

Overcoming Boundaries
High Tech Materials
for Aviation and Aerospace

Materials | Development | Solutions





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Aviation and Aerospace – Higher, Faster, Farther

The aerospace and aviation market is at the forefront of advanced technology. No other group so impressively utilizes the comprehensive resources and full portfolio of advanced materials to meet demanding and expanding needs. H.C. Starcks high tech materials are indispensable for alloys used for jet engines, harsh coating environments and extreme temperature applications, both high and low. They are fundamental for high performance electronic components, vital in the production of robust precision tools and essential in density sensitive applications.

Innovative and Reliable: A Partner of the Industry

Our material and processing know how not only delivers pioneering and economic solutions for here and now, but additionally also helps to shape the future. This is highlighted by our constant innovations, ranging from significant improvements to completely new materials. Consequently, we are a reliable worldwide partner of the aviation and aerospace industries. With round about 3,200 experienced staff members at 13 production plants and strategically located sales offices in all high tech markets, H.C. Starck is truly a global player – always close to its customers and markets.



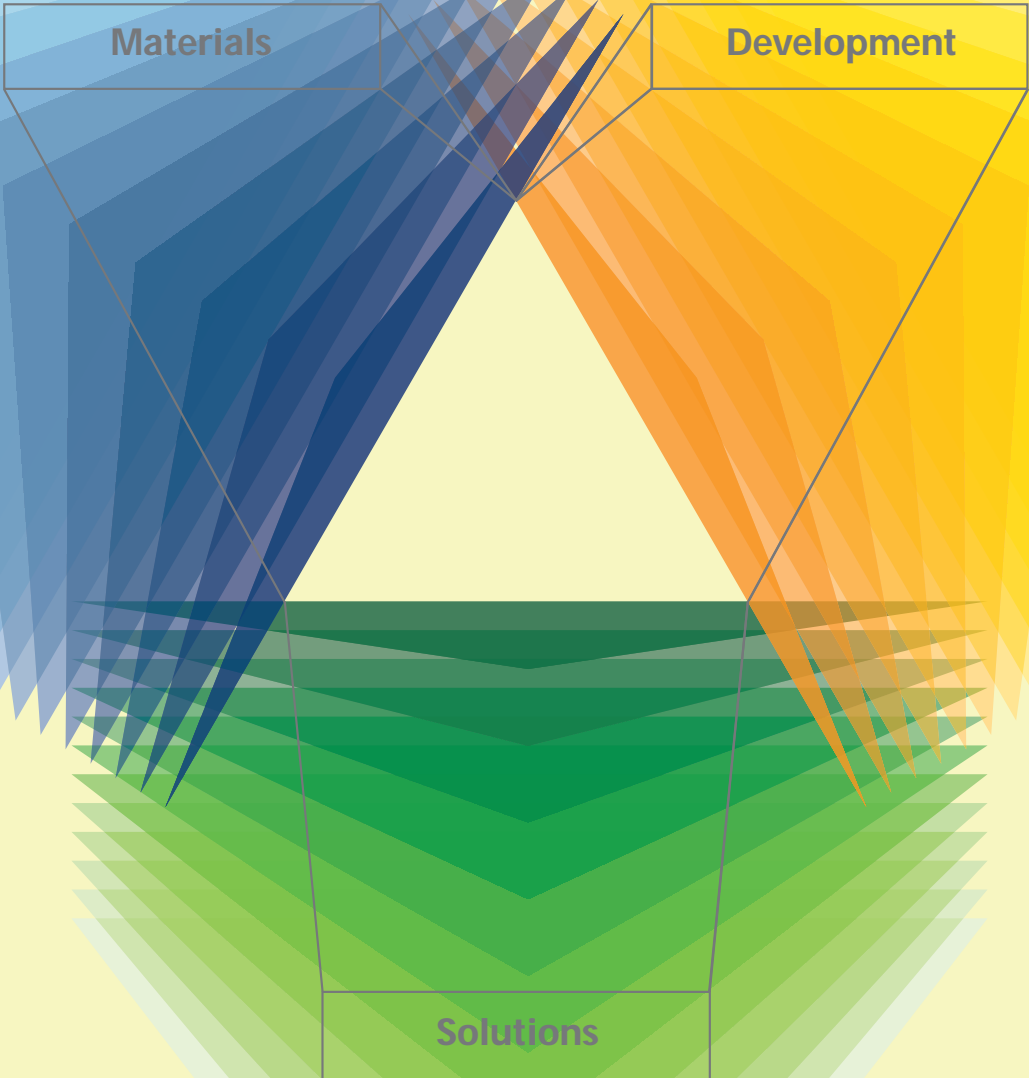
The Unique Integration at H.C. Starck

Three groups of materials represent our core products:

- Refractory metals, tungsten, molybdenum, tantalum, niobium, rhenium and their alloys.
- Ceramic materials
- Electronic chemicals and functional materials, such as conductive polymers

No single group stands in isolation. They often complement one another and make a valuable contribution to the aviation and aerospace industries and their suppliers. The product range where H.C. Starck materials are employed stretches from tools and components used in production operations, through mechanical and electronic elements for safe and secure operation right up to repairs in outer space – from high tech materials right up to individual solutions. Materials, Development, Solutions – this triangle describes the strength of our competence.

- > **Materials: precise and reliable in terms of quality and quantity, we offer a unique range of high quality intermediates and semifinished products.**
- > **Development: continual investments in R&D pave the way for new products, applications and technologies.**
- > **Solutions: flexible and customer focused specifications, we offer individual, customized solutions for special requirements.**



Aviation: Equipped for Extreme Challenges

Reliable and durable: aviation places the highest demands on man and materials.

Planes and helicopters embody examples of extreme performance made possible by modern technology. Aircraft must be extremely safe and function without complications even under very tough conditions.

Materials and know how from H.C. Starck ensure that everything works perfectly where it matters.



Robust and Durable: Engines

Turbine blades in modern engines experience extreme mechanical and thermal stress. They consist of superalloys made of tungsten, molybdenum, tantalum, niobium, and rhenium supplied by H.C. Starck. In addition, **AMPERIT®** powders from H.C. Starck for thermal spray applications enable higher performance and an extended service life.

Customers who choose to apply thick thermal insulation layers in order to run the turbines in a safe manner while extending service cycles, use yttrium-stabilized zirconium from H.C. Starck. Additional running in layers prevent performance diminishing backflow – a technology that is continuously improved and consequently will reduce specific fuel consumption.

The production of important engine parts – blades, disks and hubs – by isothermal forging and diffusion bonding requires robust molding tools. H.C. Starck supplies large quantities of molybdenum alloys for the manufacture of these tools.

500 Times Around the World Until the First Service?



The operation of modern aircraft engines requires maximum cost efficiency: only after 20,000 to 30,000 flying hours do they need to be serviced for the first time. At an average speed of 700 km/h, this corresponds to some 500 circumnavigations of the globe. Such performance is only possible at very high temperatures due to turbine blades made of superalloys and wear resistant turbine bearings and axles where high tech materials from H.C. Starck play a crucial role. Consequently, passengers can feel 100 per cent safe at all times.

Balance and Safety: Aircrafts and Helicopters

Lightweight design is a true triumph in aviation – nevertheless, one of the heaviest metals in existence is indeed used in this field: on account of the high density and very high strength of tungsten, its alloys are used in large quantities in aviation and aerospace. They serve as counterbalance weights and vibration protection parts for hydraulically controlled landing flaps and components and for counterbalancing helicopter rotor blades and airfoils. H.C. Starck produces these parts by compacting and sintering the powders followed by machining in accordance with requirements and quality standards of aviation and aerospace customers worldwide.



Against All Laws of Gravity?



Weight is just like most things in life – the right amount at the right place results in the perfect solution. The situation in aviation is not different. It is true that the maxim “the lighter, the better” applies in this case. However, the optimum control and stability of moving parts also requires high density materials in extremely small and crucial areas. This is why tungsten alloys are utilized in the construction of aircraft and helicopters. Counterbalance weights are used on ailerons and horizontal stabilizers in aircraft wing structures and in the precision balancing of helicopter rotor blades.

Aerospace: Tried and Tested in Outer Space

Use in outer space is seen as a mark of prestige for every material. What is employed in this environment – whether in the drive system, in the on board electronics or in the outer membrane – also sets standards elsewhere.

Discovery Tested: Ceramics

H.C. Starck's expertise in ceramics has proven itself in outer space. Our ceramic materials zirconium boride, yttrium oxide and silicon carbide for aerospace were successfully tested during the Discovery mission in August 2005: they are the base material of the repair kit for repairing the ceramic tiles in the spacecraft's heat shield. Another repair kit used the molybdenum alloy TZM for the fastening bolt to attach the carbon-carbon heat shields.

Perfect example of advanced technology: nothing is left to chance on space missions.



Picture: ESA

- > **Ultrasonic test of ceramic spheres for NASA.** Spheres made of ceramic material are used for the ball bearings in the main engines of a space shuttle. They undergo stringent quality control before installation. NASA puts its trust in H.C. Starck's ultrasonic testing technology which was specially developed for ball bearings.

What Remains in Shape Even at 1400° Celsius?



Extreme conditions prevail in outer space. Anyone in this environment must be protected against both extremely low and very high temperatures – from absolute zero to far in excess of 1000° Celsius. Temperature resistant and at the same time particularly light and wear resistant – these are properties that only ceramic materials provide in this combination. H.C. Starck is not only developer and producer of such customized materials, but an important partner for the aerospace industry – our testing know how for important components is also much in demand.

Electronics: Efficient and Essential

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Modern aviation and aerospace are inconceivable without modern electronics – again H.C. Starck helps the industry to set new standards.

Essential: Electronics and Communication

Electronic components, such as capacitors, chips and displays, must function reliably, quickly and efficiently in aviation and aerospace. Important required materials – e.g. innovative tantalum and niobium powders for capacitors – are supplied by H.C. Starck. Typical properties of the tantalum capacitors are: high temperature stability, great reliability and long life. Our unique powder technology, combined with the conductive polymer **CLEVIOS™**, creates new prospects for even smaller and more efficient units.



Tantalum capacitors

The vapor deposition of electronic components with ultrathin metal layers (sputtering) is an important technology, used, for example, during production of speedy microchips and modern displays. In this case, H.C. Starck supplies a wide range of specially developed materials made of tantalum, molybdenum, niobium and tungsten as well as special ceramics that are used in the production of sputtering targets. The benefits lie in the tightly controlled purity and density and in the exactly defined microstructure.

Molybdenum, tungsten and ceramic materials from H.C. Starck also ensure optimum heat management, a long life and ideal operational behavior of the electronic components.

Materials and components from H.C. Starck were, for example, used on missions to both the moon and Mars.

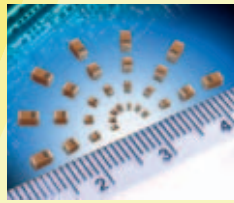
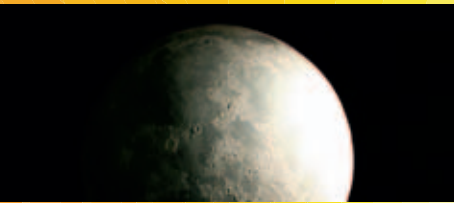
Would my Cell Phone Work on Mars?



Well, the electronics would not be a problem: as early as the seventies, the American space agency NASA, later followed by ESA, successfully used capacitors made of tantalum powder from H.C. Starck. Terms such as cell phone and laptop did not even exist at that time. In the meantime, our tantalum metal powders and also niobium oxide have been part of many missions into outer space – on board of space stations and on Mars missions, they ensured that the optical systems, the control and communications units and other important components functioned perfectly under extreme conditions. Again in this respect, aerospace is setting standards – together with H.C. Starck.

The Future Is a Question of Materials

Safe and cost effective development of ever new possibilities requires innovative materials and technologies. As high tech sectors par excellence, aviation and aerospace are both users and promoters of such materials.



Aircraft designs using “fly by wire” systems, i.e. all of the pilot’s control operations are processed by computer and forwarded to the control units, placing extremely high demands on the reliability of both digital and analog electronic systems. H.C. Starck has made a contribution in the form of new tantalum powders with nanoscale primary particles which enable ever smaller capacitors with electric storage capacities far in excess of current values. Nanostructured niobium and niobium oxide powders provide the required basis.

A new quality of ergonomics, design and in flight entertainment will be enabled by the conductive polymer **CLEVIOS™**: as the key component of brilliant displays and large screen light foils.



New Technology Fields – New Solutions

Sensor and actuator engineering will become increasingly more important: ranging from pressure, ultrasound and distance sensors to acceleration sensors and actuators for damping oscillation, e.g. on elevators and vertical rudders. H.C. Starck supplies intermediates for the required piezoceramics.

The trend towards higher performance turbine engines also requires innovative heat insulation layers and super alloys with components from H.C. Starck. At the same time, innovative processes are helping to make the cost intensive maintenance of aircraft more efficient. For example, H.C. Starck is developing a new type of repair foil for the compressor blades. The aim is that engines need no longer be removed completely for repair, resulting in a considerable saving of downtime.

Recycling, particularly of materials containing rhenium, e.g. made of super alloys, and of spray powders, is reaching strategic significance. H.C. Starck is creating a corresponding technology which will help industry to cut costs and to become less dependent on primary raw materials.

Research and Development with Prestigious Partners

Our close cooperation with renowned universities and research institutions as well as our analysis and laboratory facilities worldwide are an indispensable integral component of our research and development – everything and everyone focused on one goal:

Empowering High Tech Materials!

H.C. Starck GmbH

Im Schleeke 78–91
38642 Goslar
Germany

T + 49 5321 751-0
F + 49 5321 751-6192

info@hcstarck.com
www.hcstarck.com

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North America

H.C. Starck Inc.
Newton Office
Newton, MA 02461-1951
USA
T +1 617 630-5800
F +1 617 630-5879

Asia

H.C. Starck Ltd.
Hamamatsucho Square 9 F
1-30-5 Hamamatsucho, Minato-ku
Tokyo 105-0013
Japan
T +81 3 5776-5001
F +81 3 5402-0072