

Transparent Ceramics with Extraordinary Properties: a Material that Can Compete with Sapphire

Sapphire is the second hardest of all natural materials after diamond and is highly valued as sapphire glass for its scratch resistance and chemical stability.



Fig. 1
PERLUCOR transparent ceramics

But sapphire does have a major downside: the price. *CeramTec GmbH/DE* now presents a new material called PERLUCOR – an extremely durable and highly resistant transparent ceramic that is less expensive in its production than sapphire. This makes CeramTec the first European company to produce transparent ceramic on a series-production scale.

Keywords
transparent ceramics, sapphire, transparency, hardness, bending strength, thermal conductivity

Introduction

The requirements for PERLUCOR were clearly defined from the very beginning of this major project: The goal was to produce an advanced transparent material that can withstand the most extreme loads – whether chemical, mechanical, thermal or optical in nature – while also being more cost-effective than comparable materials. *Dr. Lars Schnetter*, Head of Research and Development at *CeramTec-ETEC*, a subsidiary of CeramTec, is responsible for the conceptual design, development and market launch of PERLUCOR. Intensive research and development work

enabled him and his experienced team to successfully transfer the advantages of ceramics to the world of transparent materials. The result is PERLUCOR, a highly pure ceramic material with a number of extraordinary mechanical, chemical, thermal and optical properties. “The development of PERLUCOR has allowed us to make a decisive step towards the future. Transparent ceramics are helping us venture into completely new dimensions for transparent solutions,” explains *Dr. Schnetter*.

High transparency and tremendous strength

Its high transparency grade of 80 % – which translates into a relative transparency of over 90 % – opens up fields of applications for PERLUCOR everywhere glass reaches its limits. Alongside its high transparency, PERLUCOR also offers convincing performance thanks to its tremendous strength and hardness, which are over three to four times that of glass. This makes it the ideal material for use in extreme wear conditions, for example as panes in blasting cabinets. Conventional glass panes can become completely opaque from the whirling, highly abrasive blasting media (garnet or corundum) after only a few blasting operations. With PERLUCOR, the operator keeps a clear view – even after many working hours.

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Fig. 2
Dental kiln:
inspection window made from PERLUCOR



Fig. 3
Blaster cabinet: conventional glass panes can become completely opaque from the whirling, highly abrasive blasting media after only a few blasting operations. With PERLUCOR, the operator keeps a clear view

This transparent ceramic from CeramTec can also be used as glass for watch faces or electronic devices as smartphones, which are otherwise very prone to scratching and cracking when worn on a daily basis. “There are almost no natural substances that can harm PERLUCOR. Thanks to the high level of hardness of this transparent ceramic it retains its use properties to a high degree when used as glass in watch or smartphone faces. This, combined with its extraordinary strength and very high break resistance, means that the face won’t easily crack if it is dropped,” explains Dr. Schnetter.

Temperature resistance and transparency in infrared applications

Not only the mechanical but also the thermal stability of PERLUCOR is exceptional. This transparent ceramic features a melting temperature with a factor up to three times that of glass, enabling it to be used at temperatures of up to 1600 °C, e.g. as an inspection window in high-temperature furnaces. Since the actual melting point is higher (over 2000 °C), there is a high margin of safety available for use in all types of high-temperature applications.

With its high level of transparency – even with wavelengths of over six micrometers – PERLUCOR opens up entirely new areas of application. For example, this transparent ceramic from CeramTec is ideal for

windows in infrared applications such as for pyrometer protection. In general, PERLUCOR is suitable for use in all types of infrared sensors.

Chemical resistance

Due to its purity and binding strength, PERLUCOR also exhibits unusually high chemical resistance. This transparent ceramic is resistant to both acids and bases and can be used as a process window in chemical processing equipment and measuring instruments even with high concentrations. Thus it is also possible to use PERLUCOR in applications to avoid product contamination. Even applications in

sulfuric acid, hydrochloric acid, hydrofluoric acid, phosphoric acid, potassium hydroxide or sodium hydroxide are possible.

Weight savings of up to 50 %

Developed for a new generation of bullet-proof glass systems, it is also possible to reduce weights and thicknesses by up to 50 % with PERLUCOR compared to conventional systems. CeramTec envisions numerous areas of application based on the material’s unique property profile, such as in the field of vehicle protection. Dr. Schnetter: “The protective properties of glass can be taken to a whole new level through the use of PERLUCOR”.

Tab. 1
PERLUCOR properties – high index of refraction and optical grade

Property	Glass	Glass Ceramics	Single Crystal	PERLUCOR
Transparency [%]	>95	90	>85	>85
Thermal conductivity [W/m · K]	1–2	1–2	15	15
Melting temperature [°C]	500–700	600–800	1800–2200	1800–2200
Hardness [GPa]	3–6	4–7	12	14
Bending strength [MPa]	20–40	40–60	150–200	150–250
Youngs modulus [GPa]	70	90	280	280
Ultrasonic velocity [Hz]	5000	5000	10 000	10 000



Fig. 4
Container with viewport: PERLUCOR as an inspection window for extremely corrosive media



Fig. 5
Thermostate: use of PERLUCOR in measurement and control technology

High refractive index and custom production

The high index of refraction (1,72) makes it possible to miniaturize optical lenses and other optical elements. This means that small part sizes can be used to realize magnifying effects that would be extremely difficult to achieve on the basis of polymers or glasses.

PERLUCOR's standard size is 90 mm x 90 mm. However, this format also enables CeramTec to design customized contours based on customer specifications. The

panel thickness of PERLUCOR can be precisely and individually tailored to a tenth of a millimeter and is generally between two and ten millimeters. PERLUCOR molds can be combined into multi-tile composites to create larger surfaces. Ceramics and adhesives have the same index of refraction, allowing the joint edges to be joined together using a special adhesive process developed by CeramTec that makes the joints and abutting edges virtually invisible, thereby creating a uniform, transparent surface.

Technische Keramische Werkstoffe

(Hrsg. Prof. J. Kriegesmann)

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