KYOCERA

SENSOR & MEASURING TECHNOLOGY

High-performance ceramics

HIGH-PERFORMANCE CERAMICS

Our customers expect precise, repeatable measuring results for sensor and measurement applications. Components made of high-performance ceramics provide long-term protection for sensitive sensors, even under the most demanding conditions.

EXTREMELY STABLE

The application area for ceramics in sensor and measuring technology starts when other materials, such as plastic or glass, have reached their limits. Components in high-performance ceramics are extremely resistant to heat, corrosion, high voltage and chemical impacts. They are also extremely resistant to deformation and wear, and retain their functionality over a longer period of time.

PRECISE AND RELIABLE

The components in high-performance ceramics are characterised by the following properties

- optical properties
- microwave properties
- oxygen conductivity
- metal coating
- small dimensions
- FDA approval
- magnetic properties
- dielectric properties

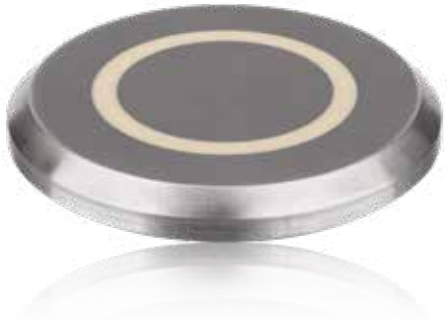
Together with our customers we develop ceramic-to-metal compounds which permanently protect sensors – even under extreme demands.

HUMIDITY AND PRESSURE MEASUREMENT

Sensors and measuring cells made of high-performance ceramics meet the most stringent requirements because of their high resistance to temperature changes and corrosion even under extreme conditions.

Source: ACO Automation Components Johannes Mergl e.K.

Individual solutions for customised applications.



Humidity sensor made of F99.7

Pressure sensor made of F99.7 for the aerospace industry

HUMIDITY SENSORS

Humidity sensors made of aluminium oxide F99.7, DEGUSSIT AL23 hf or zirconium stabilised aluminium oxide FZT are used in a wide range of areas: in crude oil conveyor units to measure water content, in mixers and on cement works conveyors, and also in food processing.

The determination of the capacity in the high frequency field is a physical principle. Due to its optical properties, with the material DEGUSSIT AL23 hf, microwaves can be focussed more precisely than with other materials, such as glass or plastic. In this way, smaller component measurements can be carried out. Other application areas are the analysis of materials and filling level measurements, where the ceramic component is used as a window or antenna. The back of the sensors is given a conductive coating to which the electronics are then connected.

PRESSURE SENSORS

Measurement cells made of aluminium oxide F99.7 for pressure sensors and pressure transducers are used in temperature ranges from -50 °C to +150 °C and at pressures of up to several 100 bar. The membranes can be produced with a thickness of 0.2 mm and diameters of up to 80 mm. Glass or active soldering is applied as joining technology for the ceramic parts.

Materials for the electrodes are selected in accordance with customer requirements. Measurement cells are used in the chemical, food processing, pharmaceutical and petrochemical industries as well as in aerospace technology.

OXYGEN AND TEMPERATURE MEASUREMENT

With their excellent material properties, components made of high-performance ceramics have established themselves globally in sensor and measuring technology. Temperature and oxygen measurements are further examples.

Source: Keramischer OFENBAU GmbH

High resistance to deformation and reliability at high temperatures.

Oxygen probes made of DEGUSSIT FZY are characterised by quick response times with constant measuring signals and high ion conductivity.

Thermocouples made of DEGUSSIT AL23 can be used at temperatures over 1,800 °C.

OXYGEN SENSORS

Oxygen sensors with yttrium oxide-stabilised zirconium oxide DEGUSSIT FZY are suitable for measuring oxygen in gases and atmospheres. The measurement electronics process the EMF supplied by the sensor into a partial oxygen pressure and the derivable value, which can be presented alphanumerically. Zirconium oxide sensors generally work in a temperature range of 400 °C to 1,500 °C. Unheated sensors that are installed directly in the high temperature process and heated sensors installed outside such processes can also be used. Ceramic oxygen sensors are suitable for monitoring annealing processes, monitoring protective gas, surface treatment (e.g. in hardening plants), for redox processes, diffusion processes, biotechnical processes and to control food packaging.

THERMOCOUPLE PROTECTIVE TUBES

Tubes and capillary tubes made of aluminium oxide DEGUSSIT AL23/AL24 are the best choice for the highest demands for thermocouple protective tubes. Because of their special structural properties they can also be used at temperatures above 1,800 °C. At the same time, improved stability can be achieved in contrast to the predominant corrosive load in the kiln or melt. In addition there is a high heat conduction and electrical insulation. The excellent processing of the closed end of the tube ensures a uniform, dense structure and, in turn, protection against cracks and leaks.

LEVEL MEASUREMENT

Reliable and flexible measurement of the level in silos or tanks: no matter with sensors made of high-performance ceramics.

Source: ACO Automation Components Johannes Mergl e.K.

Highest corrosion resistance even in aggressive media.

Level sensor made of F99.7

Electrode support made of FZM used to measure levels in the chemical industry

LEVEL SENSORS

Level sensors operate more and more frequently with radar or ultrasonic transmitters made of aluminium oxide F99.7 or F99.7 hf. Examples of this are level sensors in silos and tanks. When measuring the level, aluminium oxide ceramics are used as antennas/ transmitters of the radio waves, microwaves or ultrasonic waves. The electromagnetic waves emitted are guided along cable or rod probes and reflected on the surface of the product. By means of the connected electronic measurement device precise measurements of the level in the container can be obtained, based on travel time or frequency changes.

Adhesives, dust or vapours do not influence the measurement result. This ensures that liquids, bulk materials and separating layers are simply and reliably measured. Measurements of the level in the storage tanks are carried out using electrode carriers made of magnesium stabilised zirconium oxide FZM. A platinum electrode sintered in magnesium stabilised zirconium oxide FZM or aluminium oxide F99.7 is gas tight. These two compounds are absolutely unbeatable and provide flexible filling level measurements.

FLOW MEASUREMENT

The extraordinary properties of high-performance ceramics ensure precise and safe processes in filling systems for liquids and pasty substances.

Source: KRONES AG

Components for highest pressure requirements.

Flow meters in FZM for the food processing industry

Float bodies in F99.7 for flow monitoring in the chemical industry

SENSORS FOR FLOW MEASUREMENT

The Cermet electrode is unique and patented, a compound of magnesium oxide stabilised zirconium oxide FZM and platinum. It is used in magnetically inductive flow meters (MID). It is tested in accordance with pressure equipment standards and tenfold nominal pressure safety allowing components made of high-performance ceramics to be used without problem under very difficult conditions and enabling accurate and precise filling.

Float bodies made of aluminium oxide F99.7 extend the application spectrum of measuring devices to flow monitoring. As the material is extremely resistant to corrosion, precise control of the liquid flow can be guaranteed even for aggressive materials.

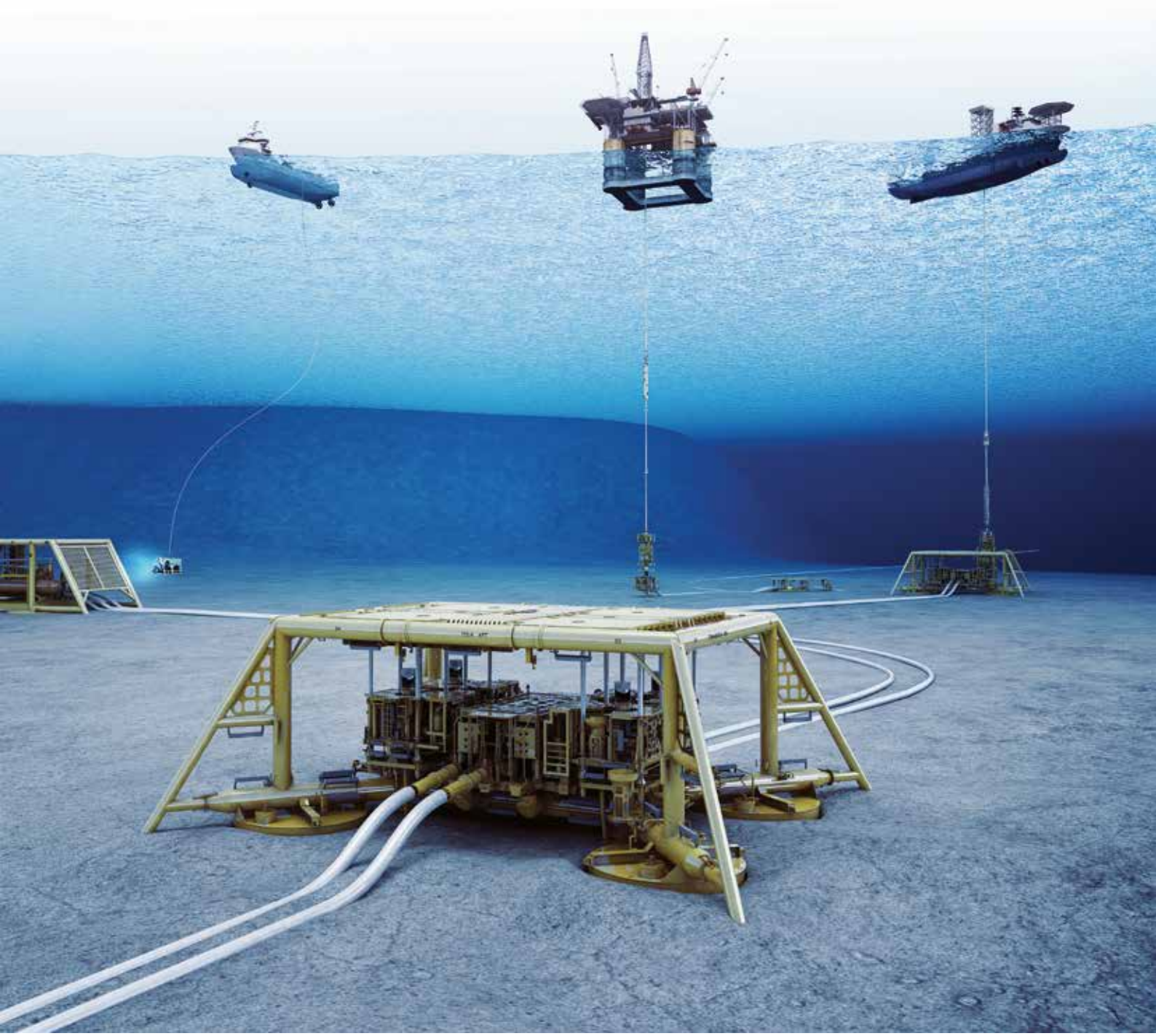
COMPONENTS FOR OFFSHORE AND SUBSEA APPLICATIONS

Oxide ceramics show their advantages under highest pressure: electrical insulation, resistance to pressure, refractoriness and combined with a material-bonded, brazed ceramic-to-metal joint.

High-pressure feedthroughs p = 450 bar made of F99.7

High-current and high-pressure feedthroughs made of F99.7

Level sensor made of FZT



Materials used in offshore and subsea applications are exposed to high pressure and high voltage. Products made of high-performance ceramics are the ideal materials and are well suited in this environment. Kyocera develops and manufactures the required individual components in cooperation with plant manufacturers. Kyocera's high- performance ceramics are produced as material-bonded assemblies using brazing technology and are used successfully to transmit microwave signals.

The filling level of single liquid phases in containers is precisely measured using capacitive sensors. Precise measurement results are decisive for efficient process control.

BEST RATINGS FOR OUR HIGH-PERFORMANCE CERAMICS

With their excellent material properties, components in high-performance ceramics have become well established in sensor technology round the world. The variety of materials from KYOCERA Fineceramics Solutions GmbH allows customised solutions for a wide range of demands in practice.

The development of high-performance ceramics has allowed us to combine the excellent properties of the individual metals and ceramic into a single component. Our high-performance ceramics have an exceptional resistance to high temperatures, wear and corrosion. Together with their breaking strength and dimensional stability, our high-performance ceramics are convincing because of their extremely long lifetime.

Our customers expect us to provide customised solutions for their individual requirements. The wide variety of materials in ceramics, metals and coatings allows us to produce optimal customised components.

The physical material properties shown in the table (p. 15) illustrate the potential of Kyocera's high-performance ceramics.

MATERIALS AND THEIR MAIN APPLICATIONS

Material	Aluminium Oxide (Al_2O_3)			
KYOCERA trade name	**F99.7**	**DEGUSSIT AL23**	**DEGUSSIT AL24**	**F99.7 hf / DEGUSSIT AL23 hf**
Properties	Pure Al_2O_3, dense, extremely resistant to wear and corrosion, very high electrical insulating	Pure Al_2O_3, dense, excellent thermal and electrical resistance properties, corrosion resistant, permeable for microwaves	Pure Al_2O_3, slightly porous, good resistance to thermal shock, extremely good creep strength	Pure Al_2O_3, dense, extremely resistant to wear and corrosion, very high electrical insulating properties
Typical applications	Matched piston / cylinder units, bearings, shafts and valve components, electrical feedthroughs, brazed ceramic to metal seals for x-ray-technology and ionic accelarators for medical technology, dielectrics for fuel cells, sensor caps	Protection tubes for thermocouples, furn ace construction party, laboratory ware e.g. crucibles, boats and plates, reactor lining in the chemical industry, microwave-technology	Tubes, laboratory ware, furnace construction parts	Matched piston / cylinder units, bearings, shafts and valve components, electrical feedthroughs, brazed ceramics to metal seal for x-ray-technology, dielectrics for fuel cells, sensor caps
Material	Aluminium Oxide fine grain stabilised ($Al_2O_3 + ZrO_2$)			
Kyocera trade name	**FZT**			
Properties	Dense, high strength, good resistance to thermal shock, extremely resistant to wear and corrosion, fine grain size			
Typical applications	Vacuum plates for paper-making, flow meter tubes for chemical industry, positioning pins for automotive industry			
Material	Zirconium Oxide partially stabilised with Magnesium Oxide (ZrO_2 + MgO)			
Kyocera trade name	**FZM**			
Properties	Dense, high strength and highly wear resistant, extremely resistant to corrosion and thermal shock			
Typical applications	High pressure pistons, pressing dies, components for mills, ceramic isolation shells for magnetic drive centrifugal pumps, metal forming tools			
Material	Pure Zirconium Oxide partially stabilised with Yttrium Oxide ($ZrO_2 + Y_2O_3$)			
Kyocera trade name	**DEGUSSIT FZY**			
Properties	Dense, high temperature and corrosion resistance, ion conducting for measuring oxygen			
Typical applications	Crucibles, heat-treatment bowls, oxygen measurements			

MATERIALS AND PROCESSES FOR COATING OF CERAMIC

Material	Ag	Au	Pt	Ag-Cu-Ti	MoMn	Ti	TiN	Ni / MoMn	Cu / MoMn	Sn / MoMn
Screen printing	■	■	■	■	■			■		
Manual applications	■	■	■	■	■			■		
PVD	■	■				■				
CVD							■			
Galvanic								■	■	■

BRAZING TECHNOLOGY

With the exception of some products, usability requires material-bonded and highly vacuum-tight joining of ceramic parts with each other and with metal parts. Various joining techniques can be used to achieve this.

GLASS BRAZING

Glass brazing is appropriate for gas-tight joining of ceramic components. This joining technique is characterised by a very good general chemical resistance and operating temperatures up to approx. 1,100 °C. These joints achieve strength values up to 100 MPa at room temperature (in accordance with DVS German Welding Society, Guideline 3101).

A coefficient of thermal expansion adjusted to the ceramic and the glass braze is decisive for the quality of the glass-braze joint. There is great freedom of design with regard to geometries, however, a suitable braze reservoir and an adequate brazing gap in the construction must be guaranteed. This joining technique is based mainly on the use of glass brazes with a thermal expansion matched to that of ceramics as glass shows no metallic ductile properties.

Fig. 1: Glass-brazed ozone generator

Fig. 2: Curved vacuum chamber with glass-brazed ceramic-to-ceramic joints bending angle: 15°, L 3,200 mm

BRAZING OF METALLISED CERAMICS

Components made of high-performance ceramics are generally metallised using the molybdenum-manganese procedure (MoMn procedure) and subsequent nickel-plating (see Figure 5a). The starting point for this process is a compound of molybdenum and manganese. The compound is applied to the ceramic surface to produce a firmly bonded metallised coating through a firing process. As the majority of commercial vacuum hard solders do not wet the metallised surface, it is nickel-plated using a galvanic or autocatalytic method. The component can be brazed on this base metallised coating.

Metallisation allows for brazing at temperatures above 1,000 °C under protective gas atmosphere and/or in the vacuum. A silver-copper eutectic alloy is used as a standard brazing material. Brazing materials with increased melting properties are applied when higher requirements are imposed on the operating temperature, corrosive properties and use of metals that are hardly wetted by the silver-copper eutectic alloy. Table 3 gives an overview of available brazing alloys. Our metallised ceramics are available with galvanic coating such as Au, Ni or Cu to allow for the use of soft solders at low temperatures.

Brazing material	Brazing temperature (°C)
Ag Cu 28	780
Ag Cu 26,6 Pd 5	800 – 850
Ag Cu 21 Pd 25	900
Au Ni 18	950
Cu Ge 10	1,000
Au Cu 65	1,020
Au	1,070

Table 3: Brazing materials and brazing temperatures

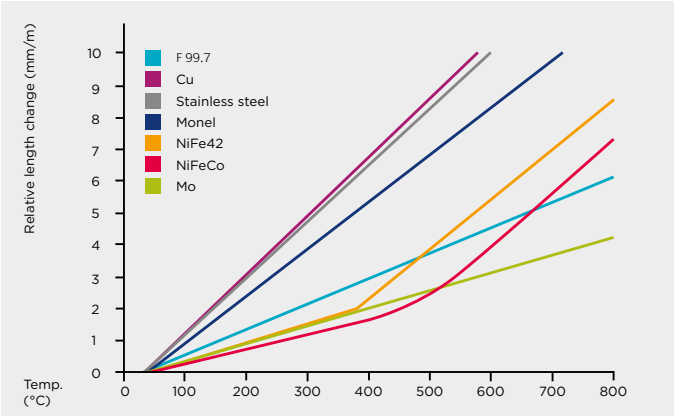


Fig. 3: Thermal expansion characteristics of metallic materials and F99.7 ceramics

BRAZING TECHNOLOGY

Ceramic components prepared using this metallisation process can be hard-soldered with thermally adapted metal components such as NiFe 42 (e.g. VACODIL), NiFeCo (e.g. VACON 10/70), Ti, Mo, CU, etc. Figure 3 shows the coefficients of thermal expansion of different metals compared to that of F99.7.

Figure 4 shows the cross-section of a joining area of a F99.7/AgCu28/1.3917 compound. Tensile tests show that this material combination results in strength values exceeding 100 MPa (in accordance with DVS German Welding Society, Guideline 3101). If the construction is appropriate, these strengths can also be achieved using active brazing.

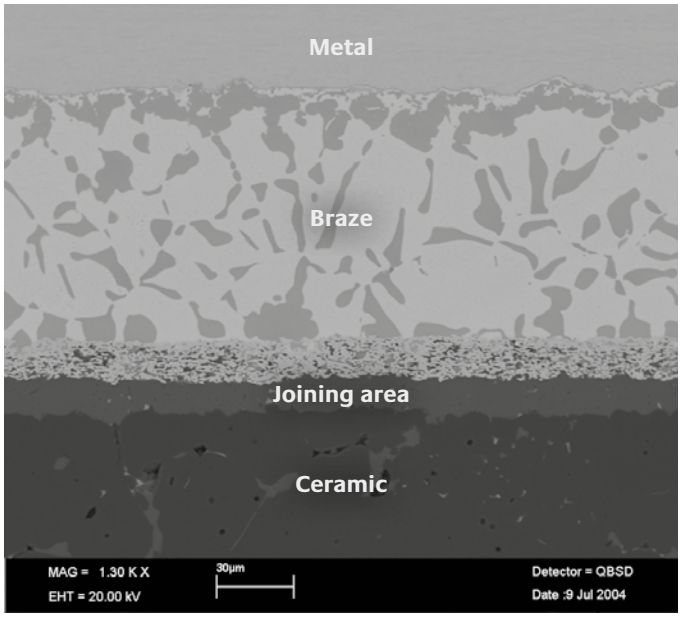


Fig. 4: Cross-section through metallised and hard-soldered Al_2O_3 ceramic

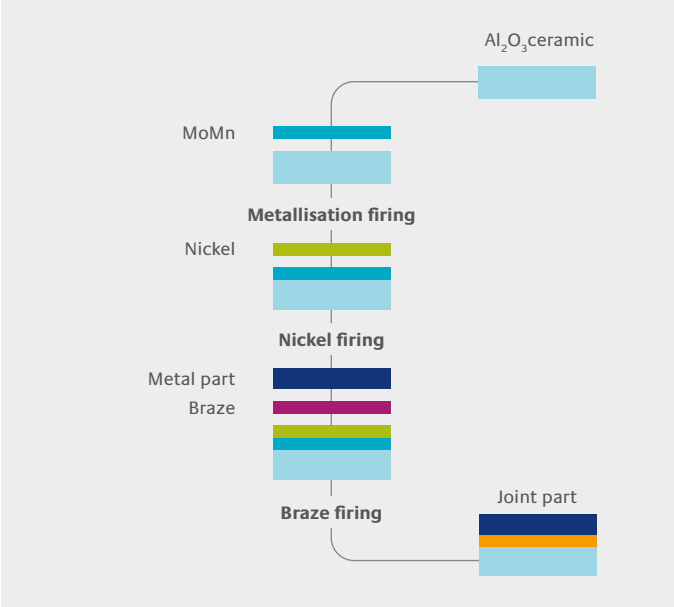


Fig. 5a: Schematic view of MoMn-brazing method

ACTIVE BRAZING

Active brazing (see Fig. 5b) is based on the use of brazing materials with a low oxygen-reactive metal content such as Ti, Zr, or Hf. They contribute to wetting of Al_2O_3 thus eliminating the need for prior metallisation. The strength values of directly brazed Al_2O_3 ceramics/Ni42 joints achieve values similar to those of brazed and metallised joints. Figure 6 shows a further example of a joining area of a ZrO_2 ceramic and steel joint brazed with AgCu26, 5Ti3.

Although active brazing is attractive from a technical and economical point of view, its use with feedthroughs is restricted because the braze does not flow into the brazing gap but remains in the braze deposit. However, these restrictions can be avoided when the constructions take this particularity into consideration.

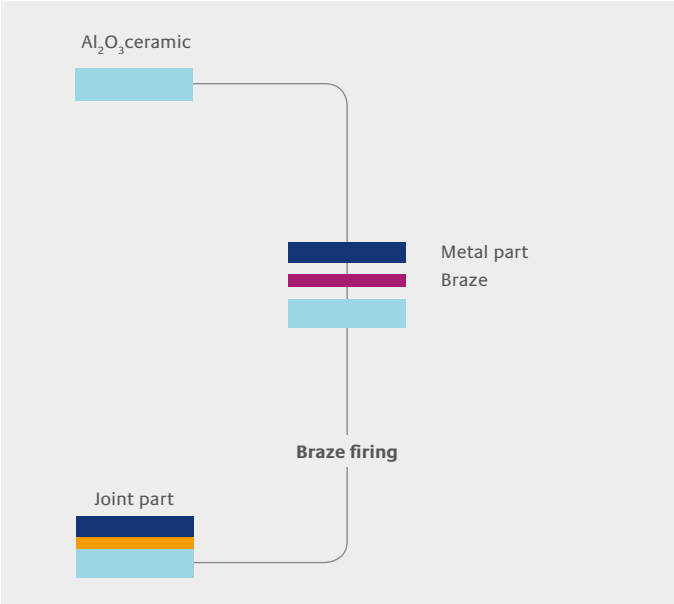


Fig. 5b: Schematic view of active brazing

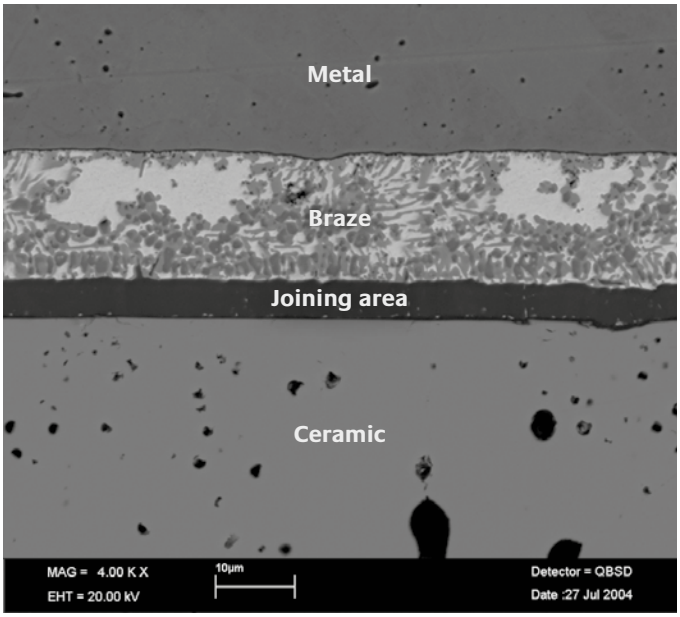


Fig. 6: Cross-section through an active-brazed ZrO_2 ceramic

MANUFACTURING PROCESS

The ceramic manufacturing process from the raw material to the finished product is fundamentally different from metal or plastic production.

Due to technical reasons, ceramic parts shrink during the sintering process at approx. 1,800 °C. For economic reasons, close tolerances should be avoided unless essential. Generally, compliance with dimensional tolerances of ± 1% is possible without subsequent treatment. Diamond tools can be used for grinding the hard-machining surfaces to achieve tolerances that are more precise.

Although no technical difficulties arise during grinding, the process requires increased effort and makes the product more expensive. Please contact us during the design phase to discuss and find the appropriate solution that meets all technical requirements and at the same is economic and suitable for ceramics – it is worth it!

PREPARATION

The preparation of raw materials is a key technology for high-quality technical ceramics.

LABORATORY TESTS

The prepared bodies are tested constantly to guarantee smooth manufacturing processes. As a result, particle-size distribution and composition comply with specifications thus ensuring the highest quality.

SHAPING

A wide range of shaping methods is available such as isostatic pressing (dry and wet bag), die pressing, extruding or injection moulding.

GREEN MACHINING

The chalky green body can be shaped quickly and effectively by sawing, turning, drilling or cutting.

SINTERING

Depending on the material, bisque firing, sinter firing and temper firing at 800 °C to 2,000 °C are required for consolidation. The components are subjected to a shrinkage of up to 50%.

IN-PROCESS INSPECTION

Pursuant to the critical sintering process step, in-process inspection (dye-penetration testing and visual inspection) is carried out to allow rejection of defective parts.

FINISHING

The cost-intensive process step is carried out when needed and only if required by the component. Diamond tools are available for grinding, drilling, sawing, cutting (5-axis CNC) and lapping / polishing.

JOINING TECHNOLOGY

Different methods are available such as brazing (metallic / glass), adhesive bonding, shrink-fitting, screwing or diffusion bonding to manufacture metal-to-ceramic or ceramic-to-ceramic bonds.

FINAL INSPECTION

The components are generally subjected to a final inspection prior to dispatch. Customer-specific testing specifications can be considered.

KYOCERA FINECERAMICS SOLUTIONS GMBH
THIS IS US. INNOVATION IN CERAMICS.

ELEVATOR MESSAGE

"Our extensive experience in high-performance ceramics and our alliance with Kyocera as a leading global technology group grant us access to innovation and resources that allow us to realize ambitious projects and take the lead for the future. We share our knowledge, and bring it together to create something new that goes beyond our company, beyond different industries and countries. As a team. Together with our customers."
Armin Kayser, General Manager of KYOCERA Fineceramics Solutions GmbH

KYOCERA Fineceramics Solutions GmbH - Summary

Location:	Mannheim, metropolitan Rhein-Neckar region
Founding year:	2019 - Spin-off from FRIATEC GmbH
Employees:	approx. 300 incl. approx. 30 trainees and apprentices
Subsidiaries:	KYOCERA Fineceramics Nordics AB (sales office for Northern Europe)

We look back on a long tradition in the manufacturing of ceramic products: Founded in Mannheim in 1863 as a brickyard known as "Deutsche Steinzeug", and later as "Friedrichsfeld GmbH", from 1993, the ceramics department continued its successful development under the brand FRIATEC GmbH. Since September 2019 we have been part of Kyocera Group, a leading global ceramics and technology company.

Kyocera companies benefit from the group's cross-department way of thinking and working. Because innovation and real milestones can only be achieved together. This is what we believe.

We are a provider of innovative solutions for numerous industries: system components for high-tech applications in electrical and sensor technology, mechanical engineering, analysis technology, medical and semiconductor technology, as well as laboratory technology.

We possess internationally recognized know-how in the field of high-performance ceramics, especially for ceramic-to-metal assemblies. Our products are characterized by high quality, precision, and durability. Our production and development location in Central Europe and our customized supply-chain solutions make us extremely agile and ensure maximum reliability for our customers.

We see ourselves as a partner in the development of high-performance ceramics solutions that provide added value for our customers and ensure their technological advantage in their respective markets. Our focus today is on where we want to be tomorrow – together. We develop sustainable solutions that meet the demands of the future, supported by an experienced team of 50 highly qualified and quality-oriented engineers, scientists, technology experts, and masters.

ELECTRICAL ENGINEERING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HIGH TEMPERATURE TECHNOLOGY


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SENSOR AND MEASURING TECHNOLOGY


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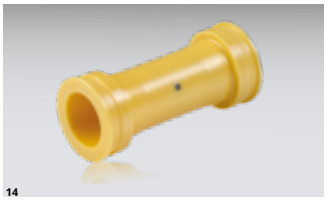
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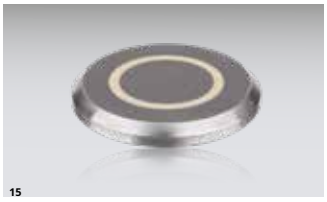
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01. UHV vacuum chamber
02. Special insulation tube for research institutes
03. Feedthroughs with ISO-KF flange
04. High-voltage feedthrough

05. Rectangular tubes
06. Multi-bore tubes
07. Crucibles, boats and annealing
06. Boxes
08. Plates with hole

09. Forming tools used in body construction
10. Dosing unit used in the pharmaceutical and cosmetic industry
11. Containment shells for the pump industry
12. Grinding tools used in metal processing

13. Pressure sensor for aerospace
14. Flow meters
15. Humidity sensor
16. Oxygen sensor

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