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101st DKG Annual Meeting

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Grußwort des Programmausschuss

Sehr geehrte Damen und Herren,
liebe Mitglieder und Gäste der Deutschen Keramischen Gesellschaft,

wir heißen Sie herzlich willkommen zur KERAMIK 2026, der 101. Jahrestagung der Deutschen Keramischen Gesellschaft (DKG), in Augsburg – einer Stadt, die für ihre Verbindung von Tradition und Innovation steht.

Es ist eine besondere Freude, dass diese Tagung in enger Zusammenarbeit mit dem Lehrstuhl für Materials Engineering mit Schwerpunkt auf keramischen Faserverbundwerkstoffen am Institut für Materials Resource Management sowie der Forschungsgruppe THA-comp „Composites for Lightweight Structures" der Technischen Hochschule Augsburg stattfindet. Beide Einrichtungen stehen für exzellente Forschung und praxisnahe Entwicklung im Bereich moderner Hochleistungswerkstoffe.

Ein besonderer Gruß gilt dem diesjährigen Gastland Großbritannien. Die britische Keramikforschung und -industrie haben über Jahrzehnte bedeutende Beiträge zur internationalen Entwicklung geleistet. Der Austausch mit unseren britischen Kolleginnen und Kollegen bereichert die Tagung fachlich wie kulturell und stärkt die europäische Zusammenarbeit in der Werkstoffwissenschaft.

Wir danken allen Organisatorinnen und Organisatoren, Vortragenden und Teilnehmenden für ihr Engagement und wünschen Ihnen eine erkenntnisreiche, inspirierende und erfolgreiche Tagung.

Mit freundlichen Grüßen

Im Namen des Programmausschusses

Prof. Dr.
Dietmar Koch
Universität Augsburg

UNIVERSITÄT AUGSBURG

Prof. Dr.
Ralf Goller
Technische Hochschule Augsburg

Technische Hochschule Augsburg

Dr.
Martin Christ
VM&P GmbH

VM&P Virtual Materials & Processes GmbH

Greeting by the Program Committee

Dear ladies and gentlemen,
Dear members and guests of the German Ceramic Society,

We warmly welcome you to KERAMIK 2026, the 101st Annual Conference of the German Ceramic Society (DKG), in Augsburg – a city that stands for its combination of tradition and innovation.

It is a particular pleasure that this conference is being held in close cooperation with the Chair of Materials Engineering with a focus on ceramic fibre composites at the Institute for Materials Resource Management and the THA-comp "Composites for Lightweight Structures" research group at the Technical University of Augsburg. Both institutions stand for excellent research and practical development in the field of modern high-performance materials.

A special welcome goes to this year's guest country, Great Britain.
British ceramics research and industry have made significant contributions to international development over decades. The exchange with our British colleagues enriches the conference both professionally and culturally and strengthens European cooperation in materials science.

We would like to thank all the organisers, speakers, and participants for their commitment and wish you an informative, inspiring, and successful conference.

With kind regards,

On behalf of the Programme Committee

Prof. Dr.
Dietmar Koch
Universität Augsburg

Prof. Dr.
Ralf Goller
Technische Hochschule Augsburg

Dr.
Martin Christ
VM&P GmbH

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Augsburg

LECTURES

Fast firing rebooted: the remarkable acceleration of sintering through ultra-rapid heating

TODD, Richard Prof. Dr.

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Plenary speaker I
Prof. Dr. Richard Todd

Organization/Company
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Sintering has been a slow process for most of its history, requiring furnace cycles of hours or even days. A reduction in sintering time to several minutes was achieved in the second half of the 20th century by "fast firing" using short heating and cooling cycles but recently, densification in only a few seconds has been demonstrated using very rapid heating methods such as flash sintering and ultra-fast high temperature sintering (UHS). In this work, detailed analysis of the densification of alumina with different heating rates shows that the sintering rate at a given temperature and density is accelerated by ultra-rapid heating. This is partly accounted for by microstructural refinement but there remains an additional increase in sintering rate at a given temperature and density of up to a factor of 20, suggesting an increase in the diffusion rate. This conclusion is directly confirmed here by adding particles of chromia to alumina green bodies as a diffusion tracer. The results demonstrate an acceleration of diffusion in the early stages of rapid heating correlating well with the sintering results. It is suggested that this acceleration of diffusion is a consequence of the formation of nonequilibrium grain boundary structures in the early stages of sintering. Independent evidence for these effects is reviewed.

Fiber-Reinforced Composites for Next-Generation Fusion and Fission Reactors: Advances and Opportunities

SCHMIDT, Johanna Dr.

Head of R&D Composites Entwicklung, Schunk Kohlenstofftechnik GmbH, Deutschland

Plenary speaker II
Dr. Johanna Schmidt

Organization/Company
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Recent advances in composite materials highlight their growing importance for both fusion and next-generation fission reactors. Tungsten fiber-reinforced tungsten (Wf/W) composites have demonstrated substantial improvements in toughness, pseudo-ductility, and thermal shock resistance, addressing tungsten's intrinsic brittleness under extreme heat loads in fusion environments. Parallel developments in silicon-carbide fiber–reinforced SiC matrix (SiC-SiC) composites show exceptional irradiation tolerance, high-temperature strength, and favorable nuclear properties, making them strong candidates for fuel cladding and structural components in advanced fission systems as well as future fusion devices.

Together, these material systems illustrate a broader trend: engineered fiber-reinforced composites enable superior resistance to neutron damage, thermal stresses, and corrosive environments, addressing key reliability challenges across reactor concepts. Their maturation is poised to significantly enhance reactor safety margins, component lifetimes, and overall performance in forthcoming nuclear energy technologies.

MXenes in Functional Applications: from Energy to Ceramic Pathways

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Plenary speaker III
Prof. Dr. Suelen Barg

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MXenes are a rapidly emerging class of two-dimensional materials with significant potential in functional applications, particularly in energy storage and related electrochemical applications. Their unique combination of electrical conductivity, surface chemistry, and processability enables high-performance materials while supporting efficient formulation and processing as well as simpler material designs. At the same time, their behaviour can be strongly influenced by processing and operating conditions, affecting stability, performance, and potential transformations. Understanding and controlling these aspects is key to unlocking their broader use. This talk provides a perspective on MXenes across functional applications, highlighting current developments and exploring how these materials may open new pathways toward ceramic systems.

Scandium and zirconium recovery from aluminum alloys

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Presenter
Maike Gamenik

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The growing demand for scandium-containing aluminum alloys for additive manufacturing is leading to an increasing generation of production waste. In particular, very fine powder fractions of Al-Mg-Sc-Zr-Mn alloys can often no longer be reused in the manufacturing process due to their small particle size and therefore accumulate as waste. These material streams alone generate approximately 7.5 tonnes of residues annually, containing the critical raw materials scandium (Sc) and zirconium (Zr).

Within the scope of this work, a hydrometallurgical recycling process was developed for the selective recovery of Sc and Zr from Al-Mg-Sc-Zr-Mn alloys. To achieve this, the metals were first transferred from the powder into solution through an innovative leaching process using copper sulfate. Subsequently, the target metals Sc and Zr were separated and concentrated by means of solvent extraction (liquid–liquid extraction). Using suitable extractants and the optimization of process parameters, Sc and Zr can be selectively separated from the matrix elements aluminum and magnesium, as well as from other accompanying elements such as manganese. Subsequent stripping and precipitation steps enable the production of various scandium- and zirconium-based products.

The developed process contributes to a sustainable supply of critical raw materials, reduces the demand for primary resources, and supports the establishment of a circular economy for high-value alloys used in additive manufacturing. Furthermore, the recovery of zirconium creates additional utilization pathways for applications in the ceramics and advanced materials industries.

Circular Approaches for Oxide Ceramic Implant Production: Valorization of Process Waste

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Presenter
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Oxide ceramic implants for dental and endoprosthetic applications are primarily manufactured from spray-dried granules. The subsequent shaping by pressing, green and white machining results in near-net-shape components. However, since the pressed blanks are usually significantly larger than the final implants, a considerable amount of material waste in the form of chips is generated. Due to the high regulatory requirements in medical technology and the associated analytical effort required to ensure quality, homogeneity, and chemical composition, this waste has traditionally been discarded. As a result, approximately 30% of the initial raw material input is lost.

Within the project "ReCerSafe", this ceramic waste is systematically investigated with regard to sustainability aspects. In addition to comprehensive analyses of the chemical and physical properties, various recycling and reprocessing strategies are being evaluated. These include both the reuse of the chips in their as-received state and after defined thermal treatments.

The resulting recyclates (granules and sintered specimens) are analysed for their properties (impurities, microstructure, density) and compared with reference materials. Both, the use as feedstock for biomedical application as well as the use as raw material for technical ceramics, e.g. sintering auxiliaries, are being evaluated.

This work was carried out within the funding program "FTI-Technologie" by Thueringer Aufbaubank, grant no.: 1004724

RECOSiC® as enabler for a circular economy in the ceramics industry

POHLSCHNEIDER, Christoph

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Previous years demonstrated the critical value of special resources to most industries. In the ceramic industry China produces more than 60 % of all raw materials and claims about 80 % of the Siliconcarbid (SiC) production worldwide. This led to a high focus across Europe to get more independency and stability in terms of the raw material availability to produce a vast variety of critical components made from aforementioned ceramics resources. ESK-SIC GmbH not only developed RECOSiC® as a method to get more independent from the SiC market but also to reduce the carbon footprint on a way to an environment friendly circular economy.

In this presentation it will be explained, which different kinds of SiC waste can be recycled through the RECOSiC®-process with a range from internal side products to end of lifetime components and side products of the Acheson process.

Furthermore physical, chemical improvements such as adjustable morphology, electrical and thermal conductivity or grain sizes and advantages for following production steps will be presented that enable the production of tailor-made SiC and therefore make RECOSiC® stand out against SiC powders produced through the conventional Acheson process.

The Potential of Urban Mining for the Brick and Cement Industries

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The brick and cement industries face significant challenges in reducing both their CO_2 emissions and their consumption of primary raw materials. Particularly problematic are process-related CO_2 emissions resulting from the decomposition of carbonates during production. In the cement industry, clinker is already partially replaced by secondary materials such as granulated blast furnace slag and fly ash. However, the availability of these supplementary cementitious materials is expected to decline in the medium term. Calcined clays are considered a promising alternative; however, their production still requires both energy and primary raw materials. In the brick industry, carbonate-bearing clays also release CO_2 during firing in tunnel kilns. Current decarbonisation strategies therefore aim to replace these clays, at least partially, with carbonate-free alternatives.

Urban mining offers the opportunity to recover secondary raw materials through advanced recycling processes, thereby reducing the demand for primary resources and lowering CO_2 emissions. Fine fractions derived from urban mining material streams can be used for the production of calcined clays or bricks. Secondary sand fractions can replace natural sand in concrete, while crushed brick can serve as a clinker substitute due to its pozzolanic properties. To fully exploit this potential, suitable quality parameters must be defined and efficient sorting technologies developed to ensure a consistent and reliable material quality.

Field-Driven Synthesis and Phase Control of Defective Rocksalt Monoxides in Stabilized Zirconia and Hafnia

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University of Oxford, Department of Materials

Presenter
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Exposure to strong electric fields at elevated temperatures drives transition metal oxides far from equilibrium. While electrochemical reduction plays a central role during direct current (DC) electrical loading and flash sintering, investigating its structural consequences has been historically obscured by the transient nature of the highly reduced states. This work overcomes these barriers through a novel electrical loading and rapid quenching method executed in oxygenfree atmospheres (Ar, N2), effectively isolating highly dynamic nonequilibrium defect structures at room temperature.

Systematic structural, microstructural, and spectroscopic characterization of electrically loaded 3YSZ, 8YSZ, magnesiastabilized zirconia (MSZ), and yttriastabilized hafnia (YSH) reveals that continuous oxygen extraction mimics a dramatic increase in stabilizer content before forcing catastrophic, highsymmetry phase transitions. Mild reduction reduces matrix tetragonality and expands the unit cell volume. Severe reduction triggers an insurgence of distinct, defective facecentered cubic (FCC) rocksalt compounds at the specimen surface: pure ZrO in Ar, Zr(O,N) in N2, and the previously undiscovered Group IV monoxide analogue delta-(Y)HfO.

Crucially, these newly accessed rocksalt structures undergo dopant segregation-evidenced by macroscopic, field-induced electromigration of various dopants, such as yttria rejection in YSZ and YSH. The retained monoxide phases exhibit distinct metallic lustres and exceptionally high room-temperature electronic conductivities. These findings establish field-driven processing as a powerful strategy for synthesizing previously inaccessible functional materials.

Impact of Cation Doping Strategies on the Sintering Dynamics and Flash Onset of Stabilized Zirconia

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Flash sintering (FS) offers an energy-efficient path to densify ceramics, yet the precise role of dopant uniformity during its onset remains poor-ly understood. This study systematically investigates the onset and progression of FS in zirconia-based ceramics processed via two distinct cation doping methods: chemical co-precipitation and reactive coball-milling (CBM). Green bodies of pure zirconia, 3 mol% Y_2O_3-stabilized zirconia (3YSZ), and 3 mol% Gd_2O_3-stabilized zirconia (3GdSZ) were evaluated under a constant electric field of 350 V/cm.

Co-precipitated 3YSZ demonstrated an exceptionally low flash onset temperature (Tonset) of 560 °C. In stark contrast, CBM 3YSZ and 3GdSZ exhibited severely delayed, markedly higher Tonset values of 1079 °C and 1095 °C, respectively. This delay is attributed to the requirement for the generation of highly conductive defects, mainly oxygen vacancies, needed to trigger the flash. The reasons for the different onset tem-pera-tures and conditions are discussed.

Post-flash characterization confirms that while co-precipitated samples sinter uniformly, CBM materials utilize the rapid thermal and electrical profiles of the flash state to simultaneously drive reactive phase stabilization and densification. These insights reveal that spatial dopant ho-mogeneity dictates early-stage electrical properties, offering a precise mechanism to tune and predict flash sintering thresholds.

Forming and Functionalization of Thermoplastic Ceramic Green Tapes

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Thermoplastic binder systems are redefining the boundaries of ceramic processing – unlocking manufacturing strategies that remain out of reach for conventional water- or solvent-based green tapes. By exploi-ting the reversible softening and solidification behavior of thermoplastics, material flow can be precisely tailored through temperature control, opening the door to a new generation of forming and functionalization techniques.

Multi-material components can be efficiently produced by laminating tapes using heated calandering, a process that ensures seamless integration of diverse materials. Complex functional structures can be directly printed onto tape substrates via Fused Filament Fabrication (FFF). This is a particularly convincing approach, as filament and substrate share the same feedstock, ensuring inherent shrinkage compatibility during sintering. Beyond planar applications, thermoplastic green tapes can be shaped into complex 3D structures using hydroforming: gas pressure conforms the tape to the mold without punch contact, eliminating friction, improving surface quality, and enabling significantly higher degrees of forming compared to conventional methods.

Across all process steps, precise temperature management is the key factor to achieving the optimal viscous state. Together, these techniques demonstrate how thermoplastic binder-based strategies can fundamentally advance ceramic manufacturing – delivering measurable benefits over traditional approaches and enabling entirely new application fields.

Fused Filament Fabrication of Continuous Fibre Reinforced Ceramic Matrix Composites

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It is well known that ceramic matrix composites, CMCs, are finding many uses in the challenging environments that are becoming increa-singly common in modern society. Fibre-reinforced CMCs offer a wide range of benefits compared to both monolithic ceramic and metallic components, being much tougher than the former and generally hig-her temperature and significantly lighter than the latter. They can also be tailored to offer a wide range of other properties.

The goal of this work is to use additive manufacturing to achieve the simultaneous fabrication of both the reinforcement and the matrix. The approach involves the controlled use of fused filament fabrication (FFF) to allow the production of geometrically complex, continuous Cf-SiC CMCs with tailored fibre reinforcing structures. Continuous carbon fibres are embedded simultaneously within the CMCs with the deposition of a SiC-based matrix, delivered via a high SiC content polymer filament, and then the printed green bodies have the polymers removed using a thermal-solvent debinding protocol before being sintered into CMCs.

Optimization of Commercial CIM ZrO_2 For Hybrid MEx?AM Printing–Milling Process

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Additive manufacturing via thermoplastic material extrusion is frequently affected by structural defects, especially when printing 0/90° layered structure. This results in compromised mechanical performance compared to conventionally pressed parts. A hybrid manufacturing strategy that integrates additive and subtractive can be used to avoid typical Mex-AM processing defects. At Empa, a dual-head FDM system equipped with both a pellet extruder and a milling unit was employed to enable hybrid manufacturing. However, when using commercial CIM feedstocks, chipping frequently occurs at milled surfaces due to their brittle behaviour. We investigated tackifier additives to avoid chipping effect. The tackifier was incorporated into the commercial ZrO_2 feedstock using a high-shear mixing process. 0.5 wt.% tackifier produced smoother surfaces and cleaner edges. However, increasing the tackifier content to 2.5 wt.% led to pronounced chipping and induced dela-mi-nation during the debinding stages.

Sintered discs were fabricated to evaluate mechanical properties. Although the Weibull modulus increased significantly with the addition of tackifier, a slight reduction in strength was observed. This decrease can be attributed to the lower sintered density, resulting from the reduced green density of tackifier-containing feedstocks.

This study demonstrates that the use of a tackifier additive is an effecti-ve strategy to avoid chipping during milling of ceramic green bodies, thereby improving subsequent subtractive processing methods such as milling. However, the sintering process must be re-optimized to achieve higher density without inducing excessive grain growth to improve the mechanical strength of the sintered parts.

Development of selfdisinfecting ceramic surfaces using UV-emitting upconverter materials

FILLINGER, Clemens | SCHMIDT, Christiane | WERNER, Jan | LIERSCH, Antje | NADJA, Kratz

Presenter
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The COVID-19 pandemic demonstrated the importance of hygienically safe surfaces, especially in public and highly frequented areas. Frequently touched surfaces can contribute to the transfer of microorganisms and therefore represent a potential risk of infection. For this reason, this study was conducted as part of a collaborative project in order to develop selfdisinfecting ceramic surfaces. The aim is to functionalize ceramic materials with an optically active component that can generate antimicrobial UV radiation under artificial illumination.

LuAG:Pr^3+ was used as the functional upconverter material as it is able to transform the blue spectral component of indoor LED light into UV radiation. After an initial functional test, LuAG:Pr^3+ was incorporated into an Al_2O_3 matrix and processed into ceramic green tapes by tape cas-ting. The content of LuAG:Pr^3+ varies between 10 wt.% and 50 wt.%.

For thermal treatment, a software enhanced two-step sintering study was carried out. The first sintering step was performed in a high temperature range around 1800 °C, while the second step was in a lower temperature range around 1650 °C with different holding times. The samples were subjected to density and SEM analyses, as well as warpage measurements. The results showed that higher first-step temperatures improved densification but also increased tape warping. Optical measurements were performed using excitation with a 488 nm Laser. UV emission around 310 nm was detected. This wavelength is in the UV-B range and can generally reduce microbial activity.

Additive Manufacturing of Ceramics: issues, potentialities and opportunities

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Presenter
Prof. Dr. Jens Günster

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Ceramic materials are difficult to process using additive manufacturing (AM) technologies because their processing requirements are challenging. The most important task to make AM of ceramics more than a niche technology is to develop AM of monolithic ceramics that allows components to retain their superior physicochemical properties. Currently, very few AM technologies are capable of producing fully dense, monolithic ceramic bodies. However, AM has the potential to open new markets for ceramic products because it is not strictly bound by the paradigms of ceramic processing. These paradigms include high processing costs for small-batch production, low flexibility, complex machining, and limited molding technologies. Therefore, if successful, AM technologies are expected to have an extraordinary impact on the industrial production of ceramic components by opening up new applications and markets for ceramics.

This presentation provides a brief overview of the current state of ceramic AM, highlights remaining challenges, and presents approaches to improving ceramic AM in terms of cost and part quality.

Development and Optimization of a Highly Filled Partially Water-Soluble Alumina Feedstock for Ceramic Fused Filament Fabrication

HEIM, Thomas

IKMT - Universität Stuttgart

Presenter
Thomas Heim

Organization/Company
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The implementation of additive manufacturing in the ceramic industry still lags behind its adoption in polymer and metal processing. In cera-mic fused filament fabrication (cFFF), four major challenges remain critical: filament green properties, debinding behavior, flow performance, and interlayer adhesion. These factors strongly affect both the mechanical performance of printed components and process reliability.

To address these limitations, a binder system based on polyvinyl butyral (PVB), polyethylene glycol (PEG), and additives is investigated. While these polymers are widely reported for tape casting, only limited studies have explored their adaptation to ceramic filament feedstocks for cFFF. First, the influence of feedstock composition on rheological behavior, mechanical properties, and debinding characteristics is analyzed using a mixture design methodology. Green mechanical properties and water debinding behavior are evaluated on extruded filaments and rectangular test specimens.

Second, starting from the center-point composition, the effects of varying solid loading, ceramic powders, and additives are investigated to optimize the targeted properties.

Finally, a dip-coating suspension is developed to improve surface quali-ty. The influence of this post-processing route on the surface roughness of the parts is evaluated using perthometer measurements on as-printed and dip-coated samples.

The feedstock and post-processing strategies developed in this work aim to enable the fabrication of dense ceramic parts with enhanced surface quality, thereby providing a foundation for expanding the applicability of ceramic fused filament fabrication in structural applications.

Molecular Approach for the Synthesis of Binary (Ge, Mo, Sn, Ti, V) S2 High-Entropy Sulfides.

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Metal dichalcogenides (MDCs) of the general formula MS2 have attracted considerable attention as electrocatalysts for the hydrogen evolution reaction (HER) owing to their earth abundance, tunable electronic structures, and layered architectures that provide a high density of catalytically active edge sites while facilitating efficient charge transport. Despite these advantages, the controlled incorporation of multiple metal species into a single-phase MS_2 framework remains a significant challenge, particularly within the emerging context of high-entropy materials. Here, we present a molecular precursor approach for the controlled synthesis of tetravalent high-entropy sulfides using metal tert-butyl thiolates, $[M(StBu)_4]$ (M = Mo, Sn, Ti, and V), and the germanium alkoxide $[Ge(OEt)_4]$. Partial thiolysis of an equimolar precursor mixture induces gel formation, generating a homogeneous molecular network in which the five metal species are pre-organized enabling precise composition control. Subsequent thermal treatment yields crystalline MS^2-type high-entropy sulfides with a single-phase structure and homogeneous elemental distribution. The synthesized high-entropy sulfides exhibit enhanced HER electrocatalytic activity compared with lower-entropy analogue. Overall, this work highlights thiolate-based sol-gel chemistry as a versatile and scalable route for synthesizing compositionally complex sulfide electrocatalysts.

Hybrid Additive Manufacturing and Geometric Optimization of a Steel-MgO Composite for Aluminum Production

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The study investigated pellet-based additive manufacturing of a metal-ceramic composite material based on MgO and 316L stainless steel, as well as its post-processing in the printed state using integrated CNC processes. The goal was to investigate the potential of this hybrid manufacturing approach for producing near-net-shape components and to evaluate the influence of post-processing on surface quality. The focus was primarily on analyzing the correlation between manufacturing parameters, post-processing, and the resulting component quality. The evaluation was performed using, among other methods, mechanical (one-on-three-balls test) and microscopic examinations.

Another focus was on optimizing the component geometry for use as an anode in aluminum production. For this purpose, a computational-design-based approach will be used to adapt the component geometry to the functional requirements and to make targeted use of the design possibilities offered by 3D printing. In this way, an efficient combination of material, manufacturing strategy, and geometry can be achieved.

The role of alumina starting powders in alumina–10 vol% zirconia composites

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Alumina–zirconia composites (ZTA) are well established materials for mechanical engineering and biomedical applications due to their high strength, hardness and abrasion resistance. While the basic material concept is simple, the influence of alumina starting powders on microstructure formation and mechanical properties is insufficiently investigated. In this study, five different submicron alumina powders were combined with 10 vol% of an unstabilized zirconia powder. Samples were consolidated by hot pressing at 1475–1600 °C and investigated with respect to microstructure, mechanical properties and phase composition. Adaptation of the sintering parameters allowed the manufacture of ZTA of acceptable quality from all starting powders. However, alumina powders of higher purity helped to retain a well dispersed and stable microstructure at higher sintering temperatures, whereas powders of lower purity promoted zirconia segregation and grain growth. The results show that the selection of the alumina starting powder is a de-cisive factor for preserving microstructural homogeneity during sin-tering.

Endformnahe Herstellung hochtemperaturfester nanoporöser Keramikbauteile im 3D-Druck - Eigenschaften und erste Anwendungen

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Ein Verbund mehrerer europäischer Unternehmen entwickelt gemeinsam ein Verfahren zur Herstellung hochtemperaturbeständiger, nanoporöser keramischer Bauteile durch selektrives Lasersintern (SLS) mit blauem Laser. Vorgehen, Ergebnisse und Anwendungspotentiale werden vorgestellt.

An association of several European companies jointly develop a process for the production of high temperature resistant nanoporous ceramic components by selective laser sintering (SLS) with blue laser. The approach, results and application potentials are presented.

Advancing Quality Control in Ceramic Additive Manufacturing Using Optical Coherence Tomography

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Additive manufacturing (AM) of ceramics is a multistep process involving precursor preparation, printing of the green part, debinding, and sintering, where defects may arise at different stages. Optimizing process parameters is therefore essential to achieve high-quality complex structures.

We applied Optical Coherence Tomography (OCT) to inspect ceramic structures produced by Digital Light Processing, Fused Filament Fabrication, and Multimaterial Jetting using zirconium, aluminum, and titanium oxides. Measurements on both green and sintered samples enabled quantitative characterization of surface topography and geometry, as well as the detection of subsurface defects such as pores, cracks, and delamination.

OCT is a nondestructive volumetric imaging method that uses short-coherence light in the near-infrared range and can penetrate transparent and semitransparent materials to depths of a few hundred micrometers to several millimeters. In our analysis, differences in the back-scattered signal caused by material optical properties, grain size, and porosity were evaluated. OCT provides volumetric imaging for understanding defect origin and location, as well as large datasets suitable for statistical analysis. Statistical methods were used to detect outliers and highlight inhomogeneities responsible for signal variation, enabling automatic defect labeling and training of machine learning (ML) models. Our results demonstrate that OCT can accelerate process optimization in ceramic AM and serve as a standard inspection tool for quality control.

2PP of ceramic – What's next?

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Photon-based additive manufacturing technologies such as SLA, DLP, LCM, moreover volumetric two-photon-polymerization (2PP), Xolography and holographic technologies promise the highest accuracy and dimensional freedom. To transfer the light through the feedstock it needs sufficient transparency. Ceramic particles used for powder processing routes act as scattering sites and therefore hinder the light transmission, unless…

The particle size and particle size distribution are chosen small and narrow enough. Particles smaller than roughly 1/10th of the light wavelength, mostly nanoparticles around 5nm size, decrease scattering vastly. This turns resins even with homogeneously distributed ceramic weight fraction of up to 80% transparent again. Feedstocks were prepared for the highly accurate two-photon-polymerization gaining the smallest yttria stabilized zirconia structures with a resolution of 500nm and unique mechanical properties.

The same feedstock was applied to DLP and LCM as layer-by-layer AM-technologies for bigger parts. Hybridizing both technologies enables ceramic parts with microscopic accuracy at macroscopic dimensions. The feedstock was even applied to the volumetric Xolography with the highest transparency requirement so far and to versatile and flexible holographic AM.

What are the next steps? Can those proof-of-concept studies be transferred to industrial applications and what are the hurdles on the way? How to make the stretch between fundamental research and application-oriented development?

Hybrid additive manufacturing of a silicon carbide-boron carbide composite for high-temperature applications

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Silicon carbide (SiC) is highly desired due to its excellent thermomechanical properties. This makes it an ideal candidate for applications in harsh environments, such as aerospace and defence, where operational temperatures can exceed 1200°C. Interest is increasingly on optimising the performance of these parts with new, more complex designs. However, traditional shaping methods cannot produce the geometries that industry desires. Additive manufacturing (AM) offers a promising alternative.

Vat photopolymerisation (VPP) has emerged as the most popular ceramic AM technique however, the progress with carbides has been severely limited due to their unfavourable optical properties. High solid loadings of fine SiC powders cannot be achieved which limits the densification pathways and the high temperature performance of the final parts. The hybrid AM technology developed by Hydra Manufacturing offers a solution. The technique is based on the layer-by-layer extrusion of a ceramic paste followed by in-situ green machining. By combining the material compatibility of robocasting with the accuracy, resolution and surface finish of CNC machining, complex geometries from fine SiC powder can be produced.

This work explores the development and optimisation of a SiC composite paste to produce complex geometries which retain their mechanical properties up to 1500°C. The rheology, drying kinetics and green strength of the paste have been studied to optimise the shaping process. The parts have been densified through solid state sintering and characterised with respect to their mechanical and thermal properties. Finally, an AI-driven, in-situ, defect detection system has been demonstrated as a solution for reliable, defect-free printing.

$Ti_3C_2T_x$-MXene als Multifunktionales Additiv für Direct Ink Writing

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MXenes sind eine Familie zweidimensionaler Materialien, die ein breites Spektrum funktionaler Eigenschaften aufweisen, darunter hohe elektrische und thermische Leitfähigkeiten, mechanische Festigkeit, elektro-magnetische Abschirmung sowie katalytische Aktivität für bestimmte chemische Reaktionen. Ihre effektive Integration in keramische Matrizes eröffnet neue Möglichkeiten zur Entwicklung von Materialien mit verbesserter Leistungsfähigkeit und erweiterten Funktionalitäten für An-wendungen über Umgebungsbedingungen hinaus.

Aufgrund ihres hohen Aspektverhältnisses, ihrer Stabilität in wässrigen Dispersionen sowie ihrer einstellbaren Oberflächenchemie eignen sich MXene besonders gut für kolloidale Verarbeitungsverfahren, einschließlich des 3D-Drucks. In der vorliegenden Arbeit untersuchen wir die Möglichkeiten zur Entwicklung druckbarer $Ti_3C_2T_x$-MXene-basierter keramischer Strukturen. Durch die gezielte Gestaltung effizienter MXene-basierter Formulierungen zeigen wir, dass sich kolloidale Tinten mit geeigneten rheologischen Eigenschaften herstellen lassen, die für die Fertigung keramischer Strukturen mittels extrusionsbasiertem 3D-Druck, insbesondere Direct Ink Writing, geeignet sind.

Zur effizienten Bestimmung geeigneter Zusammensetzungen und Prozessparameter setzen wir einen Bayes'schen Optimierungsansatz ein, mit dem bereits nach wenigen Optimierungszyklen gute Druckergebnisse erzielt werden können. Die Ergebnisse eröffnen vielversprechende Perspektiven für den 3D-Druck funktionaler MXene-basierter Keramiken mit potenziellen Anwendungen in zahlreichen Bereichen, die sowohl funktionale als auch strukturelle Eigenschaften erfordern.

From Ceramics to Joining of Metal: Alumina Tools for Friction Stir Welding

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Friction Stir Welding (FSW) is an established solid-state joining process for aluminum alloys and is commonly performed using metallic tool materials such as steels or hard metals. Although these materials pro-vi-de sufficient mechanical performance, tool wear and manufacturing costs remain important challenges, particularly for industrial applications requiring high process reliability and long tool lifetimes. Alumina re-presents a promising alternative due to its high hardness, excellent wear resistance, and the potential for cost-efficient manufacturing.

In this study, the feasibility of using alumina tools for FSW of EN AW-6082-T6 sheets was investigated. Two manufacturing routes were con-si-dered: conventional pressing and milling, and additive manufacturing by Lithography-based Ceramic Manufacturing. Welds produced using both ceramic tool concepts were compared with joints manufactured using a conventional steel tool.

The resulting welds were characterized regarding their mechanical and metallurgical properties. Tensile testing and microstructural analyses were conducted to assess weld quality and identify potential process-related defects. In addition, the ceramic tools were analyzed before and after welding to evaluate their integrity.

The results demonstrate that defect-free welds can be produced using both alumina tool variants. Mechanical properties and microstructural characteristics were comparable to those obtained with conventional steel tools. Furthermore, no critical tool degradation was observed after welding. The findings highlight the potential of conventionally and additively manufactured alumina tools for FSW of aluminum alloys and provide a basis for further development.

Assessing the Influence of a Magnetic Field in the Chemical Vapor Deposition of TiN from Paramagnetic Precursors

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Titanium nitride (TiN) is a technologically important material widely used in microelectronics, wear-resistant coatings, and energy-related applications due to its excellent electrical, mechanical, and chemical properties. In this work, paramagnetic titanium precursors were synthesized and structurally characterized to investigate the influence of an external magnetic field on the chemical vapor deposition (CVD) of TiN thin films.

Following crystallographic characterization of the precursor compounds, TiN films were deposited by magnetic-field-assisted chemical vapor deposition (mfCVD). The impact of the applied magnetic field on film growth and material properties was systematically evaluated. The deposited films were characterized by scanning electron microscopy with integrated elemental mapping (SEM:EDX) and X-ray diffraction (XRD) to assess their morphology, microstructure, and crystallinity. The results reveal that the magnetic field significantly influences the chemical composition of the deposited TiN films and promotes enhanced crystallinity compared to films grown under identical conditions without magnetic field assistance. Elemental mapping shows altered chemical compositions in the TIN/TiC system. These findings demonstrate that the combination of paramagnetic precursors and magnetic-field-assisted CVD provides a promising approach for controlling thin-film growth and tailoring the structural properties of TiN coatings.

From Conventional Extrusion to Additive Manufacturing: Processing of Ceramic–Steel Composite Materials

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Extrusion is a well-established manufacturing technology for ceramic products and has recently been extended to advanced materials such as metals and metal–ceramic composites. By combining powder-metallurgical processing with ceramic-based extrusion routes, complex near-net-shape components can be produced efficiently from highly filled plastic pastes. These pastes, prepared using aqueous plasticizing systems, are shaped at ambient temperature and subsequently transformed into dense materials through drying, debinding, and sintering. While conventional extrusion offers high productivity and excellent material versatility, component geometry is inherently restricted by the fixed cross-section of the extrusion die. As a result, the fabrication of complex three-dimensional structures is limited and often requires ex-tensive post-processing. To overcome these constraints, extrusion can be integrated with computer-controlled multi-axis motion systems, enabling additive extrusion manufacturing and the layer-wise fabrication of geometrically complex components.

This contribution presents the processing of ceramic–steel composite materials based on highly alloyed steels combined with selected ceramic constituents using both conventional and additive extrusion technologies. The influence of the processing route on shaping capabilities, geometric flexibility, and potential application fields is discussed. Conventional linear extrusion and three-dimensional additive extrusion provide complementary manufacturing strategies, addressing the growing demand for advanced engineering materials and high-temperature components with tailored properties and complex architectures.

Additive manufacturing and characterization of nature-like bone models for clinical training based on polymer-infiltrated micro- and macroporous ceramics

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In practical medical training, realistic surgical exercises prior to treating patients are essential. Surgical fracture management requires hands-on experience in drilling and inserting screws into hard bone tissue. However, access to natural bone for training is limited and increasingly questioned ethically. Meanwhile, current polymer-based models often lack sufficient anatomical accuracy, bone-like mechanical properties, and realistic haptic feedback.

Additive manufacturing (AM) of ceramics offers a promising approach for producing biomimetic bone models with tailored macro-geometry, micro-porosity, and mechanical properties. Based on real computed tomography (CT) data, cortical thickness and cancellous structure can be precisely adjusted. This enables the production of diverse bone types and fracture scenarios suitable for patients of varying ages and bone densities.

The ceramic process allows the fabrication of an interconnected porous microstructure. Subsequent polymer infiltration creates a composite material that combines ceramic hardness, compressive strength, and stiffness with polymer flexibility, elasticity, and tensile strength. This ap-proach enables the exact and realistic replication of human bone structure and its mechanical properties.

In addition to micro- and macrostructural analyses and mechanical testing, the study included a practical evaluation of haptic feedback during drilling and screwfixation by experienced orthopedic surgeons.

High Throughput Development of Porous Piezoelectric Ceramics

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Porous piezoelectric ceramics are used in various fields such as ultrasonic transducers, energy harvesting devices or sonar applications. Traditionally, publications in this field investigate ten or less different porosities, as the high accuracy needed to obtain exact target porosities increases the production and characterization time drastically. However, a high sample number can lead to a more intricate understanding of porosity property relationships, such as the influence of pore geometries. In this work porous lead free piezoceramics with more than 30 different total porosities were fabricated from $K_{0.5}Na_{0,5}NbO_3$ (KNN) via the incorporation of four geometrically different sacrificial templates (spherical and fibrous). To upscale the process, an automated dispensing system was employed. The microstructure of samples was analyzed via SEM imaging. The piezo and ferroelectric measurements were carried out with partially automated equipment to realize lower human interaction times. This works shows the enormous potential of High Throughput processing and testing in the field of porous piezoelectric ceramics.

Engineering grainboundary character by texturing for dislocation transmission in polycrystalline $SrTiO_3$

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Dislocation engineering has developed into a versatile tool for tuning the mechanical and functional properties of ceramics, but has so far been largely restricted to single crystals. In polycrystals, grain boundaries (GBs) block dislocations and trigger cracking during room-temperature deformation, yet polycrystalline ceramics find wide and practical applications. Whether a GB blocks or transmits dislocations in ceramics is set by its character: high-angle boundaries act as barriers, whereas low-angle boundaries permit transmission. Here we show that crystallographic texturing engineers this GB character in $SrTiO_3$ polycrystals. To do so, we compared textured $SrTiO_3$ with strong <001> alignment (Lotgering factor ~91%), fabricated by magnetic alignment and spark plasma sintering, to polycrystals with random (untextured) grains. We observe that texturing shifts the GB population away from high-angle boundaries towards transmission-permissive low-angle boundaries (<15°) by 30% of overall grains compared to 3% in random polycrystals. As a result, upon room-temperature dislocation imprinting via cyclic Brinell scratching, the textured sample shows long-range dislocation transmission with averaged density $\sim 3 \times 10^{13}$ m^{-2}. This allows pre-imprinted dislocation network to accommodate plasticity during subsequent Vickers indentation, reducing the indentation-induced damage footprint by up to 19% compared to unscratched textured $SrTiO_3$ control, while revealing dislocation multiplication, motion, and work hardening. This combined grainboundary texturing and dislocation-engineering approach opens a new pathway for designing plastically deformable polycrystalline oxides at room temperature.

From pressing to printing: how processing governs LTD in 2Y-TZP

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Low-yttria stabilized zirconia has recently gained attention due to its increased transformability and resulting improvement in fracture toughness compared to 3Y-TZP. Building on recent advances in additively manufactured 2Y-TZP, this work investigates the low-temperature de-gradation (LTD) behavior of AuerTec® 2Y with a focus on processing-dependent effects.

Conventionally pressed and sintered AuerTec® 2Y materials are compared to additively manufactured counterparts, with 3Y-TZP serving as a reference. Accelerated hydrothermal aging is used to evaluate the tetragonal-to-monoclinic transformation kinetics. Phase composition is assessed by X-ray diffraction, while mechanical performance is characterized via biaxial flexural strength measurements.

Previous studies on additively manufactured 2Y-TZP demonstrated enhanced fracture toughness and strength compared to 3Y-TZP due to increased phase transformability. In this contribution, particular at-tention is given to how processing route influences phase stability and degradation behavior under hydrothermal conditions. Initial results indicate distinct transformation characteristics between pressed and additively manufactured materials, with implications for both strength retention and reliability.

The study provides new insights into the relationship between manufacturing route, phase composition, and long-term performance of 2Y-TZP. These findings support the positioning of AuerTec® 2Y as a promising material for applications requiring a balance between high toughness and resistance to LTD.

Experimental Investigation of the Thermal Properties of Ceramic Open-cell Foams using the Hot Disk Method

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Ceramic open-cell foams are widely used in industrial applications due to their diverse advantageous properties. However, their highly heterogeneous structure, complex material composition and anisotropy impede accurate characterization of their thermal properties, which are essential for efficient system design and optimization.

This study presents a comprehensive experimental investigation of the effective thermal conductivity of alumina open-cell foams using the Hot Disk method (transient plane source technique). First, a parametric study was conducted at room temperature to analyze the influence of the sensor size as a function of the pore size of the foam, with the aim of minimizing the required sample dimensions and, consequently, the effort for sample preparation. The results also revealed a pronounced effect of the penetration depth achieved during the measurement, arising from manufacturing-related porosity inhomogeneities within the foams. To validate the findings, computed tomography scans, numerical simulations of heat propagation during Hot Disk measurements and comparative measurements using a guarded hot plate apparatus were performed. This also enabled a targeted analysis of the anisotropy of the effective thermal conductivity, which can reach up to appr. 30 %. Finally, the suitability of the Hot Disk method for determining the effective thermal conductivity at temperatures up to 700 °C was evaluated, with particular emphasis on the potential influence of thermal radiation, especially in foams with semi-transparent strut materials.

Ceramic Quality Evaluation via OCT-Based Homogeneity Analysis

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The overall quality of a ceramic component is directly related to its homogeneity. Homogeneous ceramics perform better in terms of mechanical strength, wear and corrosion resistance, and thermal stability. In the simplest terms, structural and property characterization of any section of a ceramic component should yield very similar results. Characterizing the homogeneity of ceramics is a challenging task and requires the use of sophisticated, often expensive, tools and instruments such as Scanning Electron Microscopy (SEM) and related methods, including Energy Dispersive X-ray Spectroscopy, Backscattered Electron Imaging, and Electron Backscatter Diffraction (EBSD), as well as computed tomography (CT and µCT), among others. Most of these methods are destructive, require special sample preparation, and provide valuable information from a limited sample area or volume.

We propose the use of Optical Coherence Tomography (OCT) to characterize the homogeneity of ceramic materials. OCT is a volumetric imaging method operating with lateral and axial resolutions in the range of single micrometers. It can be applied to ceramic materials that are at least partially transparent to wavelengths ranging from 800 nm to 1600 nm. We tested the method on materials such as aluminum oxide, zirconium oxide, silicon nitride, and electroporcelain. We were able to visualize buried defects such as cracks, contamination, inclusions, and pores. Using statistical analysis, we were able to isolate many of the defects as statistical outliers. Our results indicate that data obtained with this method can be used to train machine learning (ML) models, increasing the potential of OCT for automated inspection in many industrial applications.

Impact of Hydrogen Combustion Atmosphere on Additively Manufactured Alumina for High-Temperature Applications

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The transition to carbon-free process heat has led to growing interest in hydrogen-based combustion. However, the effects of hydrogen and its combustion atmosphere on typical high-temperature components used in thermal process technology have so far only been rudimentarily investigated. Due to their high chemical stability, alumina ceramics are considered promising candidates for such applications. By using the innovative production technology of additive manufacturing via fused pellet fabrication printing, it is possible to systematically combine closed micropores and functional microcavities, enhancing thermal shock resistance.

This study investigates the impact of hydrogen combustion atmosphere on the thermophysical properties of additively manufactured alumina. Therefore, the samples were analysed regarding thermal diffusivity, thermal conductivity, thermal expansion and specific heat capacity in their initial state and after 600 h of exposure to the combustion atmosphere at 1500 °C. In addition, methane combustion atmosphere was investigated as a reference case representing conventional natural gas firing.

Specific heat capacity and thermal expansion remained stable under both conditions. In contrast, thermal conductivity and diffusivity increased by 20 to 40 %, with methane combustion having a more pronounced effect. The observed changes indicate porosity reduction and microstructural densification as the dominant mechanisms.

AI-Assisted Virtual Optimization of Ceramic Sintering Processes

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Sintering is a key process step in ceramic manufacturing, directly affecting dimensional accuracy, mechanical properties, product quality, and production yield. Even small deviations during firing can cause deformation, cracking, higher reject rates, and unnecessary energy consumption. Therefore, robust and industry-oriented process technologies for optimizing firing cycles and reducing waste are highly important for modern ceramic production.

This work presents a practical process technology that virtually models, analyzes, and optimizes the complete sintering process by combining classical numerical simulations with artificial intelligence. The approach is designed for industrial applicability and enables process optimization before physical production trials, reducing development time, material usage and costs.

The methodology combines multimodal heat transfer simulation with prediction of shape and deformation during sintering through coupling physics-based models with Physics-Informed Neural Networks (PINNs). Based on this, both firing cycles and component topology can be optimized in a targeted manner.

Practical benefits include reduced production waste through minimized stress and deformation, shorter firing cycles with lower energy consumption and faster process development with fewer experiments.

A major advantage is the low implementation barrier, as the model only requires material parameters commonly available in ceramic production, such as density, porosity, bending strength, grain size distribution, and pyroplastic index. Industrial case studies demonstrate the practical suitability of the methodology for improving process reliability and increasing manufacturing efficiency.

Numerical investigation of anisotropic sintering of the fused filament fabricated metal–ceramic components

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Co-sintering of metal–ceramic components manufactured by fused filament fabrication (FFF) is strongly affected by anisotropic shrinkage and distortion caused by printing-induced microstructural heterogeneity and mismatched sintering shrinkage between the constituent materials. To address these challenges, this study developed a thermo-mechanical-metallurgical framework for predicting the anisotropic sin-tering behaviour of 17-4PH stainless steel and TZ-3YS-E zirconia composite components fabricated by FFF. A modified Skorohod–Olevsky Viscous Sintering (SOVS) model with anisotropic porosity-dependent pre-exponential factors was established for TZ-3YS-E zirconia, while a modified Kwon model incorporating phase-transformation effects was developed for 17-4PH stainless steel. Optical dilatometry and pore morphology analysis revealed pronounced direction-dependent shrinkage associated with anisotropic interlayer pore structures generated during the layer-wise deposition process. Based on the experimental results, the directional model parameters were identified, and the developed coupled model was subsequently validated against the experimentally observed shrinkage behaviour. The validated framework was further applied to the co-sintering simulation of metal–ceramic multilayer structures to investigate distortion evolution, stress development, and crack formation during the entire sintering process.

Development of an innovative hydrogen-based tunnel kiln technology concept for the production of ceramic materials

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The ceramics industry is one of the most energy-intensive manufacturing sectors, which is why its decarbonisation represents a crucial challenge for achieving climate targets. Hydrogen, as an alternative energy source in competition or combined with electrification, offers a promising solution for certain ceramic processes, but its implementation requires a simultaneous and coordinated transformation across the sectors of energy supply, kiln construction and material adaptation. As part of the H2TO project, a hydrogen-based conversion concept is being developed for tunnel kiln operation in the production of refractory fireclay ceramics. The project aims to draw up a demonstration plan setting out how existing kiln facilities can be gradually converted to hydrogen operation. The concept highly depends on the interlinking of expertise on (1) assessment of local green hydrogen production and supply logistics, (2) development of adapted tunnel kiln technology with a particular focus on process-related and energy-related emissions under hydrogen combustion conditions, and (3) systematic investigation and adaptation of ceramic materials to altered firing atmospheres and temperature profiles. The project, in 2026 resulting in pilot scale testing, has shown that the technology, besides the effect of decarbonization, also I this case leads to new energy reduction possibilities and even new product qualities. These results will be highlighted.

Potential use of xonotlite-containing residues from calcium silicate board production as Wollastonite substitute in sanitaryware

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Wollastonite is a well-established functional raw material used in the production of sanitary ware, primarily for its strength-enhancing properties. Due to significantly increasing prices for imported wollastonite as well as growing demands for resource efficiency, lower CO_2 emissions and greater independence from global supply chains, a joint research project investigated whether wollastonite could be replaced by xonotlite-containing residues (milling dust) from the production of calcium silicate boards. The main mineral phase of this milling dust is xonotlite, which transforms into wollastonite at temperatures above 650 °C while releasing water. Within the project, the residues were comprehensively characterised and their application in ceramic casting slips was investigated on a laboratory scale. The processing behaviour of various slip formulations containing the substitute raw material, as well as the properties of the test specimens produced, were compared with those of conventional compositions containing wollastonite. Following the successful laboratory trials, the transfer to an industrial production process for sanitary ceramics using pressurecasting was also investigated. Despite drawbacks upon complete substitution of the wollastonite, the results demonstrate considerable overall potential for replacing wollastonite with xonotlite-containing residues, although further research is required to optimise the process.

Design and Optimization of APS Parameters for Dense Environmental Barrier Coatings

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This work analyses the influence of process parameters on the microstructure especially density and phase composition of an EBC (Environmental Barrier Coating) based on $Yb_2Si_2O_7$, deposited by APS (Atmospheric Plasma Spray) and subjected to a single post-annealing treatment in an argon atmosphere. Three process parameters are considered: hydrogen content in the plasma, torch current and deposition distance, each set at three levels (2, 6 and 10 slpm for H_2, 320, 420 and 520 A for current, 60, 90 and 120 mm for spray distance). The analysis is made using a statistical Box–Behnken Design of Experiments implemented with Design-Expert® software, which allows to identify the conditions that lead to low porosity, low crack density and a high fraction of disilicate and crystallinity. Later, the optimized samples are produced, achieving low-crack gas tight coatings. Microstructural characterisation was performed on cross-sections using scanning electron microscopy (SEM), while an automatic quantification of porosity and crack density was performed using a Python workflow. Hardness was determined by indentation testing in order to correlate the presence of defects with the hardness of the coating, and XRD analyses were used to evaluate crystallinity and the relative content of disilicates and monosilicates before and after heat treatment. The 10 hours annealing at 1300 °C in an Ar atmosphere resulted in a reduction in porosity and cracks, from initial values of 4–8 % to values around 1 %.

Application of the calphad method for the development of new thermal barrier coatings

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Rare-earth zirconates with fluorite or pyrochlore structures have attracted considerable attention as promising candidates for thermal barrier coatings (TBCs) in aircraft and gas turbines due to their low thermal conductivity and high phase stability at high temperatures. The properties of these materials can be enhanced by applying the high-entropy oxide (HEO) concept, which involves mixing at least five different rare-earth cations. Therefore, developing a thermodynamic database using the CALPHAD approach for the ZrO_2-Y_2O_3-Dy_2O_3-Nd_2O_3-Sm_2O_3-Gd_2O_3 multicomponent system provides a powerful tool for predicting microstructures and phase transformations between ZrO_2 and rare-earth oxides, as well as for identifying suitable compositions for new TBC materials. Given the lack of experimental phase equilibria data in certain subsystems, specific phase diagrams required investigation and thermodynamic assessment. To this end, selected sample compositions were synthesized via solid-state reaction and heat-treated at 1500 °C for 100 hours to achieve equilibrium. Microstructural observations and phase identification were performed using SEM, EDX, and XRD. Isothermal sections were experimentally determined, and thermodynamic parameters were assessed within the CALPHAD framework. The calculated phase diagrams reproduce the experimental findings within experimental uncertainties and serve as a predictive tool for the development of new TBCs.

Electrically heatable refractory composite components for high-temperature applications, using pressure slip casting

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The present study focuses on the development of a heatable model ladle shroud with improved high-temperature properties for steal casting applications. The innovative material used is a combination of a "denser" alumina outer shell of the component and an electrically conductive, carbon-containing composite material, which is located in the core. By applying a voltage, the conductive core leads to a heating of the refractory component. This results in a reduction of temperature gradients and the associated critical thermo-mechanical stresses of the ladle shroud during heating or cooling processes. The corrosion-resistant alumina ceramic is in direct contact with the molten steel; thus there are no or only very slight interactions with the melt to prevent the formation of inclusions and clogging. The coarse-grained ladle shroud is developed using pressure slip casting, which is ideally suited for the production of complex geometries. In this manufacturing process, it is possible to cast different slurries sequentially in one casting cycle. For the steel industry, it offers advantages such as a denser surface, which also reduces corrosion by the steel melt. The presentation outlines not only the complex development of the casting process, but also the properties obtained from the composite material and the results of initial heating tests of the sintered ladle shroud.

Single-Phase Formation in Gd–La–Y–Hf–Zr–O High-Entropy Oxides via Stepwise Reduction of Metal Cations

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High-entropy oxides (HEOs) are multicomponent oxides with near-equiatomic compositions that can form single-phases due to their high configurational entropy. However, single-phase materials with high configurational entropy may also occur as conventional solid solutions that are not primarily stabilized by entropy.

To distinguish between entropy-stabilized phases and conventional solid solutions, the influence of decreasing configurational entropy is investigated in the equiatomic Gd–La–Y–Hf–Zr–O HEO system. Starting from a single-phase five-cation composition, the number of cation species is stepwise reduced by removing one element at a time, generating corresponding n-1 compositions. If the original phase behaves as a conventional solid solution, the reduced systems are expected to remain single-phase, whereas entropy-stabilized phases should de-compose into multiple phases.

Samples are synthesized by laser melting in an aero-acoustic levitator, enabling homogeneous melts and rapid cooling. Phase formation is analyzed as a function of the number of cation species and the corresponding configurational entropy. The results reveal highly symmetric cubic single phases for most compositions, while only one n-1 composition shows clear phase separation, indicating behavior intermediate between entropy stabilization and conventional solid-solution formation.

XRT – a versatile coupling of an analytical imaging method and computational based materials property characterization

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X-ray computed tomography (XRT) provides a non-destructive method for advanced three-dimensional characterization of e.g. refractory components and their microstructure. The wide range of its analytical possibilities is demonstrated through three case studies. The first two examples illustrate the capability of XRT to apply a repetition measurement technique on the same specimen, enabling from it direct and quantitative before-and-after comparisons. One study focuses on the effects of chemical treatment on bauxite raw materials, while the other examines temperature-dependent microstructural evolution and be-ha-vior. The final example demonstrates how XRT data can be processed further for simulation purposes of materials properties.

Refractories for the Retrofitting of Industrial Furnaces for Hydrogen Technologies and Decarbarbonization

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Refractory materials are an integral part of metallurgical processes. The main objective in these studies funded by the European Union is the demonstration of an advanced heat transfer process for industrial melting and reheating furnaces, by the utilization of hybrid burners in or-der to increase the introduction of hydrogen for direct combustion with oxygen. This process will be controled by a Digital Twin. The focus here is on applicability or the degradation of the refractory materials under the changed conditions; changed process parameters not only reduce refractory service life and thus sustainability, but can also lead to considerable risks for metal processing and for the environment. The change in combustion atmospheres to higher H2 amounts also leads to altered interactions of the refractories with other parts of the processes, such as melts and scale.

Thermochemical and thermodynamic calculations using the FactSage computation package of the industrial refractories and refractory model materials are used to make predictions about the behaviour of refractory materials under the modified combustion atmospheres with higher H2 concentrations. Laboratory corrosion tests in tube furnaces with applied H2 containing combustion atmospheres according the industrial application are performed. Changes in chemical composition, mineral phase composition as well as their microstructure, which are in-fluenced by the process conditions, analysed by means of XRF, ICP-OES, XRD, mercury porosimetry and SEM/EDS methods. Changes of the refractory microstructure and its impact on the furnace operation are discussed in correlation to the Digital Twin model as well as the influence on the technical operation of the reheating furnace.

From Random to Tailored: Advanced Replica for Next-Generation Porous Ceramics

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The replica technique is one of the most established manufacturing methods for highly porous ceramics. However, conventional templates are limited in terms of reproducibility and structural periodicity. To overcome these constraints, we combine polymer 3D printing with the classical replica technique, using designed periodic polymer templates to fabricate cellular ceramics with adjustable micro- and macrostructure. Kelvin cell geometries were 3D printed from rigid polymer and subsequently processed via the replica technique. This talk explores the opportunities and challenges of this combined approach of additive manufacturing and the replica technique. By presenting results on different strut widths and geometries, porosities, and materials we demonstrate how properties can be controlled with the advanced replica technique.

When drying matters: the influence of an overlooked process step

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A well-established technique for tailoring the microstructure and enhancing the mechanical and thermal properties of porous ceramics is gel casting. Gel casting offers a wide range of technological applications requiring lightweight materials with high permeability such as thermal insulation, filtration, catalysis or biomedical implants. High mechanical stability is achieved by using a polymer gel to solidify the ceramic network prior to sintering. Rapid drying of the gelled foams causes stresses within the gel network, often resulting in cracks. To prevent the formation of cracks, it is advisable to use drying under constant conditions of humidity and temperature. In this study, alumina gel casting foams were produced using agarose as gelation agent and drying was carried out in a climate chamber to maintain a constant temperature and humidity until complete drying. Different temperatures and humidity levels were used and the influence on time-dependent mass loss was recorded. The influence of the different drying conditions on microstructural, mechanical, and thermal properties was investigated. It was observed that slower drying conditions due to increased humidity result in an improvement in mechanical properties.

Additive manufacturing of reaction-bonded alumina for the production of complex support structures used in ultra- and nanofiltration membranes

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Membranes are essential elements in nature. Acting as barriers within microscopic cells or macroscopic organs, they control the transport of substances within the body. With its filtration properties and capabilities, the human kidney represents a highly efficient membrane, characterised by an exceptionally large surface area compared to the volume. Every day, 1,500 l of blood are filtered through these organs to produce 180 l of primary urine and ultimately approximately 1.5 l of urine.

The aim of the research is to apply additive technologies to generate complex support structures with a high surface area by taking advantage of geometric freedom. This offers opportunities to optimise mass flow within the membrane module and, according to our research, increase the volume-specific membrane surface area by up to 300 %. The material under investigation is a reaction-bonded alumina. Therefore, the filament- and pellet-based material extrusion (MEX) is characterised. Subsequent post-processing, comprising debinding, sintering and coating regimes, is an additional research topic. The resulting support structures are open-pored bodies with a maximum pore size of ~ 1.5 µm. Membranes for ultra- and nanofiltration are additionally applied to these with coating processes. The current state of this research achieves pore sizes of 3 – 0.9 nm.

The presentation will depict the entire process chain (CAD, slicing, additive manufacturing, debinding, sintering and coating) and the properties realised in the structures.

Preparation of ceramic membranes for water treatment

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Water treatment is the largest field of membrane application. Ceramic membranes are used to produce portable water from surface water. Large scale monolithic membranes operating at higher feed pressure of 2-5 bar are used as well as submerged multichannel plates with reduced pressure of 0.8-0.5 bar on the permeate side. Dynamic crossflow filtration is applied in high viscos applications. An increasing market is the use of ceramic membranes for the treatment of industrial wastewater combined with the recycling of water. Often the recycling of hot water gives a short payback time. The pores in ceramic membranes are formed by holes between particles. Therefore, the porosity is limited to 30 % whereas the pore size is approximately 1/3 of the particle size. The talk will give an overwiev about the state of the art of membranes on the market as well as new topics in membrane development to improve the efficiency of the separation and to meet new applications.

Investigation of Barium Nickel Niobate (BNN) doped BT and BCZT ferroelectric relaxer ceramics for nonlinear MLCCs with very low hysteresis in passive control of inductive power transfer

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Lead-free ferroelectric relaxer ceramic materials have become increasingly important for MLCC capacitors in recent years. In contrast to the ceramics of this type used to date, passive control of inductive power transfer requires materials with moderate permittivity (er < 10000), strongly nonlinear polarization or dielectric displacement behavior with electric field strength, and very low hysteresis [1]. In our investigations, BCZT barium nickel niobate (BNN) compositions were synthesized using a chemical solid-state process. The ceramic pellets were sintered at temperatures between 1450 °C and 1480 °C. This resulted in high-density, sintered homogeneous samples, as confirmed by scanning electron microscope (SEM) analysis of the microstructure. X-ray diffraction studies showed that the material is single-phase. The material exhibited nonlinear dielectric displacement behavior at low electric field strength, with nearly closed field strength-strain curves and zero remanence. Our results were verified on fabricated multilayer capacitors and by measuring the field strength dependence of mechanical strain on sintered, metallized pellets [2].

[1] Yves Olsommer et al., Physics-Based Modeling of Ferroelectric Hysteresis for Ceramic Capacitors in Inductively Coupled Microstimulators, IEEE Transactions on Power Electronics, 39, 6, (2024) 7696-7707
[2] Li Jin, et al., Diffuse Phase Transitions and Giant Electrostrictive Coefficients in Lead-Free Fe3+-Doped $0.5Ba(Zr_{0.2}Ti0_{0.8})O_3$?$0.5(Ba_{0.7}Ca_{0.3})TiO_3$Ferroelectric Ceramics, ACS Appl. Mater. Interfaces, 8, (2016) 31109?31119

Investigation of steam electrodes for proton-conducting ceramic electrolysis cells: From microstructure to cell-performance

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Proton-conducting ceramic electrolysis cells (PCCEL) are capable for usage in a mid-temperature-range of approximately 400 °C to 700 °C. Going along with possibilities like waste heat usage from industry, nearly dry hydrogen production on the fuel electrode side and thus avoidance of purification steps, as well as less risk of oxygen gas storage due to slight dilution on the steam electrode side makes PCCEL a promising technology which positively delimits it from low- and high-temperature electrolyzer systems. However, making PCCELs applicable to foster the contribution of green hydrogen production from water electrolysis and cheapen this technology compared to hydrogen derived from fossil sources requires improvement of performance and lifetime which is highly influenced by the steam electrode in the PCCEL development. In our current research, steam electrodes were selected for investigation, to study interactions between steam electrode and electrolyte material as well as generating an electrochemical understanding of the (degradation) processes occurring in the electrolyte-steam electrode system. After varying the steam electrode microstructure first symmetrical pellet samples and proton-conducting full-cells were characterised in impedance and single cell tests respectively. The development progress up to a first influence of the change in microstructure on the resulting electrochemical properties of the PCCEL will be presented.

Ammonia as a Hydrogen Carrier: What Role Can Ceramic Materials Play? Catalysis, Porosity, Regeneration and Technical Transferability

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Ammonia is increasingly discussed as a potential hydrogen carrier for future transport and storage infrastructures. However, the technical use of ammonia-based hydrogen pathways depends not only on infrastructure and process design, but also on suitable materials. In particular, the recovery of hydrogen from ammonia requires catalytic systems that are active at comparatively low operating temperatures, stable, regenerable, shapeable and technically transferable.

In this context, ceramic materials can play a key role: as porous supports, structured catalyst bodies, functional materials, membranes, or thermally and chemically resistant components. This presentation provides a strategic overview of possible application fields for ceramic materials in ammonia-based hydrogen technologies and discusses central challenges such as porosity control, deactivation, regeneration, scale-up and shaping. As an example, an emerging research approach at Hochschule Koblenz is presented, focusing on potentially regenerable catalytic systems for ammonia-related hydrogen technologies.

Flexible Fuel Power Generation via Proton-Conducting Membrane Reactors

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EU transport and power generation accounts approximately each one-third of all CO_2 emissions from fossil fuel combustion. An innovative way to reduce the resulting greenhouse gas emissions is a new multi-fuel supply system that will deliver low, zero or carbon negative fuels like ammonia, biogas or alcohols to the Compact Membrane Reactor (CMR). The CMR will transform this fuel by means of chemical and electrochemical processes into H_2, as a temporary energy vector, to feed an Internal Combustion Engine or a Fuel Cell System to produce mechanical and electrical power.

The core of the CMR is an electrochemical cell consisting of a multi-layered ceramic compound. We show the complete process chain from synthesis of the ceramic raw materials to the final sintered half-cell with a size of 50 x 50 mm^2. The half-cell consists of a dense electrolyte layer composed of $BaZrO_3$-based material and an electrode from a mixture of $SrZr_{0.5}Ce_{0.4}Y_{0.1}O_3$ and NiO. The powder synthesis is accompanied by detailed characterization. The powders are used for tape-casting, which is an appropriate method for producing flat and large area sheets and is highly scalable. Several ceramic layers can be applied on top of each other by sequential tape-casting. Finally, the tapes are cut into the desired shape and sintered in one thermal treatment step. The sintered half-cells are investigated by SEM and ready for electrochemical performance evaluation.

Luminescent $MgAl_2O_4$ in Powder, Bulk and Ceramic Tape Form

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The controlled adjustment of emission wavelengths is important for the development of functional luminescent materials. One promising approach is the targeted doping of transparent ceramics, such as magnesium aluminate spinel ($MgAl_2O_4$). This material provides a chemically and thermally stable host material that can be doped with transition metal and rare earth ions. The resulting luminescence is influenced by the type and concentration of the dopant, its oxidation state and lattice site, as well as on defects, processing atmosphere and thermal treatment.

This work investigates the use of commercially available raw materials for the production of doped $MgAl_2O_4$ ceramics. The aim is to enable the transfer of the process to larger production scales. The solid state reaction method is preferred because it is suitable for upscaling and can be integrated into established ceramic processing routes. The investigations include doped powders, pressed bulk samples and ceramic tapes. Depending on the material form and the specific research question, different dopants, dopant concentrations and thermal treatments are applied. The optical properties are mainly examined by excitation and emission spectroscopy. This allows the influence of processing conditions and material form of the luminescence behavior to be studied.
The aim is to develop a reproducible and scalable process for $MgAl_2O_4$ materials with defined and stable emission properties. Possible applications include LED conversion materials, spectrally tailored light sources, photonic and laser-related components, as well as planar luminescent ceramic tapes.

Material Development for 3D Printing of Leadfree PTC Heating Ceramics

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The rapid progress in the 3D printing of ceramics places new demands on the development of functional materials for it. This progress and the freeform parts made by additive manufacturing allow for new applications that cannot be serviced by classic forming methods. For this reason, we have developed a leadfree material for the 3D printing of PTC electric heating ceramics with positive temperature coefficient (PTC). These ferroelectric materials show an anomalous increase in resistance during their phase transition from a polar crystal structure to a non-polar one. The prototype, doped barium titanate $BaTiO_3$, shows this transition at a Curie temperature T_c of 120 °C, in this case from the tetragonal phase to a cubic phase. The resistance jumps several orders of magnitude, and the semiconductor becomes almost insulating. These self-regulating PTC heaters are used in electric cars as pressed ceramic blocks, but new structures could allow new applications for electric heating.

Thus, the material and its processing were studied and adapted to allow for 3D printing of electroceramics. The focus was on heating structures with large surfaces areas for optimal heat exchange as well as structures that could not be achieved with pressing, extrusion, or other classic forming methods. The processing of these samples was optimized to allow debinding, sintering, and metallization while preserving structural details and integrity. We present the challenges encountered during processing and the methods employed to achieve dense, highly functional heating ceramics with complex geometries. Additionally, we discuss the functional, structural, and thermal properties of these ceramics.

Relationship between Crystal Structure, Microstructure, and Breakdown Field Strength in PTCR Ceramics

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Barium titanate ($BaTiO_3$) based Positive Temperature Coefficient of Resistance (PTCR) ceramics have renewed interest due to electrification needs. Increasing operating voltages require adjustment of PTCR materials, especially the development of lead-free compositions. Therefore, understanding compositional influences is essential.
We investigate the effect of isovalent dopants like strontium (Sr), calcium (Ca) and lead (Pb) in $BaTiO_3$ based PTCR ceramics regarding crystallography, microstructure, breakdown field strength, and temperature dependent resistivity.

Emphasis is placed on the relation between crystal structure and microstructure for calcium doping, which determines resistivity. Increasing Ca content up to 12.5% raises tetragonality from 1.018 to 1.019, compensates refined grains, and stabilizes room temperature resistivity. Our results show that larger grains at constant mean grain size determine the PTCR characteristics, challenging the common use of mean grain size to predict behavior.

Samples are sintered to comparable resistivity by adapting parameters. A reduction in breakdown field is observed with increasing dopant content, varying by element. Thus, proper crystal lattice design via isovalent doping can enhance breakdown field, especially for PTCR ceramics with jump temperature >120?°C. Increasing Sr content lowers jump temperature and enhances breakdown field. Conversely, more Pb content reduces jump temperature and breakdown field. The influence of Ca is overshadowed by microstructural changes.
Optimized isovalent doping can enhance breakdown field by up to 100?V/mm for $BaTiO_3$ based PTCR materials at equal resistivity.

Rotary Screen Printing and Laser Sintering of Functional Layers for Solid Oxide Cells

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Solid oxide cells (SOCs), operating as fuel cells and electrolyzers, have a great potential to play a crucial role for hydrogen demanding industries. However, in order for SOCs to make a significant contribution to achieving the German government's hydrogen targets, limiting factors, such as costs and scalability of cell production need to be overcome. Therefore, the RotoSOC project investigates the development and implementation of two promising approaches - rotary screen printing and laser sintering - for the manufacturing of electrolyte-supported SOCs. The project, funded by Federal Ministry of Economic Affairs and Energy, is a collaboration between Fraunhofer ISE, Corning Inc. and Forschungszentrum Jülich. Unlike the state-of-the-art flatbed screen printing, rotary screen printing offers the possibility of continuous printing, which holds great potential for high-throughput production. With regard to this, experiments are performed to identify the correlations between the properties of relevant ceramic pastes and the printing results. In order to achieve this objective, the compositions of state-of-the-art pastes are modified to vary the rheological properties. The quality of the printed layers is assessed by analyzing various parameters, including layer thickness, edge accuracy, and the presence of defects. Rapid thermal processing with laser could be an additional contributor for reduced manufacturing time as well as a measure to lower energy costs and enable a more controlled heat treatment of the layer structure. For cell manufacturing, thin electrolyte substrates from Corning Inc. are being used with the aim of increasing the efficiency of electrolyte-supported cells by reducing ohmic resistance.

Local Joining of brittle materials - Process technology and application

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When sensors are used in components for hydrogen production, transport, storage, and utilization, the materials used are subject to high stress due to hydrogen corrosion and hydrogen diffusion. At the same time, these materials must be nonconductive and temperature-stable in order to meet safety requirements.

Alumina (Al_2O_3 ceramics) and glass solders are now among the materials used for hermetic encapsulation and housings of electrical assemblies, sensors, or optics that are used under the highest stresses in extreme environments and conditions. Depending on the functional requirements of the components to be encapsulated, conventional joining methods are unsuitable due to the necessary joining temperatures and process times. For this reason, technologies are now being developed to apply the energy to the joining zone in a time- and space-limited manner in order to achieve the necessary joining temperature.

This contribution presents a sensor concept for a hydrogen pressure sensor consisting of a ceramic base unit and membrane. Within a research project, the complex individual components and sensor layers are developed and manufactured separately by the project partners involved. The housing and membrane were then joined with a gas-tight seal using special glass solders and laser soldering. The systematic development of the material and process parameters for laser soldering and the system technology used are described. Manufactured test specimens and functional assemblies were characterized using materials engineering methods and the results will be presented. The results are suitable for housings for encapsulating sensors in low-pressure applications in hydrogen technology and other applications that require local joining technology.

Fiber-reinforcement of proton conducting solid oxide cells

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In order for solid oxide cells (SOC) to meet the manufacturing targets set as part of the agenda to achieve climate neutrality [1], they need to be manufacturable using automated systems. The mechanical stability of solid-oxide cells to date, especially that of the proton-conducting variant, is too low for this purpose. The flexural strength of oxygen-ion conducting SOCs ranges from roughly 130 to 230 MPa [2], [3], [4], while that of proton conducting SOCs ranges only from 50 to 100 MPa [5]. One reason for this is the porosity required for unrestricted gas flow. Every pore can trigger a fracture and represents a weak point in the layer. A potential solution to allow for automated handling of cells and thus industrial scale manufacturing is fiber-reinforcement of the sub-strate layer. Results regarding material compatibility tests and initial re-sults on the manufacturing of fiber-reinforced substrates will be presented.

[1] Zugegriffen: 4. Juni 2025. [Online]. Verfügbar unter: https://www.bmbf.de/SharedDocs/Downloads/DE/20/230726-fortschreibung-nws.pdf?__blob=publicationFile&v=4
[2] doi: 10.1002/fuce.201300153.
[3] doi: 10.1016/S0167-2738(00)00714-1.
[4] doi: 10.3390/membranes14020044.
[5] doi: 10.1016/j.ceramint.2025.07.377.

Multilayer Thermoelectric Generators based on ceramic oxides

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Thermoelectric generators (TEGs) offer a promising approach for the direct conversion of waste heat into electrical energy, thereby enabling the power supply of low-power devices, such as autonomous sensors in Industry 4.0 applications. State-of-the-art commercial TEGs are pre-dominantly based on doped bismuth telluride or lead telluride and require comparatively complex manufacturing processes. In contrast, transverse multilayer thermoelectric generators (TMLTEGs) employ cost-effective, non-toxic oxide ceramics in combination with a small amount of metal. They offer an environmentally friendly alternative based on scalable multilayer ceramic technology.

This presentation outlines the optimization of the thermoelectric properties of oxide ceramics for implementation in TMLTEGs, using $CaMnO_3$ ceramic as an example. Particular attention is given to the optimization of the chemical composition, including substitution strategies and the use of sintering aids. Physical calculations support the evaluation of the effective thermoelectric properties of ceramic-metal composites as a function of the combined materials and geometric design. In addition, finite element method (FEM) simulations are employed to determine optimal TMLTEG geometries for defined ceramicmetal combinations, taking technological constraints into account. Finally, the latest advances and current challenges in scaling up the production of monolithic TMLTEGs using multilayer ceramic technology are discussed.

Protective spinel coatings for Solid Oxide Cell interconnects: Correlating electrical performance with microstructural evolution

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Ferritic stainless-steel interconnects are a key component in solid oxide cell (SOC) stacks. Within these, the evaporation of volatile chromium species and the formation of resistive oxide scales that are intrinsic properties of ferritic stainless steels can have a detrimental impact on the SOC stack performance. Protective ceramic coatings based on Mn-Co spinels are well established to mitigate these effects. However, a thorough understanding of the relationship between microstructural evolution and electrical performance under operating conditions remains essential for the development of advanced coating solutions. In this work, Mn-based spinel coatings deposited by electrophoretic deposition (EPD) on ferritic stainless steels are investigated after 3000 h exposure at 800°C in air. Two two-step thermal treatment protocols involving pre-reduction in Ar/H2 at different temperatures and subsequent oxidation are compared, with atmospheric plasma sprayed (APS) coatings and uncoated steels serving as references. The study further addresses the influence of substrate selection, contrasting SOC-specific steels with a conventional ferritic grade. Cross-sectional characterization by scanning electron microscopy (SEM) and Raman spectroscopy is correlated with ex-situ area-specific resistance (ASR) measurements to establish links between oxide scale constitution, coating microstructure, and electrical behavior.

Building on these findings, the optimized coating approach is transferred to stack-relevant interconnect components, demonstrating scalability and practical implementability.

Photonic sintering of Strontium Titanate

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Fe doped $SrTiO_3$ was sintered by photonic sintering using a blue laser. The impact of processing parameters such as the output laser power density and sintering time on shrinkage, microstructure evolution, and grain boundary properties was investigated. Samples had 97.5 % to 99 % relative density after sintering, depending on processing parameters. Changes in density were correlated to pore coarsening, swelling, or pore coalescence. This study presents the first experimental evidence for pore separation in Fe doped $SrTiO_3$. Analysis by scanning electron microscopy revealed gradients in local microstructure. Rapid grain growth occurred during photonic sintering, which was three orders of magnitude faster than grain growth during conventional sintering. Average grain sizes were between 0.6 to 11.3 µm after sintering for 15 to 120 s. Grain boundaries in photonic sintered samples exist in a nonequilibrium state, and feature low space charge potential as well as low Fe segregation at grain boundaries. The rapid grain growth during photonic sintering correlate to rapid heating rates (> 1000 °C-min-1) and low Fe segregation at the GBs.

Polymer Derived Ceramics for UHT TBC Systems and for TBCs on Lightweight TiAl Components

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Polymer derived ceramics offer a promising route to fabricate ceramic layers on metallic components with high flexibility in chemical composition and excellent phase stability. Using oxide particles as additional filler material allows to produce relatively thick layers and further adjustment of coating properties such as thermal expansion and thermal conductivity. $A_6B_2O_{17}$ superstructure oxides with (A = Hf, Zr and B = Ta, Nb) are synthesized as potential filler materials and their thermal properties are investigated, showing excellent high temperature phase stability and strengthening their potential as coatings in UHT applications.

A second approach to utilize polymer derived ceramics is presented as a coating system for lightweight TiAl components as in areo-engine applications. SiAlOC glassy layers are used as a bond coating / environmental barrier coating on TiAl substrates and below a standard YSZ thermal barrier coating prepared by EB-PVD. The application of SiAlOC coating alone can significantly reduce the oxidation rate of TiAl at 750 °C. In this work, the oxidation behavior of a coating system with SiAlOC coating and EB-PVD YSZ top layer is investigated in quasi-isothermal oxidation experiments in air up to 900 °C.

3D-Printed Resorbable Scaffolds Combining Biopolymers and Bioactive Glass for Bone Regeneration

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Large bone defects are a global health challenge because they do not regenerate spontaneously and therefore require surgical implants, additionally in the case of load-bearing sites, there is a supplementary need of mechanical stability subjecting the tridimensional structures (scaffolds) to mechanical loads. Over the past four decades, tissue engineering has identified resorbable composites as promising materials for bone repair. In particular, biodegradable scaffolds that combine bioactive glasses (BGs) and biopolymers show strong potential for hard tissue regeneration [1]. BGs provide high reactivity with osteoconductive, osteoinductive and angiogenic effects, while biopolymers supply mechanical support and elasticity, enabling scaffolds to better mimic native tissue and be tailored to individual needs [2]. Biocompatible biopolymers such as poly(hydroxybutyrate-co-hydroxyvalerate) (PHBV) have been explored due to their biodegradable properties without toxic degradation byproducts and high elastic modulus [3]. In this study, fused deposition modelling (FDM) was used to produce 3D-printed, resorbable scaffolds composed of PHBV and 45S5-BG and characterized for morphology, hydrophilicity, mechanical properties, and bioactivity, with particular attention to degradation kinetics to evaluate their structural changes over time and suitability for bone tissue engineering.

Acknowledgments

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References

[1] A. Philippart, et al., Expert Rev. Med. Devices. 2015, 12, 93-111.
[2] Jones, J. R., Acta Biomater, 2013, 9, 4457–4486.
[3] Aráoz, B. et al., J. Mater. Res, 2021, 36, 4000–4012.

Wear of a ceramic-on-ceramic hip resurfacing under activities of daily function

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Introduction
Hip resurfacing is a treatment for osteoarthritis of the hip which is particularly suited to younger or more active patients often resulting in bet-ter postoperative function and reduced dislocation rates than those with a Total Hip Replacement. Historically, metal-on-metal bearings were used in hip resurfacings however, issues relating to metal ion release and subsequent implant failure has led to investigations into al-ternative materials. Ceramics offer high wear resistance even under ad-verse conditions. In this study, the wear of a ceramic-on-ceramic (zir-conia-toughened alumina) hip resurfacing was investigated under conditions representative of those the device would undergo during several activities of daily function using experimental simulation.

Methods
Six ceramic-on-ceramic (BIOLOX Delta, CeramTec) hip resurfacing devices were studied in a 6-axis hip simulator. Initially, 2 million cycles of wear simulation were carried out under a walking gait then additional testing was carried out under either a stop-dwell-start protocol or jogging conditions. The wear of the head and cup were measured gravi-metrically.

Results
At the conclusion of each phase of the study, no wear scar or damage was visible on either the heads or cups. Under walking gait conditions with and without the stop-dwell-start protocol, wear of the head and cup were very low and at the limit of the measurement sensitivity. Under jogging conditions where the applied load was higher, the wear of the head and cup increased but the wear rate remained low.

Conclusions
This pre-clinical study showed low wear of this ceramic-on-ceramic hip resurfacing and the potential of this material combination for the next generation of large-diameter hip bearings.

Modifying mesoporous bioactive glass nanoparticles to tailor particle–cell interactions

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Intracellular ions play an important role in regulating cellular processes and biomaterials able to deliver biologically active ions directly inside cells represent an attractive strategy to modulate cell behaviour. Nevertheless, this approach remains poorly explored, as it requires materials that combine efficient uptake, cytocompatibility and ion release in intracellular environments. In this context, mesoporous bioactive glass nanoparticles (MBGNs), known for their ability to release ions in biological fluids, are particularly interesting [1]. Their biological performance depends on the interface between MBGNs and cells, which controls protein adsorption and membrane interactions [2]. To tailor this interaction, MBGNs were functionalized with poly(ethyleneimine) (PEI) and modified with acetic anhydride (AA) or succinic anhydride (SUC). The obtained MBGNs maintained their spherical and mesoporous morphology, while further investigations confirmed the successful modifications. Zeta potential measurements showed that PEI shifted the surface charge to positive values, whereas AA resulted in nearly neutral particles, and SUC in negatively charged particles. Primary amine quantification showed a similar decrease for both post-modifications compared to PEI-functionalized MBGNs. Particle degradation was assessed in different simulated fluids. All together, these results show that surface changes influenced protein adsorption, degradation and cytocompatibility, showing that controlled surface modification can tailor the MBGN–cell interface.

[1] Damian?Buda, A., Boccaccini, A.R., Adv. Healthc. Mater. 2026, 15: 202502754
[2] Ritz, S., Schöttler, et al, Biomacromolecules 2015, 16, 1311–1321

Apatite-forming calcium phosphate cement modified by addition of bisphosphonates

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Calcium phosphate cements (CPCs) are established for bone repair. Addition of antiosteoporotic bisphosphonates (BPs) is a promising ap-proach to achieve local BP delivery directly at the bone defect, enhancing bone regeneration [1].

In this study, a hydroxyapatite (HA) forming CPC composed of tetracalcium phosphate (TTCP) and dicalcium phosphate anhydrous (DCPA) was modified with 1 or 2 wt.% of alendronate (AL), risedronate (RIS) or zoledronic acid (ZOL). 10 wt.% of a Na_2HPO_4/NaH_2PO_4 mixture were added as setting accelerator. The setting reaction at 37 °C was studied by in-situ X-ray diffraction and Imeter (automated Gillmore needle) measurements. Cements set for 1 or 7 d in humid atmosphere were characterized by Rietveld refinement.

1 wt.% of each BP strongly retarded cement hardening; this effect was less pronounced for ZOL. Initial setting times of the BP modified ce-ments ranged between 20 and 35 min, final setting times between 38 and 56 min. Both HA formation and dissolution of the starting compounds was retarded by the BPs. Increasing the AL concentration from 1 to 2 wt.% had a strong effect, while doubling the ZOL content only slightly increased retardation.

The set cements contained HA and residual TTCP, while DCPA completely reacted. A decrease of TTCP fraction, accompanied by an increase of HA fraction, between 1 d and 7 d indicated further reaction progress. The BPs only had a minor influence on the phase composition after 7 d. BP release from the set cements was proven.

In conclusion, the BPs did not impede HA formation on the long term, despite their retarding effect on cement setting. Hence, the BP modified CPCs are promising systems for controlled drug release.

[1] MP Ginebra et al., Adv Drug Deliv Rev 2012; 64:1090-1110.

The tribology of composite ceramics in hip joint replacement

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Ceramic matrix composite biomaterials, such as zirconia-toughened alumina (e.g. BIOLOX®delta, CeramTec) and alumina-toughened zirconia (e.g. ceramys™, Mathys Medical), are widely used in hip joint replacement, either coupled with a polyethylene (liner) or as a ceramic-on-ceramic bearing. Building on prior generations, these materials exhibit improved fracture toughness, phase stability, and resistance to slow crack growth.

Historically pre-clinical wear simulation of hip replacements was performed under a standard walking cycle considering a correctly positioned prosthesis in an average standard patient. It is now accepted that to understand, evaluate and reduce (low) failure rates, pre-clinical testing needs to be performed under the much wider envelope of conditions found clinically. For example, for ceramic-on-ceramic hip replacements, in vitro edge loading through translational malpositioning (microseparation) has been shown to be the only wear mechanism to replicate stripe wear, wear rates, and a bimodal wear particle distribution as found in vivo. However, the occurrence, severity of edge loading, dynamic separation and wear of ceramic-on-ceramic bearings is influenced by variations in component (rotational and translational) positioning. This understanding led to an international standard describing this test method, that is now in use (ISO 14242-4:2018).

Overall, the evidence indicates that these latest generation of ceramic composites offer robust tribological performance with enhanced safety margins, supporting their continued use in younger and more active patient populations. Indeed, their performance potentially widens the design envelope, allowing for larger femoral head sizes and thinner liners, while offering a wider range of hip motion.

Can we adequately replace Y-TZP by Ca-TZP ?

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In the last decades yttria stabilized zirconia has been established as a state-of-the-art material for mechanical engineering and biomedical applications such as dental implants and restorations. However, due to the high demand in energy applications and upcoming trade restrictions, yttria together with other rare earths has been classified as a critical raw material by the EU. This raises the question if we can adeqately replace Y-TZP by zirconia materials stabilized by non rare earth oxides in order to avoid upcoming problems in availability and material costs.

The most promising substitute material nowadays seems to be calcia stabilized zirconia tetragonal polycrystals Ca-TZP which since the 1990s is known to provide similar mechanical properties and enhanced low temperature degradation resistance. Until recently these findings were based solely on lab scale experiments. Recently the first Ca-TZP powders of different stabilizer contents have become commercially available as ready to press powders. This talk summarizes our experience with Ca-TZP materials over the last two years.

The most important challenge in processing Ca-TZP is the low critical grain size of ~100 nm which requires fine grained and sinterable starting powders. The typical sintering temperatures are in the range of 1250-1300°C. Mechanical properties particularly fracture toughness show an extreme sensitivity to sintering temperature and grain size. Fracture toughness doubles within a 25-50K temperature range. Over-firing and thereby exceeding the critical grain size leads to spontaneous failure. Replacement of Y-TZP by Ca-TZP in comparable quality is feasible but requires strict control of processing parameters.

Ceramic injection moulding versus CNC-manufacturing for ATZ shoulder resurfacing

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Alumina and YTZP ceramics have been established in joint endoprosthetics since the 1970s and 1980s. Zirconia rich dispersion ceramics made of alumina and YTZP are known for high strength and fracture toughness and low wear rates for decades. Thus, alumina toughened zirconia (ATZ) material was introduced to the endoprosthetics market in 2007. New efforts have been made to use ATZ for production of shoulder implants. CNC-technology will be compared with ceramic injection moulding.

This paper summarizes the designer's elaboration, challenges and economic aspects for the respective manufacturing technologies. Clinical needs and material requirements for ATZ on basic of standards (ISO 13356, ISO 6474-2) hane been formulated.

First investigation results for material samples and shoulder implant made by CIM and CNC are shown. Debinding process and thermal treatment were deveolped with the aim of achieving high purity and removal of any porosity. Green density, microstructure, sinter density, phase composition, etc. were investigated.

Injection moulding technology was developed, based on the design and construction of a moulding tool and the choice of a suitable ATZ feedstock. Manufactured parts were investigated according to geometry. Green parts with densities? 2,75g/cm^3 and sinter densities? 5,4 g/cm^3 were prepared. By adjusting the thermal process, the microstructure could be optimized so that grain sizes for Al_2O_3 and for YTZP met the requirements of standards. A homogeneous microstructure and phase distribution in material samples could be achieved. First shoulder implants made of ATZ ceramic were successfully realized with both technologies.

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Commercial composite resins for additive manufacturing in dentistry – what can in vitro characterization predict regarding clinical performance?

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Additive manufacturing of photopolymerizable composite resins is increasingly used in dentistry to produce accurate and patient-specific restorations. This presentation summarizes in vitro findings on additively manufactured dental materials, with emphasis on how printing parameters and post-processing influence accuracy, mechanical properties, and color stability. Resin composition, layer thickness, build orientation, exposure settings, and post-curing conditions were shown to affect dimensional precision and material performance. In general, optimized processing improve fit, strength, and optical stability, which may influence clinical outcomes. These findings highlight that clinical success depends not only on the material itself, but also on the full manufacturing workflow. Standardized printing and post-processing protocols are therefore essential to ensure reliable and reproducible results in daily dental practice.

From Richard Raupach GmbH to ECT-KEMA GmbH - 150 Years of Ceramic Machinery Manufacturing in Goerlitz

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For nearly 150 years, the city of Goerlitz has been a significant hub for the manufacture of ceramic machinery. It began with the founding of the Richard Raupach machine factory in 1878. The company was specialized in manufacturing preparation and shaping machinery for the clay industry, supplying high-performance equipment to brickworks and, later, porcelain factories across Europe. In the aftermath of World War II, the family-owned business was expropriated, and the Goerlitz plant was largely dismantled under the supervision of the Soviet military administration. In 1948, the company was nationalized and transformed into "VEB Keramikmaschinen Görlitz" (KEMA). Within the GDR and the Eastern Bloc, this enterprise became the leading manufacturer of ma-chinery for fine and electrical ceramics. The political changes of 1989/90 brought further major shifts for the plant. The business was returned to private ownership in 1990. The period between 1990 and 2012 was marked by changes in ownership and the associated economic difficulties. A collaboration with ECT GmbH Mühlacker boosted the Goerlitz company's innovative capabilities. Together, they realized numerous projects worldwide in the field of technical ceramics, laying the foundation for their current market leadership in specific technological areas. This close cooperation culminated in 2012 with the merger of the product portfolios and expertise of KEMA GmbH and ECT GmbH to form ECT-KEMA GmbH.

80 Years Ferrites from Hermsdorf

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By 1946, HESCHO was world-renowned for its expertise in ceramic materials and technologies. At the same time, it was under Soviet military administration. A return to products for the civilian market was vital for the company's survival. The company responded by stepping up its development efforts. In quick succession, products for radio technology under the "MANIFER" brand (manganese-nickel ferrites) went into series production. Starting in 1952, hard magnetic barium hexaferrites were produced under the "MANIPERM" brand. Materials and products were further developed in line with market demands. Ferrites were essential for the company to meet the government's export quotas. By 1989, Hermsdorf had become Germany's largest manufacturing site for ferrites. To this day, both soft- and hard-magnetic materials are produced at two separate limited liability companies (GmbHs). This presentation highlights the milestones of this development and key figures, drawing on company documents and photographs.

The importance of Gotthelf Greiner for the development of the porcelain industry in Thuringia and beyond

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Georg Heinrich Macheleid is generally mentioned as the inventor of Thuringian porcelain, who discovered the composition of the right porcelain mass, the Arcanum, in 1760 after years of experiments in the Glücksthal glassworks.

The fiscal foundations of porcelain factories that arose in the second half of the 18th century as a result of the betrayal of Meissen and Vienna fell into crisis due to mostly technological inadequacies. In this situation, the glassworks owner Johann Gotthelf Greiner founded a porcelain factory in Limbach (Thuringia) in 1772 with little capital. His inventions and innovations had far-reaching significance for the development of the porcelain industry beyond Thuringia. This reinvention was independent of the achievements of Johann Friedrich Böttger and Ehrenfried Walther von Tschirnhaus in Meissen. The invention of the Thuringian furnace, the use of regional and suitable raw materials and the construction of mass mills for the preparation of raw materials were essential. This provided the foundation for the production of lowcost consumer porcelain for broad sections of the population (massproduced goods) and an increasingly successful export. The expansion of the Central German porcelain industry began in the Thuringian Forest and continued to Bavaria, Bohemia and Silesia.

From Böttger's workshop or from the Plaue manufactory? A guide to identification the origin of stoneware using SEM and EDS analyses

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In parallel with attempts to develop white Chinese porcelain, experiments were also underway in Dresden in the early 18th century to produce 'red porcelain or jasper porcelain'. This ceramic, later known as Böttger stoneware, was probably developed in 1706. The technical and technological insights, as well as the artistic experience, gained in this process were also required for the production of European hard-paste porcelain, which was first successfully produced in 1708. However, the production of white hard-paste porcelain later pushed Böttger stoneware into the background.

Jasper is a variety of quartz and was very popular as a gemstone in the 18th century; by grinding and polishing, a surface with a high gloss can be achieved. For marketing purposes, the term 'Jaspisporzellain' was initially used. This was intended to highlight the new quality of the ceramics, which was only achievable because, in addition to the selection of raw materials, improvements had been made in particular to the processing stages and firing techniques.

Efforts were also made in other regions to develop these jasperware and white porcelain pieces. In Prussia, red stoneware was already being produced as early as 1713 at the Plaue an der Havel manufactory, with a former colleague of Böttger contributing his expertise. However, different raw materials naturally had to be used. The conditions for firing the ceramics were probably also different, as there was less experience in kiln construction.

The aim of the material analysis using SEM and EDS is to deduce the parameters used in production based on an assessment of the microstructure, thereby providing clues for classification.

From Porcelain Fuse Bases to High-Speed EV Fuses with Ceramic Fuse Bodies: 140 Years of Ceramics in Fuses

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Electrical fuses are among the oldest and most widely used electrical protection devices. Yet their dependence on ceramic materials, predominantly for the fuse body, is often overlooked. Although the current-carrying element of a fuse is usually metallic, ceramics have played a vital role in fuse design by providing electrical insulation, thermal stability, mechanical strength and the ability to contain arcs.

This presentation reviews the historical development of ceramic components in fuses, beginning with the earliest fuse concepts in the 1880s, through to the emergence of porcelain-based fuse holders and fuse bodies at the end of the nineteenth century. Particular attention is given to the transition from simple fusible conductors to enclosed, sand-filled, high-rupturing-capacity (HRC) fuses, in which ceramic fuse bodies became essential functional components. The evolution is discussed from a materials perspective.

The presentation also examines the ceramic materials used in modern fuses, such as electroporcelain, steatite, cordierite and alumina-based ceramics, relating their properties to current performance requirements. Finally, it addresses emerging demands arising from applications such as renewable energy systems, battery storage, electric vehicles, and high-voltage DC networks, highlighting how ceramic materials enable safe and reliable circuit protection.

Near-Net-Shape Manufacturing of Triaxially Reinforced C/C Profiles by Pultrusion

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Carbon fiber-reinforced carbon composites (C/C composites) offer a unique combination of low density, excellent mechanical stability even at temperatures above 2000°C in vacuum or inert atmospheres, and high resistance to thermal shock. Polymer Infiltration and Pyrolysis (PIP) is an established manufacturing process for producing C/C composites. It involves the fabrication of a carbon fiber-reinforced polymer (CFRP) green body by lay-up technique, filament winding, or hot pressing, which is subsequently converted into a C/C composite by pyrolysis. Currently, C/C profiles are mainly manufactured by hot pressing and are used, among other applications, in high-temperature furnaces, as edge protection elements, and for the construction of fixture systems. The serial production of near-net-shape CFRP and, consequently, C/C profiles by pultrusion has the potential to significantly improve the economic efficiency of the PIP process. However, pultrusion differs fundamentally from hot pressing with regard to achievable fiber orientations and process conditions, which may considerably affect the properties of the resulting C/C composites. Therefore, the presentation addresses the manufacturing of triaxially reinforced C/C profiles by pultrusion and discusses the physical, microstructural, and mechanical properties of the resulting C/C composites. Furthermore, approaches to tailor the material properties are presented.

Characterisation of $Al_2O_{3(f)}/Ti_2AlC$ MAX Phase Composite system

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Composite materials based on MAX phases show great potential for use in high-temperature applications in resource-intensive sectors such as energy and aerospace. They combine the properties of ceramics, such as high-temperature and oxidation resistance, with those of metals, including increased fracture toughness and good damage tolerance. This makes them particularly well-suited to applications involving high thermomechanical stresses in aggressive environments.
However, as MAX phases cannot be processed using melt-based methods due to their incongruent melting behaviour, a ceramic slurry system has been developed to enable processing via wet-winding.
$Al_2O_{3(f)}/Ti_2AlC$ composite samples are produced using wet-winding and undergo further processing. The mechanical properties of these samples, particularly their strength and fracture behaviour, are characterised using a Vickers hardness test (10 kg) and 4-point bending tests at 20 °C and 1200 °C. Additionally, the thermal stability and oxidation resistance of the material system under high-temperature conditions are investigated. These investigations aim to identify how the composite material behaves under thermomechanical stress and reveal possible degradation mechanisms using SEM and EDS. Based on these findings, the potential of the $Al_2O_{3(f)}/Ti_2AlC$ composite system for use in high-temperature, oxidising and aggressive environments will be evaluated.

Bayesian optimization of inductive heating for pyrolysis and siliconization of phenolic resin-based slurries

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In the field of ceramic matrix composites, a shift towards more sustainable and energy-efficient processing strategies is required. Conventional thermal treatment of fiber-reinforced silicon carbide ceramics typically relies on resistance furnace-based heating of entire components and the surrounding furnace volume, even when only localized material conversion or repair is needed. Induction heating offers a promising alternative, as it enables direct heating and processing of defined areas of a component. In this work, phenolic resins were modified by targeted mixing with additives such as graphite powders, silicon carbide powders, and carbon fibers to enable their inductive coupling to an electromagnetic field. Bayesian optimization was used to systematically optimize the material composition and process parameters in order to increase the achievable heating performance and improve silicon infiltration behavior. Based on this approach, inductive heating was successfully established for both pyrolysis of phenolic resin systems and subsequent siliconization of the resulting carbon material, enabling its conversion into a silicon carbide matrix. The heating process was monitored using a pyrometer, and the resulting materials were analyzed by non-destructive testing. The presented concept of optimized inductive heating opens a new route towards localized and energy-efficient manufacturing of CMC structures, while also providing a promising basis for future repair strategies without the need to reprocess the entire component.

Micro- and nanoscale characterisation and testing of interphases in SiC-based CMCs

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Over recent years, we have developed a suite of SEM in situ micromechanical techniques to quantify the local mechanical properties of interphases and fibers in SiC-based ceramic matrix composites (CMCs). I will show how these methods are being used to assess the behavior of current state-of-the-art PyC interphases, with particular emphasis on their degradation under extreme environments relevant to fusion applications. I will then show how similar approaches are also being used to support the development and evaluation of alternative interphase concepts aimed at overcoming the limitations of existing systems.

More recently, this experimental toolbox has been extended to enable high-temperature testing of interphases, with measurements performed up to 1000°C. These studies reveal how elevated temperature alters interfacial properties and I will discuss the implications this has for the overall mechanical response of CMCs. In parallel, we are developing in situ TEM testing to investigate interphase behavior at the nanoscale and to identify the mechanisms active during crack propagation.

Together, these micro- and nanoscale approaches provide new insight into interphase mechanics, damage evolution, and environmental degradation, helping to guide the design of more robust interphases for next-generation SiC-based CMCs.

Gradual corrosion of BN/SiC coated SiC Fibers in Boron containing Silicon Melt Infiltration

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Liquid silicon infiltration (LSI) enables the fabrication of highly dense SiC/SiC composites. To lower infiltration temperatures, boron is commonly alloyed with silicon to exploit the Si–B eutectic. However, during infiltration the Si–B melt reacts with BN–coated SiC fibers, leading to the dissolution of the coating and, ultimately, fiber degradation. This study aims to elucidate the reaction mechanisms when boron–bearing silicon melt contacts coated SiC fibers.

We prepared "micro–composites" by embedding 100 mm long SiC fiber tows (?500 filaments per tow, BN/SiC coating) in a SiC–based matrix using slurry processing to emulate CMC architecture. The dried, porous green bodies were infiltrated with a Si–B melt in a thermooptical measurement furnace that provides in–situ optical access during infiltration. A tailored sample geometry allowed for unidirectional infiltration along the tow length, providing a controlled gradient in melt travel distance and contact time. This configuration enabled spatially resolved assessment of corrosion progression as a function of melt path and exposure duration. After solidification, the microstructure was examined by light and electron microscopy, and elemental distributions were quantified by line–scan analysis.

The approach provided direct insight into the sequence and extent of coating degradation, subsequent fiber attack, and boron transport during LSI, offering a framework to guide the design of more stable fiber/coating chemistries and melt compositions for SiC/SiC processing.

Towards Sustainable Pyrolysis Processing of C/SiC Materials Using Experimental and Simulation Approaches

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The thermal processing of CMC requires significant amounts of energy. While past research focused on optimizing mechanical properties, reducing energy demand has become an increasingly important objective.

This presentation first examines the significant impact of the pyrolysis process on overall CO_2 emissions by comparing it to the ecological footprint of raw material production and other involved processing steps. One way of enhancing the ecological sustainability of pyrolysis is improving the thermal processing parameters during pyrolysis such as heating ramps and holding temperature. The influence of these processing variables on reaction kinetics was evaluated by using thermal characterization techniques such as STA.

Furthermore, during pyrolysis pronounced microstructural changes take place in the phenolic resin. These changes affecting the effectiveness of heat transfer within the C/C material can be tracked by a combination of LFA and TGA. This provides information that is useful for planning the thermal processing of bigger structures.

Multiphysics simulation can combine the changes of thermal properties and reaction kinetics to predict accelerated thermal processing strategies for C/C structures with varying geometries. This acceleration leads to considerable savings in energy consumption and CO_2 emissions.

Material removal mechanisms and surface formation in grinding of C/C-SiC composites

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Carbon fibre-reinforced silicon carbide composites (C/C-SiC) are used in applications demanding lightweight, excellent thermal stability, and wear resistance. However, their anisotropic and heterogeneous microstructure, along with hardness and brittleness, makes machining challenging. Diamond grinding is a widely used method for high-quality finishing of C/C-SiC composites. The final component quality is influenced by multiple factors, namely the grinding parameters and the material microstructure. Understanding the behaviour of the fibre and matrix phases during grinding is therefore essential for interpreting the material response and the resulting surface integrity.

The present work investigates the surface formation in grinding of woven reinforced C/C-SiC. The underlying material removal mechanisms of the individual phases of the composite are first identified. Grinding experiments are conducted to analyse the influence of the grinding parameters and material composition on surface roughness. Characteristic grinding-induced surface features are discussed in relation to their contribution to surface formation. The results indicate a predominantly brittle removal, with a limited influence of the grinding parameters but a remarkable effect of the material composition on surface roughness.

All-oxide ceramic matrix composites: Influence of sintering program based on monolithic crack energy assessment

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A comparative evaluation between an alumina-zirconia and a mullite-zirconia matrix for all-oxide ceramic matrix composites (Ox/Ox) was performed based on monolithic samples fabricated by slip casting. In previous works, the monolithic testing has been proven valid to allow a differentiated investigation of the matrix for Ox-Ox composites without the overlapping effects of including fibers. The focus in this work was placed on the sintering-induced shrinkage and its impact on the mechanical properties of the monolithic and composite samples. Four different sintering programs were applied with variations in heating rate, dwell time and maximum temperature. Additionally, the impact of an additional thermal annealing step after sintering on the mechanical properties of both sample types was assessed. Considering the He-Hutchinson model, the mechanical testing included the determination of the Young´s modulus as well as the fracture energy. For their analysis, the impulse excitation technique and a single-edge V-notch beam test were applied. Ox/Ox were fabricated by a colloidal processing route and mechanically tested in a 3-point bending test to correlate the monolithic results with the composite behavior.

The results obtained for mechanical testing of monolithic and com-po-site samples are presented and aligned with the shrinkage of the matrices. Finally, the applicability of the monolithic testing method for the evaluation of the sintering process is assessed.

Additive Manufacturing of Carbon/Carbon Components from Carbon PEEK Feedstocks: Opportunities for Industrial High-Temperature Applications

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Carbon/Carbon composites are attractive materials for aerospace, energy and industrial thermal processing thanks to their low density, thermal shock resistance and stability at high temperatures. However, conventional manufacturing routes often limit geometric complexity and require costly tooling and long lead times.

This work presents a digital manufacturing route based on the additive manufacturing of Carbon PEEK feedstocks followed by thermal conversion into Carbon/Carbon components. The approach combines the geometric freedom of high-temperature Fused Filament Fabrication (FFF) with established carbonization processes to produce lightweight structures and near-net-shape components.

Flat plates and representative benchmark geometries were manufactured and converted into Carbon/Carbon to evaluate dimensional stability, shrinkage, defect formation and mechanical behavior. The influence of component thickness and geometry on processability and final component quality was assessed.

The results demonstrate the feasibility of producing complex Carbon/Carbon architectures through a fully digital workflow, reducing dependence on conventional tooling while enabling new design opportunities. Beyond Carbon/Carbon, the proposed approach represents a potential manufacturing platform for future ceramic and ceramic matrix composite components intended for operation in extreme environments.

The presented technology opens new opportunities for industrial adoption of advanced high-temperature materials where geometric complexity, weight reduction and rapid design iteration are critical requirements.

Innovative Machining Technologies for Advanced Ceramics

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The cost-effective machining of technical ceramics poses significant challenges due to the material's high hardness and brittleness, placing demanding requirements on both cutting tools and process design. This presentation introduces the development of innovative polycrystalline diamond (PCD) multi-edge cutting tools and novel tool concepts specifically designed for machining ceramic materials. Particular emphasis is placed on tool design, machining strategies, and their influence on process stability and component quality. Experimental results demonstrate the potential of the new technology in terms of tool life and economic efficiency, while also highlighting its prospects for industrial application.

Thermochemical and Interfacial Effects of Silicon Alloys during SiC/SiC Production by Liquid Silicon Infiltration

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Silicon alloying provides an effective approach to tailor thermochemical interactions during the fabrication of silicon carbide fiber reinforced silicon carbide (SiC/SiC) composites by liquid silicon infiltration, particularly regarding the stability of BN-SiC interphases. In this work, five Si-based alloy systems (Si, Si-B, Si-Zr, Si-Hf, and Si-Mo) were investigated through differential scanning calorimetry and infiltration experiments using composites with BN-SiC interphases. Melting and reaction temperatures together with the corresponding enthalpies were determined and related to the resulting SiC/SiC interphase condition. The study demonstrates that thermal characteristics alone are insufficient to explain interphase preservation. Instead, interphase stability depends on the combined influence of thermochemical behavior and interfacial reactions. While the Si-B and Si-Zr systems maintain interphase integrity through SiC microstructure stabilization and the formation of protective interfacial layers, the Si-Hf and Si-Mo alloys lead to significant degradation. The results identify alloy composition as a decisive factor for achieving damage-tolerant SiC/SiC composites manufactured by liquid silicon infiltration.

Influence of the type and stacking of oxide ceramic fabric on the mechanical properties of OCMC

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Oxide ceramic matrix composites (OCMC) are suitable for use in the aerospace industry due to their low specific weight and good high-temperature properties. In order to select the appropriate material for the respective field of application, it is crucial to understand the influence of different fiber materials and their arrangement in the composite on the resulting properties.

The aim of this work is to investigate the mechanical properties (e.g. flexural strength, fracture behavior) of OCMCs as a function of the type and stacking of the fabric. Also, non-destructive tests (e.g. Air-coupled ultrasound, determination of density and fiber volume fraction) were carried out to detect inhomogeneities in the material which can influence the resulting mechanical properties. Various mullite fabrics were used for the production, which were stacked in different ways and infiltrated with an Al_2O_3 slurry using vacuum-assisted infusion (VASI). Mechanical tests at room temperature showed significant differences between the investigated fiber fabrics and fabric-matrix combinations in terms of fracture behavior and maximum stress and strain. In addition, crosswise stacking in different orientations (0°, 45°, 90°) can lead to an increase in strength and strain, depending on the type of fabric.

Influence of the geometric joining design on the machining performance, the microstructure, and the flexural strength of liquid silicon infiltration-joined silicon carbide ceramic composite

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In this study, silicon carbide (SiC) composite specimens were machined with diamond grinding tools, joined and densified by liquid silicon infiltration. The SiC composite was first manufactured by liquid silicon infiltration (LSI) of a short carbon-fiber-reinforced carbon preform. To investigate the influence of geometry and joining area, four different joining shapes were machined into SiC composite. The samples were joined by polymer before being subjected again to an LSI process, in which the polymer at the joining interface was pyrolyzed in situ and subsequently infiltrated with silicon. As long as dimensional machining accuracy showed a maximum deviation of 50 µm, results showed a robust interface with a thickness of approx. 80 µm, independent of the joining shape. The microstructure of the joint consisted of two thinner silicon-rich layers and a core layer consisting mostly of SiC. Finally, the flexural strength of the joined specimen showed no significant influences to the joining shape and area and had more than 60% of the strength of the SiC composite. This approach improves the ability to fix SiC composite structures and to prepare the repair geometry by machining.

Silica Fiber-Reinforced O-CMCs for Applications up to 1,000 °C: A Cost-Effective Alternative

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Oxide ceramic matrix composites (O-CMC) are considered a promising class of materials for high-temperature applications in aviation. However, the high material costs of conventional oxide fibers have so far limited their economic use. Within the NEUTRON project (Lufo VI), conducted in cooperation with Airbus Helicopters Donauwörth, a cost-sensitive approach based on commercially available silica fibers was therefore investigated. The main focus of this work was the development of a low-sintering oxide ceramic matrix based on Al_2O_3 and SiO_2, which can be processed at a maximum sintering temperature of 950?°C to prevent thermal damage to the silica fibers during manufacturing. Various types of silica fibers were systematically characterized and evaluated with regard to their suitability. The mechanical properties of the produced composites were comprehensively determined, including selected high-temperature properties relevant to the intended application range up to 1,000 °C. Additionally, a surface coating for the finished components was developed to further improve their resistance and functionality under operating conditions. The results demonstrate the potential of silica fiber-based O-CMC as a cost-efficient alternative to conventional oxide fiber composites for selected applications in the aviation sector.

Polymer systems for reactive melt infiltrated ceramic matrix composites – C/C-SiC based on established and novel commercially available materials

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To date, only few polymers are known as suitable carbon matrix precursors for manufacturing ceramic matrix composites (CMC). Predominantly, phenolic resins or high-performance thermoplastics such as PEEK are used. However, these polymers exhibit inherent processing disadvantages such as pore formation tendency of phenolic resins or the formation of a melt during the pyrolysis of thermoplastics.
To overcome the limitations of the currently known matrix precursors, commercially available polyaddition curing cyanate esters were investigated regarding their applicability for reactive melt infiltration (RMI) processing.

Dilatometry, TGA, DMA, SEM and phase composition analysis were conducted to characterize the suitability of resins for CMC manufacturing. C/C-SiC based on phenolic resin, PEEK and three different cyanate ester resins were manufactured by liquid silicon infiltration.

Damage tolerant C/C-SiC materials with bending strength > 130 MPa were acquired by using high-char yield (> 60%) cyanate esters. Correlations between the char yield of the resins, shrinking behaviour, phase composition and mechanical properties were derived. All cyanate ester based materials showed remarkable fibre protection properties during RMI. Cyanate ester resins show a unique combination of low viscosity, polyaddition cure, high char yield and exceptional fiber protection during siliconization and can therefore be considered as an out-standing polymer class for the next generation of RMI based CMC.

Repair of microcracks in carbon fiber reinforced silicon carbide via self-healing using residual silicon

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Components made of ceramic matrix composites (CMC) typically are considered failed when microcracks occur, either during manufacturing or service. To avoid replacing such components, repair approaches are being explored. For carbon fiber reinforced silicon carbide (C/SiC) materials produced by reactive melt infiltration, the residual free silicon (5–20 vol%) offers a promising self-healing potential. Silicon can melt upon heating, refill small cracks and react with carbon to SiC. Investigations show that molten silicon preferentially migrates toward carbon-rich regions rather than flowing freely, while the average porosity increases only slightly. To study this self-healing mechanism, cracks were simulated by assembling two C/SiC plates with controlled gap widths between 0.5 and 75 µm and heating them to 1450 °C. A strong dependence of crack healing on crack width is observed: gaps with a width ? 5 µm are completely filled with silicon and SiC crystals. For gap widths between 5 and 15 µm, complete silicon filling occurs, but without SiC formation. For gap widths ? 15 µm, the available silicon is insufficient to fully close the crack. The desired formation of SiC is assumed to be linked to C-saturation of the silicon melt, which occurs more rapidly in smaller gaps. For larger gaps, additional silicon and carbon sources are required.

The results demonstrate the high potential of microcrack self-healing in C/SiC as a method for CMC repair.

Draping studies and fibre preform shaping of SiC/SiC stator guide vanes with more complex geometries

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Efficient aircraft engines require higher cycle and component efficiencies, reached through the use of advanced materials and innovative manufacturing methods. The aims are higher temperature resistance and reduced weight of combustor and turbine components. Ceramic matrix composites (CMC) with cooling features and coated with environmental barrier systems are strong candidates for combustor and turbine components.

Prismatic nozzle guide vanes made of silicon carbide fiber-reinforced silicon carbide composites (SiC/SiC) have previously been manufactured and tested at DLR. The next step toward vanes with engine-relevant geometry requires the integration of more complex features, including adaptations of the outer contour, improved leading edge connections of the fabric layers, and adjustments in vane size. The DLR SiC/SiC manufacturing route specifies requirements that define the boundary conditions, such as a removable inner core and the draping of dry fabric layers instead of prepregs. This work develops concepts for the layup of the fiber preforms to address the increased geometric complexity of engine-relevant vane designs. The very small dimensions of the vanes (chord length below 60 mm), pose significant manufacturing challenges. A new design criterion for the minimum bending radius at the leading edge is introduced. The reduction of the minimum achievable radius at the leading edge and the incorporation of twist are essential for enhancing aerodynamic performance.

Bioactive glasses: from ion release to multifunctional biomaterials

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While conventional biomaterials were mainly designed to replace damaged tissues or provide structural support, modern bioceramics are expected to actively interact with the biological environment and stimulate specific cellular responses. In this context, bioactive glasses represent a key class of materials, as their controlled dissolution led to the release of biologically active ions that can stimulate mineralization, angiogenesis or tissue regeneration. Thus, this talk will focus on mesoporous bioactive glass nanoparticles (MBGNs) as advanced ion-releasing bioceramic platforms and their incorporation into hydrogels. Following a brief overview of MBGNs synthesis, the presentation will highlight their physicochemical characterization. The results show that the synthesized MBGNs present a spherical morphology, mesoporous structure and the ability to release biologically relevant ions in aqueous environments. The incorporation of MBGNs into hydrogels will then be discussed as a strategy to combine the bioactivity of inorganic nanoparticles with soft three-dimensional matrices able to better mimic native tissues. The obtained composite hydrogels showed stable three-dimensional structures, swelling capacity and degradation behaviour influenced by the presence of MBGNs. Overall, this talk will show how nanoscale bioactive glasses can be integrated into polymeric networks to develop multifunctional bioceramic-based platforms for regenerative medicine.

Thermal Processing of Ceramic Matrix Composites: Potential Energy Savings and Their Impact on Material Characteristics

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Carbon fiber reinforced silicon carbide (C/SiC) ceramic matrix composites (CMC) produced via Liquid Silicon Infiltration (LSI) are attractive materials for high-temperature applications. C/SiC- Ceramic Matrix Composites produced via the LSI-Process require a high temperature pyrolysis step to convert a carbon fiber reinforced polymer (CFRP)-preform into a highly porous C/C structure.

Using a cradle-to-gate Life Cycle Assessment (LCA), this study identifies the pyrolysis process parameters with the greatest potential to reduce energy consumption and CO_2 emissions. The environmental impacts of varying pyrolysis parameters are assessed and correlated with material characterization results to identify favorable trade-offs between sustainability performance and material properties.

The thermal decomposition behavior of the carbon CFRP-Preform was investigated using STA coupled with FTIR. The findings quantify the influence of a varying heat rates on the reaction kinetics of pyrolysis. To broaden the scope of the investigation and assess the effects of process modifications on the resulting C/C structure, computed tomography and in-situ dilatometry were used. These techniques provide information on how the pore- network is influenced by changes in processing parameters.
By combining LCA, material characterization techniques and statistical analysis, the study identifies key process indicators for reducing the environmental footprint of the pyrolysis step while maintaining suitability for subsequent silicon infiltration.

Sustainable MgO-C Refractories Based on Recyclates and Eco-Friendly Binder Systems: Properties and Performance Evaluation

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This study presents the synthesis of sustainable carbon-bonded MgO refractories using recycled MgO-C materials with varying recyclate contents combined with fresh raw materials and environmentally friendly fructose–tannin-based binder systems. The work focuses on the development of eco-friendly binders as alternatives to conventional resin- and pitch-based systems, with citric acid as a cross-linking agent to enhance cold crushing strength and functional additives to further improve binder performance. In addition, a comparison between laboratory-pressed samples and industrially pressed bricks was conducted to evaluate processing effects and scale-up challenges. Extended investigations of different bio-based binder combinations were carried out with emphasis on binder analysis aimed at achieving properties comparable to conventional systems. The impact of different recyclate contents on the physical, mechanical, and thermomechanical properties was evaluated. The produced MgO-C refractories were characterized in terms of their physical, mechanical, and thermomechanical properties, including immersion tests in molten steel using a steel casting simulator, while SEM and EDS analyses after exposure provided insights into microstructural evolution and material interactions with molten steel.

Use of Lignin as Partial Replacement of Phenolic Resin as Carbon Precursor for the Manufacturing of C-SiC Composites via Liquid Silicon Infiltration

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Ceramic matrix composites, particularly C-SiC, are widely used in high-temperature and tribological applications due to their high thermal stability, low density, and excellent mechanical properties. These materials are commonly manufactured via Liquid Silicon Infiltration (LSI) using fossil-based raw materials such as phenolic resins as carbon precursors.

The aim of this work is to investigate lignin as a partial replacement for phenolic resin as carbon precursor in the production of C-SiC composites via the LSI process. Due to its aromatic molecular structure, lignin exhibits similarities to phenolic resins and may therefore be integrated into existing matrix systems. However, the influence of lignin content on pore structure formation, silicon infiltration behavior, and microstructural development throughout the process chain has not yet been sufficiently investigated.

For this purpose, materials containing different lignin contents are manufactured, pyrolyzed, and subsequently infiltrated with liquid silicon. Characterization is carried out by means of thermogravimetric analysis, density and porosity measurements, as well as microstructural and mechanical investigations. The objective is to evaluate the influence of lignin on material development and to identify suitable substitution levels for a more sustainable production of C-SiC composites.

Holmium-Doped Bioactive Glasses for Biomedical Applications

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Rare-earth-doped mesoporous bioactive glasses (MBGNs) are gaining attention for diverse biomedical applications due to their tunable iron release and potential biological activity. In this work, Ho-doped MBGNs were synthesized via a microemulsion-assisted sol–gel process and evaluated for their structural properties and in vitro response. Characterization by FTIR, XRD, SEM, and zeta potential analysis confirmed the formation of compositionally homogeneous mesoporous particles with a negative surface electrical charge. SBF immersion did not yield conclusive evidence of crystalline hydroxycarbonate apatite formation, although morphological changes suggested progressive particle degradation. Extract-based cytocompatibility studies using MC3T3-E1 and MG63 cells demonstrated good tolerance of both undoped and Ho-doped nanoparticles. These MBGNs were further incorporated into alginate–dialdehyde/gelatin hydrogels, which enabled extrusion-based 3D printing of composite scaffolds with good shape fidelity and homogeneous particle distribution, as well as cytocompatibility, supporting further investigation of these systems for biofabrication applications.

Influence of Inert Gas Pressure on the Infiltration Behavior in the LSI Process

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The Liquid Silicon Infiltration (LSI) process is one of the key processes for manufacturing C/SiC Materials. In industry, the siliconization step of the LSI process is typically carried out under an inert gas atmosphere pressures between 3 mbar and 20 mbar. However, the influence of these pressures on the process has only been investigated to a limited extent, and until now only in model systems without transfer to real pore networks. Therefore, this study investigated the effect of inert gas pressure by conducting siliconization experiments under Argon gas pressures ranging from 3mbar to 1atm. This contributes to a better understanding of the mechanisms controlling infiltration behavior and corresponding infiltration depths.

CT-scans were performed to investigate how inert gas pressure affects the maximum infiltration depth. Pycnometry measured the density increase during siliconization to evaluate the completeness of the Carbon to SiC conversion. In addition, scanning electron microscopy (SEM) was employed to provide a more detailed insight into local phase composition in the final C/SiC materials.

Characterization and optimization of a C-SiC ink for the direct ink writing process

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Carbon-silicon carbide (C-SiC) inks were prepared, characterized, and optimized for the additive manufacturing process direct ink writing (DIW). The main goal was to establish a reproducible procedure for ink preparation and characterization to ensure comparable properties of printed components. The inks were prepared using a speed mixer and characterized by optical evaluation, particle size analysis, and rheological measurements. In addition to optimizing the preparation process, selected parameters of the ink composition, such as the solid content, were varied to investigate their influence on material behavior and printability. Based on the optimized and reproducibly prepared inks, green bodies with different structural complexities were successfully manufactured using the DIW process.

The results showed that the developed C-SiC inks could be stored for several weeks without detectable aging effects. Furthermore, reproducible ink preparation enabled the successful fabrication of components such as lattice structures. These findings demonstrate the suitability of the developed inks for the DIW-based manufacturing of complex ceramic green bodies. In future processing steps, these green bodies are intended to be converted into silicon-infiltrated silicon carbide (SiSiC) components by reactive melt infiltration.

Tribologische Charakterisierung kurzfaserverstärkter Keramiken für Bremsanwendungen

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Aufgrund ihrer thermischen Stabilität und geringen Verschleißneigung bieten C/C-SiC-Werkstoffe (SF-CMC) großes Potenzial für Hochleistungs- und Notbremssysteme in der Elektromobilität. Aus Nachhaltigkeitsgründen rückt dabei zunehmend der Einsatz recycelter Carbonfa-sern (rCF) anstelle von Primärfasern (vCF) in den Fokus. Da das tribologische Verhalten rCF-basierter SF-CMCs bisher unzureichend erforscht ist, validiert diese Masterarbeit deren Eignung als ökologische Alternative.

Mittels Pin-on-Disk-Verfahren wird das Reib- und Verschleißverhalten von vCF-, rCF- und Standard-Proben gegen Al_2O_3- oder Stahlkugeln systematisch auf Probenebene untersucht. Dabei werden Normalkräfte, Geschwindigkeiten und Umgebungsbedingungen (Feuchtigkeit) variiert. Zentrale Fragestellungen sind der Vergleich der Reibkoeffizienten der Materialien, deren Stabilität unter Lastwechseln sowie die werkstoff-wissenschaftlichen Ursachen für abweichendes Reibverhalten.

Ergänzend erfolgt eine detaillierte Oberflächenanalyse im Vorher-Nachher-Vergleich mittels Mikroskopie und Fokusvariation. Durch die Auswertung von Topographie und Rauheit lassen sich dominante Verschleißmechanismen wie Adhäsion, Abrasion oder Tribofilmbildung identifizieren.

Ziel ist ein grundlegendes Verständnis der Zusammenhänge zwischen Werkstoffzustand, Prüfbedingungen und Reibcharakteristik. Die Erkenntnisse ermöglichen eine direkte Bewertung der Recycling-Werkstoffe und leisten einen Beitrag zur Auslegung nachhaltiger, tribologisch beanspruchter Komponenten.

Der Keramische Nachwuchs (DKN): Building a Network for the Next Generation of Ceramists

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Founded in 2024 as the young professionals initiative of the German Ceramic Society (DKG), the "Der Keramischer Nachwuchs (DKN)" aims to connect, support, and inspire the next generation of researchers and professionals in the ceramic community. After a successful first year focused on building structures and establishing initial activities, the DKN is developing into an important platform for young ceramists in Germany. The DKN is supported by the DKG office, benefits from advice and mentorship from experienced ceramists, and works closely with its own committee as well as the "Young Ceramists Network (YCN)" of the European Ceramic Society (ECerS). This structure provides guidance and stability while also giving members the opportunity to actively shape the network and contribute their own ideas and initiatives. A DKN membership offers several benefits for students and early-career professionals. It creates valuable opportunities to connect with people from both academia and industry, helping members build professional networks at an early stage. At the same time, members are encouraged to take responsibility, work independently, and actively contribute to projects and events. The DKN also supports its members in finding internships, job opportunities, and career entry positions. In addition, ECerS membership is included, which is an important requirement for applying for opportunities such as JECS Trust grants.

By combining mentorship, networking, and international collaboration, the DKN aims to create an open and supportive community where young ceramists can develop professionally, exchange ideas, and actively help shape the future of ceramic science and engineering.

POSTERS

Sustainability & Critical Raw Materials – Challenges & Opportunities

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#1

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The European Union has identified 34 critical raw materials. Seventeen of these are classified as strategic raw materials due to an anticipated increase in demand over the coming years, driven by their high economic relevance. Concurrently, demand is projected to far exceed production capacity and availability. Furthermore, environmental regulations are continuously tightening, potentially restricting the utilization of certain raw materials or processed goods in the future.

Given Germany's reliance on raw material imports, challenges such as supply chain dependencies, geographic concentration of resources, and single-source vulnerabilities are contrasted by opportunities, including technological competition and the efficient recycling of intelligently designed products.

Consequently, a pivotal approach lies in the integrated analysis of material, design, and process. This evaluation must encompass supply chains and technologies, as well as alternative materials and recycling processes across the entire product life cycle.

Controlled Synthesis of Tin Sulfide Thin Films from Molecular Single-Source Precursors

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Metal chalcogenides have attracted considerable attention as promising materials for sustainable energy conversion due to their favourable electronic properties, earth abundance, and tunable optoelectronic characteristics. Therefore, the synthesis of phase-pure chalcogenides with tailored properties is of interest. One promising strategy involves the use of molecular single-source precursors containing preformed metal–chalcogen bonds, which can be decomposed to yield the desired materials. Here, a molecular single-source precursor approach for the synthesis of tin chalcogenides is presented. Tailored precursor design enabled controlled decomposition pathways and selective formation of the targeted tin sulfide phases under ambient conditions. Thin films were deposited by spray pyrolysis, yielding homogeneous coatings with good surface coverage and phase purity. Structural and spectroscopic characterization confirmed the successful conversion of the molecular precursors into crystalline tin sulfide materials of the desired phase. The deposited films were investigated as photoactive materials for photoelectrochemical water splitting and exhibited a clear photocurrent response under illumination, demonstrating their potential for solar-driven hydrogen production.

Chemical Vapor Deposition under the Influence of a Magnetic Field

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Chemical Vapor Deposition (CVD) is a versatile and widely established technique in materials science and semiconductor manufacturing for the synthesis of thin films, coatings, and nanostructured materials. The integration of magnetic fields into the CVD process introduces an additional degree of freedom for tailoring material growth and properties beyond the capabilities of conventional deposition approaches. By deliberately applying magnetic fields during synthesis, morphological, structural, and compositional characteristics can be systematically modified, enabling the design of materials with enhanced and application-specific functionalities.

Magnetic-field-assisted growth affects crystal nucleation and growth kinetics, resulting in altered surface morphologies and the preferential orientation of crystalline nanostructures. Furthermore, the interaction between deposition parameters and magnetic field effects provides additional control over the chemical composition and microstructure of the deposited films. These modifications can significantly improve material performance, leading to enhanced magnetic properties, increased photoelectrochemical activity in photoabsorbers, and improved electrical output in piezoelectric systems. The presented findings demonstrate the potential of magnetic-field-assisted CVD as a powerful strategy for engineering advanced functional materials with tailored properties.

Advanced Bone Models for Surgical Training Based on Polymer-Infiltrated Microporous Ceramic Structures

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#4

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In surgical training, realistic practice scenarios are essential before treating patients. Fracture fixation procedures, in particular, require hands-on experience in drilling and screw insertion into bone tissue. However, access to realistic surgical training opportunities is limited, while existing training models often lack anatomical accuracy and bone-like haptic feedback.

Lithography-based Ceramic Manufacturing (LCM) provides a promising approach for producing biomimetic bone models with tailored macro-geometry, microporosity, and mechanical behavior. By adjusting the wall thickness of cortical bone structures, different bone densities and anatomical characteristics can be reproduced.

The shaping process, in combination with a defined slurry composition, results in an interconnected porous microstructure after sintering, which is subsequently infiltrated with polymer phases to mimic the stiffness and toughness of natural bone. This ceramic–polymer composite concept enables the replication of structural and mechanical features of human bone tissue.

A key aspect of this study is the practical evaluation of the developed bone models by surgeons, demonstrating promising results regarding realistic bone-like haptic feedback during drilling and screw fixation procedures.

Coating of Fe_2O_3 Particles with CuO by Pulsation Reactor and study the effect of thermal post-treatment in Forming gas on coated Particles for Iron slurry/Air Batteries application

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In order to be able to store large amounts of energy in the future in an environmentally friendly, cost-effective manner and using widely available raw materials, the Fe-slurry/air storage system was proposed as a new concept. A proof of concept showed that an iron slurry battery mass can be discharged in an iron slurry/air flow cell with a cell voltage of approx. 0.8 V to approx. 28 % of its capacity. However, only a low Faraday efficiency could be achieved in the charging step. One promising approach to improving performance is the use of core/shell particles with an iron-containing core and a porous, electrically conductive shell material, which is intended to reduce the contact resistance between the particles in the slurry.

The coating of Fe_2O_3 fine particles with CuO particles having specific properties can be thermally synthesized by the pulsation reactor. This work describes the characteristic properties of the CuO coated Fe_2O_3 particles with the addition of Carbon materials to improve the conductivity. The characteristic process parameters such as compositions and art of the coating materials, on properties of the produced particles were investigated applying diff. analytical methods. The produced particles were successively therm. reduced using rotary kiln to increase the conductivity of the produced. The produced particles were successively dispersed using wet milling process. Also, the effect of milling parameters were investigated to produce stable non agglomerated suspensions for the application in iron slurry/air batteries. The electrochemical charging and discharging behaviour was investigated in a small electrochemical cell with a stirrer electrode.

Quantifying Sources of Uncertainty in SEM Dimensional Measurements: Insights from Ceramic Nanofibre Analysis

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Dimensional measurements from scanning electron microscope (SEM) images are widely used to characterize microstructures, nanoparticles, and nanofibres, yet the uncertainty arising from image acquisition, analysis, and measurement procedures is rarely quantified. Current studies primarily address microscope calibration and instrument limitations, whereas the contributions of image acquisition and manual measurement procedures remain poorly understood.[1] To identify the largest sources of this uncertainty and determine how to minimize them, TiO_2-SiO_2 nanofibres were used as a model system. A series of SEM images were taken to isolate and quantify the effects of resolution, focus, magnification, feature edge detection, feature orientation, and line angle, with theoretical analysis to validate and isolate the line angle error. Each image set was of the same nanofibres while varying a single acquisition or measurement parameter with repeated measurements of the same feature in each image to understand the trend. Preliminary results indicate that focus, magnification, and image resolution have the greatest influence on measurement uncertainty, with associated uncertainties of 1-4 pixels. These findings provide an evidence-based framework for standardizing SEM dimensional measurements, establishing reference data for automated image analysis and AI-assisted characterization, with the possibility of extending similar uncertainty analyses to other image-based techniques.

[1] https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.250-96.pdf

Multiphysics modeling of the pyrolysis process of milled-fiber reinforced CFRP materials

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#7

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The production of C/SiC components involves the pyrolysis of CFRP green bodies, inducing the formation of a porous carbon network. During pyrolysis, this transformation process leads to a continous change in thermal properties due to increased porosity and changed chemical composition in the matrix. Dynamically changing thermal properties make it difficult to properly predict Temperature Fields within the green body using simulation tools. This consequently leads to ineffcient and possibly incomplete thermal processing.

Combination of several thermal characterization techniques make it possible, however, to mitigate this problem. Thermogravimetric Analysis (TGA-)Measurements on one hand make it possible to accurately track the progress of pyrolysis. Matching this mass loss with the results of Laser Flash Analysis (LFA)- and Differential Scanning Calorimetry (DSC)- measurements of samples at different progression states make it possible to construct quasi in-situ curves for thermal properties.
These thermal property curves were incorporated into the context of a Comsol Multiphysics Model, covering the oven environment of a lab-scale Tomac+ analysis oven as well as the green body itself. On top of making it possible to predict transient temperature distributions inside of samples, other future usages aiming for process optimization become possible. This ranges from prediction of reactions taking place within the sample to adaption of improved temperature programs tailored for the individual size of the green body. The model focuses on the prediction of transient temperature distributions inside the specimen and the surrounding furnace environment.

Characterization and simulation of porosity in ceramics

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Porous ceramic foams have a wide range of applications as catalyst support structures, lightweight materials, filtration, energy or sound adsorption or energy storage materials. In addition, porous ceramic scaffolds for bone replacement are a promising future material to ensure faster medical healing.

Porosity is particularly important in nature, where graded and hierarchical porosities play an important role. However, the generation of gradients in porosity is also necessary in ceramic materials for a wide range of applications, but also to optimize the physical properties in the composite. Especially in combination with a hierarchy over several length scales in the porosity, functionalization can be achieved, e.g. by increasing the surface area for catalytic activities.

When characterizing the microstructure, the choice of representative volume is particularly important for hierarchical porosities, so that simulations based on them do not include too small a volume. The generation of these pore structures (gradient and hierarchical) is achieved by a variety of processes, ranging from different particle distributions and pore formers to additive manufacturing including high-throughput processing.

SusMat-VR - Virtual Material Testing

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#9

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As part of the innovation project SusMat-VR – Sustainable Material Testing, material testing is digitally replicated utilizing virtual reality (VR) headsets. Real-world equipment and processes can be mapped directly into the virtual environment. As a case study, the tensile test was implemented via Virtual Reality. Mirroring real-world interactions, specimens can be positioned virtual within the testing machine, and various experimental parameters can be selected.

Following the virtual execution of the test, digital evaluation is performed. This framework allows specimens to be systematically compared and analyzed within a graphical diagram. Furthermore, users can select and contrast different specimen materials as well as experimental parameters. In addition, micrographs and fracture surfaces of the selected materials are integrated into the database, formatted for detailed inspection and microstructural analysis.

In conclusion, the results demonstrate that this approach enhances the sustainability of processes and equipment. Moreover, the interactive environment fosters a deeper comprehension of underlying processes and causal correlations.

Additively Manufactured Lead-Free $BaTiO_3$ Piezoceramics: Architecture and Texture Design for High-Figure-of-Merit Energy Harvesting

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Lead-free $BaTiO_3$-based piezoceramics are promising materials for sustainable energy harvesting, sensing, and electronic applications. In this work, additive manufacturing is used to tailor the architecture and texture of $BaTiO_3$ piezoceramics for improved energy-harvesting performance. Direct ink writing and fused filament fabrication are investigated as complementary routes to introduce controlled porosity, engineered infill structures, and microstructural alignment in functional ceramic components.

The study establishes processing–microstructure–property relationships by correlating printed architecture, porosity, texture, dielectric permittivity, piezoelectric response, voltage coefficient, and energy-harvesting figure of merit. Architectured $BaTiO_3$ structures show a maximum FoM33 of 3.63 pm2/N, corresponding to an approximately 2.86-fold improvement compared with dense reference samples. This enhancement is attributed to a reduction in dielectric permittivity while retaining useful piezoelectric activity, resulting in improved piezoelectric voltage response. In parallel, texture engineering provides an additional route to enhance anisotropic electromechanical performance, with selected textured structures showing up to 50–75% improvement in functional response.

Synchrotron and neutron diffraction-based analysis is used to support texture and structure–property evaluation, while future in situ studies can clarify field- and temperature-dependent electromechanical mechanisms. Overall, this work demonstrates that additive manufacturing enables architecture- and texture-guided optimization of lead-free piezoceramics for high-performance energy-harvesting devices.

Development of CeO_2- and TiO_2-doped ZTA ceramics for biomedical oxide ceramics from European raw materials

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In view of increasing demands for supply security and sustainability, European raw material sources for technical ceramics are gaining importance. This poster presents the evaluation of selected European Al_2O_2 and ZrO_2 raw materials for the production of oxide ceramic materials by slip casting and assesses their suitability for biomedical applications. Several European alumina and zirconia raw materials were characterized with respect to their processability in slip casting, slurry properties, and sintering behavior. Based on these criteria, suitable raw materials were selected and used to produce zirconia-toughened alumina ceramics (ZTA). The materials were processed into plate-shaped test specimens. To optimize the mechanical properties, the ZTA system was additionally doped with CeO_2 and TiO_2. The resulting ceramics were characterized in terms of microstructure and mechanical performance. Their potential for biomedical applications was subsequently evaluated.

Fracture Resistance of Repaired 5Y-PSZ Zirconia Crowns after Endodontic Access

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This study analyzed the fracture load before and after a chewing simulation of zirconia crowns that were trepanned and repaired using composite resin. Overall, 3 groups with 15 5Y-PSZ crowns in each group were tested. For group A, the fracture load of the unmodified crowns was evaluated. For group B, the crowns were trepanned and repaired using composite resin, also followed by a fracture test. For group C, crowns were prepared like in group B but received thermomechanical cycling before the final fracture tests. Furthermore, scanning electron microscopy (SEM) and X-ray microscopy (XRM) analysis were performed for group C. The mean fracture loads and standard deviation were 2260 N ± 410 N (group A), 1720 N ± 380 N (group B), and 1540 N ± 280 N (group C). Tukey-Kramer multiple comparisons showed a significant difference between groups A and B ($p < 0.01$) and groups A and C ($p < 0.01$). After ageing, surface fissures were detected via SEM, but no cracks that reached from the occlusal to the inner side of the crown were detected via XRM. Within the limitations of this study, it can be stated that trepanned and composite-repaired 5Y-PSZ crowns show lower fracture loads than 5Y-PSZ crowns without trepanation. Finite element analysis is ongoing for the system previously studied in vitro, and the preliminary results will be incorporated into the poster.

Investigation of the interfacial fracture toughness of coated SiC-fibers via single fiber push-out test

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#13

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In SiC fiber-reinforced SiC (SiC/SiC) composites, the interfacial region between fiber and matrix, the so-called interphase, typically features a chemical vapor deposited BN-SiC coating system. It plays a pivotal role in determining the composites' failure behavior. The BN layer establishes weak interfacial bonding that enables quasi-ductile failure behavior, while the SiC layer protects both the BN coating and the SiC fibers from degradation. As the mechanical properties of the interphase govern composite failure behavior, direct characterization of the interfacial fracture toughness of the BN-SiC coating is essential for targeted coating optimization.

This work provides a dedicated approach, where the interfacial fracture toughness of the SiC-BN-coating itself is determined via the single-fiber push-out test. Coated fibers are embedded in an epoxy resin, thinned via lapping, and polished. The samples are then tested by cyclically loading a single fiber with a flatend indenter and evaluated by an energy-based approach.

Initial results confirm the successful embedding of coated fibers in epoxy resin, with crack initiation and propagation occurring within the BN-SiC coating region, validating the suitability of the proposed method. This methodology provides a basis for systematic quantitative characterization of the interfacial properties, ultimately supporting the targeted optimization of the interphase.

Development of virtual testing methodologies for the characterization of Ceramic Matrix Composites (CMC) for aerospace application and identification of design criteria

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#14

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Ceramic Matrix Composites (CMCs) are extensively investigated for aerospace applications, particularly thermal protection systems, due to their low density and exceptional high-temperature resistance. Despite this potential, establishing design criteria via virtual testing remains challenging due to limited microstructural data, complex failure mechanisms, and defects induced by multi-stage Liquid Silicon Infiltration (LSI) manufacturing. To address this, a multiscale Representative Volume Element (RVE) analysis is first utilized to predict elastic properties. Next, microstructural variations are captured via extensive μ-XCT analysis across three manufacturing stages (CFRP, C/C, and CMC) to evaluate porosity, phase volume distribution, and textile architecture. To establish a robust baseline for numerical validation, a comprehensive experimental campaign is executed. This includes evaluating the static behavior (tensile, compression, and flexural) of 0°/90° and ±45° layups at each stage, alongside interlaminar and translaminar fracture testing (DCB, ENF, and SENB) on the final coated CMC, coupled with SEM fractography. Finally, non-linear numerical model development is underway in Ansys to validate these static and fracture experimental results, closing the loop to define reliable structural design criteria.

Cold Sintering of Industrial Lead-Free (K,Na)NbO_3 Ceramics: A Low-Temperature Route Towards Sustainable Piezoelectric Devices

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#15

Presenter
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Piezoelectric ceramics are indispensable in sensors, actuators, and energy harvesters. The dominant material, lead zirconate titanate (PZT), contains over 60 wt% toxic lead oxide. Potassium sodium niobate (KNN, $K_{0.5}Na_{0.5}NbO_3$) is the most promising replacement: high Curie temperature (TC ? 415°C), piezoelectric response up to 800 pC/N, full biocompatibility, and RoHS compliance. Target applications include medical implants, automotive sensors, and capacitors for electric vehicles.

Conventional KNN sintering above 1050°C causes alkali volatilisation, secondary phases, and coarse grain growth. The cold sintering process (CSP) exploits a transient KOH-NaOH liquid phase to achieve densification at 250–400°C – over 700°C lower. Industrial TAN-KNN powder (TANOBIS GmbH) was cold sintered in a spark plasma sintering apparatus at IMD-2, Forschungszentrum Jülich. A systematic study of temperature (250–350°C), pressure (88–389 MPa), heating rate, and holding time across 12 pellets yielded a maximum relative density of 94.3% at 350°C/389 MPa.Density was measured by the Archimedes method in isopropanol. Pressure was the dominant densification parameter. X-ray diffraction and Rietveld refinement confirmed single-phase orthorhombic KNN (Amm2) with crystallite sizes of 19–36 nm – far finer than conventionally sintered KNN.The fine microstructure supports a targeted core-shell grain boundary architecture. Cold sintering reduces energy consumption by over 700°C compared to conventional processing.

Results are preliminary; impedance spectroscopy and electron microscopy are ongoing and will be incorporated into the final presentation. This work was carried out under the supervision of Prof. Dr. Christian Pithan.

HWH COMPETITION

Mechanically driven catalytic activity of highly porous ceramics

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#1

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Catalytic technologies use different types of energy to generate charge carriers and reactive oxygen species that can, for example, be used to degrade pollutants in water treatment applications. Current research on ceramic catalysts mostly focuses on nanoscale powders because a large surface area is essential for catalytic processes. However, nanoparticles have the drawback of complicated recycling and possible secondary pollution. Here, porous structures, which also provide an enlarged surface area, can offer a significant advantage, as they are easier to separate from aqueous systems. In this work, the mechanically driven catalytic activity of ceramics with high porosity of 80 % was analyzed. Different TPMS structures and foams were produced from barium titanate and alumina by vat photopolymerization and the replica technique. The different structures were then stimulated with ultrasound to degrade Rhodamine B as an organic contaminant. The highest dye degradation of 83 % after two hours of ultrasonication was achieved with the alumina replica foams and can be attributed to sonocatalytic effects. The 3D-printed TPMS structures exhibited a lower degradation rate than the foams but proved to be mechanically more stable during ultrasonication. Electrical poling of the barium titanate TPMS structures further improved the relative dye degradation by up to 67 %, due to enhanced piezocatalytic activity. It was thus shown that porous structures can be tailored to achieve effective dye degradation, while being easily reusable, and causing low secondary pollution compared to particulate catalysts.

MicroJet Reactor based Synthesis for Lithium-Zirconium-Oxide Coatings for All-Solid-State Battery Applications

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The transition to an electrified economy requires continuous improvements in battery technology. All-solid-state batteries (ASSBs) offer a promising next generation battery concept, with increased energy density and safety. Due to the interfacial incompatibility between most electrode materials and solid electrolytes, protective coatings are required. Unwanted side reactions and the degradation of the solid electrolyte are detrimental for the long-term electrochemical performance.
Continuous synthesis methods offer advantages over batch-based processes in terms of scalability, sustainability, and cost efficiency. These characteristics make continuous processes highly attractive for large-scale manufacturing of advanced battery materials.

In this work, we propose a continuous MicroJet reactor based coating concept, demonstrated for lithium-zirconium-oxide coatings. To increase the sustainability in the production of these coatings, a water-based synthesis is used in accordance with Green Chemistry principles, reducing the use of organic solvents and therefore minimizing the environmental impact of the process. The proposed concept is compared with batch-based processes with the same synthesis chemistry in terms of coating behaviour, coating homogeneity and chemical composition.

Anodic Nanostructured TiO_2 Coatings as Immobilized Photocatalysts for Removal of 4-Chlorophenol by Heterogeneous Photocatalysis

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The development of nanostructured TiO_2 coatings as immobilized photocatalysts for treatment of contaminated water through heter-ogene-ous photocatalysis is gaining attention for a potential industrial scaling of this technology. One of the most promising methods for synthesis is anodic oxidation of titanium, which allows obtaining of nanotubular TiO_2 with a large surface area [1].

Chemically decapacitated titanium plates serving as substrates were anodized at various voltages (10, 20, 30, and 40 V) for a duration of 2 hours using an ethylene glycol solution containing 0.27 M FNH_4 and 3.5% v/v water as electrolyte. After thermal treatment at 450 °C for 2 hours, the resulting coatings were characterized using scanning elect-ron microscopy, X-ray diffraction, and diffuse reflectance spectroscopy. The resulting nanotubular anatase TiO_2 coatings exhibited a bandgap of 3.2 eV. The inner diameter (ranging from 20-90 nm), wall thickness (25-27 nm), and length (1-3 µm) of the nanotubes increased with the applied voltage.

To assess the photocatalytic performance of the TiO_2 coatings in oxidation reactions, 4-chlorophenol (0.5 mM, pH 3) was selected as a model contaminant. The photocatalytic tests indicated that the nano-tubes produced at 40 V demonstrated the highest activity, achieving a degradation of over 50% in 5 hours under UV radiation, correlating with the largest diameter, wall thickness, and length. Reactivation treatment using hydrogen peroxide proved effective fully restoring the activity two times.

These results contribute to advancements in water treatment technol-ogies by optimizing the photocatalytic efficiency of immobilized TiO_2, while maintaining structural stability and reusability.

Development of a water-based slurry for producing a silicon carbide matrix in LSI-SiC/SiC ceramic matrix composites

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#4

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This thesis investigates the development of a water-based slurry system tailored for producing SiC/SiC ceramic matrix composites (CMCs) via the slurry cast liquid silicon infiltration (LSI) process. The main objective is to formulate and optimize slurries composed of silicon carbide (SiC) and carbon (C) powders with different ratios, enabling the formation of defect-free green bodies suitable for subsequent silicon infiltration. A comprehensive set of experiments was conducted using water-based slurries with varying solid loading (5 – 25 vol%) and C:SiC powder ratios (0:1, 1:3, 1:1, 3:1, 1:0), combined with dispersants (Tween20, SLES) and polyvinyl al-cohol (PVA) as a binder.

Rheological characterization revealed pronounced shear-thinning behavior across all formulations, with viscosity strongly dependent on solid loading and to a lesser extent on powder composition. An increase in solid loading generally resulted in an increased viscosity for all C:SiC ratios.

Green bodies were fabricated from selected slurries and subjected to liquid silicon infiltration to obtain mini-composites. Optical microscopy of mini-composite crosssections was used to assess microstructural integrity, silicon infiltration behavior, and phase distribution. The results showed that solid loading has a significant influence on the resulting microstructure of the final CMCs while the impact of the C:SiC ratio is less pronounced.

The findings contribute to a better understanding of how slurry formulation affects the processability and final properties of SiC/SiC composites produced via the slurry cast LSI route.

Aliovalent B-site doping in $SrTiO_3$: correlating local distortions, defect chemistry and optical properties of perovskite nanoparticles

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#5

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Solar-driven CO_2 conversion and H2 generation offer sustainable routes to renewable fuels, yet progress hinges on catalysts whose active states can be tracked under working conditions. $SrTiO_3$ is an ideal platform: its structural flexibility tolerates extensive B-site substitution and accom-modates defect chemistry that directly governs the optical response of the resulting nanoparticles. We report SrTi1-xMxO3-? nanoparticles (M = Co, Ni, Cu) synthesized hydrothermally, and combine Raman and diffuse reflectance UV-Vis spectroscopy (DRS) to correlate aliovalent doping with local structural distortions and the evolution of the optical properties. The two techniques prove highly complementary: for Ni- and Cu-doped systems, secondary phases are detected with sensitivity far beyond standard XRD. In situ DRS as a function of temperature and gas atmosphere further reveals a temperature-dependent spin-state transition for Co, and – most strikingly – the emergence and evolution of surface plasmon resonance features on Cu-doped $SrTiO_3$ under inert (Ar) and reducing (H2) atmospheres, signaling the in-situ formation of metallic Cu nanostructures at the perovskite surface. Coupling Raman and DRS in operando and in situ mode thus delivers quantitative access to defect-driven bandgap variations and to the dynamic onset of plasmonic behavior – two design levers central to tailoring complex perovskite catalysts for photo- and thermocatalytic applications.

Process Development for Lead-Free Piezoelectric Multilayer Actuators based on the KNN-LTM System

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#6

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Piezoelectric multilayer actuators are essential for precision positioning, dosing and vibration control systems. However, replacing lead-based $Pb(Zr,Ti)O_3$ (PZT) systems remains a challenging task and requires lead-free alternatives with similar properties.

This work presents a laboratory scale manufacturing process chain for lead-free multilayer actuators based on the KNN-LTM system $(K_{0.45}Na_{0.52}Li_{0.03})(Nb_{0.8}Ta_{0.2})_{0.995}Mn_{0.005}O_3$.

The established process includes an upscaling of the mixed-oxide powder synthesis up to a batch size of 300 g, tape casting, USP laser cutting, screen printing, stacking, lamination, dicing and thermal treatment. This process enables reproducible fabrication of multilayer actuators with Ag:Pd – electrodes, high dimensional accuracy of around 50 µm, stable dielectric loss factors (tan?) of less than 0.022 and highly reproducible piezoelectric performance with a room temperature d*33 of close to 250 pm/V.

The process allows for systematic variation of KNN-based compositions, electrode materials (e.g. Ni, Cu) and layer designs, providing a scalable basis for industrial lead-free actuator technologies.

Development of Continuous Fibre-Reinforced Ti_2AlC MAX Phase Matrix Composites via Wet Filament Winding

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#7

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This work presents a novel continuous fibre-reinforced ceramic matrix composite (CMC) based on the MAX phase Ti_2AlC. The material is manufactured via wet filament winding (WFW) using alumina Nextel™ 610 fibres with the goal of producing oxide-fibre-reinforced MAX phase composites with high fibre volume fractions and reproducible microstructures for high-temperature load-bearing applications.

A Design of Experiments approach is used to investigate how solid loading and additive concentrations influence slurry rheology, zeta potential, and wetting behaviour under process-relevant shear conditions. Based on these results, an optimized slurry formulation is derived using a mathematical model. After establishing a suitable liquid milling route, the effect of particle size distribution on sintering kinetics and microstructure development is studied. Submicron particles enable significantly more homogeneous microstructures, although nanoparticles also introduce challenges for slurry processability.

During winding, fibre tension is identified as a critical parameter, requiring a balance between fibre damage, fibre spreading, and pore formation. Microstructure and phase composition are analysed by SEM and XRD, while mechanical properties are evaluated by RFDA dynamic modulus measurements and four-point bending tests.

Although the produced composites still exhibit porosity and microstructural inhomogeneities that limit flexural strength, the achieved stiffness already matches or exceeds fully oxide CMCs. The results demonstrate a clear proof of concept for continuous fibre-reinforced MAX phase CMCs with promising potential for high-temperature applications.

Optimized Solvent Extraction of Manganese from Battery Leaching Solutions

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#8

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This presentation investigates the selective extraction of manganese from hydrometallurgically leached NMC black mass using D2EHPA as the first purification step. After leaching, the solution contains Ni, Co, Mn, and Li. The objectives were to determine suitable extraction parameters, evaluate selectivity, and transfer laboratory results to continuous mixer-settler operation.

The theoretical part covers leaching, solvent extraction, and the pH-dependent proton-exchange mechanism of D2EHPA. Continuous pH control was selected over saponification due to its industrial relevance. Batch tests identified optimal conditions at 15 vol.-% D2EHPA and pH 2.75–3.25. At pH 3.0, about 72 % of Mn was extracted with high selec-ti-vity over Co and Ni, requiring multistage countercurrent extraction. McCabe–Thiele analysis indicated that at least four extraction stages are needed for near-complete Mn removal.

The process was scaled to a continuous four-stage MSU 0.5 mixer-settler operated in countercurrent mode. Individual pH adjustment enabled high Mn extraction while minimizing Co and Ni co-extraction. Under steady-state conditions, Mn extraction reached up to 100 %, producing an almost Mn-free raffinate.

Scrubbing experiments showed that low H_2SO_4 concentrations are required to remove Co and Ni impurities without significant Mn back-extraction. Stripping with 3 M H_2SO_4 enabled nearly complete Mn recovery, although high A:O ratios caused spontaneous crystallization. The results demonstrate that D2EHPA, combined with precise pH control and multistage countercurrent operation, enables highly selective and scalable Mn separation from NMC leachates, supporting efficient battery recycling and the supply of secondary raw materials.

Development of Nextel(TM) 720/mullite ceramic matrix composites based on the characterization of monolithic specimens

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#9

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This work focused on the selection of suitable mullite-based matrix materials for all-oxide ceramic matrix composites. Through monolithic characterization, data points for the He-Hutchinson model were generated, and conclusions were drawn regarding the potential damage-tolerant behavior of the composites. Various matrix compositions with different coarse and fine fractions were fabricated by slip casting, allowing a more detailed investigation of the influence of different powders and particle sizes. Monolithic samples were characterized using the impulse excitation technique to determine the Young´s modulus, as well as an adapted single-edge V-notch beam (SEVNB) test to analyse the fracture energy.

In addition to monolithic samples, all-oxide ceramic matrix composites with the same matrix material were investigated to validate the conclusions drawn from the monolithic specimens. The composite specimens were manufactured using a prepreg process with the same powder compositions as for monolithic samples with subsequent infiltration of NextelTM 720 fabrics. These specimens were tested by a three-point flexural test.

The results obtained from the monolithic samples were in excellent agreement with the failure behavior of the composites. The mullite/mullite samples reached flexural strengths of up to 158 MPa, which are comparable to values reported by previous studies. The generated data enabled a selection of suitable matrix materials for use in composites. This is intended to support the development of all-oxide ceramic matrix composites with high strength and damage tolerance, while contributing to a reduction in research costs for new material systems.

High-Entropy Perovskite Oxides in Photocatalysis

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#10

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Photocatalysis is a versatile method applied to various research fields, including water splitting, self?cleaning surfaces, CO_2 reduction, and pollutant removal, and is a key technology for green chemistry. The discovery of high-entropy ceramics has introduced new possibilities for compounds with exceptional photocatalytic capabilities. This study focuses on the synthesis and characterization of high-entropy perovskite oxide (HEPO) $(CaSr)(TiZrTa)O_3$, its parent systems, and derived structures. Elements on both cationic sites were strategically substituted to assess the synthesizability of derived compounds. For characterization, a combination of X-ray diffraction, X-ray photoelectron spectroscopy, UV/vis spectroscopy and photocatalytic H_2O_2 production for comprehensive characterization were employed. In this work, four new HEPOs were synthesized and evaluated for their photocatalytic performance, resulting in valuable insights into the synthesis processes and catalytic behavior of HEPOs. These findings provide information that can assist optimizing synthesis procedures and enhancing properties of high-entropy oxide photocatalysts.

In-situ silicon carbide bonded silicon carbide (SiC) and silicon nitride (Si_3N_4)

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#11

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Ceramic matrix composites (CMCs) combine the outstanding properties of ceramics, such as high temperature stability, excellent corrosion resistance and high stiffness, with a damage tolerant fracture behavior. This enables their application in extreme environments, which are not accessible to any other material classes.

Non-oxide CMCs such as SiC/SiC and C/SiC predominately rely on a weak fiber/matrixinterface to ensure damage tolerant fracture behavior. C/C and SiC/SiC with a porous matrix produced via a costly chemical vapor infiltration process are also available, although in the case of SiC/SiC they still rely on a weak fiber coating as well.

By contrast in this work non-oxide matrices with a focus on a weak matrix concept (WMC) were developed. The matrices comprised primary particles of either SiC or Si_3N_4, which were bonded by an insitu formed SiC-phase. This bonding phase is formed at temperatures of 1250-1400 °C by an in-situ-reaction of Si powder and carbon black. This provides a cost-efficient method to obtain non oxide WMC matrices. The influence of the process parameters on the matrix properties + microstructure, such as phase composition, porosity and bending strength was investigated using a design of experiment (DoE). Additionally, the interaction between the in-situ SiC formation and carbon fibers was investigated and first WMCs were manufactured using the developed matrices.

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