The demonstration system »CoShape« represents a metal/ceramic composite component showing a solution for co-shaping and co-sintering processes for multi-functional components. For this demonstration system steel powder and zirconia powder were selected as they have similar sintering temperatures and similar linear thermal expansion coefficients. Additionally, they offer interesting chances to combine different properties of individual sintered partners in one joint component: hard and ductile, heat conducting and insulating, electrically conducting and insulating as well as magnetic and non-magnetic. For the manufacturing of composites two main requirements have to be met: On the one hand, both material partners have to homogeneously develop their microstructure in the sintering process, and on the other, adhesion between the joining partners has to be ensured. In order to guarantee the same shrinkage behavior, the packing densities of the individual materials have to be adapted to each other in the shaping process. The simulation of shrinking processes and the resulting stresses helps to choose the appropriate parameters. Thermo-optical measurement methods (demonstration system »TOMMI«) can be used to evaluate the development of the material compound in complex-shaped components. By using multi-component injection molding not only the geometry of the component can be variably designed, but also its interface. This attractive technology is presently in the focus of different joint projects with industrial manufacturers and users.

»CoShape« is one of six projects within the Fraunhofer Demonstration Center »AdvanCer« (system solutions with advanced ceramics) that have already been completed.
Survey

Strength and wear tests for ceramic components

Due to their excellent mechanical and thermal properties it is hard to imagine high-temperature and wear applications without ceramic materials. Ceramic components usually cannot be designed like metallic components due to their properties. Therefore, the following article refers to the dimensioning of components that are subject to cyclic loading. Additionally, friction and wear tests for ceramic components are focused.

Determination of fatigue strength

The determination of fatigue strength is based on cyclic parameters which correctly describe the local supportable stress amplitude in critical regions of the component. If these parameters are not known for ceramics, they are often experimentally determined by four-point bending tests. A multi-axial stress situation in the component has to be transformed into an equivalent state with regard to the test data. For ceramic materials the use of the maximum principal stress criterion is recommended. If critical regions are to be evaluated with an increased stress concentration, appropriate parameters have to be used. From the test results a stress-number curve (S-N curve), also known as Wöhler curve, can be derived. This curve shows the local supportable stress amplitudes and the number of cycles to failure with a probability of survival $P_s = 50\%$. For a demanded survival probability, a Wöhler curve must be derived taking into account the scattering of the data caused by the material, by the manufacturing process, and by the service loading. The strength of a component is evaluated by comparing the local stresses obtained by finite-element calculations with the allow-able stresses. Figure 1 shows a Wöhler curve for $\text{Si}_3\text{N}_4$ which was obtained at ambient conditions under cyclic four-point bending. Many ceramic materials are characterized by a very low slope of the Wöhler curve ($k = 85$) as compared to metallic materials. Ceramic materials are not appropriate to operating loads with variable amplitudes which could exceed partly a critical upper value. If the maximum of the operating load is below this value failure is not expected.

Ceramic materials for wear protection

Wear-resistant ceramic materials are typically used for plain and roller bearings, rotating mechanical seals or cutting tools. For new applications, such as forming tools, ceramic materials have to be first qualified and then optimized, if required. From the viewpoint of a tribology expert, who mainly considers the aspects of friction and wear, each application represents a new "tribological system" subjected to various loads whose effects are not known. In this case, experimental and numerical methods are used to reproduce the real application conditions in a simplified manner. It is important to create test conditions in such a way behavior that the wear corresponds to the expected wear mechanisms of the application. The pin-on-disk method at room temperature, for example, is less representative for ceramics under lubrication (mechanical seal in a pump) or at high temperatures (tools for thermoforming of metals or glasses). Nevertheless, this method is remarkably variable. By adjusting at least the solid/solid contact partners, the environmental conditions or the lubricants (if required) as well as the contact forces and the sliding velocity, application-relevant friction and wear parameters can be determined. Additionally, comparative experiments can be used to analyze the potential for improvement when using the appropriate material combination. Thus, time-consuming experiments in test stands or real applications can be avoided. Finally, application-oriented tests have to be used to determine life time or reliability of ceramic components subjected to wear. In this stage it is decided, whether and which ceramic material can be used for specific applications. The application behavior of ceramic components can be improved by:

- Improvement of mechanical, thermal and chemical properties of the material
- Suitable selection of material combinations
- Surface structuring and increase of surface strength
News

»AdvanCer« in Hannover

»AdvanCer« once again presents its numerous highlights at this years Hannover Messe taking place from April 21 till 25. In addition to a test stand for ceramic rolls as well as results for fatigue strength tests and in-situ measurements under controlled atmosphere, »AdvanCer« introduces »CerGear«, a new demonstration system. This system illustrates how bearing capacity and fatigue strength of gears can be increased by shot peening. Another highlight is the computed tomography »CT-Compact« which allows one to detect possible defects in green bodies. Thus, the formation of cracks, pores, weld lines and cavities can be avoided early by adjusting the process parameters.

300 Years of European Porcelain

On the 15th of January 1708 Johann Friedrich Böttger successfully accomplished the first test firing of white porcelain in the Dresden casemates of the Jungfern bastei – the European porcelain was born. Since 1707 Böttger had tried to manufacture white porcelain in collaboration with Ehrenfried Walter von Tschirnhaus, Gottfried Pabst von Ohain as well as miners and steelworkers from Freiberg. After his success Böttger perfected his experiments and moved to Meißen where the first European porcelain factory was opened in 1710. Since the end of last year, Dresden casemates of the Jungfern bastei – the European porcelain was born. Since 1707 Böttger had tried to manufacture white porcelain in collaboration with Ehrenfried Walter von Tschirnhaus, Gottfried Pabst von Ohain as well as miners and steelworkers from Freiberg. After his success Böttger perfected his experiments and moved to Meißen where the first European porcelain factory was opened in 1710. Since the end of last year, Dresden casemates of the Jungfern bastei – the European porcelain was born. Since 1707 Böttger had tried to manufacture white porcelain in collaboration with Ehrenfried Walter von Tschirnhaus, Gottfried Pabst von Ohain as well as miners and steelworkers from Freiberg. After his success Böttger perfected his experiments and moved to Meißen where the first European porcelain factory was opened in 1710. Since the end of last year, Dresden casemates of the Jungfern bastei – the European porcelain was born. Since 1707 Böttger had tried to manufacture white porcelain in collaboration with Ehrenfried Walter von Tschirnhaus, Gottfried Pabst von Ohain as well as miners and steelworkers from Freiberg. After his success Böttger perfected his experiments and moved to Meißen where the first

Festive Colloquium for Professor Waldemar Hermel

As recognition for his research in the field of advanced ceramics, Fraunhofer IKTS held a honorary colloquium for Professor Waldemar Hermel within the framework of the conference »Ceramics Vision 2008« and celebrated his 70th birthday. Dr. Udo Gerlach, former deputy director of Fraunhofer IKTS, gave a speech honoring the achievements of Professor Hermel. Numerous scientific awards and honors, such as Heinrich-Hertz-Award, Skapuy Award or Seger badge, reflect his international reputation. For his efforts in and for the Fraunhofer-Gesellschaft he was awarded the Fraunhofer medal, the highest honor of FhG. As founding director and first director he significantly contributed to today’s success of Fraunhofer IKTS.

Current Training Courses

»AdvanCer« continuous its training courses »Advanced Ceramic Materials for Technicians and Engineers«. The three training parts on offer are meant to be taken consecutively, but they can also be taken individually. Dates and locations are as follows:

- Part 1: Machining of advanced ceramics. May 6 and 7, 2008 in Berlin
- Part 2: Machining of advanced ceramics. May 6 and 7, 2008 in Berlin
- Part 3: Construction, materials testing, quality assurance and application behavior. November 13 and 14, 2008 in Freiburg

For further information please see www.advanCer.fraunhofer.de

Furthermore, the following advanced training courses of the German Ceramic Society (DKG) will take place at Fraunhofer IKTS in Dresden:

- April 24 and 25, 2008 »Technology fundamentals of granulation and granulate processing«
- September 10 to 12, 2008 »Spray drying of ceramic suspensions – Technology and statistical test planning«
- October 8 and 9, 2008 »Thermoplastic shaping of advanced ceramics – Technology and training«

For further information please see www.dkg.de

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Foundation of the Expert Group on Ceramic Injection Molding

Ceramic injection molding (CIM) provides various possibilities for designing sustainable products and system solutions. It combines the almost unlimited possibilities of plastic molding with the excellent properties of ceramic materials. The expert group is a technical working group supported by the German Ceramic Society (DKG). It consists of industrial companies and research institutes which apply ceramic injection molding and cover the in-house process chain injection molding, binder removal and sintering. The expert group has the objective to further develop this innovative process chain. Its members and the DKG contribute to create a common brand of ceramic injection molding in Germany and Europe, and to develop a strong position in global competition with regard to materials, technologies and markets.

Junior Doctor

Having a doctorate before leaving school? The event »Junior Doctor« was initiated within the framework of »Dresden – City of Science 2006« and has become very popular. 400 students from form 3 to 12 visit different institutions working in the field of science, medicine, economy and art, and demonstrate their newly acquired knowledge. In January 2008 Fraunhofer IKTS invited 30 students to visit Ceramics Meeting Point and to get to know interesting facts about advanced ceramics. Due to the very positive response Fraunhofer IKTS will once again participate on April 29th.

For further information please see www.advanCer.fraunhofer.de
Success Stories

Ceramic-reinforced tools for sheet metal forming

In sheet metal forming tools are usually subjected to high stresses. During the forming of high-strength and high-alloy steels, particularly, tool wear occurs very early resulting in a loss of productivity due to maintenance services. P.C. Turck is one of the first companies worldwide that encounters this problem by using ceramic-reinforced tools. The use of advanced ceramics (silicon nitride, zircon oxide) in tool regions subjected to high loadings significantly reduces the wear rate. The real challenge is to realize the geometric complexity of the tools. Two requirements have to be met: On the one hand, the tools have to be designed according to the properties of the steel/ceramic compound, and on the other, the tool inserts have to be produced efficiently and in high quality. Thus, P.C. Turck collaborates with research institutes (IFUM Hannover, Fraunhofer IPT) and industrial companies. The consistent application of FE methods for tool design and the use of optimized finishing methods only allow the successful production of ceramic-reinforced tools. For decades, P.C. Turck has been one of the significant manufacturers and suppliers of components for automotive system engineering and high-quality consumer-goods. The company’s product range includes chassis and steering systems, shock-absorbers and gear change systems. Punching and extraction of sheets made of steel, stainless steel, aluminum and other non-ferrous metals are the core competencies of P.C. Turck. Therefore, P.C. Turck uses different punching machines (40-250 t) as well as eccentric and hydraulic presses (5-160 t). The own tool design and construction department develops and manufactures the related punching and forming tools.

From sheet metal forming to medical engineering: New applications for advanced ceramics

When DOCERAM® GmbH introduced its centering and locating pins for automated welding applications five years ago, there were many doubts about the usability of the pins made of Cerasur®, a impact-resistant advanced ceramic material: Does a material that is thought to be brittle resist the extreme mechanical and thermal stresses to which it is subjected during the welding process? However, the users became convinced of the «tailored» material, and today, many automotive manufacturers and suppliers use locating and centering pins as well as complete electrodes of DOCERAM® GmbH in their welding lines. These components are immediately visible as they are azure blue. They have a life time that is often 25 to 30 times higher than that of conventional hard metal pins.

Centering and locating pins of Cerasur®

Centering and locating pins of Cerasur® are only one product group of DOCE-