# Mechanical Seal Ceramics

## Face seal rings · Valves · Bearings

CeramTec
THE CERAMIC EXPERTS

# High-performance ceramics for mechanical seals



With their outstanding material properties, pump, appliance, and machine components made from high-performance ceramics offer new solutions through manufacturing techniques at the cutting edge of technology. Ceramics set ultimate standards in terms of wear resistance and durability, most especially under heavy loads or exposure in corrosive environments and heat.

**Quality**

Our QS 9000 and ISO 9001 based systems operate to the latest standards of quality management. With the aid of proven processes and closely monitored production cycles we can supply volume production parts as per customer specification to the same precision standards as samples and prototypes.

NSF Certified
CeramTec AG
Plant Lauf
Material Rubalit® A 1896
Certified to ANSI/NSF 61 • Section 9 • NSF 61/9

DVGW

WRAS APPROVED PRODUCT

TÜV CERT

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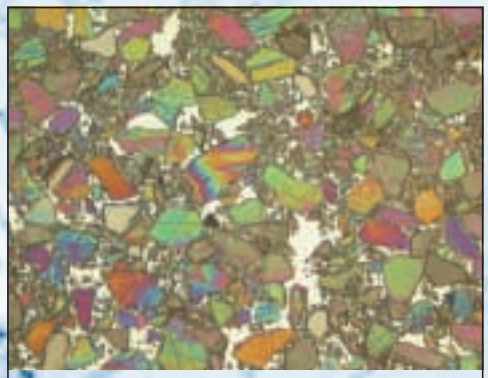
silicon carbide (page 6)



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# Dynamic sealing technology



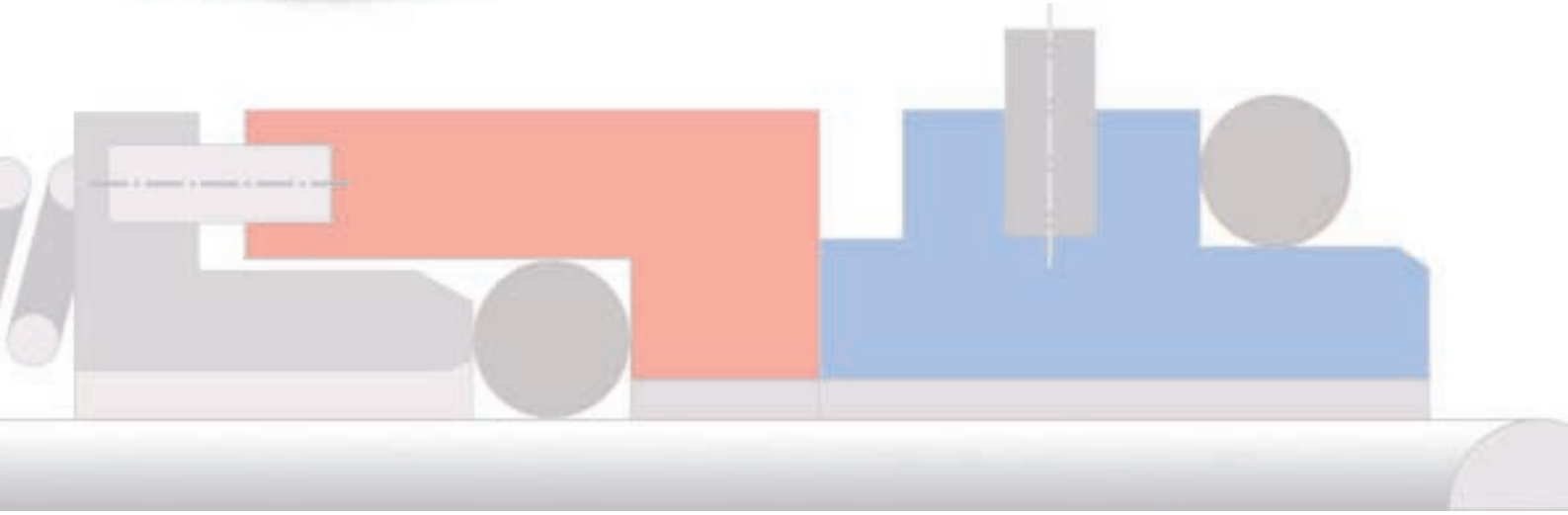
*Pump parts for household appliances*

When and wherever fluids are being pumped, it is the face seal rings and plain bearings that undergo the most punishment, particularly if the medium is corrosive or abrasive. In fact, the durability and profitability of many items of plant and equipment hinge largely on the wear and corrosion resistance of these parts. Materials engineering therefore plays a major role in the seal ring industry. Whereas 20 years ago, steel or gray cast rings were used for such purposes, nowadays it is high-performance ceramics that do the same job. With their outstanding material and application properties, such ceramic parts have a service life extending many times over, even in aggressive media.

The job of a face seal ring is to plug the gap between the housing and the rotating shaft so tightly that no liquid or gas may escape. This leakproof seal is achieved by means of a rotating sealing surface at the point of shaft entry. With their outstanding thermal conductivity, low heat expansion coefficient and high Young's modulus, high-performance ceramics minimize any deformation to the face seal or packing ring under mechanical and thermal loads. Alongside such resistance to corrosive media it is the tribological properties of the sealing system that figure predominantly in the selection of material. The important factor is whether or not the seal gap is lubricated by a fluid medium (be it liquid or gas). For this reason there is standard combination of materials. If there is lubrication in the system, ceramic to ceramic matings are possible. In other instances, one of the two components must possess lubricating properties. One well proven combination consists of ceramics to carbon graphite.

*Bearing combination in alumina*

By mating alumina and silicon carbide we are able tune the sliding and sealing properties exactly to the actual operating environment. Combined bearings in high-performance ceramics are remarkable for their lightness, stiffness, low centrifugal forces, function and dry-running properties. CeramTec AG engineers develop face seal rings and bearings ranging up to 900 mm in diameter.



# A superior substance: silicon carbide



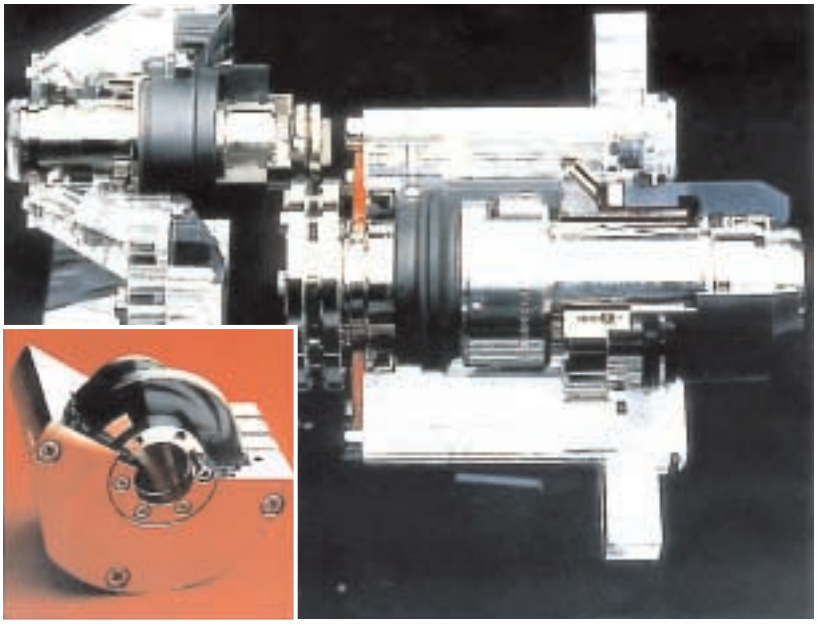
Possessing vast hardness and strength, good temperature, and excellent abrasion and corrosion resistance, silicon carbides are a very superior material, one that manifests its tribological superiority specifically under sliding conditions. Because of these properties, SiC face seal rings and plain bearings of various diameters are used for sealing purposes. Due to SiC's mechanical and chemical resistance, these bearings can be immersed in the conveying medium, which itself performs the lubricating function. In this way, hermetically sealed pumps are used for conveying abrasive and corrosive liquids.

For pumping viscous media (f.e. sludges), these themselves can act as lubricants, thus dispensing with the need for lubricants (as required by metallic bearings) since the SiC seal is able to resist the abrasive substances.

*Silicon face seal ring and bearing*

**Silicon carbide (SiC)**

Silicon carbides are among the non-oxide ceramics; they are remarkable for their extreme hardness and wear resistance, properties that make them ideal for use in pumps and pump systems. This hardness is due to the bonding of the silicon and carbon atoms, this close bond also being the reason for the high Young's modulus and low thermal expansion. Silicon carbide has good thermal conductivity combined with very low thermal expansion. Good chemical and thermal stability enable silicon carbides to work in aggressive media, at elevated temperatures, and while exposed to tribological stress.



*Ceramic face seal rings and bearings for pumps*

**Silicon infiltrated (SiSiC) and sintered silicon carbide (SSiC)**

SiSiC is a silicon infiltrated silicon carbide with a three-dimensional matrix, in which the remaining pores are infiltrated with metallic silicon. It is specifically this matrix structure that gives the material its excellent mechanical properties and wear resistance. As firing shrinkage is very slight, large and complex seal rings can be produced to close dimensional tolerance. However, due to the metallic silicon's melting point, working temperatures are limited to around 1400 °C. In highly alkaline environments, sintered silicon carbon (SSiC) is recommended since this stays stable in all chemical media. Unlike SiSiC, SSiC is pure silicon carbide and contains zero metallic silicon. However, the shrinkage that occurs may require the part to undergo machining in order to meet the specified tolerances.

# Materials Table



| | Units | Test Specification | Alumina | |
|---|---|---|---|---|
| **Material Characteristics** | | | | |
| Trade Name | | | **Rubalit® A 1896** | **Rubalit® A 1999,5** |
| Material | | | 94% $Al_2O_3$ | 99% $Al_2O_3$ |
| **General characteristics** | | | | |
| Bulk density | g/cm³ | DIN EN 623-2 | 3.71 | 3.88 |
| Water absorption | % | DIN EN 623-2 | 0 | 0 |
| Gas permeability | | | 0 | 0 |
| **Mechanical Properties** | | | | |
| Flexural strength<br>20 °C<br>1000 °C | MPa | <br>DIN EN 843-1<br>DIN EN 820-1 | <br>330 | <br>380 |
| Compressive strength | MPa | DIN 51067T1 | 3400 | 4000 |
| Young's modulus | GPa | DINV ENV 843-2 | 330 | 350 |
| Vickers hardness HV 0.5 | | DINV ENV 843-4 | 1520 | 1600 |
| Fracture toughness $K_{IC}$ | MPa $m^{1/2}$ | DIN 51109 | 4.0 | 4.0 |
| Weibull modulus | | DINV ENV 843-5 | > 10 | > 13 |
| Poisson's ratio | | DINV ENV 843-2 | 0.23 | 0.23 |
| **Thermal and Electrical Properties** | | | | |
| Thermal conductivity<br>20–100 °C<br>1000 °C | W/mK | DIN EN 821-2 | <br>24 | <br>30 |
| Linear thermal expansion coefficient<br>20–200 °C<br>20–400 °C<br>20–600 °C<br>20–1000 °C | $10^{-6}$ $K^{-1}$ | DIN EN 821-1 | <br>5.4<br>6.9<br>7.5<br>8.3 | <br>7.5<br>7.5<br>7.5<br>8.5 |
| Specific heat<br>$c_p$ 20–100 °C<br>$c_p$ 1000 °C | kJ/kgK | DINV ENV 821-3 | <br>0.9 | <br>0.9 |
| Resistivity<br>20 °C<br>400 °C<br>800 °C | Ω cm | IEC 672-1 | <br>> $10^{14}$<br>> $10^{11}$<br>> $10^{7}$ | <br>> $10^{15}$<br>> $10^{12}$<br>> $10^{7}$ |
| Dielectric strength | kV/mm | IEC 672-1 | 20 | 30 |
| Dielectric constant | | IEC 672-1 | 10 (10 MHz) | 10 (10 MHz) |
| Dielectric loss factor | | IEC 672-1 | $1 \cdot 10^{-3}$ (10 MHz) | $0.5 \cdot 10^{-3}$ (10 MHz) |
| Thermal shock resistance | °C | DINV ENV 820-3 | 150 | 150 |
| Maximum usage temperature<br>• in oxidizing atmosphere<br>• in reducing or inert atmosphere | °C | | <br>1450<br>1450 | <br>1400<br>1400 |

[1] *HV 0.2 1200 (Si) / 2700 (SiC)*

The measured properties given above were determined for test samples and are applicable as standard values.

| | Zircona | Silicon Carbide | | | | Silicon Nitride |
|---|---|---|---|---|---|---|
| **B 40** | **ZN 40** | **CD 101** | **Rocar® S** | **Rocar® SiG** | **Rocar® SiF** | **SL 200 ST** |
| 99% $Al_2O_3$ | $ZrO_2$-MgO | SiC-$ZrB_2$ | SSiC | SiSiC | SiSiC | $Si_3N_4$-$Y_2O_3$ |
| 3.82 | 5.74 | 3.26 | 3.15 | 3.07 | 3.07 | 3.21 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300 | 500 | 330 | 410 | 340<br>340 | 350<br>350 | 900 |
| 2000 | 1600 | 2000 | 3500 | 3500 | 3500 | 3000 |
| 360 | 210 | 415 | 430 | 380 | 395 | 305 |
| 1700 | 1240 | 2750 | 2300 | two-phase[1)] | two-phase[1)] | 1500 |
| 4.2 | 8.1 | 3.8 | 4.4 | 4.0 | 4.0 | 7.0 |
| 8 | 25 | 8 | > 10 | > 14 | > 14 | 15 |
| 0.23 | 0.30 | 0.16 | 0.17 | 0.17 | 0.17 | 0.26 |
| 28 | 3 | 100 | 115 | 115 | 120<br>40 | 21 |
| 7.2<br><br><br>8.7 | <br>10.2<br><br>11.0 | 3.5<br>3.5<br>4.5<br>4.5 | 3.0<br>3.6<br>4.1<br>4.6 | 3.4<br>4.1<br>4.4<br>4.9 | 3.8<br>4.3<br>4.5<br>4.9 | <br>3.2<br><br>4.3 |
| 0.9 | 0.4 | 0.6 | 0.6 | 0.7<br>1.3 | 0.7<br>1.3 | 0.7 |
| $1 \cdot 10^{14}$<br>$1 \cdot 10^{10}$ | $5 \cdot 10^{13}$<br>$5 \cdot 10^{5}$ | $3 \cdot 10^{4}$<br>$1 \cdot 10^{2}$ | $1 \cdot 10^{3}$<br>< 10 | < 1<br>$1 \cdot 10^{2}$ | < 1<br>$1 \cdot 10^{2}$ | $1 \cdot 10^{14}$ |
| 20 | | | | | | |
| 9 (10 MHz) | 27 (1 MHz) | 29 (1Mhz) | | | | 8 (1 MHz) |
| 6000 (9 GHz) | $2 \cdot 10^{-2}$ (9 GHz) | $2 \cdot 10^{-1}$ (9 GHz) | | | | $4 \cdot 10^{-3}$ (1 GHz) |
| 150 | | | | | | |
| 1400<br>1400 | 850<br>850 | 1400<br>1800 | 1500<br>1800 | 1350<br>1350 | 1350<br>1350 | 1300<br>1600 |

**Indexes and parameters for ceramic substances**
In order to profile ceramic substances certain parameters are indicated. The crystalline nature of these substances, statistical fluctuations in the composition of the substances and in the factors that impact on the production processes indicate that the figures quoted are typically mean values and hence the substance parameters quoted in this brochure are only standard, recommended or guide values that might differ given dissimilar dimensions and production processes.

**Rubalit® A 1896**

An outstanding alumina with low density, good corrosion and wear resistance, very good electrical insulation and outstanding sliding properties. A polishing process opens the pores on the sliding surfaces, enabling the material to absorb lubricants and solid particles, thus making it the ideal mate for carbon, glass-fiber reinforced plastic, and sintered metals.



**Rubalit® A 1999,5**

Mechanically stronger, with superior thermal conductivity and greater corrosion resistance. Ultrapure alumina, which when mated with carbon, is especially suitable for plain bearings and face seal rings.

**B 40**

The ideal sliding mate, with the same properties as Rubalit® A 1896. A larger share of $Al_2O_3$ for superior chemical stability.

**ZN 40**

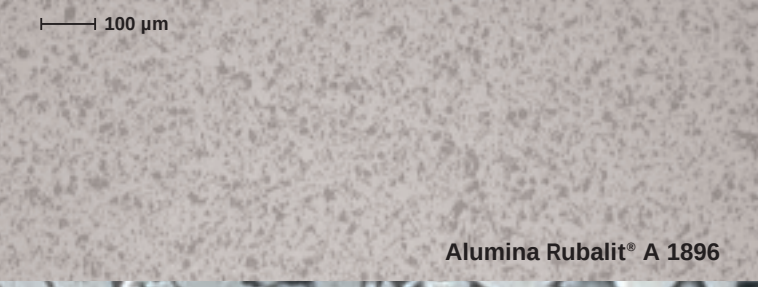
Zirconia is a ceramic with excellent surface quality and greater strength than alumina. The low Young's modulus and the high resistance in sliding/wear applications combined with steel-like thermal expansion make this material the ideal mate for steel in high-temperature bearing applications.

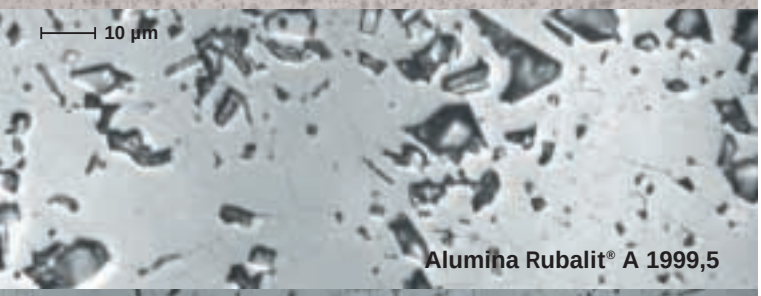
**Silicon carbide**

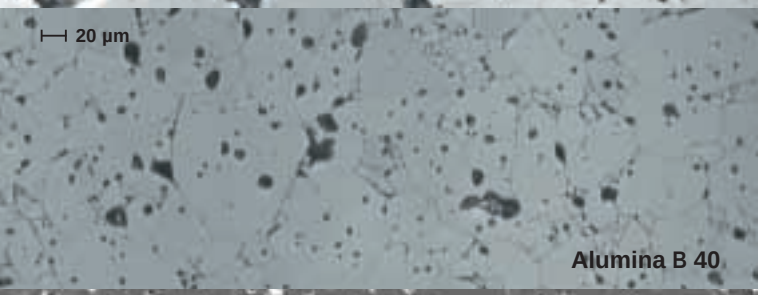
Extremely hard, with excellent corrosion and thermal shock resistance. Outstanding sliding properties and superior thermal conductivity make this the ideal tribological mate.

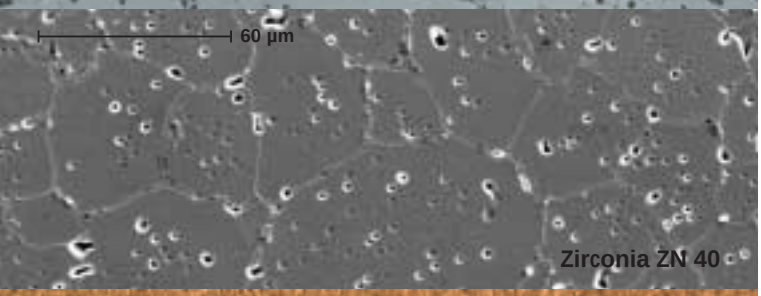
**SL 200 ST**

A silicon nitride ceramic for mechanically stressed parts as well as elevated temperature applications. Remarkable for its strength and mechanical resistance plus thermal shock insensitivity. In contrast to the other silicon nitride materials, this is a gas-pressure sintered $Si_3N_4$ and hence possesses much superior mechanical properties such as greater flexural strength, fracture toughness and a higher Weibull modulus.

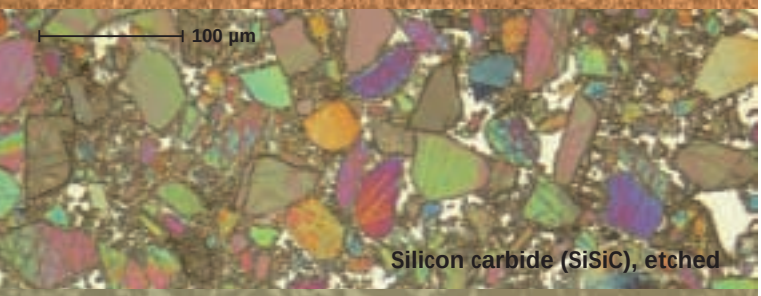

100 µm
Alumina Rubalit® A 1896

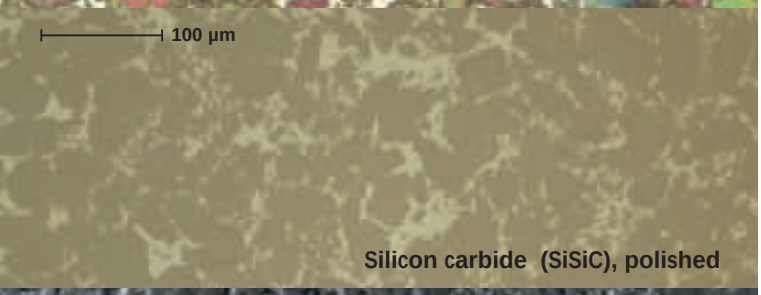

10 µm
Alumina Rubalit® A 1999,5

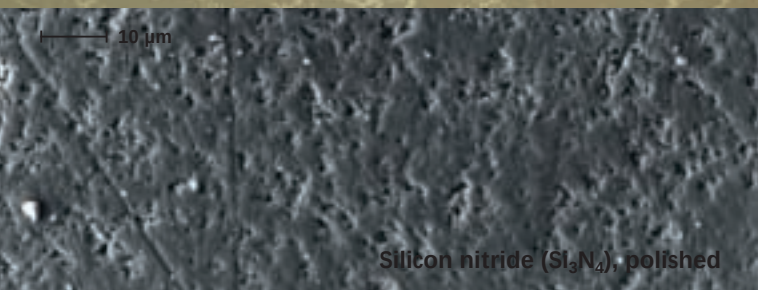

20 µm
Alumina B 40


60 µm
Zirconia ZN 40


100 µm
Silicon carbide (SSiC), etched


100 µm
Silicon carbide (SiSiC), etched


100 µm
Silicon carbide (SiSiC), polished


10 µm
Silicon nitride ($Si_3N_4$), polished

# High-performance ceramics for plant and appliances



With such specific hallmarks as

- wear resistance
- corrosion resistance
- thermal shock resistance
- temperature stability

high-performance ceramics are moving into more and more applications.

From household appliances to medical equipment to industrial plant, ceramics and components add value and generate benefits. We achieve best possible results in product and system generation by working closely with our customers and through intelligent ceramics engineering. In this way, manufacturing costs are minimized right from the beginning. Test samples and prototypes are produced at our own pilot plant where they are tested and developed until ready for series production.

# Consultancy and systems partnership



As part of our systems partnership approach, our experts are always available at your side. We advise you in the development of new products and technologies and in the constructive integration of ceramic parts and components. We decide the most suitable processes for making, samples, prototypes, batch and series production quantities. Our Project Management Team ensures efficient cooperation and a process driven system for maximum quality.

*We analyze and decide:*

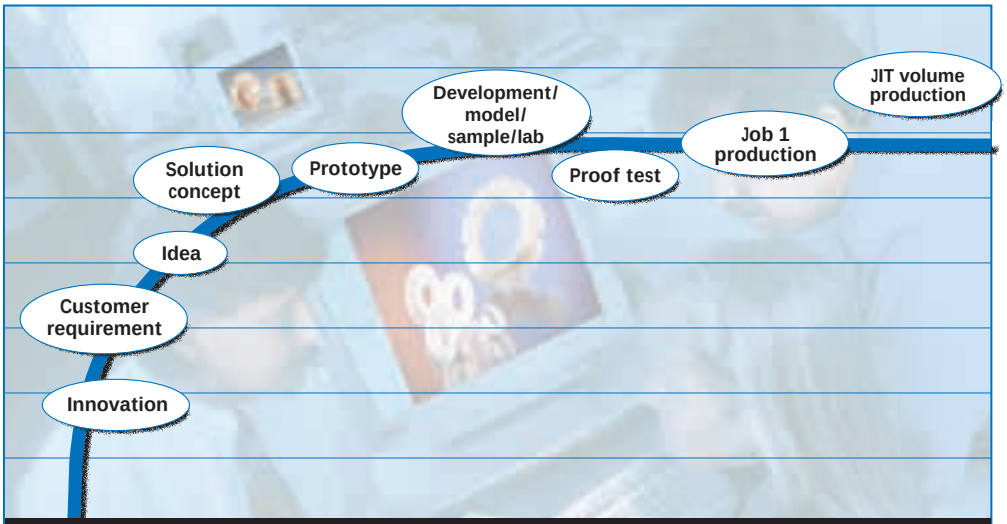
*CeramTec – the materials experts*

*We manufacture and refine:*

*CeramTec – the production experts*

*We advise and develop:*

*CeramTec – the development experts*




**Simultaneous engineering closes the time gap between idea and finished product**

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ST • 020 • GB • ~~1000~~ • 3070 • P&W • Printed in Germany

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