KYOCERA

TECHNICAL CERAMICS FOR HYDROGEN APPLICATIONS

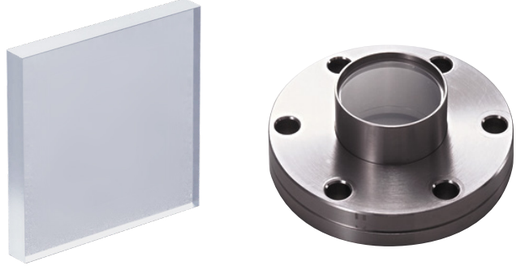
High-performance ceramics

TECHNICAL CERAMICS FOR HYDROGEN APPLICATIONS

Brazed ceramics compatible with liquid hydrogen

FEEDTHROUGHS IN CRYOGENIC ENVIRONMENT

It is expected that the demand for products that can be used in a liquid hydrogen environment (-253 °C) will increase toward the realization of a hydrogen society. Kyocera is conducting joint research with Japan Aerospace Exploration Agency (JAXA). It has been confirmed that Kyocera feedthroughs can be used in a cryogenic environment.



Bare sapphire window for optical sensor | Sapphire embedded in metal flange

OPTICAL SENSORS FOR HYDROGEN CONTROL

Features

- High mechanical strength
- High transparency
- High hermeticity through bonding with metal

Ceramic rods for hydrogen processes

DENSE AND POROUS PROTECTION TUBES

Features

- High chemical resistance
- High thermal stability
- Adjustable porosity/pore size

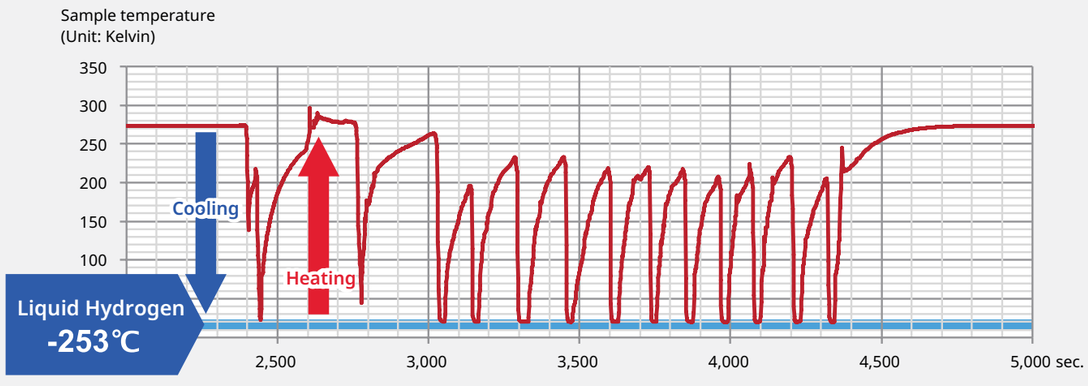
One-layer SiC heat exchanger | Stacked heat exchangers

HEAT EXCHANGERS FOR THERMAL MANAGEMENT

Features

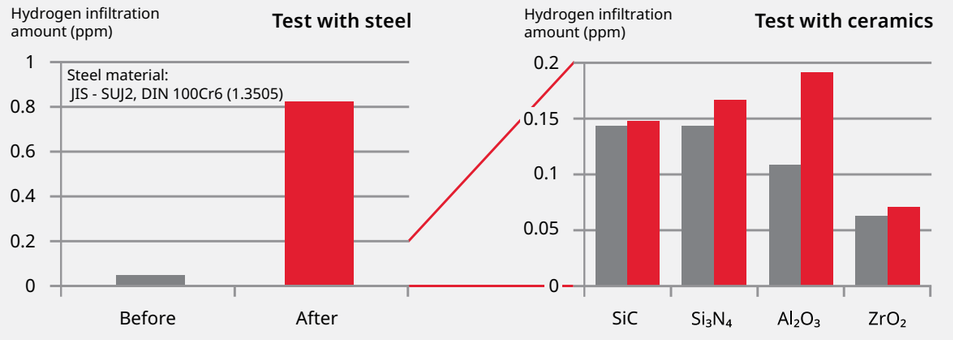
- High chemical resistance
- High temperature resistance
- High thermal conductivity

TEMPERATURE CYCLE TEST CONDITIONS
UNDER ATMOSPHERIC PRESSURE AND HYDROGEN ENVIRONMENT



Rapid temperature cycle test (provision of data: JAXA)

REACTIVITY CONFIRMATION WITH HYDROGEN



Ceramics are stable in the tested Hydrogen environment compared to steel.

Test conditions
- Pressure: 40 MPa
- Temperature: 100 ℃
- Duration: 200 h

Please note: Material properties are typical values.

TECHNICAL CERAMICS FOR HYDROGEN APPLICATIONS

Ceramic pistons and containment shells

Insulation tubes

PUMP COMPONENTS

Zirconia FZM has proven itself as an ideal ceramic material for pump components.

Ceramic pistons are used to transfer media ranging from liquids to high viscosity substances, even with an abrasive filler. High resistance to wear and optimal sliding properties ensure a long operational life.

Renewable energies, for example, use hydrogen, which is pumped under high pressure and in liquid form. Additional heat input should therefore be avoided in that process to minimize evaporation effects. Ceramic containment shells provide a suitable solution here, as they are non-magnetizing and thermally insulating. Ceramics material also provide high electrical insulation.

With the development of FZM+, the application range of our materials can be extended even further. The white zirconia is characterised by improved flexural strength and high fracture toughness. This allows test pressures of up to 95 bar (pressure rating PN 63) for a temperature range from -200 °C to over 450 °C.

INSULATORS FOR CRYOGENIC APPLICATIONS

Insulators and insulation tubes made of alumina F99.7 and F99.7 hf can be fitted with ribs and glaze on the outside. The rib structure increases the creepage distance, leading to higher electric strength when used in atmospheric applications. The glaze facilitates handling and cleaning of the component. The ceramic-to-metal assemblies can be customised to suit the requirements of the respective application by selecting suitable metal parts and brazing materials as well as appropriate constructions and wall thicknesses. They are ideally suited to withstand stresses from pressure, corrosion and temperature. Depending on the type of construction, the insulating tubes can be used in temperatures ranging from -271 °C to 450 °C and for internal pressures up to approx. 100 bar. Electrical insulators made of alumina F99.7 are used e.g. for four liquid argon based neutrino detectors ProtoDUNE installed at CERN (France) and the Short Baseline Far and Near Detectors installed at FERMILAB (Batavia/Chicago US).

MATERIAL PROPERTIES

Properties		Unit	Alumina (Al_2O_3) AO476O	Sapphire SA100	Silicon carbide SC140A
Content		%	96.0	99.99	-
Colour			white	transparent	black
Density		g/cm³	3.7	3.97	3.1
Mechanical characteristics					
Hardness (HV9.807N)		GPa	13.7	22.5	23
Flexural strength 3 P.B.		MPa	350	690	450
Young's modulus		GPa	320	470	430
Poisson's ratio			0.23	-	-
Thermal characteristics					
Coefficient of linear thermal expansion	40 - 400 °C	x 10^{-6}/K	7.2	7.0 (perpendicular C-plan)	3.7
	40 - 800 °C		7.9	-	-
Thermal conductivity 20 °C		W/(m*K)	24	41	180
Specific heat capacity		J/(g*K)	0.78	0.75	0.67
Electrical characteristics					
Dielectric strength		kV/mm	15	48	-
Volume resistivity	20 °C	Ω*cm	>10^{14}	>10^{14}	5.0x10^{8}
	300 °C		10^{10}	-	-
	500 °C		10^{8}	10^{11}	-
Dielectric constant (1 MHz)			9.4	9.3 (perpendicular C-plan)	-
Dielectric loss angle (1 MHz)		(× 10^{-4})	4	<1	

▸ Visit **www.kyocera-fineceramics.de** to find more information about characteristic values of alumina F99.7, alumina F99.7 hf, zirconia FZM and other materials.

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 (further subsidiaries in Europe)

About the KYOCERA Group

KYOCERA Europe GmbH is a company of the KYOCERA Corporation headquartered in Kyoto/ Japan, a world leader in 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.

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 a leading European supplier 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.

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

Our hearts beat completely for ceramics. Our team provides comprehensive advice on the selection of ceramic materials, product design and project execution – from the development stage to prototyping.
We supply system components for high-tech applications in numerous industries. Our products are characterised by high quality, precision and durability.

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.

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