

KYOCERA

HIGH-TEMPERATURE TECHNOLOGY

Components made of
high-performance ceramics

INVENTIVE, EXPERIENCED, SUCCESSFUL

The quality of materials used in high-temperature applications is important. For decades, products made of DEGUSSIT High-Performance Ceramics have proved efficient in many demanding branches of the glass and metal processing industry as well as in process and analysis technology.

High-purity ceramic materials and excellent manufacturing quality provide exceptional corrosion resistance and outstanding shape stability of our products - even at maximum temperatures. Our success is based on a combination of these properties allowing higher product functionality, process safety and enhanced service life.

Thus, DEGUSSIT High-Performance Ceramics contribute towards outstanding economic customer benefits. Our experts constantly develop new and customised ceramic solutions and products in collaboration with our market partners.

ADVANTAGES

- Extreme resistance to heat
- High dimensional stability
- Excellent resistance to corrosion
- Resistant to wear
- Good resistance to high electrical voltage

DEGUSSIT materials have been specially developed for use in high-temperature technology. They are specially convincing when exposed to combined stress from high temperatures and corrosive atmospheres. Our customers have been using our products for decades and their experience speaks for itself.



More than 150 years’ experience in ceramic manufacturing.

TUBES AND CAPILLARIES

Tubes made of DEGUSSIT ceramic such as protection tubes, firing or guide tubes have been used successfully in different applications for many years. They are increasingly used in many fields of application because of their outstanding material properties and numerous feasible geometries.



Tubes made of DEGUSSIT AL23



Tubes one end closed made of DEGUSSIT AL23



Capillaries made of DEGUSSIT AL23

TUBES

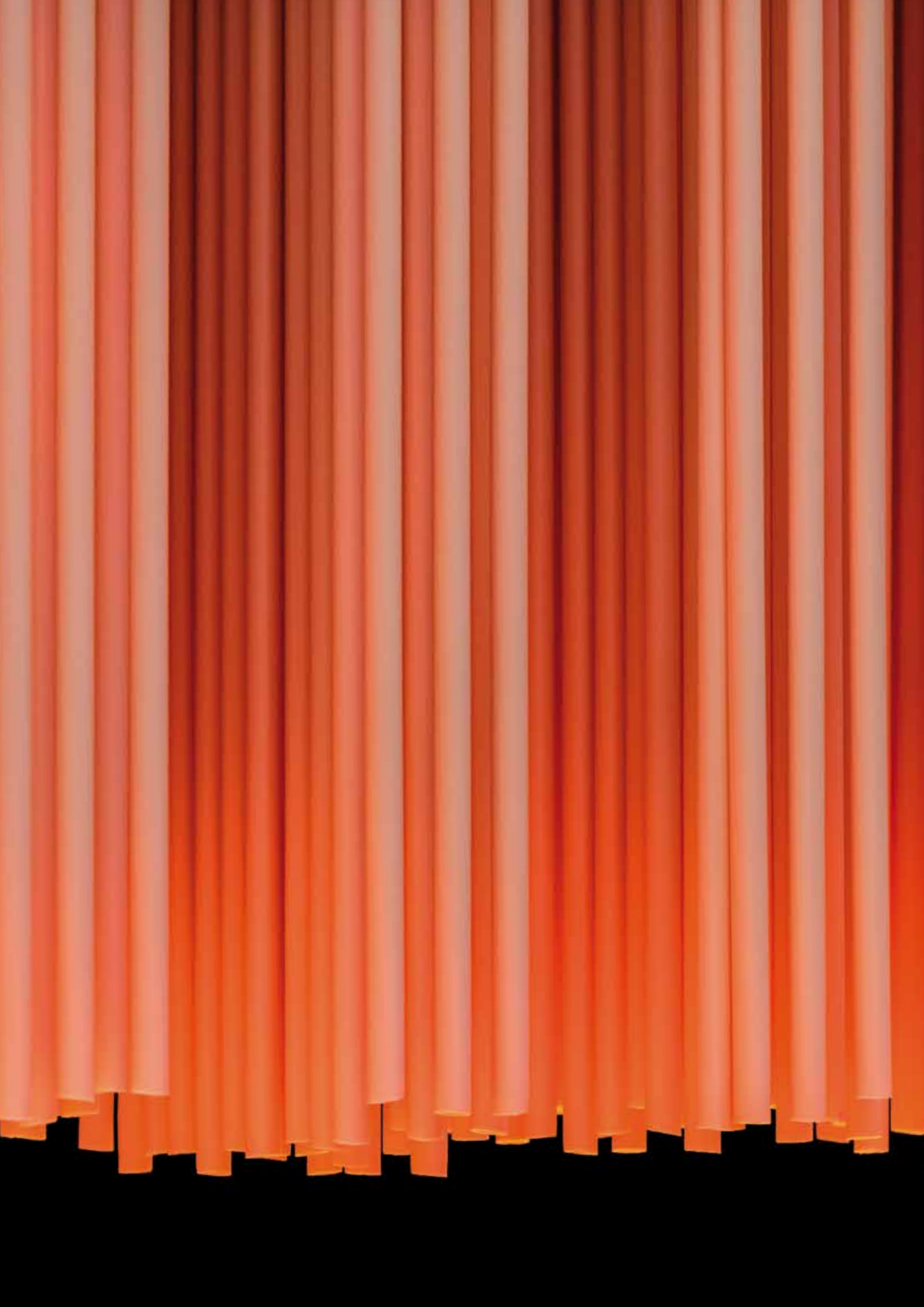
The DEGUSSIT standard programme comprises delicate thin insulation tubes with outer diameters of up to 0.5 mm and large tubes with outer diameters of up to 170 mm. Individual dimensions are adapted to customer requirements.

TUBES ONE END CLOSED

DEGUSSIT tubes are also available with one end closed. The technology used to close the tubes guarantees constant wall thicknesses in this area. The tubes can be fitted with a flange for easy installation in customer applications.

CAPILLARIES

Round and oval multi-bore tubes belong to our standard range of extruded products. Diameter dimensions usually range from 0.2 to 1.6 mm and can be manufactured with different bore quantities.



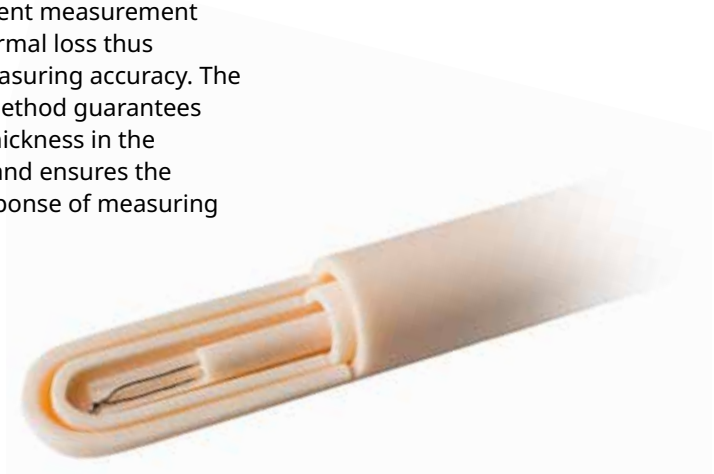
TEMPERATURE MEASUREMENT

For decades, KYOCRA Fineceramics Europe GmbH has been supplying key components made of DEGUSSIT oxide ceramics to obtain exact and repro-ducible temperature measurement. The highly resistant ceramic tubes protect measuring equipment from ambient conditions thus enhancing service life.

THERMOCOUPLE PROTECTION TUBES

Protection tubes made of DEGUSSIT oxide ceramics ensure temperature measurement at extreme ambient conditions during high-temperature processes. Thermocouple protection tubes must meet the highest requirements.
DEGUSSIT protection tubes show excellent dimensional stability at temperatures up to 1,950°C because of their purity and homogeneous microstructure.
Exceptional corrosion resistance allows them to be used under extremely difficult conditions.

The material's electrical insulating capacity and good thermal conductivity prevent measurement errors due to thermal loss thus allowing high measuring accuracy. The manufacturing method guarantees a constant wall thickness in the closed tube end and ensures the best possible response of measuring systems.





Quelle: Keramischer OFENBAU GmbH

CERAMIC CAPILLARIES

As well as tubes with one end closed, ceramic capillaries are also of particular importance for measuring and controlling processes. Different measuring wires must be separated and electrically isolated from each other to guide them to the point of measurement. This requires very thin channels and thin wall thicknesses. Our excellent manufacturing capabilities create sophisticated components that meet any electrical and mechanical requirement even in confined spaces.

The low SiO_2 content of 0.01% reduces the oxidation of platinum in noble metal thermocouples to a minimum and prevents early corrosion.

FIELDS OF APPLICATION

- Glass industry
- Semi-conductor industry
- Chemical and process technology
- Heat treatment units
- Metallurgy

Highly resistant to temperature and corrosion, high dimensional stability

OXYGEN MEASUREMENT

Yttria-stabilised zirconia has been successfully established in the field of high-temperature technology for many years. It was specially developed for the high-temperature lambda probe. Outstanding resistance to temperatures up to 1,700°C and excellent surface qualities open up new applications in high-temperature technology.



Special geometry for oxygen sensor made of DEGUSSIT FZY

Tubes one end closed made of DEGUSSIT FZY



Ceramic-to-metal assembly using DEGUSSIT FZY

OXYGEN MEASUREMENT

Only suitable setting of welding atmospheres allows the perfect welding seam under protective gas. Industrial welding monitors the protective gas atmosphere.
Hardening, annealing or surface treatment require precise control of furnace atmospheres and oxygen measurement is important.
Redox processes in diffusion processes, metal melting and biotechnological processes also require this type of analysis technology.

Ham, vegetables or potato crisps - requirements imposed on the atmosphere in food packaging always depend on the product using most precise measuring technology.
Partially stabilised zirconia displays oxygen ion conductivity from 400°C. Analysis technology uses this specific physical property to determine the oxygen content of gases. DEGUSSIT FZY is used as separating layer between the test and reference gases.

Ions travel from higher to lower potential from one side of the ceramic to the other depending on the oxygen content. This ion surplus i.e. electrical voltage delivers the signal to measure the oxygen content.
DEGUSSIT FZY has rapid response times at constant measuring signals with temperatures up to 1,500°C.



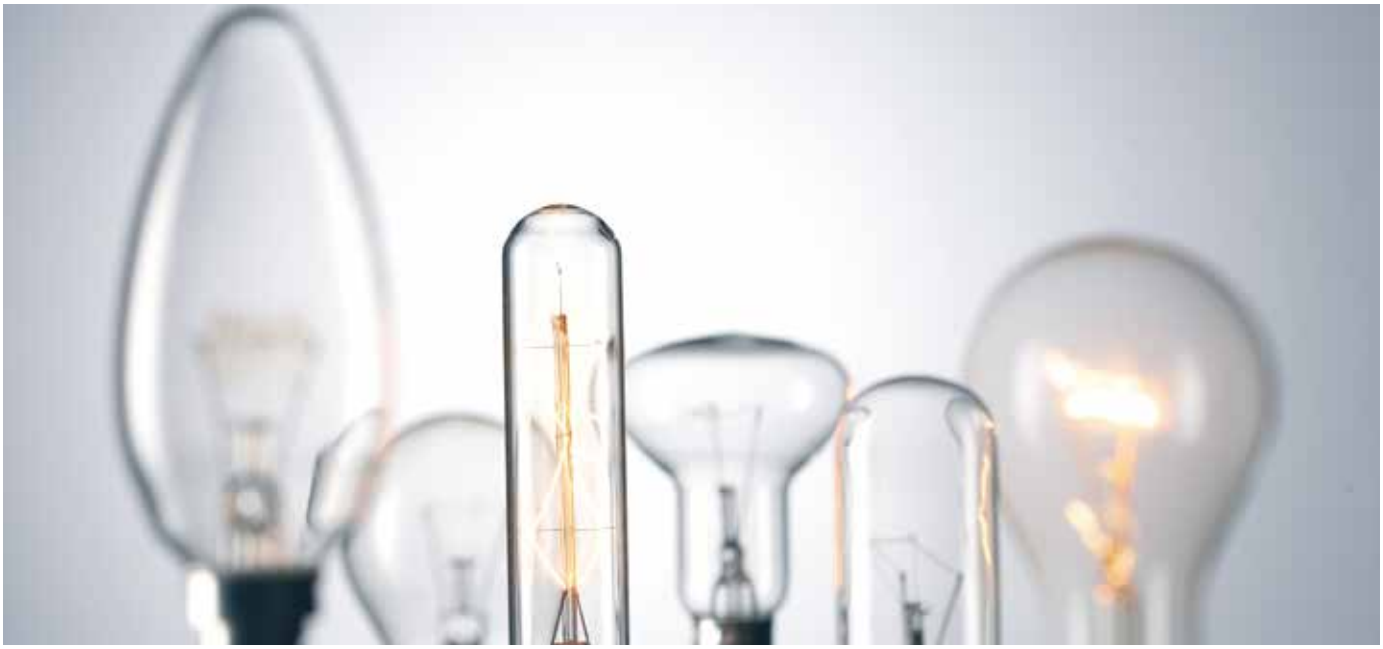
Quelle: Dansensor A/S

The particularly fine surface structure and temperature resistance up to 1,700°C of DEGUSSIT FZY are impressive. Low adhesion tendency efficiently reduces sticking of reagents in crucibles, plates or tubes.
The material is used successfully particularly when growing crystal in research establishments.

DEGUSSIT FZY is characterised by low adhesion tendency and outstanding resistance to temperature.

GLASS INDUSTRY

Materials DEGUSSIT AL23 and DEGUSSIT AL24 show their strength in thermal-corrosive atmospheres of molten glass. A variety of customised precision components essentially helps manufacture and shape glass and its final products. Their resistance to high temperatures and corrosion allow the components to achieve long service lives in demanding applications.



High process safety in thermal-corrosive atmospheres.



Bubble tube with 17 bores made of DEGUSSIT AL23



Shape roller made of DEGUSSIT AL23 for the glass industry



Glow block made of DEGUSSIT AL23 used for filament production

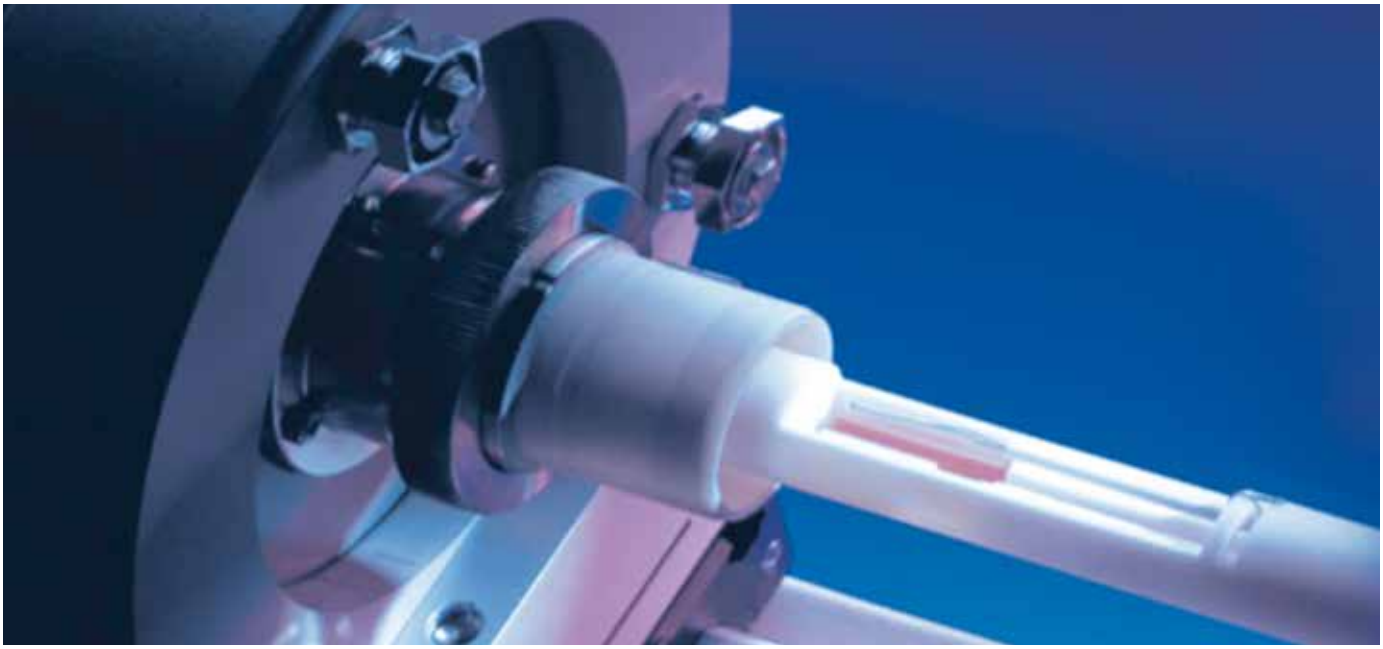
DEGUSSIT components are used at different stages in the manufacturing process of glass. Tubes made of DEGUSSIT ceramic are mounted in thermocouples (see pages 06+07) and bubbling systems during the first production step i.e. the melting process. Bubbling is used in glass melt tanks to provide efficient process design. Compressed air or oxygen is blown through the bubble tubes from the base into the melting tank.

A current develops in the melt accelerating the homogenisation of glass. The bores inside the bubble tubes have a very small diameter eliminating any possibility of infiltration or cooling of the glass melt inside the ceramic tube.
DEGUSSIT crucibles and annealing boxes are used for developing and manufacturing special glasses. The high-purity crucibles with dense surfaces withstand aggressive glass melts.

DEGUSSIT ceramics such as holders, shape rollers and glow prisms allow the shaping of delicate glass components. The interaction of properties such as high-temperature resistance, corrosion resistance and dielectric strength contributes specifically towards optimising manufacturing processes.

ANALYTICAL TECHNIQUES

High-purity DEGUSSIT materials allow constant and accurate measuring results in research & development and industrial process control especially through chemically neutral behaviour in contact with samples. Just one versatile material can be used for a wide range of temperatures and applications.



Safe measuring results at maximum temperatures.



Special tube made of DEGUSSIT AL23
used as sample holder in dilatometry



Special tube made of DEGUSSIT AL23
used in thermogravimetry



Slip-on crucible made of DEGUSSIT AL23
used for differential thermal analysis

DILATOMETRY

Dilatometry is used for high-precision measurement of temperature-sensitive dimensional changes in solids, melts, powders or pastes. Using a push rod and displacement sensor, the horizontal dilatometer measuring system evaluates the thermal expansion of the test material. Sample holders made of DEGUSSIT AL23/AL24 ensure highest precision, reproducibility and long-term stability at temperatures up to 1950°C.

THERMOGRAVIMETRY

Thermogravimetry determines mass changes in samples over a defined temperature and time range. The mass change can result from different physical processes (e.g. vaporisation) or chemical processes such as reduction or oxidation.
The DEGUSSIT sample holder is connected to a microbalance that records mass changes precisely while the test sample is exposed to heat. DEGUSSIT AL23 is an inert material and resistant to temperatures up to 1.950°C ensuring accurate measurements for this procedure.

DIFFERENTIAL THERMAL ANALYSIS

Differential thermal analysis is a comparative measurement using the characteristic energy transformation during phase transitions as a basis for measurements. The test and reference samples are exposed to constant energy supply in two symmetrical measuring chambers. Crucibles made of DEGUSSIT AL23 do not react chemically with the sample material thus ensuring precise measurement. High thermal conductivity of DEGUSSIT materials improves sensitivity towards minimal temperature changes.

LABORATORY TECHNOLOGY

Excellent temperature and corrosion resistance as well as mechanical strength make DEGUSSIT oxide ceramics true all-rounders. The all-purpose material dispenses with an annoying variety of materials in the laboratory. Easy storage of testing equipment allows clear structuring of the laboratory and helps reduce sources of errors such as mix-up of materials.

Source: Waldner Laboreinrichtungen GmbH & Co. KG



Excellent raw materials and materials analysis.



Crucibles made of DEGUSSIT AL23 in different geometries



Annealing box and boat made of DEGUSSIT AL23



Plates made of DEGUSSIT AL23

DEGUSSIT oxide ceramics are also convincing when preparing samples for raw materials analysis and materials analysis. The use of pure raw materials and decades of experience ensure process safety in accordance with industrial standards for temperatures up to 1,950°C.

The DEGUSSIT product range comprises a variety of annealing boxes, boats and crucibles in different geometries and materials used for annealing and melting processes. The crucibles are available cylindrical, conical or as cylindrical crucibles with round base. We are pleased to implement other dimensions and geometries according to your specific requirements.

The dense surface of DEGUSSIT oxide ceramics is highly resistant to particularly aggressive melts. The low SiO_2 content of DEGUSSIT materials helps produce the widely recognised and impressive corrosion resistance significantly enhancing the service time of crucibles (see also Chapter “Corrosion resistance”).

FURNACE CONSTRUCTION

DEGUSSIT materials have outstanding high-temperature properties and meet highest requirements of functional components exposed to maximal mechanical and thermal stresses in furnace construction thus contributing to economic operation with enhanced service lives.



Plates made of zirconia used as sintering plates



Plates made of alumina with polished surface used as slide blocks in pusher furnaces



Tubes made of alumina used as guide tubes for heating elements

SINTERING PLATES

Because of their good corrosion resistance and shape stability, plates made of DEGUSSIT High-Performance Ceramics are used as sintering plates or crucible covers in annealing and melting processes at high temperatures. Universities and research institutes often use simple plate geometries. Specially designed products can greatly facilitate the manufacturing process in industrial plants.

SLIDE BLOCKS

Slide blocks made of DEGUSSIT AL24 are ideally suited to extreme high-temperature processes in oxidising and reducing atmospheres up to 1,950°C. They are used in electrically operated or gas-fired pusher furnaces and have best sliding properties and good hot bending strength that allow economic and reproducible production. Extensive manufacturing options are available for the production of high-precision slide blocks.

GUIDE TUBES FOR HEATING ELEMENTS

The efficiency of electrically operated furnaces is directly related to the condition of the heating element wires. To guarantee the highest possible service life for these elements, many furnace constructors use alumina support tubes that allow exact positioning and ensure the distance between the coils. Standard tubes or tubes with specially trimmed threads can be used.





Insulation beads made of alumina used to partially insulate wires

INSULATION BEADS

In furnace construction, insulation beads made of DEGUSSIT AL23 are used to separate wire end connections from loose wires. Stringing the beads together keeps the wire flexible. The DEGUSSIT standard range comprises insulation beads with interior diameters from 1 to 5 mm.

FIELDS OF APPLICATION

DEGUSSIT supplies a variety of products used in different fields of furnace construction. In addition to the specified components, we also manufacture guide elements, spyholes, anchors and many more products in accordance with customer requirements - ranging from small laboratory equipment to large industrial units.

RESEARCH AND DEVELOPMENT

Do you have a new idea but conventional materials and composites cannot meet your requirements? KYOCERA Fineceramics Europe GmbH is ready to help you implement your project. Whether you are a start-up, medium-sized business or group: we are pleased to provide knowledge and extensive experience.

KYOCERA Fineceramics Europe GmbH stands for decades of experience in ceramic manufacturing, a wide variety of joining methods, extensive knowledge in process and product development as well as for products “made in Germany”.

Our research department comprises a team of inter-disciplinary experts specialising in material research, process development and product innovation.

Our ceramic materials are subject to regular inspections and controls to meet highest quality requirements. We are currently developing innovative high-performance materials that exhibit excellent properties in applications up to 2,300°C.

Is the solution you are seeking for an application requiring resistance to high temperatures and corrosive conditions? Please discuss your ideas with us.

We cooperate with you and develop new concepts to obtain customised products that are technically and economically optimised.

Our principal objectives in process development are to implement stable processes and modern machinery. We are also determined to achieve continuous improvements and ensure that you consider us an attractive partner for your projects.



Innovative engineering for customised products.

CORROSION RESISTANCE

Corrosion resistance is often an involuntary but crucial factor when it comes to the race for quality, productivity and, of course, profitability. KYOCERA Fineceramics Europe GmbH is continually optimising the corrosion resistance of its alumina materials to maintain and further develop their recognised superior quality.

The purity of raw materials and careful manufacture are parameters that lift material properties to KYOCERA Fineceramics Europe GmbH level. The chemical stability of grain boundary phases determines the chemical strength of polycrystalline structures. Surprisingly, the smallest amount of by-products has a decisive effect on
corrosion in naturally minimal grain boundaries.

Adding SiO_2 seems to be eco- nomically attractive to improve sintering activity and reduce the required firing temperature.
However, KYOCERA Fineceramics Europe GmbH follows a different strategy and focuses on the consequent improvement of corrosion resistance. Careful selection of raw materials and constant controls reduce the harmful SiO_2 content without compromise.

The chemical composition of in- evitable by-products in high-purity alumina is a decisive factor for corrosion resistance, making this remarkable observation easy to understand:
Materials with the same purity such as 99.7% Al_2O_3 display very different corrosive properties depending on the manufacturer; the composition of the by-product is crucial.

Outstanding corrosion resistance..



DEGUSSIT AL23 sample after the corrosion test described below. The absence of methylene blue staining indicates that sulphuric acid did not corrode the microstructure.



Comparative sample of a 99.7% Al_2O_3 ceramic; the cross-section clearly shows corrosive attacks of the microstructure.



This comparative sample (99.7% Al_2O_3) also shows noticeable weakening of the microstructure caused by sulphuric acid.

DETERMINING CORROSION RESISTANCE

Consistent material development with respect to corrosion resistance is accompanied by sophisticated testing methods. KYOCERA Fineceramics Europe GmbH carries out corrosion tests, followed by colour infiltration controls to obtain essential information. A material sample is exposed to boiling sulphuric acid for several days. After submerging the sample in a bath of methylene blue solution, the cross section clearly shows advanced leaching of grain boundaries.

The figures above show the comparative test result of DEGUSSIT AL23 and two other 99.7% alumina ceramic samples under identical conditions.
The reproducible test using standard methods allows the depth of colour infiltration to be measured and product batches to be compared with other materials. KYOCERA Fineceramics Europe GmbH uses sound property controls to maintain established quality levels.

HIGH-TEMPERATURE STRENGTH

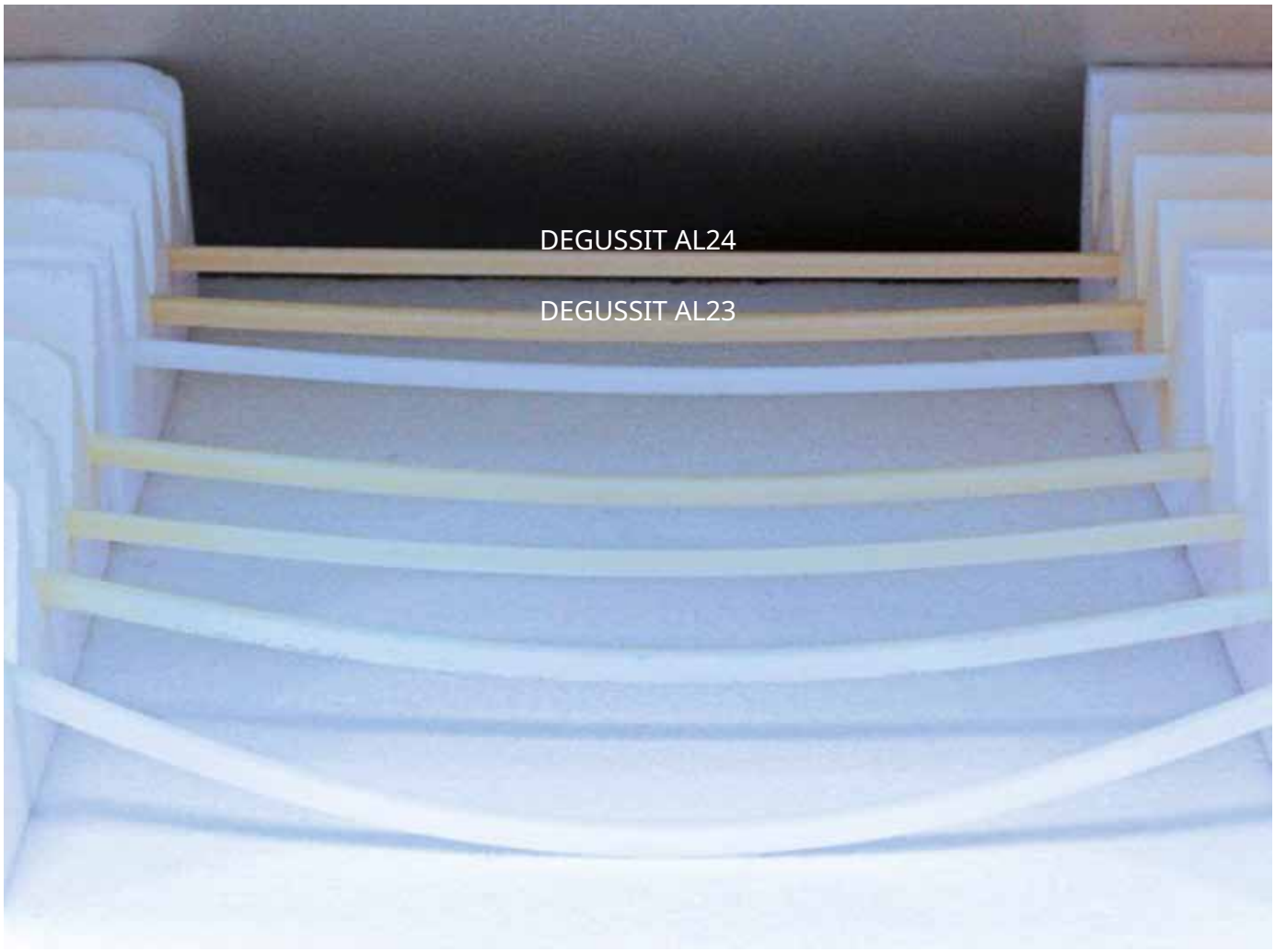
Technical processes at the highest temperature levels impose extreme requirements on units and plants, materials and technical personnel. KYOCERA Fineceramics Europe GmbH is committed to providing economical high-temperature solutions and manages temperatures up to 1,700°C or even 1,950°C safely.* Fully developed products enable DEGUSSIT materials to maintain their top-level market position.

Elevated temperatures generally contribute to a drop in mechanical strength and shape stability.
High-purity ceramics from various sources show significantly different behaviours when exposed to high temperatures.
The dreaded creep deformation at extremely high temperatures (1,700°C) has been compared experimentally.
Our materials show an excellent result:

The comparative test was carried out using bars cut from different alumina ceramics. The bars had identical dimensions and were exposed to temperature stress at 1,700°C. Although each sample has >99.5% Al_2O_3, the degree of deformation is very different under constant thermal stress.

Optimised DEGUSSIT AL23 and DEGUSSIT AL24 alumina ceramics are characterised by exceptional dimensional stability under the most demanding thermal stresses.

* Please contact our technical support for your individual application.



Comparative test used to determine Al_2O_3 high-temperature strength

DEGUSSIT materials prove highest shape stability under constant temperature stress.

MATERIAL DATA

Properties		Unit
Main components		-
Purity		wt-%
Density		g/cm^3
Open Porosity		vol.-%
Average size of crystallites		µm
Bending strength σ_m	DIN EN 843-1	MPa
Weibulls modulus		-
Toughness K_{Ic}	SEVNB	MPa*m^{0,5}
Compressive strength		MPa
Young's modulus	static	GPa
Poisson's ratio		-
Hardness	Knoop, 100 g	GPa
Maximum service temperature in air		°C
Linear coefficient of expansion	-100 – 20 °C 20 – 100 °C 20 – 500 °C 20 – 1,000 °C	10^{-6}/K
Specific heat	20 °C	J/(kg*K)
Thermal conductivity	20 °C 100 °C 1,000 °C 1,500 °C	W/(M*K)
Resistivity	20 °C 600 °C 1,000 °C	Ω*cm
Dielectric strength	20 °C	kV/mm
Typical colour		-

The data indicated on this table are in line with the introductory German Industrial Standard DIN 60672-2 and relate to test specimens from which they were obtained. They are not unconditionally applicable to other forms of the same material. The data must be regarded as indicative only.
All data refer to a temperature of 20°C, unless otherwise specified.

To find information about characteristic values of other materials, please go to www.kyocera-fineceramics.de

Material DEGUSSIT AL23	Material DEGUSSIT AL24	Material DEGUSSIT AL25	Material FZT	Material DEGUSSIT FZY
α – Al_2O_3	α – Al_2O_3	α – Al_2O_3	α – Al_2O_3, ZrO_2	ZrO_2, Y_2O_3, Al_2O_3
> 99.5	> 99.5	> 99.5	> 99.5	> 99.7
3.70 - 3.95	> 3.4	> 2.8	≥ 4.05	≥ 5.5
0	≤ 5	20 - 30	0	0
10	40	70	5	30
300 - 350	150	70	460	400
-	-	-	> 15	-
-	-	-	3.3	-
3,500	1,000	300	3,000	2,000
380	-	-	360	200
0.22	-	-	0.24	-
23	-	-	20	17
1,950	1,950	1,950	1,700	1,700
- - - 8.2	- - - 8.2	- - - 8.2	3.9 - 7.5 8.3	- 9.2 10.4 10.9
900	-	-	850	400
34.9 - 6.8 5.3	27.8 - 5.5 45	- - - -	- 25 - -	- 2.5 - -
- - -	- - -	- - -	- - -	10^{10} $4 * 10^2$ 15
20 - 30	-	-	-	
ivory	creme white	white	white	white

ABOUT KYOCERA





The global Kyocera corporation - a strong partner.

Headquarters:	Kyoto, Japan
Foundation:	1959
Employees:	over 80,000 worldwide
European headquarters:	Esslingen, Germany
European production sites:	Mannheim, Germany Selb, Germany Erfurt, Germany (further subsidiaries in Europe)

KYOCERA = KYOTO CERAMICS

KYOCERA – it all began with ceramics

KYOCERA Fineceramics Europe GmbH is a subsidiary of KYOCERA Europe GmbH, which has been successful in Europe for over 50 years. The Kyocera Group is one of the world's leading providers of high-performance ceramic components for the technology industry, offering over 200 different ceramic materials, as well as state-of-the-art technologies and services tailored to the specific needs of each market.

KYOCERA Fineceramics Europe GmbH has grown steadily in recent years – and is now one of the leading European suppliers of customised solutions made of technical ceramics. Working in partnership, we develop and manufacture products that offer our customers added value in their respective markets and secure their technological lead in the long term. We are committed to this every day.

We have also been active in the field of environmental technology for 30 years. Our solutions for treatment of exhaust air and waste water from chemical laboratories and industrial processes are known worldwide under the FRIDURIT brand.

Throughout Europe, we are represented by three production and development sites in Mannheim, Selb and Erfurt (Germany), as well as five sales offices – in Mannheim, Selb, Neuss (Germany), Rungis (France) and Frimley (United Kingdom).

Our business partners benefit from the fact that we think and work across divisions within the Kyocera Group. Because innovations and real milestones can only be achieved together – across industries and national borders.

This is what we believe.

About the KYOCERA Group

KYOCERA Europe GmbH is a company of the KYOCERA Corporation headquartered in Kyoto/Japan, a renowned supplier for semiconductor, industrial and automotive components as well as electronic components, printing and multifunction systems, and communications technology. The technology group is one of the world's most experienced manufacturers of smart energy systems, with more than 45 years of industry expertise. The Kyocera Group comprises of around 300 subsidiaries.

Kyocera aims to create a better future for the world, using the power of technology to solve issues we face as a global society. This ambition is rooted in our Kyocera Management Rationale: to contribute to the advancement of society and humankind.

We will continue to work together with people around the world to solve issues critical to society leveraging all of the technologies and management capabilities we have accumulated during our 60-plus year history.

The company also takes an active interest in cultural affairs. The Kyoto Prize, a prominent international award, is presented each year by the Inamori Foundation established by Kyocera founder Dr Kazuo Inamori to individuals worldwide who have contributed significantly to the scientific, cultural, and spiritual betterment of humankind.



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