. The objective is to enhance our ability to respond more flexibly to variations in raw material availability in the short and medium term without compromising application results. These efforts aim to consistently develop the best possible powder solutions that meet our customers' requirements, even in volatile markets.

A key component of this strategy is the integration of sustainable principles into research and manufacturing. This includes recycling scrap metal or optimizing production parameters. Powders that do not conform to the required specifications are reused - where technically feasible - instead of being discarded.

Also the ethically sourcing critical raw materials such as cobalt is vital for the Deloro Group.

Deloro, therefore, understands sustainability not as an add-on, but as an integral part of its growth and development strategy. And even more so: as an **attitude**. All this with the aim of conserving resources while providing technologically leading (powder) solutions.

Deloro's Code of Business and Ethics

# Conclusion: Metallic powders – more than just materials

Metallic powders have become a strategic material in modern manufacturing. They play a vital role in additive manufacturing, welding, and coating processes, as the demands on quality, purity, morphology, and process stability are constantly increasing.

But what exactly makes powder now a „good powder“? It is not just that its chemical composition and particle morphology are optimized; it also guarantees reliable performance and process stability throughout the entire manufacturing cycle.

Good powders are tailor-made solutions precisely aligned with the specific requirements of the application and manufacturing process, delivering exactly the desired results. They are characterized by high purity, uniform particle sizes, and minimal impurities – factors that ensure the mechanical properties, biocompatibility, and long-term stability of the final product.

But good powders are more than just technically flawless. They are more than the sumof strategy, research, and partnership with the customer, especially with regard to sustainable practices and ethical sourcing of raw materials.

Deloro delivers more than just powders – we deliver the technological foundations for the technologies of tomorrow. With over 115 years of experience, we understand powders as strategic materials that pave the way for future applications.

**Questions? Get in touch with us. We will be happy to help.**

**Email:** info@deloro.com

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**Linked.in:**
deloro-wear-solutions-gmbh

Helping patients worldwide: Deloro materials for dental use.

# Metal powders in medical applications

## The backbone of durable dental solutions: Biocompatible Metal Powders

Whether it is a crown, a bridge, or an inlay, patients expect their dentures to be not just functional, but one that lasts a long time, fits perfectly in the mouth, and does not cause any adverse reactions. One thing matters: the quality of the material used. Dental prostheses must not only be strong and precise, but also biocompatible and corrosion resistant.

Metal powders play a vital role in this context. Their quality is a decisive factor in dental technology for the manufacturing of safe and durable dental prostheses. For the manufacture of dental prostheses, the chemical composition and powder properties must be precisely tailored to the application requirements, and the quality assurance process must meet medical standards.

Deloro supplies the necessary base materials, which are not only corrosion-resistant but also biocompatible, making them an ideal choice for use in the human body.

In close collaboration with dental manufacturers and medical experts, Deloro continuously develops and refines its powder technologies to meet evolving industry standards, regulation and patient needs.

> *„We manufacture cobalt-based materials, for example as pre-material for the dental industry. In addition to metal powders for additive manufacturing, we offer these materials in various other product forms, primarily as solids such as discs or ingots. These provide ideal conditions for our customers to achieve CE-compliance for their very product."*
>
> ***Jasmin Lang***
> *Director of Welding Solutions at Deloro*

## Strict quality requirements and certifications

Since the medical technology sector places extremely high demands on material quality, providing an ISO 13485 certification is a fundamental requirement for the manufacturing and delivery of powders. This certification ensures that Deloro's quality management system also reliably meets the demanding requirements of this industry.

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## Fine particles and powerful performance: Powder morphology in the field of medical application

For products intended to be used in medical applications, powder morphology plays a crucial role when it comes to 3D-printed products. Particle distribution and shape are particularly important – spherical particles offer the best flow properties and can be uniformly integrated into the printing process. They guarantee consistent bulk density and flow characteristics, which is essential for the powder‘s processability.

In practice, however, irregular particles or so-called satellite particles often occur, impairing these properties. Such deviations negatively affect the quality of the final product. To prevent this, Deloro monitors powder morphology using state-of-the-art measurement methods.

A CamSizer, for example visually captures each particle and delivers precise measurements, enabling seamless quality control across numerous batches. In addition to morphology, the chemical composition of the powder melt is mandatory. The purity of the material guarantees that the mechanical properties, biocompatibility, and stability of the dental prosthesis remain unaffected for years.

Quality and reliability are indispensable in this field of application.

## Future prospects of materials in dental application

The development of powder solutions for dental technology remains a dynamic and constantly evolving process. With the ongoing advancement of additive manufacturing and the growing demand for customized dental prostheses, the importance of high-quality powder solutions will continue to increase.

Continuous research and collaboration with customers are at the center of Deloro‘s corporate strategy, ensuring that its products not only meet current standards but are also future proof.

Deloro
Wear Solutions

**Discover the new Deloro**

**Product Materials Finder online:**

**https://www.deloro.com/productfinder**