The name »Advancer« conveys a sense of foresight, progress and benefit. Ceramics manufacturers and users find in it their »Advanced Ceramics« – materials holding great promise for the future. »Advancer« presents innovative applications for high-performance ceramics: systems solutions with »Ceramics inside« for today and tomorrow.

After establishing its main location in Dresden, »Advancer« has branches at all other participating Institute locations now. In November 2004 the Aachen location at the Fraunhofer Institute for Production Technology (IPT) was inaugurated. Now visitors to Fraunhofer IPT in Aachen can also visit the demo center to find out about »Advancer«’s service offerings.

On June 2-3, 2005 the »Advancer« demo center will be opened to the public for the first time in conjunction with the Aachen Machine Tool Colloquium (AWK’05), this year’s theme being »Production Engineering as a Competitive Edge – The Aachen Approach.« Renowned experts from manufacturing firms and scientists from Fraunhofer IPT, the Laboratory for Machine Tools and Production Engineering (WZL) at RWTH Aachen and the German Academic Society for Production Engineering (WGP) will make presentations on new concepts for successful product development/production and corporate strategies.

Tradition and history alongside youthful exuberance in the university city of Aachen.

Fraunhofer Institute for Production Technology (IPT) Aachen

The »Advancer« project management team visiting the new demo center at Fraunhofer IPT.
Featured overview:
Fine finishing of high-performance ceramics (Part 2)

Industrial processes for fine finishing technical ceramics, e.g. classic grinding, lapping and polishing exhibit relatively low material removal rates and limited capabilities with respect to possible part geometries. The costs of hard machining can reach 80 percent of the total costs of producing a functional ceramic part. Given this scenario, innovative solutions for improving productivity in ceramic finishing processes are urgently needed. New technologies that can improve or replace classic hard machining processes are hence the focus of current efforts of the »AdvanCer« team. In the 2/04 edition of our newsletter, we introduced a series of innovative hard machining processes, including abrasive-flow machining and surface grinding with planetary heads. In Part 2 of our overview on fine finishing of high-performance ceramics, we present some other interesting technologies.

Ultrasonic lapping
In the process of ultrasonic lapping, high-frequency vibrational energy is transferred from the tool to the workpiece surface via loose hard particles. This induces controlled microscopic cracking, which ultimately leads to brittle material removal. This process is thus ideal for materials with brittle fracture behavior, i.e. high-performance ceramics as well as glass and graphite. Replication ultrasonic lapping (ultrasonic molding) is frequently used; in this process, the mold assumes the negative shape of the workpiece to be produced. With this process, recesses with diameters of less than 1 mm can be produced. In addition, ultrasonic lapping can be performed on substrates with thicknesses of less than 200 µm. Depending on the specific high-performance ceramic material used, the machining rate can reach 150 mm³/min. The best results are achieved for materials such as alumina, i.e. brittle materials with relatively low KIC values.

ELID grinding
ELID (»electrolytic in-process dressing«) grinding makes use of a conventional grinding machine in which a so-called ELID system is integrated. An ELID system consists of a tool, a generator and an electrolyte that additionally serves as a coolant and a lubricant. The grinding wheel is continuously sharpened during the grinding process. This enables, for instance, grinding tools with metallic binders and ultrafine grains (less than 3 µm in diameter) to be used without relinquishing process stability or reproducibility. Surface roughness levels of less than 10 nm can be attained without the need for expensive and time-consuming polishing processes. Sharpening of the grinding wheel is achieved via an electrolytic process in which a copper electrode is positioned at a specific distance away from the workpiece. The electrically conductive coolant-lubricant emulsion acts as an electrolyte. The tool's metallic binder oxidizes and breaks away from the tool immediately on contact with the hard workpiece. Without this integrated sharpening process, the small chip space would fill up quickly with removed particles and the wheel would become blunted.

ELID systems are currently employed in the direct production of optical components on glass. However, they can also be used for hard machining of technical ceramic parts with complex geometries and high dimensional and shape accuracy requirements.

Laser-assisted machining
Materials with strengths that decrease with increasing temperature are suitable for laser-assisted machining. The laser introduces heat into the material and warms it. This has the effect of reducing the deformation resistance and hence decreasing the strength of the material in the machining zone. Through use of laser-assisted machining, the process boundaries for machining of technical ceramics can be greatly expanded. Functional components made of silicon nitride could previously only be shaped via grinding; laser-assisted machining with cutting edges having predefined geometries enables these parts to be produced in a wider range of shapes and without the need for a coolant.

The relatively short times required for tool exchange and maintenance enable individual prototype parts as well as small and medium-sized batches to be produced economically using this technology. In addition, the variety of machining tools that can be used enable generation of complex contour and geometry elements with high dimensional and shape accuracies. With an optimally designed process, Ra surface roughness values of 0.3 µm and machining rates of up to 12 mm³/s can be achieved. The laser-assisted turning variant can be used to produce rotating parts, e.g., ceramic rollers, valves and roller bearing components, with grinding-level surface qualities (see figure). Laser-assisted milling technology could potentially widen this range of machinable components. Fraunhofer IPT is currently evaluating this process within the framework of »AdvanCer« to determine its suitability for the use in the production of ceramic tool inserts for highly stressed forming tools.
Ceramics represents a core competency at combination of functional and structural properties ranging from cutting knives to chemical resistance. Young's modulus and good high-temperature performance make ceramic components with integrated heaters and understanding of sintering processes. The highlight of »AdvanCer« presentation at HANNOVER MESSE 2005 will be TOMMI, whose successful career began at CERAMITEC 2003. The compact thermooptical measurement system was developed at Fraunhofer ISC especially for process and structural optimization in ceramic workpieces in order to gain better control and understanding of sintering processes.

TOMMI can be used to control sintering or melting processes at temperatures up to 1750°C. The advantages: maintenance-free optical measurement method, 2D contour mapping and software-assisted image analysis with simultaneous measurement of up to 20 different parameters. Further highlights of the »AdvanCer« trade show presentation will include ceramic rollers as a tool module, a freeform reflector and magnetically driven shaped parts made of ceramic-metal composites. A numerical simulation will demonstrate fatigue-resistant design of ceramic components. Ceramic components with integrated heaters will also be shown. Through combination of the favorable properties of high-performance ceramics – high hardness, high Young's modulus and good high-temperature strength – and extended functionalities, a number of interesting new applications ranging from cutting knives to chemical reactors have arisen.

Prof. Dr. Alexander Michaelis, director of Fraunhofer IKTS and spokesperson for the Thematic Group on High-Performance Ceramics, contributed the following: »The combination of functional and structural ceramics represents a core competency at the Fraunhofer IKTS. Thus, for instance, heating conductor structures can be applied on structural ceramics with diverse geometries. Integration of functions into structural ceramics creates considerable added value. At IKTS, we are at home in both the structural and functional ceramics worlds. We can successfully combine materials and production technologies to open up new application areas.« Visit us at HANNOVER MESSE on April 11-15, 2005! »AdvanCer« will be in Hall 5 at Stand F44 (joint stand with TASK-Ceramics Meeting Point). Additional ceramics applications will be presented at the Fraunhofer Energy stand (Stand 58-07 in Hall 13) and the Fraunhofer Adaptronics stand (Stand E30 in Hall 2).

News:

Successful start to »AdvanCer« training series
»AdvanCer«'s first training seminar was held at Fraunhofer IKTS on March 15-16, 2005. More than 20 participants from industry found the first event (Block 1: Manufacture, Properties, Applications) to be very rewarding. According to Dr. B. Springmann from Linn High Therm GmbH, »The High-Performance Ceramic Materials seminar was informative, practically oriented and very well organized.« A tour of the »AdvanCer« demo center, displaying in part astounding applications for ceramics, rounded of the event. We would like to take this opportunity to thank the organizers and presenters for a job well done!«

Keen participants and interesting discussions at »AdvanCer«'s first seminar.

The training blocks offered by »AdvanCer« build on each other but can also be taken alone. Block 2 (Machining of Ceramics) is scheduled for June 21-22, 2005 in Aachen, Block 3 (Systems Integration, Quality Assurance, Materials Testing) is scheduled for September 27-28, 2005 in Freiburg. By popular request, we will be repeating Block 1 (starting in autumn 2005).

At the annual meeting of the Deutsche Gesellschaft für Materialkunde e.V. (DGM) at the end of 2004, Prof. Hermann Riedel, head of the Materials-Based Process and Component Simulation business unit at Fraunhofer IWM, was awarded the Tamman-Gedenkmünze. This commemorative coin, awarded once a year by DGM (the German society for materials science) honors the lifetime achievements of the physical chemist Gustav Tammann (1861-1938). With the simulation models developed over the last decade under the leadership of Prof. Riedel, the PM manufacturing process for ceramic components can now be quantified and thereby optimized.

»AdvanCer«'s main location to be City of Science 2006

On March 15, 2005 the jury of the Stifterverband für die Deutsche Wissenschaft (Donors’ Association for German Science) in Bremen decided to allow Dresden to carry the title of »City of Science 2006« next year. The Saxony capital city emerged as the winner in a head-to-head race against Magdeburg and Tübingen. According to Jury Chairman Joachim Treusch, the arguments in favor of Dresden were »the particularly strong connections between the business and scientific communities and the public« and »its European character.« »AdvanCer« is pleased to be able to organize numerous activities in conjunction with the awarding of this title to Dresden. During the »Long Night of Science« on July 1-2, 2005 in Dresden, the public will get the chance to see how entertaining science can be. We hope to see you there!

Dresden Mayor Ingolf Roßberg (left), TU Chancellor Alfred Post and Stadtentwasserung Dresden CEO Gundla Rößel accepting the 125,000-Euro prize from Association President Dr. Arend Oetker (right).
Success stories: Ceramics innovations for high-temperature applications

Together with CRYSTAR® (RSiC), SILIT® (SiSiC) and HEXOLLOY® (SSiC), ADVANCER®, the refractory material made of silicon carbide with a silicon nitride binder (NSiC) and patented by Saint-Gobain Industrie-Keramik GmbH, is one of the company’s most successful materials. The company has been producing ADVANCER® at its Rödental location for several years. Components made from this material are shaped using the ceramic slip casting process (solid or hollow casts). Solid parts such as plates or hollow objects, nozzles, beams, supports, pipes and other complex parts can be produced. Nearly every component is designed and produced according to the requirements of customers’ processes. After being shaped and dried, parts are fired in a nitrogen atmosphere at ca. 1400°C. Formation of Si₃N₄ bridges between the SiC grains results in strengthening and actual formation of the material. Unlike most other ceramic materials, ADVANCER® exhibits no shrinkage during production. Hence, tight geometric tolerances can be maintained without the need for mechanical postmachining – even for very large parts. As individual parts, parts in large quantities or combined structures, components made of ADVANCER® are found in a wide range of applications: as kiln shelves for firing porcelain tableware and sanitary ware, as supports and beams for firing high-voltage insulators, as ceramic honeycomb catalyst supports and diesel particulate filters and as roller conveyors and burner nozzles in fast-firing furnaces in the technical and structural ceramics industries and in processes occurring at high temperatures or in corrosive environments.

High-performance ceramics in corrosive and abrasive environments

FRIALIT*-DEGUSSIT® is a ceramic material that has been used successfully in industry for decades. Wear and corrosion, the main factors limiting the lifetime of equipment and machines, can be successfully minimized in numerous applications through the use of FRIALIT*-DEGUSSIT®. Continuous developments made in the production technology have now made it possible to produce large parts made of high-purity oxide ceramics. Apart from the sintering technology, the process of cold-isostatic densification was optimized to minimize density gradients in the component. The more uniform shrinkage during the sintering process is associated with a lower probability of crack formation. This improved technology is particularly interesting for structural machine parts in direct contact with corrosive and abrasive media. These conditions are often found in high-pressure pumps. Products such as pistons, plungers, plain bearings, stirrers and strips can be used successfully; FRIATEC AG makes these products with maximum diameters of 200 mm and lengths of up to 1200 mm. Even for such large parts, in-house grinding achieves high accuracies and excellent surface qualities. These large parts made of FRIALIT*-DEGUSSIT® are used as dielectric materials in fuel cells, as crucibles and as high-temperature components and components for piezolinear motors as well as in oil production, the petrochemical and water treatment industries, hydroelectric plants and steel mills.

Publication information

- Newsletter of the Fraunhofer Alliance for High-performance Ceramics
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