ceramitec conference

Munich/DE
15./16.Sept.
2021

- Programme
- Abstract Book
- Exhibitor Listing
- Floor Plan

CERAMIC APPLICATIONS – Components for high performance
AM CERAMICS
Institut für Anwendungstechnik Pulvermetallurgie und Keramik an der RWTH Aachen e.V.
Fraunhofer
Expertenkreis Keramikspritzguss


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Welcome to the ceramitec conference 2021

Finally live again, finally face to face again, finally Munich again – and finally ceramitec conference again. After 18 months of pandemic and home office, each of us can certainly add many personal "finally" or even "finally no more". In any case, the ceramitec team is delighted to finally be able to welcome you back to an live event.

Dr Robert Schönberger

We have all had to demonstrate a great deal of flexibility and adapt to new developments over the past year and a half. No one would have expected that a ceramitec would have to be postponed and that this ceramitec conference would also only be able to take place around three months later than originally planned. However, the fact that we are now meeting in late summer, even though there are still challenges and planning uncertainties, confirms the desire to finally exchange ideas again in a face-to-face meeting and underlines the necessity and the significantly higher quality of knowledge exchange in a live conference.

A trade fair, a conference and other event formats can only be carried out together and in very close coordination with customers, partners and conceptual sponsors. It is a great honor for us to have been trusted to organize a conference in these challenging times and to have been asked from many sides to realize not only a conference program, but explicitly also an accompanying exhibition, where people can come together and network again after this long time. So now it is called: Two days of full program in three parallel conference tracks, a strong accompanying exhibition and plenty of space for communication. The ceramitec conference is designed to provide a platform for the fast-moving, innovation-intensive sectors of the ceramics industry and a presentation opportunity in the application industries.

There will be visible changes in the usual processes for all participants. In order to meet the new, current demands on event organization, we will all have to demonstrate flexibility again and adapt accordingly. But if any group of participants can do this, it is you!

Special thanks therefore go to you for being part of this new start. We would also like to thank our numerous partners, first and foremost the Ceramic Applications Network, Lithoz AM Ceramics, Fraunhofer HTL, the CIM Expert Group and IAPK, who have used their expertise to shape the high-quality technical program.

I wish you good discussions and many new insights.

Welcome to Munich

CERAMIC APPLICATIONS
Components for high performance

CERAMIC APPLICATIONS aims to give Technical Ceramic components more visibility. At present, over 70 companies from 20 countries worldwide are under the roof of this marketing and communication platform.

AM CERAMICS

The **AM Ceramics** is the key event for additive manufacturing of high performance ceramics and one of the most important opportunities that gives you the chance to connect with 3D printing professionals from all over the world.

Expertenkreis Keramikspritzguss

The **Expert Group Ceramic Injection Moulding** is an association of companies and institutes under the umbrella of the German Ceramic Society DKG e.V. The group has set itself the goal of innovative further development of the entire ceramic injection moulding process chain.

Institut für Anwendungstechnik Pulvermetallurgie und Keramik an der RWTH Aachen e.V.

The **IAPK** is an institute affiliated with RWTH Aachen, a leading technical university in Germany. The institute has been carrying out R&D, providing expert consulting and offering many other services in all matters relating to powder metallurgy and technical ceramics since 1987 and operates at the interface between scientific research and practical application.

Fraunhofer

The central R&D topics of **Fraunhofer Institute HTL** are sustainable and efficient thermal processes. For this purpose, new high temperature materials and components are developed, materials are characterized at high temperatures and heat treatment processes are optimized with regard to energy efficiency and product quality.

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Published by Göller Verlag GmbH, Baden-Baden, Germany (03/09/2021)

Moderators

Karin Scharrer, Editor-in-Chief, CERAMIC APPLICATIONS, Göller Verlag/DE

Prof. Dr Friedrich Raether, Director, Fraunhofer HTL, Bayreuth/DE

Dr Anke Kaletsch Deputy Managing Director, IAPK/DE

Dr Moritz von Witzleben, Managing Director, INMATEC Technologies GmbH, Rheinbach/DE

Dr Andraž Kocjan, Jožef Stefan Institute, Slowenia

9.00–10.15 Words of Welcome from the Organizers
Dr Robert Schönberger, Messe München GmbH/DE

Plenary Lecture
Task Force Hydrogen: Hydrogen for and with Ceramics – a Common Initiative of the Federal

FORUM 1, 15 September 2021

11.00–17.30
New Horizons for Additive Manufacturing (AM) of Ceramics
Organized by CERAMIC APPLICATIONS
Moderator Karin Scharrer, Editor-in-Chief, CERAMIC APPLICATIONS, Göller Verlag/DE

11.00-12.30
Keynote
Scene Additive Manufacturing – Together to a Productive Level of Ceramic AM
Dr Tassilo Moritz, Task Force Additive Manufacturing DKG, Senior Scientist, Fraunhofer IKTS/DE

New Materials / Additives for Enhanced Performance of AM-Technologies

Plant-Based Hydrocolloids and Biopolymers – Bio-Based Solutions for Ceramic AM?
Sascha Galic, Senior Product Manager, J. Rettenmaier & Söhne/DE

Ceramics and Metal AM by FFF Process and Use-Cases
Elisabeth To, Ingénieur technico-commercial, NanoE/FR

FORUM 2, 15 September 2021

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High-Temperature Technologies
Organized by Fraunhofer HTL
Moderator Prof. Dr Friedrich Raether, Director, Fraunhofer HTL/DE

11.00–13.00
Thermoprocessing Equipment

Application of Electric Current Assisted Sintering Techniques for Advanced Processing of Energy Materials
Apl.-Prof. Dr Martin Bram, Team Leader, Institute of Energy and Climate Research, Forschungszentrum Jülich/DE

Clean and Green – Opportunities and Challenges for Industrial Kiln Construction in a Post-COVID Era
Andreas Hajduk, Sales Manager Technical Ceramics, Riedhammer GmbH/DE

Debinding and Sintering under Advanced Atmospheres
Heinz-Jürgen Blüm, Managing Director, MUT Advanced Heating GmbH/DE

Using Hydrogen in Ceramic Industry Kilns – H_2 Hybrid Kilns Gaining Ground?
Hartmut Weber, Vice President Sales, CREMER Thermoprozessanlagen GmbH/DE

Concept and Benefits of Digital Furnace Twins
Dr Gerhard Seifert, Senior Scientist, Fraunhofer HTL/DE

14.00–15.40
High-Temperature Materials

Oxide/Oxide Ceramic Matrix Composites – Replacement Possibility for Metallic Alloys at High Temperatures
Walter Pritzkow, Managing Director, Keramikblech/DE

FORUM 3, 15 September 2021

11.00–17.30
AM Ceramics / Making Innovation Happen
Organized by Lithoz/AT
Moderator Dr Andraz Kocjan, Jozef Stefan Institute, Ljubljana/SL

11.00–12.30
Market Insights and Innovation Strategies

Market Potential for Technical Ceramics Additive Manufacturing Part Production
Davide Sher, 3D pbm/GB

Patents in AM and why they Matter
Judy Ceulemans, European Patent Office/BE

Don't Sit and Wait but Innovate
Prof. Roland Ortt, TU Delft/NL (no abstract)

13.30–15.30

Industrial Applications and Production, Part 1
AM of Novel Piezocomposite Structures
Barry Robinson, Ceramic Manufacturing Manager, MSI, Transducer Corp./US

Association of the German Ceramics Industry (BVKI) and the German Ceramic Society (DKG)
Prof. Dr Alexander Michaelis, Institute Director, Fraunhofer IKTS/DE

10.15-11.00: Visit of Exhibition/Coffee Break
18.00 –22.00: Happy Hour in the Exhibition Area

13.30–15.00
New Technologies for the Manufacture of AM-Parts

3D-Printing of Ceramic Structures via Material Jetting
Alexander Kremer, TechCenter Additive Fertigung, Rauschert Heinersdorf-Pressig/DE

Ceramic AM for New Space
Richard Gaignon, CEO, 3DCERAM Sinto/FR

Making Binder Jetting Really Work for Technical Ceramics
Boris Agea-Blanco, Development Engineer, CerAMing/DE

15.30–17.00
Ceramic Components Made by AM – the Economic Alternative?

CerAMfacturing of Ceramic-Based Multi-Material Components
Uwe Scheithauer, Fraunhofer IKTS/DE

New Approaches of AM of Dense and Porous Ceramics for Advanced Refractory Applications
Dr Patrick Gehre, Scientist, Institute of Ceramics, Refractories and Composite Materials, TU Bergakademie Freiberg/DE

3D-Screen Printing of Solar Absorbers Made of SiSiC, Sintered in an Efficient High-Performance Furnace
René Kirchner, Head of Sales, FCT Systeme GmbH/DE;
Daniel Bienenstein, Project Manager, Exentis Technology/CH

New Refractory Materials and Concepts for the Reduction of CO_2-Emissions of High-Temperature Processed
Dr Rainer Gaebel, Managing Director, Refratechnik Holding GmbH/DE

Reaction Bonding of Mullite-Based Ceramics
Rabea-Naemi Cegla, Researcher, STEULER-KCH/DE

A Cost-efficient Direct Foaming Technique for Ceramic Foams Based on Renewable Raw Materials
Joachim Vogt, Researcher, Fraunhofer HTL/DE

Ceramic Coatings for High-Temperature Applications
Jonathan Maier, Researcher, Fraunhofer HTL/DE

16.10–18.00
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The Challenge of Drying Technical Ceramics
Markus Lindner, Design Manager, Lippert GmbH & Co KG/DE

L2P Program -Scaling from Batch to Continous Production- Up-scaling Processes for Advanced and Thin-film Ceramics
Simon Schurr, Vice President Sales, Onejoon GmbH/DE

EnerViT – Energy-Efficient Kiln Plants between Present and Future
Thomas Alten, Managing Director, Keramischer OFENBAU GmbH/DE

Debinding and Sintering Optimization via Apps
Dr Holger Friedrich, Senior Scientist, Fraunhofer HTL/DE

Energy Efficiency in Practice
Frank Veitengruber, Project Engineer, Forschungsgesellschaft für Energiewirtschaft mbH/DE

Additive Manufacturing and Material Considerations for Medical Devices
Mark Mirigian, Boston Scientific Ireland/IR

Powder Bed 3D-Printing for the Production of Reaction-Bonded Silicon Carbide
Dr Minas Payamyar, Schunk Ingenieurkeramik/DE

3D-Printing of Ceramics: Binder Jetting Versus Material Extrusion
Dr Wolfgang Kollenberg, Managing Director, WZR ceramic solutions/DE

16.00–17.30
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Manufacturing and Testing of a 500 000 rpm Rotor for Micro-Turbine Applications
Lukas Badum, Technion Israel Institue of Technology/IL

Lithoz Cerafab 8500 at Sandia National Laboratories – A Year in Review
Dale Cillessen, Sandia National Laboratories/US

Additive Manufacturing at JPL: Research and Applications
Samad Firdosi, NASA/US

FORUM 1, 16 September 2021

09.00–12.00
Industry 4.0 / Ceramic Components
Organized by CERAMIC APPLICATIONS
Moderator Karin Scharrer, Editor-in-Chief

9.00–10.30
Progress of Industry 4.0 Concepts in the Ceramic Industry

Data Management in Production of Ceramic Membranes
Christian Goebbert, Managing Director, Nanostone Water/DE

Transformation from Manufactory to Smart Production
Wolfgang Heining, Project Manager, Lippert GmbH & Co KG/DE

Data-Centric Smart Factory
Matteo Tellarini, Data Analyst, SACMI Innovation Lab, SACMI/IT

10.30–12.00
Redefining Interactions with High-Temperature Furnaces and Equipment ! Unlock AR Empowered Processes
Daniel Mirbach, Head of Marketing, Oculavis/DE

The Next Challenge in Digital Production with Powder Metal Presses
Herbert Gröbl, Competence Team IoT, DORST Technologies/DE

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13.00–16.00
Ceramic Components for Enhanced System Solutions

Environmental and Process Technology / Electronics

Silicon-Nitride Speciality Materials for Product and Process Innovation in Semiconductor and Analysis Technology
Dr Ulrich Degenhardt, Head of R&D, FCT Ingenieurkeramik/DE

Development of Custom-made Silicon Carbide RTP Powders
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FORUM 2, 16 September 2021

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CIM – Material Performance and High Functional Integration – Economic Solutions for Many User Industries
Panel Discussion
Organized by Expert Group CIM/DE, Moderator Dr Moritz von Witzleben, Managing Director, INMATEC Technologies GmbH/DE

Participants
Dr Karin Hajek, Sales Director, INMATEC Technologies GmbH/DE
Marko Maetzig, Process Development PIM, ARBURG/DE
Harrie Sneijers, Sales Director, Formatec Technical Ceramics/NL
Phillip Ninz, Scientist, IFKB University Stuttgart/DE

11.00–16.00
Additive Manufacturing (AM) of Metals
Organized by IAPK
Moderator Dr Anke Kaletsch,
Deputy Managing Director, IAPK/DE

11.00–13.00 ***Keynote***
Accelerating the LPBF Process by the Combination of AM and HIP
Dr Anke Kaletsch, Deputy Managing Director, IAPK/DE

Efficient Production and Qualification of New Materials for the LPBF Process
Daniel Beckers, Head Metal Powder Production,
Rosswag Engineering/DE

FORUM 3, 16 September 2021

9.00–16.00
AM Ceramics / Making Innovation Happen
Organized by Lithoz/AT
Moderator Dr Andraz Kocjan,
Jozef Stefan Institute, Ljubljana/SL

09.00–11.00
Dental Applications and Implants

Multi-material Ceramic Additive Manufacturing for Medical Applications
Dr Francesco Moscato, MedUni Vienna/AT

Ceramic Dental Implants – 3D-Printed Applications
Dr Jens Tartsch, European Society for Ceramic Implantology/CH

Bone Regeneration with 3D-Printed Biodegradable Ceramic Scaffold
Prof. Dr Annelie-Martina Weinberg, MedUni Vienna/AT

Ceramic Additive Manufaturing in Prosthetic Dentistry
Dr Ing. Franziska Schmidt, Charité Universitätsmedizin Berlin/DE

11.30–13.00
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Sebastian Geier, Lithoz GmbH/AT

Exploring New Concepts to Design Damage Tolerant Ceramics Using AM
Prof. Dr Raul Bermejo, Montanuniversität Leoben/AT

Ceramic Filters for Advanced Process Technologies
Martin Simon, Head of design and project manager, ETC-KEMA/DE

Tailoring Natural Fertilizer
Christian Münch, Head of Division Ceramic Membrane Discs, Kerafol/DE

Silicon Carbide Material: Solutions for Laser Processes, Semi-conductor, Opto-Mechanics OEMS and Chemical Industries
Marc Ferrato, Responsible R&D, Mersen Boostec/FR;
Patrick Chereau, Ingenieur Arts et Metiers, Mersen Boostec/FR

Water-Based Tape Casting Process: An Innovative Environmental Friendly Process for Mass Production of Thick and Thin Ceramic Substrates for Electronic Applications
Dr Simona Illiescu, R&D Manager, Sedal/ES

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Advanced Ceramics for Healthcare – Materials, Properties, Applications
Ulrich Werr, Area Sales Manager, Rauschert/DE

Consequences of Stretching Ceramic Mechanical Properties to their Limits for Technologically Challenging Applications, t.b.c.
Senad Hasanovic, Vice President Innovation & Development, Ceramaret/CH

Highly Leak-Tight Ceramic-Metal Assembly for a Novel, Three-Dimensional Imaging X-Ray Process
Dr Kai Sauerzapfe, Head of Business Unit Battery Systems, Alumina Systems/DE

Until 17.00 Farewell Exhibition Area

Lithography-Based Metal Manufacturing (LMM)
Dr Gerald Mitteramskogler, Managing Director, Incus/AT

Improvement of AM by HIP Postprocessing
Marc Knauff, Managing Director,
CREMER HIP Innovations/DE

14.00–16.00
Hard Metals – Innovation Trends

Keynote
100 Years of Hard Metals and not an End
Dr Jürgen Schmidt, Director, Extramet AG/CH;
Dr Margarethe Traxler, R&D Group Leader Material Development, Boehlerit GmbH & Co. KG/AG

Current Trends in the Development of Hard Metals
Dr Johannes Pötschke, Scientist, Fraunhofer IKTS/DE

AM of WC–Co Hard Metals Using Laser Powder Bed Fusion
Sofia Fries, Team Leader Hard Metals and Cermets,
IWM, RWTH Aachen University/DE

The Potential of Innovative Furnace Technology for the Development of Hardmetal Products for Specific Applications
Dr Jaqueline Gruber, Executive Assistant,
CREMER Thermoprozessanlagen/DE

Until 17.00 Farewell Exhibition Area

AM of Alumina Ceramics for the Selective Laser Induced Metallization
Philip Ninz, IFBK, Universität Stuttgart/DE

14.00–16.00 ***New Applications***

Characterisation of the Components as a Function of the Orientation in the Installation Space
Dr Uwe Scheithauer, Scientist, Fraunhofer IKTS/DE

AM of Ceramic Porous Structures for Application to Combustion Systems
Dr Sadaf Sobhani, Cornell University/US

AM – Activities and Success Stories from the Ceramic Industry
Astrid Lang, Project Manager Technology Materials,
Bayern Innovativ GmbH/DE

Uncovering the “Hows” and the “Whys” of Colloidal Stability in Ceramic Resins for Stereolithohgraphy
Wadih Yared, M. Sc., Institute for Manufacturing Technologies of Ceramic Components and Composites – IMTCCC, University of Stuttgart/DE

Until 17.00 Farewell Exhibition Area

Task Force Hydrogen: Hydrogen for and with Ceramics – a Common Initiative of the Federal Association of the German Ceramics Industry (BVKI) and the German Ceramic Society (DKG)

The ceramics production process has severe energy demands due to the required high temperature processes such as de-binding and sintering. In order to lower the associated CO_2 footprints, new technologies have to be evaluated. The use of hydrogen – but also power based or oxyfuel processes offer promising solutions for ecological and economic process schemes.

Moreover, due to the unique material properties ceramic products play an essential role for the development of system solutions for the envisioned future hydrogen economy. Hydrogen cannot be efficiently produced without the use of ceramic materials. Examples such as ceramic based electrolysis (SOEC: Solid Oxide Electrolysis Cell) for H_2 production or sensor technology for harsh environments will be discussed.

It can be concluded: There will be no hydrogen economy without the ceramics industry.

Initiated by DKG and BVKI these aspects will be further substantiated in a white paper to advice the public authorities. Furthermore, a "hydrogen task force" of industrial and academic partner will be implemented to facilitate joint R&D projects.

Fraunhofer Institute of Ceramic Technologies
and Systems, Dresden/DE
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Prof. Dr Alexander Michaelis
Institute Director, Fraunhofer IKTS/DE

Prof. Dr Alexander Michaelis studied physics at the Heinrich-Heine University of Düsseldorf/DE, and received his doctorate there in the field of electrochemistry. He then went to the University of North Carolina/US at Chapel Hill for 1 year as a scholarship holder of the DFG (German Research Foundation), where he worked in the field of high-temperature superconductors. In 1996 he accepted a position at Siemens AG/DE in semiconductor process integration and was delegated to the DRAM Development Alliance in East Fishkill, New York/US for 4 years. After his return from the USA in 2000, he joined Bayer AG in Leverkusen/DE. From there he went to Bayer's subsidiary H.C. Starck GmbH/DE, where he headed the Electroceramics and New Business Development departments and served as Managing Director of the high-temperature fuel cell company InDEC B.V. Since 2004, Prof. Michaelis has headed the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden with more than 800 employees and an annual budget of EUR 77 million. He also holds the professorship for Inorganic Non-Metallic Materials at the Technical University of Dresden. He has published over 400 papers. Currently, Prof. Michaelis is also President of the German Ceramic Society DKG. He is an Academician of the World Academy of Ceramics WAC, Fellow of ECerS and ACerS (European and American Ceramic Society).

Scene Additive – Together to a Productive Level of Ceramic Additive Manufacturing

The Scene Additive in the DKG (German Ceramic Society) has been founded as an open platform and sees itself as a service, technical, and lobbying point for the additive manufacturing of ceramics. The contribution takes a look back at the activities of the scene in the past. However, times are changing and the technology hype of Additive Manufacturing is already behind us. Now, we are faced with the slope of enlightenment for reaching the level of productivity in this technological area. The scene would like to tackle these new challenges and offers those who are interested in and using additive manufacturing a platform for exchanging experiences, further technological development and better representation of the interests of its members. After intensive discussion of the board members with industry representatives of companies which are already using Additive Manufacturing for ceramic components production or which are on the jump to do so, the Scene Additive intents to transform into the structure of a committed association offering its members unity for solution of upcoming technical tasks. The contribution shall act as initiator for a subsequent discussion about the contents of future work, about the frame of collaboration, and about the goals to be defined for the very next steps.

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Dr Tassilo Moritz, Chairman Szene Additiv DKG,
Senior Researcher, Fraunhofer IKTS/DE

Tassilo Moritz did his studies in the field of Development of Inorganic-Nonmetallic Materials at the Freiberg University of Mining and Technology/DE. He got a doctoral degree in 1995 for his PhD thesis in the field of Advanced Ceramics. After working as scientific collaborator at the Freiberg University and the Technical University of West Saxony in Zwickau/DE, he started working at the Fraunhofer IKTS in February 2000. Since 2010 he has been leading the Working Group Shaping and Additive Manufacturing at Fraunhofer IKTS. He is Chairman of the Expert Group Ceramic Injection Molding (CIM) in the German Ceramic Society and Co-Chairman of the Szene Additiv in the same society. His specialized fields are Thermoplastic Shaping, Wet Shaping Technologies and Additive Manufacturing of ceramic components.

Plant-based Hydrocolloids and Biopolymers – Bio-based Solutions for Ceramic AM?

Hydroxypropyl Methylcellulose (HPMC)

Aqueous systems of this cellulose ether can increase the viscosity and form gels upon heating. A special property is the reversibility of this thermal gelation. HPMC is mainly defined by the degree of substitutions (DS) and the viscosity. Thereby thickening of mixtures can be regulated and different gelling points can be achieved.

Alginate

A natural hydrocolloid extracted from brown algae. They differ in their capacity to react with calcium ions and other di- or trivalent ions. By this reaction the rheology changes and the state of aggregation changes from liquid to solid. Therefore, water insoluble, temperature stable gels and films can be produced.

Microcrystalline Cellulose Gel (MCG)

MCG is a gel forming agent which is co-processed from MCC and a water-soluble thickener such as e. g. CMC or xanthan. The thickener in combination with the MCC ensures an easy dispersibility and prevents the re-aggregation of the MCC particles in water. To activate the MCG and form a gel, high shear mixing is necessary. After activation in water, MCG forms a 3D-elastic gel-network of insoluble cellulose fibrils.

Pectins

Pectin is a versatile biopolymer which is found in the cell walls of fruits, especially citrus fruits and apples. Pectins are complex polysaccharides that chemically consists of partial methyl esters of polygalacturonic acid and their salts (sodium, potassium, calcium and ammonia).

J. Rettenmaier & Söhne, Rosenberg/DE
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Sascha Galic
Sales Director, J. Rettenmaier & Söhne/DE

- 1996
  Furtwangen University of Applied Sciences, campus Villingen-Schwenningen/DE – degree: Dipl.-Ing. (FH) Verfahrenstechnik/Process Engineering
- 1997–1998
  ChemSoft GmbH, Schwäbisch Hall/DE – Project Engineer Environmental and Recycling Technology
- 1999–2001
  THEN Maschinen- und Apparatebau GmbH, Schwäbisch Hall, – Project Manager Chemical Dosing Systems, Dyehouse Networks
- Since 2002
  J. Rettenmaier & Söhne GmbH + Co KG, Rosenberg/DE – Senior Product Manager Ceramic/Paper Applications

Ceramics and Metal AM by FFF Process and Use-Cases

Due to the price of molds and the constraints of casting, technical ceramic parts are costly and complicated to produce by regular processes, in particular for small series or on demand parts. Companies and labs have to make compromises between the choice of the material and the price, sometimes giving up ceramic for a less suitable but more affordable material.

Zetamix filaments enable companies to solve these issues and to produce parts in the most suitable material for the application. Zetamix range offers 3 ceramic filaments – alumina, zirconia, and black zirconia – and two metal filaments – H13 steel and 316L stainless steel –. They are all compatible with almost every FFF printers, and make it possible to cut down investment cost of ceramic and metal 3D-printing implementation. Inspired by ceramic powder injection process, the Zetamix manufacturing process consists of three stages: printing, debinding and sintering. With a density of over 99 %, the finished product benefits the same properties as its counterparts made with traditional methods.This technology is used in a wide range of fields: aerospace, foundry, luxury industry, automotive but also labs and research centers. Possibilities of applications are endless: Zetamix range is relevant to produce on demand parts, complex parts, prototypes but also tools. From the production of aeronautic probes to sample holder, Zetamix filaments solve many production issues.

Elisabeth To
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3D-Printing of Ceramic Structures via Material Jetting

Since licensing the patented additive manufacturing process direct inkjet printing in 2020 Rauschert Heinersdorf-Pressig GmbH/DE pushes its development towards industrialization. Direct inkjet printing is a material jetting process that is characterized by a direct deposition of aqueous ceramic suspensions onto a substrate via inkjet printheads. After deposition, each printed layer is dried in a controlled manner, resulting in high packing densities of the sub-micron particles. This leads to sintered parts with theoretical densities of up to 99,9 %. Furthermore, by simply using multiple printheads simultaneously, the drop-wise deposition of material allows for an easy manufacturing of multi-material parts with a high freedom of design analogous to colour transitions in graphic printing.

Rauschert Heinersdorf-Pressig GmbH, Pressig/DE
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Alexander Kremer
Rauschert Heinersdorf-Pressig GmbH/DE

- Received a BSc and MSc in Business Administration and Engineering of Materials and Process Engineering from RWTH Aachen University/DE
- From 2015 until 2020, he was Scientific Assistant at the Institute for Mineral Engineering (RWTH Aachen University) where he conducted research on multi-material additive manufacturing of ceramic materials by the material jetting process direct inkjet printing. He is currently waiting to receive his PhD.
- In 2020, he has joined Rauschert Heinersdorf-Pressig GmbH/DE as a R&D Engineer. His fields of activity are additive manufacturing as well as material and process development.

Ceramic AM for New Space

3D-printing is a technology which remains associated with prototyping and spare parts for the majority of industry. However, early adopters from markets such as, aerospace or biomedical, rapidly understood how to use to their advantage and jumped, from the very beginning, on the opportunity to actively participate in its development. They could see the capabilities to produce parts not possible with traditional processes, with new designs to enhance parts and add new functionalities to obtain better performances. Above all, 3D-printing works with different materials including technical ceramics! For over 15 years, at 3DCERAM, experts have been working to perfect the prototype and material qualification stage. Now it arrived at the production stage, the so-called mass customization. Is it reliable now? The answer arises from 2 case-studies coming from the spatial industry. The first one concerns a new-space industrial nanosatellites builder, the second is a company that designs and manufactures spacecraft thrusters for nanosatellites.

3DCERAM Sinto, Limoges/FR
E-mail: richard.gaignon@3dceram.com

Richard Gaignon
CEO, 3DCERAM Sinto/FR

- CEO of 3DCERAM Sinto (former 3D Ceram) since 2009
- Since 2016 Vice President of the French Ceramic Manufacturer
- President of EuTeCer, the European Technical Ceramics Federation from 2013–2016
- Graduated from ENSCI French School of Ceramic Engineer and from HEC MBA
- Former General Manager of Ceric/FR, an engineering company specialized in turnkey solution production of heavy clay building materials

Making Binder Jetting Really Work for Technical Ceramics

As an alternative shaping method to the traditionally used processes, Additive Manufacturing (AM) can produce economical ceramic components in small lot sizes and/or with complex geometries. Powder-based AM processes like binder jetting are popular in the field of metal AM. One reason is the increased productivity compared to other AM technologies. For ceramic materials, powder-based AM technologies result in porous ceramic parts, provided they are not infiltrated. CerAMing GmbH unites the advantages of powder-based processes with the production of dense ceramics by means of the layerwise slurry deposition. By using a slurry, a high packing density of the powder bed is achieved which leads to high green body densities. Furthermore, a very economical debinding time allows the production of parts with high wall thicknesses. The advantages of the technology will be discussed in detail."

CerAMing, Berlin/DE
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Boris Agea-Blanco
CerAMing/DE

- Boris Agea is the CTO and co-founder of CerAMing GmbH
- Led the technological development of an embodiment of the underlying ceramic 3D-printing technology
- Conducted researched on 3D-printing of ceramics and glass surface physics at the Federal Institute for Materials Research and Testing (BAM) in Berlin/DE
- Received a BSc in Chemistry, BSc in Chemical Engineering and MSc degrees in Material Science and Engineering from IQS School of Engineering, Barcelona/ES, in 2013, 2014 and 2016, respectively

CerAMfacturing of Ceramic-based Multi-Material Components

Additive Manufacturing (AM) is on everyone's lips, as previously unknown possibilities arise in the field of shaping. However, AM processes also have their limitations in terms of design freedom and still have some catching up to do compared to conventional processes in terms of realizable component properties and manufacturing costs.
By adapting AM to the manufacturing of multi-material components, the component properties can be further increased, so that advanced ceramic components with previously unattainable properties and property combinations can be realized. The presentation will summarize our current status for two different manufacturing strategies. With simultaneous manufacturing, thermal co-processing of the different materials is necessary, while this can be avoided with sequential manufacturing. However, the geometric freedom in simultaneous manufacturing is much higher than in sequential manufacturing, but the choice of material combinations that can be processed is much smaller.

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Uwe Scheithauer
Researcher, Fraunhofer IKTS/DE

- Born in 1980 in Dresden/DE
- Study of mechanical engineering at TU Dresden
- Since 2005 Scientific Researcher at Fraunhofer IKTS, Dresden
- Since 2013 responsible for three different suspension-based AM technologies for ceramic and metal-ceramic components
- Since 2018 responsible for the AM strategy of Fraunhofer IKTS, Dresden
- Since 2021 Team Leader AM

New Approaches of AM of Dense and Porous Ceramics for Advanced Refractory Applications

Additive Manufacturing (AM) enables the production of specially designed foams, grids, and bulk structures for customized applications. The combination of additively manufactured sacrificial templates with flame-spray technique enables the production of ceramics for high-temperature applications with excellent thermal shock resistance and chemical inertness, such as ceramic filters for molten metal filtration and casting moulds. Water-soluble templates based on hydroxypropyl methylcellulose and manufactured by Selective Laser Sintering (SLS) were covered by an alumina flame-spray coating, which acts as standalone ceramic object after removing the organic template. The resulting microstructure and phase composition were analysed and the interaction of the products with molten metal evaluated.

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Dr Patrick Gehre
Senior Researcher, TU Freiberg/DE

- Patrick Gehre was born in Freiberg/DE
- He received his diploma degree in Ceramics, Glass and Construction Materials at TU Bergakademie Freiberg/DE and holds a PhD and habilitation in the same field from the TU Bergakademie Freiberg
- His PhD thesis involved the development of reliable chromia-free refractories for gasification process
- His habilitation thesis involved the development of coatings for high-temperature

Dr Patrick Gehre leads the Research Group Ceramic Technologies and Special Processes at the Professorship of Ceramics, Refractories and Composite Materials of the University of Freiberg. His research interests include studies of thermal shock and corrosion resistant refractories and flame-sprayed structures for high-temperature application.

3D-Screen Printing of Solar Absorbers Made of SiSiC, Sintered in an Efficient High-Performance Furnace

Exentis Group AG, as the inventor of Exentis 3D Mass Customization, an innovative manufacturing technology of industrial 3D-screen printing, can produce the finest ceramic structures by layer-wise build-up. By changing the screen with different structures, complex and at the same time fine geometries are possible, such as the 3-way stepped solar absorber with spikes, which in the finest structure has a web width of 450 µm (as green body). But also more delicate structures such as walls with a thickness with a minimum of 100 µm can be realized with this technology. A variety of metals, polymers and ceramics can be processed due to the adaptability of the developed paste recipes for this process. The afore mentioned solar absorber which can be made of SSiC or SiSiC is sintered at FCT Systeme GmbH.

FCT Systeme is a producer of innovative high temperature furnaces for sintering predominantly non-oxide materials. Together with its partner, Exentis Group AG/CH, FCT Systeme developed efficient sintering methods which are designed especially for filigree, fine-structured parts. Besides the optimized combined process (de-binding and sintering in one furnace), FCT Systeme also integrated a fast-cooling system in order to guarantee an economic production of the parts. In the framework of this project it has succeeded, to provide solar absorber with finest structures via an innovative forming process combined with an efficient sintering process to the market in an economic way.

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René Kirchner, Head of Sales, FCT Systeme GmbH/DE;

René Kirchner has been Head of the Sales Department of FCT Systeme GmbH/DE since 2002. An important part of his function is the handling of projects according to customer specifications with a focus on process development and the implementation of the results in hardware and software of the FCT sintering furnaces. Furthermore, he is responsible for the active execution of R&D projects, especially in the field of sintering technology.
He studied Materials Science at the University of Applied Sciences in Jena/DE and obtained his MS degree in 1994.
From 1994 to 2002 he worked as a Project Manager in the resin moulds department at Netzsch in Sonneberg/DE.
Since 2002, he has been responsible for worldwide activities as Head of Sales at FCT Systeme GmbH.

Daniel Bienenstein, Project Manager Exentis Group AG

Education

09/2011 – 07/2013	Upper Vocational School, Weißenburg i. Bay.
10/2013 – 05/2019	Technische Hochschule Nürnberg Georg Simon Ohm (University of Appl. Sciences)

Work Experience

09/2015 – 01/2016	Intern (R&D) – Benteler Sgl Composite Technology Gmbh, Ried i. Innkreis, Austria
02/2016 – 04/2019	Photo- & Videographer – Self-Employment
05/2019 – 01/2020	Development Engineer – Exentis Group AG
Since 02/2020	Project Manager - Exentis Group AG

Application of Electric Current Assisted Sintering Techniques for Advanced Processing of Energy Materials

At Forschungszentrum Jülich, the Institute of Energy and Climate Research (IEK-1: Materials Synthesis and Processing) has long-term expertise in the field of Electric Current Assisted Sintering (ECAS) techniques. IEK-1 operates a broad spectrum of related equipment including Field Assisted Sintering Technology/Spark Plasma Sintering (FAST/SPS), Hybrid FAST/SPS with additional heater, Ultra-fast High Temperature Sintering (UHS), Flash SPS, Flash Sintering (FS) and Sinter Forging (SF). Current research topics – ranging from fundamental to applied research – are discussed on selected examples.

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Apl.-Prof. Dr Martin Bram
Team Leader, Forschungszentrum Jülich/DE

Martin Bram studied Materials Science at the Friedrich-Alexander-University Erlangen-Nürnberg/DE and received his diploma degree in 1995. Afterwards, he got his PhD degree in Materials Science in 1998 from University of Saarland, Saarbrücken/DE. Currently, he is working as a Group Leader in the field of Powder Based Processing and Sintering at the Institute of Energy and Climate Research (IEK-1: Materials Synthesis and Processing) of Forschungszentrum Jülich GmbH/DE.
In 2012, he finished his habilitation at Ruhr University Bochum/DE, where he is active as a lecturer. In 2020, he got an adjunct professorship at this university. His main research interests are devoted to powder based processing and sintering of materials for energy applications like metal-supported fuel cells, electrolyzers, batteries and high temperature materials. A special focus lies on electric current assisted sintering technologies.

Clean and Green – Opportunities and Challenges for Industrial Kiln Construction in a Post-COVID Era

Despite Covid-related restrictions, Riedhammer - together with the SACMI Group – has a far-reaching organization that is fully capable of meeting customer needs, all thanks to decentralized supply chains, flexible production, virtual maintenance tools and a skilled international workforce.
For the calcination of Li-ion-battery powder, a single contract can contain 20 or more production lines. Such high-volume orders require extensive experience, pre-engineering and testing. Detailed designs need to be in place at the time of project negotiation.
Customers are looking to replace fossil fuels with cleaner energy sources. At the same time, standards are becoming ever-stricter and thermal processes more complex. In response, we already offer multiple sustainable heating concepts.
One example of Riedhammer kiln technology – developed for the needs of tomorrow – is the ELK (Extra Large Kiln), designed to meet demand for ultra-high production capacity in the Li-ion-battery sector. One ELK provides the throughput of 4–8 modern RHKs (Roller Hearth Kilns) while matching or even surpassing RHK performance parameters.

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Andreas Hajduk
Sales Manager Technical Ceramics, Riedhammer GmbH, Nuermberg/DE

- 1987–1992 studies at the Georg-Simon Ohm University of Applied Sciences in Nuremberg with a degree in precision engineering / mechatronics
- 1996 joined Riedhammer GmbH as a test and commissioning engineer
- 1999–2003 project manager
- From 2003 sales engineer in the field of technical ceramics / advanced materials worldwide (focus on Asia and Europe)
- From 2007 additional function as division manager in the Riedhammer application center
- Main tasks of sales: customer advice and support, acquisition of new customers, contract negotiations, development of new markets and products, formulation of concepts for product development, interface function between customers, engineering and suppliers taking into account new and trend-setting process requirements.
- Main tasks of the application center: Management of the application center, customer advice and support, development of test concepts, conclusion of test contracts

Debinding and Sintering under Advanced Atmospheres

Debinding and sintering is one of the key steps in powder-based manufacturing. Especially in powder metallurgy, when processing reactive metals, clean and controlled atmospheres are key to get as little impurities as possible and to meet highest material properties. To achieve this it is necessary to understand the chemical and physical processes happening during debinding and the thermodynamics of sintering. This will be discussed in general as well as for stainless steel and titanium as these two materials are of big interest and used a lot in additive manufacturing. Furthermore, the ISO furnace concept will be explained which combines debinding and sintering in one furnace to reduce the pick-up of impurities and shorten the process time. The quality that can be achieved with this system will be illustrated by some examples.

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Hans-Jürgen Blüm, Managing Director
MUT Advanced Heating GmbH, Jena/DE

Since 1994 Dipl.-Ing. Heinz-Jürgen Blüm is head of MUT Advanced Heating GmbH in Jena as Managing Partner.

Using Hydrogen in Ceramic Industry Kilns – H_2 Hybrid Kilns Gaining Ground?

Hydrogen is of huge importance for the success of the energy transition. After all, hydrogen promises that everything can stay the way it is. Fossil fuels are replaced by hydrogen that is generated with renewable power. This vision is also very tempting for the fuel-intensive ceramics industry with its kilns, in order for it to become CO_2 emission-free. The current potential applications for hydrogen as fuel in kiln engineering as well as the current technical limitations are presented. Besides the corresponding burner technology, the paper also addresses the novel heating concepts resulting from this. Moreover, the paper aims to provide thought-provoking impulses with regard to the question: Will today's kilns be H_2 hybrid kilns in the future?

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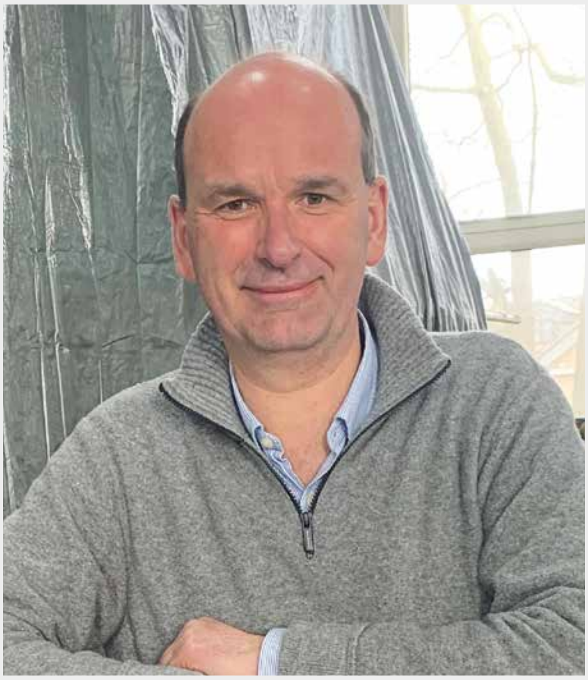

Hartmut Weber, Vice President Sales, CREMER Thermoprozessanlagen GmbH/DE

Hartmut Weber received his Diploma in Process Engineering/High Temperature Process Engineering at the TU-Clausthal/DE in 1991. He started his professional Career as Process Engineer for Ceramic Furnaces in R&D Development Department of HEIMSOTH Keramische Öfen, Hildesheim/DE.
After 5 years, he moved to EISENMANN MASCHINENBAU, Boeblingen/DE. Here he build up the department for atmosphere furnaces and powder metallurgy. Hartmut Weber worked as Sales and Project Manager.
In 2009, Hartmut Weber moved to RIEDHAMMER, Nuremberg/DE. Here he took over responsibility as Director Sales + Marketing for Technical Ceramics in Europa und USA/CAN. From 2012, on he worked also as Director Sales for Electrodes & Special Carbon Products, worldwide. Within the SACMI Group/IT, Hartmut Weber coordinated all the time the TEAM Activities (Technical Ceramics) of the SACMI group members LAEIS, RIEDHAMMER, ALPHA Ceramics, SAMA and SACMI Imola.
Since 2020, Hartmut Weber is Director Sales/Vice President at CREMER Thermoprozessanlagen GmbH, Düren/DE, and responsible for Global Sales and Marketing activities for processes and furnace plants for applications in powder metallurgy, technical ceramics, hydrogen processing, carbon treatment, rare-earth and special processes.

Concept and Benefits of Digital Furnace Twins

The worldwide demand for minimizing greenhouse gas emissions causes a continually increasing need for energy-efficient and flexible operation of large industrial kilns. In spite of the apparent challenges of getting reliable sensor data on the furnace performance under harsh conditions like temperatures above 1000 °C and aggressive turbulent combustion gases, digital representation and control of high temperature processes and facilities has a large potential for efficient furnace operation. In particular, flexibility against fluctuating supply of regenerative energy sources requires reliable predictions of the behavior of the fired (ceramic) material in dependence of the processing parameters. A digital furnace twin is a combination of such models comprising combustion, heat transfer and material flow in the furnace as well as the process-related material changes under thermal treatment. Such a twin can either be designed for automated real-time control of furnace operation or for a completely digital, model-based construction of new kiln systems. In this talk, the current state of research in this field will be reported.

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Gerhard Seifert, Senior Researcher, Fraunhofer-Center for High Temperature Materials and Design HTL/DE

Gerhard Seifert obtained a PhD in physics at the University of Bayreuth/DE, in 1994 and habilitated in physics in 2003 at the Martin-Luther-University of Halle-Wittenberg/DE.
In 2012, he joined the Fraunhofer-Gesellschaft, where he is Head of the Simulation Team at Fraunhofer Center for High Temperature Materials and Design HTL, Bayreuth/DE, since 2015. His current interests comprise many aspects of digitalization of thermal processing such as material, process and furnace simulations, with an emphasis on ceramics production.

Oxide/Oxide Ceramic Matrix Composites – Replacement Possibility for Metallic Alloys at High Temperatures

When working on high temperature applications, mechanical engineers are used to think in metals and high temperature alloys. Working at temperatures higher than 600°C with metals, it is seen that the material reduces their strength dramatically. In addition it can be seen that due to the high thermal expansion of metals on structures permanent deformations or stress induced cracks occur. Also high temperature corrosion will be seen.
Can be a high temperature fiber reinforced composite material an alternative? With Oxide/Oxide Ceramic Matrix Composites (Ox/Ox-CMC) a material is developed that combines the positive properties of metals like damage tolerance and the high temperature performance of ceramic. Looking at the high temperature strength it is seen that above 800 °C Ox/Ox-CMC has better values than metals. Regarding the specific tensile strength at temperatures lower than 600 °C Ox/Ox-CMCs have the same values than metals, above 600 °C they are much better.
Due to that with Ox/Ox-CMC thin-walled ceramic structures can be produced, this ceramic material can replace perfectly thin-walled sheet metal structure. The much lower density of Ox/Ox-CMC gives the possibility to produce light weight structure.
In this presentation several high temperature applications were shown with a better life time and a much better performance than metal parts. These are applications in the field of aeronautics, careers for heat treatment, chemical engineering and in special for high temperature solar receivers for central receiver systems.

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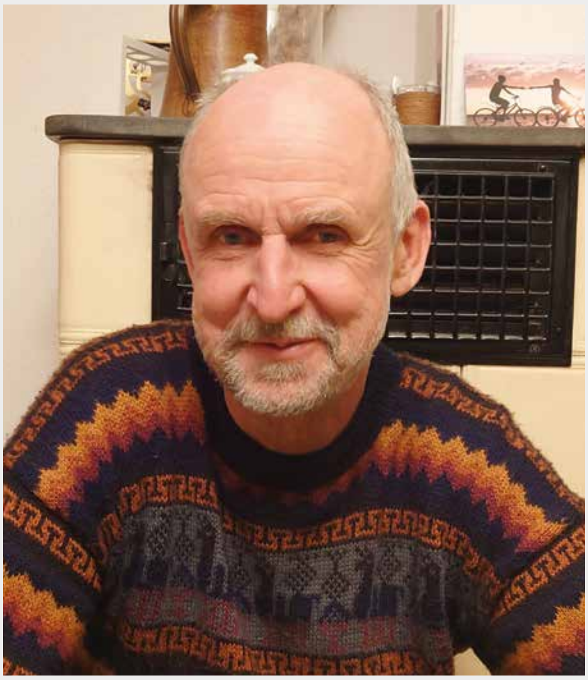

Walter Pritzkow
CEO, Walter E. C. Pritzkow Spezialkeramik/DE

- Studies in aerospace engineering at the University of Stuttgart/DE
- Specialisation in lightweight construction and fibre composites
- Thesis on a wind energy driven pumped storage power plant
- Diploma thesis: Volumetric Receiver for Solar Tower Power Plants Using Ceramic Fibre Composites
- 1987 Research Associate at the German Aerospace Center (DLR) in the field of volumetric receiver design
- 1990 engineering office Walter E.C. Pritzkow, focus on constructive solutions with ceramics
- 1994 Walter E. C. Pritzkow Spezialkeramik Development and production of oxide ceramic fibre composites and components for high-temperature applications

New Refractory Materials and Concepts for the Reduction of CO_2 Emissions of High-Temperature Processes

Reducing or minimizing the carbon footprint of industrial processes is one of the essential tasks of the current decade. In order to reach the global goals of reducing the greenhouse gas emissions significantly, the energy efficiency of high-temperature processes has to be improved. Such energy consuming process steps are the essential basis for the production of many raw materials and primary products. At operating temperatures of >1400 °C or even >1600 °C a controlled heat management is crucial. Hence, refractory products have to fulfill several tasks. On the hot face, the refractory material has to withstand the high temperature and corrosive media whereas towards the cold face it shall offer a low thermal conductivity. For many high-temperature processes, a layered structure consisting of different refractory materials is the current standard.
Several new approaches of improved and carbon footprint optimized refractory products are discussed. Several examples of refractory concepts for a direct CO_2-saving are given for several industries e.g. steel, cement and ceramic industry.

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Education
- 1992–1996 Doctorate in Mechanical Engineering
  KIT / Karlsruhe Institute of Technology/DE
- 1988–1992 Diploma in Mineralogy
  Georg-August-University Göttingen/DE
- 1986–1988 Intermediate Diploma in Mineralogy
  Philipps-University Marburg/DE

Professional Experience
- 05/2011–Present Managing Director
  Refratechnik Holding GmbH – Munich/DE
- 04/2005–04/2011 Managing Director
  Refratechnik Steel GmbH – Düsseldorf/DE
- 05/2003–03/2005 Managing Director
  Refratechnik Casting GmbH – Ismaning/DE
- 07/1997–04/2003 Process Engineer Sales
  Refratechnik Cement GmbH – Göttingen/DE
  Sales and Area Sales Manager North America, Northern Europe
  Key Account Manager
- 10/1992–05/1997 Research Assistant
  Fraunhofer Institute for Mechanics of Materials IWM – Freiburg/DE

Reaction Bonding of Mullite-based Ceramics

The production of ceramics based on mullite, require high temperatures up to 1750°C, in order that a heat or creep resistant product will reach the relevant product parametersPreviously work in our group was focused on lowering the temperature of sintering mullite based ceramics, by using silicon (Si) – and aluminium metal (Al) powders, as sintering partners, to generate a reaction bonding process that produces fully reacted materials, which will not react with further heat treatments, including heat treatments over the initial sintering temperature.
This paper describes how it was possible, by the use of silicon metal and aluminium hydroxide, to produce mullite based ceramics with enhanced properties.

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Rabea-Naemi Cegla, Development and Application Engineer, Steuler KCH/DE

- Born 1985 in Andernach/DE
- Previous Studies in Biophysics, Technische Universität Kaiserslautern/DE
- Dipl.-Engineer Material Science for Glass and Ceramics, Höhr- Grenzhausen/DE
- Thesis works:
  - Imperial College London/GB, Supervisor Prof. Saiz Gutierrez
  - University of Technology Sydney/AU, Supervisor Prof. Ben-Nissan
- Since 2019 Development and Application Engineer, Steuler KCH, Höhr-Grenzhausen

Research and Development are a key point to our company as we specialise in customised product. As part of the development department for refractories, our focus is on creating products to our customer´s needs and making refractories as save as possible for the industrial application.

A Cost-efficient Direct Foaming Technique for Ceramic Foams Based on Renewable Raw Materials

Highly porous ceramics, also referred to as ceramic foams, combine the high rigidity, hardness and thermal stability of ceramics with typical properties of highly porous structures like very low density, low thermal conductivity, high specific surface and high permeability. Therefore, they offer high potential in various applications like e.g. high-temperature insulation, metal filtration, catalysis, lightweight structures, refractories and bone replacement.

Direct foaming techniques are a very cost- and resource-efficient way to prepare ceramic foams. At the Fraunhofer-Center HTL, a highly flexible direct foaming technique has been developed which aims for minimal production cost and carbon footprint. For this purpose, renewable raw materials are used for stabilizing mechanically frothed ceramic slurries. Aiming at an application in high temperature insulation >1400 °C, open porosities up to 85 vol.-% and a thermal conductivity down to 0,5 W/mK could be achieved. Beside thermal insulation, other applications are also discussed.

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Joachim Vogt, Head of Team Additive Manufacturing, Fraunhofer-Center for High Temperature Materials and Design HTL/DE

- Received his BSc in Materials Science/Technology of Functional Materials in 2011, and his MSc in Technology of Functional Materials in 2013, both at the Julius-Maximilians-University of Würzburg/DE
- Since October 2013, he has been working as a Research Associate at the Fraunhofer-Center for High Temperature Materials and Design HTL, mainly in the material and process development, in the fields of ceramic 3D-printing, ceramic foams, matrices for Ceramic Matrix Composites (CMCs) and Environmental Barrier Coatings (EBCs) for non-oxide CMCs. Since 2014, he is involved in the development of a direct foaming technique for the cost-efficient production of ceramic foams.
- Since March 2020, he is Head of the Team Additive Manufacturing at the Fraunhofer-Center for High Temperature Materials and Design HTL

Ceramic Coatings for High-temperature Applications

A wide range of ceramic coatings for high-temperature applications is being developed at Fraunhofer ISC/Center HTL. These include environmental barrier coatings, fiber coatings, wear and corrosion-resistant coatings for furnace materials and others. The coatings are produced primarily via wet-chemical coating processes and slurry deposition processes. Various material systems can be used for the coatings, e.g. Al_2O_3, Al_2O_3-SiO_2, SiO_2, rare earth silicates, yttrium aluminum garnet, ZrO_2, zirconium titanates, TiO_2, SiC, BN or SiBNC. The institute's material and coating process development will be presented in relation to the state-of-the-art.

Of particular interest are the Environmental Barrier Coatings, in short EBCs, which are used as protective coatings at high temperatures in corrosive atmospheres. These EBCs are used for the protection of oxide and non-oxide ceramic matrix composites in aerospace and power generation applications. To minimize thermal stresses due to different thermal expansion coefficients, the EBCs are designed as multilayer systems.

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Jonathan Maier, Research Associate, Fraunhofer-Center for High Temperature Materials and Design HTL/DE

- 05.2011–09.2011 Interdisciplinary Orientation Semester at the Nürnberg University of Technology Georg Simon Ohm/DE
- 10.2011–02.2015 Studies in materials engineering at the Nürnberg University of Applied Sciences Georg Simon Ohm
- 02.2015 Bachelor of Engineering (BEng) in Materials Engineering
- 03.2015–09.2016 Master's programme New Materials, Nano and Production Technology at the Faculty of Materials Engineering at the Nürenberg University of Applied Sciences Georg Simon Ohm
- 09.2016 Master of Engineering (MEng) "with distinction" in the degree programme New Materials, Nano and Production Engineering
- 02.2017–03.2017 Research Sssistant at the Fraunhofer Centre for High-Temperature Lightweight Construction HTL
- 04.2017–09.2020 PhD student at the Fraunhofer Centre for High Temperature Lightweight Construction HTL. Subject: Development of Fibre Coatings for SiC/SiC Ceramic Matrix Composites
- 10.2020–Present Research Associate at the Fraunhofer Centre for High-Temperature Lightweight Construction HTL in the Fibre Ceramics Group

Research focus: ceramic coatings (e.g., fibre coatings, EBCs, cermet coatings, ceramic foams)

The Challenge of Drying Technical Ceramics

The drying of technical ceramics is a challenge for the manufacturers of drying systems, as a very wide range of ceramic materials is used here. Due to the countless geometric shapes, a wide variety of manufacturing processes are used, which in turn have a significant influence on the drying of the components. When using appropriate auxiliaries in the ceramics or in the manufacturing process, an after-treatment of the exhaust air from these drying systems is necessary. The combination of material diversity and geometries, some of which sound out the physical limit of ceramics, requires drying solutions that are designed in such a way that good process control of the drying process is made possible. Economic and efficient drying can only take place if the process parameters specified by the ceramic materials and the design of the components are adhered to.

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Markus Lindner
Design and Sales Manager, Lippert GmbH & Co KG/DE

- Born in Eschenbach i. d. Opf./DE
- He received his degree as Dipl.-Ing. (FH) Graduate Engineer (UAS) from the Nuremberg Georg Simon Ohm University of Applied Sciences/DE
- He has been working in the development of drying systems for ceramic products for more than 20 years
- Since 2018, he has been Head of the Drying Technology Department at company Lippert
- His scope of duties comprises the technical design, development and sales of drying solutions as well as consultation of customers in the field of ceramic drying

L2P Program – Scaling from Batch to Continuous Production. Upscaling Processes for Advanced and Thin-film Ceramics

There is a high focus on the development of advanced materials and ceramics for new applications and industries, e.g. oxide and non-oxide powders for battery applications, SOFC / SOEC and other multi layer ceramics as well as high performance electronics. Where new materials and products have been successfully approved on a lab scale, the challenge is to define the next steps towards a product validation and the realization of high volume production. Where material performance is a key driving force in the development phase of a new product, for a large-scale production this is not enough. Production cost, sustainability and reproducibility are equally important as investment cost for equipment.

The lecture will give an insight of how this process can be accelerated in close cooperation between furnace supplier and ceramic producers. Onejoon's L2P program ensures that our customers get the support they needed depending on their readiness level in the key success areas (1) plant, (2) process and (3) people. When joining the program, these three areas are developed alongside four levels, depending on the maturity level of our customers in each of these areas.

Typical steps during the program steps include experiments and measurements in batch furnaces, test firings in pilot scale kilns and in the Onejoon Test Center, using near to production scale carriers or saggars. They sometimes contain the realization of pilot scale kilns and small volume kilns, aimed to allow the validation of the process under "near to" production conditions. The final step is the ramp up scenario for the production. During this last phase, production efficiency is almost as important for the success of a new product.

You will see examples for all three key success areas based on an analytical and innovative route towards an efficient production concept. Using a wide range of experiments, test facilities and the profound engineering excellence of Onejoon, as well as supporting CFD and FEM Simulations.

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Simon Schurr, Vice President Business Unit Advanced Materials and Processes & Marketing Onejoon, Onejoon GmbH/DE

Since 2011 with Eisenmann / Onejoon (takeover EN by OJ in Jan. 2020)
Currently: Head of Department Advanced Ceramics and Materials

Previously:
Department Manager Product Management and Development
Sales Area Manager Advanced Ceramics and Metals
Technical Project Manager
Key Account Manager and Sales Engineer

Previous positions:
GGB Consulting Group GmbH
Mürdter Werkzeug- und Formenbau GmbH Company

Education:
Diploma Engineer Mechanical Design
Diploma Economist

Area of expertise:
Kiln construction and process technology around technical ceramics

EnerViT – Energy-Efficient Kiln Plants between Present and Future

There are worldwide efforts to implement alternative, clean solutions for reducing global warming and enabling zero-emission processes CO_2 output. Overall change from fossil fuels, such as natural gas or LPG to alternatives such as hydrogen, Syngas and electric energy and building up the corresponding capacities and supply chains worldwide may take up to 10 years. With EnerViT plus, Keramischer OFENBAU offers an energy-efficient bridging technology for today's kiln plants. Besides the equipment of new continuous kilns with this highly efficient heating system, a big advantage is the conversion / retrofitting of existing kilns by implementing the EnerViT firing technology. Significant reduction in specific energy consumption and CO_2-emission were shown in many successful kiln conversions all over the world.

Thus, while using existing plants, it is possible to achieve high energy savings and reduction of carbon footprint TODAY.

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Thomas Alten
Managing Director, Keramischer OFENBAU GmbH/DE

- Born 1962 in Einbeck/DE
- Education: studies of ceramics at Technische Hochschule Nürnberg Georg Simon Ohm/DE

Professional career:
- Grown up in family-owned brick factory
- Commissioning, Service, Sales for ceramic kilns, Heimsoth/DE 1987–1996
- One of the Founder, Share holder, Managing Director at Keramischer OFENBAU since 1996, kiln building company at Hildesheim/DE

Special skills and knowledge:
- Ceramics
- Commissioning and service experience worldwide for 8 years
- Profound R & D expertise
- Excellent sales and management experience in the field of kilns for more than 25 years

Debinding and Sintering Optimization via Apps

Debinding and sintering are critical steps in ceramic processing with respect to time, cost and quality.
For a sophisticated optimization, more quantities than weight loss and shrinkage over temperature have to be evaluated. These encompass thermal diffusivity, gas permeability, reaction products and strength, viscous parameters as well as heat transfer from the oven. Hereby, all of these properties do depend on the degree of debinding / sintering and temperature.
Finite element models have been developed, which allow an accurate prediction of material response to a heating process based on measured data. Once a type of green samples has been characterized different components can be simulated. For that, HTL has developed apps, which calculate optimized heating cycles for flexible geometries and oven settings for a given, well-characterized material. The apps are run directly by the user, providing flexibility, fastening the development process and solving issues of confidentiality.

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Energy Efficiency in Practice

Companies are facing major challenges in the course of the energy transition. In the future, in addition to the pure increase in energy efficiency, especially the reduction of CO_2 emissions will become even more important and both key figures and company targets will be aligned with this. In order to successfully achieve the climate policy goals for reducing emissions in the entire sector, companies therefore need an energy or decarbonization strategy that is fit for the future and with which they can master the upcoming challenges. Following the proven structure of energy efficiency networks, which focus on increasing energy efficiency, decarbonization networks such as dekarbN, also connect companies to each other to take advantage of the time and cost-saving benefits of working together to develop their decarbonization strategy. A parallel workshop series presents targeted methods and measures that are important for developing a decarbonization strategy and facilitates the transfer of research into practice.

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Frank Veitengruber, Project Engineer and Researcher
Forschungsgesellschaft für Energiewirtschaft mbH/DE

- He studied Renewable Energies and Energy Efficiency at the University of Kassel/DE and received an MSc in 2018
- Since then he is part of FfE Munich/DE and works as a project engineer and researcher in the field of industrial energy management

His key activities are:
- Energy audits according to DIN EN 16247-1
- Energy efficiency networks
- Detailed energy analyses for companies (energetic, ecological and economic evaluation of energy efficiency measures for cross-sectional technologies, such as heating or cooling supply)
- Heat flow analyses for industrial customers (pinch analysis)
- Training of energy managers on technical topics (heat, cold, ISO 50001, DIN EN 16247-1, regression analysis etc.)
- Hybridization options and (partial) flexibilization of production processes and industrial energy supply
- Industrial decarbonization (measures and pathways)
- Environmentally compatible energy supply concepts and municipal energy management

Market Potential for Technical Ceramics Additive Manufacturing Part Production

When we discuss Additive Manufacturing (AM) of ceramics we need to always differentiate between AM processes for technical ceramics, which leverage certain high resolution technologies such as stereolithography in particular, and AM processes for traditional ceramics, which mainly use binder jetting processes.

Applications of technical and traditional ceramics differ greatly: the first are used to produce advanced, high performance parts that usually weigh just a few grams while the latter are mainly used to produce very large molds and foundry cores that weight several kilograms. There are many other applications for AM of both technical and traditional ceramics, which sometimes blur the lines between technologies and materials (for example in the case of glass), however there are generally two very distinguished ceramics AM markets that need to be described and analyzed and that is what we will do in this report.

In a niche market such as ceramics AM the challenges in accurately estimating and mapping the market that 3dpbm identified in its metal market study are more evident. In particular, large data and market analysis firms are not able to understand the complexities and the diversification among market operators in a market segment that they cannot and do not consider large enough to invest significant resources on.

As a leading media and market research firm entirely focused on AM, 3dpbm Research is uniquely positioned to address these issues. By leveraging our proprietary index – the 3D Printing Business Directory – which is the largest global directory of validated and verified AM companies around the world, we were able to identify 80 firms that have an invested in ceramics AM, representing nearly the entirety of ceramics AM market segments, intended as metal AM hardware, metal AM materials and metal AM services companies.

These firms have been surveyed to produce the most accurate and detailed database to date of the core metal AM market and to produce subsequent analyses forecasts based on a consolidated forecast model which has been implemented in previous reports.

Davide Sher
3D pbm/GB

As a journalist and entrepreneur, with a great passion for the Additive Manufacturing (AM) industry and its potential to change the world for the better, he co-founded 3dpbm, a growing global agency, and resource for 3D printing-related businesses. 3dpbm publishes several editorial and news websites focusing on 3D-printing/AM.

Leveraging his previous experience as a Senior Analyst researching AM industry verticals, and an internally developed, unique forecast model, 3dpbm has now expanded into providing advanced market research products and services. 3dpbm specializes on AM adoption in different market verticals, spanning from vertical AM applications (automotive, aerospace, medical, energy, tr ansportation, industrial tooling and automation) to specific AM industry verticals (materials and material families, hardware and technologies, soft-ware and services).

3dpbm also offers business development consultancy and communication services to both startups and estab-lished companies interested in implementing 3D-printing services or adopting 3D-printing technologies and applications. 3dpbm organizes webinars, events and participate in conferences worldwide focusing on 3D-printing.

Patents in AM and Why they Matter

Additive Manufacturing is still developing at a high speed. This is also reflected in the increasing number of patent applications filed at the European Patent Office (EPO) and worldwide on the topic. A landscaping study on AM by the EPO published in 2020 provided some clear insights on the geographical origins as well as on the sectors and applicants. Patents but also IP rights in general have proven to be an essential factor for success, not only for large companies but also for SME's. Especially in a technology-driven business environment, having the right IP strategy can pave the way for high growth.

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Judy Ceulemans, Senior Expert
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Senior Expert, Patent Examiner at the European Patent Office (1998 -),
in the field of Powder Metallurgy, in particular Additive Manufacturing (AM);
Chair in opposition; internal expert for Computer-Implemented Inventions;
internal coordinator for Communities of Practice in AM; EQE passed (2011)
Industry experience (1992-1998)
Materials Engineer (MSc)

Don’t Sit and Wait but Innovate

Ceramics and metal additive engineering represent radical innovations in production technology. There are several reasons why companies producing metal and ceramics parts are cautious or even reluctant to adopt this technology. These reasons will be discussed using success and failure studies in innovation and by referring to Gartner’s hype cycle model. Success and failure studies show that radical innovations are less (often) successful compared to incremental innovations and the hype cycle illustrates how expectation can be quite unrealistic and hence lead to disappointment. In contrast, there are also several reasons why companies should seriously consider adopting radical innovations like ceramics and metal additive engineering. Markets can be disrupted by radical technologies and companies in those markets can go bankrupt overnight. The disagreement between those who are against and those who are in favour of adopting and implementing radical innovative production technologies will be put into perspective by presenting a generic pattern of development and diffusion of radically new technologies. This pattern is based on studying more than hundred radically new technologies and it shows that groups in favour or against innovation are right in different stages of the pattern. A managerial implication of this observation is that it is crucial to assess the position of ceramics and metal additive engineering in the pattern of development and diffusion. Furthermore we will describe how the status of a few important market building blocks can help track further future developments of the radical technologies. A managerial implication of this approach is that companies can assess the market around the innovative technology and then decide when to wait and when to innovate.

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Roland J. Ortt (1964) is Associate Professor of technology and innovation management at Delft University of Technology, the Netherlands. Before joining the faculty of Technology Policy and Management Roland Ortt worked as R&D manager for a telecommunication company. He authored articles in journals like the Journal of Product Innovation Management, the Market Research Society and the International Journal of Technology Management. His research focuses on development and diffusion of high-tech systems, and on niche-strategies to commercialize these systems. Roland is research dean of the European NiTiM network of researchers in innovation and technology management and is member of the board of the ICE-conference, the IAMOT Conference and of the editorial board of Transactions on Engineering Management. Roland won several best-paper awards.

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FGK
JFCA Japan Fine Ceramics Association

Additive Manufacturing of Novel Piezocomposite Structures

Lithoz-America, LLC has applied a patented method of additive manufacturing (AM), called lithography-based ceramic manufacturing (LCM), to repeatably create PZT-5H (DoD Type VI) structures. The LCM method utilizes a digital micromirror device (DMD) to quickly create piezoelectric ceramic parts with customizable geometry and high feature resolution of 100 µm or less. Compared with conventional manufacturing practices, LCM utilizes a photopolymerization process that imparts little stress on the green part and allow for the creation of highly resolute, periodic structures. MSI Transducers Corp. has pioneered material preparation and post-processing methods unique to the AM material to yield sintered piezoelectric parts with properties comparable to conventionally manufactured piezoelectric ceramic. Early studies indicate AM test geometries compliant with ANSI/IEEE Std 176-1987 possess material density, dielectric constant values and piezoelectric charge coefficient values consistent with those measured from traditionally manufactured material. An AM 1-3 piezocomposite resonant at 88 kHz was fabricated into a simple transducer and is compared to a bulk transducer of the same specification. The MITRE Corporation has been engaged with modeling and simulation efforts to predict acoustic performance of the AM material, using Finite Element Analysis (FEA), as well as the design of novel structures previously not accessible through traditional manufacturing methods. The LCM process has shown feasibility in the creation of spatial apertures, periodic 3-3 piezocomposite and auxetic structures that demonstrate AM's ability to not only streamline manufacturing processes of piezoelectric ceramics but also augment the piezoelectric performance in acoustic transducers.

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Received his BS in Ceramic Engineering from Alfred University, College of Ceramics. He has managed both the manufacturing process and process development of PZT ceramic for MSI Transducers Corporation for over 20 years. Barry has applied his experience and knowledge in ceramic processing towards injection molding of piezoceramic materials.

Additive Manufacturing and Material Considerations for Medical Devices

The medical devices industry has been a relatively slow adopter of additive technology compared to aerospace and automotive. In our experience, there are significant advantages with respect to component prototyping, rapid iteration, and novel designs when the technology is utilized to its full potential. Additive has a wide range of applications for all of Boston Scientific's divisions: Endoscopy, Interventional Cardiology, Neuromodulation, Peripheral Interventions, Rhythm Management, and Urology and Pelvic Health. The main challenges and considerations include resolution and tolerances, capacity and throughput, technology cost, and biocompatibility. The smallest commercial machines available are suitable for small tooling and large components; and more customized technology is required for printing smaller components, which are most common in minimally invasive devices. The current standard for our applications is metal powder bed fusion. However, there are some drawbacks and challenges associated with metal powder for certain applications. These applications could benefit from resin-based raw materials, such as ceramics, that have a variety of biocompatible properties. Finding applications that have 'market pull' represent the fastest way to develop a technology and achieve commercialization. This requires a confluence of factors including an unmet clinical need, a committed technology partner, and medical device supplier that believes in additive technology.

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Mark has spent 14 years with Boston Scientific in R&D, product development for cardiac ablation catheters in San Jose, CA, USA and technology development for metal additive manufacturing in Clonmel, Ireland. Mark Mark holds a M.Sci in Engineering (Biomedical Devices) and a B.Sci in Mechanical Engineering.

Powder Bed 3D-Printing for the Production of Reaction-Bonded Silicon Carbide

Binder jetting, classically also known as three-dimensional printing, is one of the most efficient Additive Manufacturing (AM) technologies to create large and complex shaped ceramic parts. It enables the production of prototypes as well as final products, which may not be realized by established shaping techniques. One main drawback of the technology is the immanent porosity of printed green bodies, due to dry powder deposition methods. This usually prevents the creation of parts with material properties which are technically sufficient.

In contrast to the vast majority of technical ceramics, powder bed porosity is not an obstacle for the production of components made of Reaction Bonded Silicon Carbide (RBSiC). Instead a porous network is a prerequisite for the Liquid Silicon Infiltration (LSI) process which follows the creation of green bodies. However, green part porosity as well as microstructural inhomogeneity have to be kept on a very low level to be able to produce technical components by binder jetting.

The presentation will give some insights into material and process development, which was key to enable the production of three dimensional printed RBSiC with excellent properties. Today, we can exploit process-related advantages of additive manufacturing providing a new dimension of constructive design potentials and address demanding market segments of lithography, metrology and thermal process technology.

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  Master Student, ETH Zürich/CH
- 2016–2017
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- 2014–2018
  PHD Student, ETH Zürich
- 2020–present
  Development Engineer, Schunk Ingenieurkeramik GmbH/DE

3D-Printing of Ceramics: Binder Jetting vs. Material Extrusion

The technological fundamentals of Binder Jetting go back to developments at MIT at the end of the 1980s. In this process, a binder is applied locally to a powder bed by means of a print head, which bonds individual powder particles together.

Particles can also be added to the binder liquid. The printed powder layer is lowered by a defined amount and covered with a new layer of powder. The printed binder also ensures that the layers are bonded together. In this way, layer by layer, the three-dimensional body is created, which must be made free of loose powder after the binder has cured.

In Material Extrusion, a viscous material is forced through a nozzle, which is moved along a predefined path. The basic requirement for the material to be processed is that it solidifies after being deposited as a strand. Two basic mechanisms are possible for this purpose:

- Analogous to ceramic injection molding, a mixture of the ceramic powder with thermoplastics or wax is converted into a viscous liquid by increasing the temperature near the nozzle. If the material cools down, the viscosity increases rapidly and solidification occurs. This approach is followed with filaments or granules.
- Pastes based on either clay or powder mixtures with organic plasticizers, for example cellulose, can be processed in the cold state. The paste solidifies by drying and/or chemical processes.

During the presentation, the possibilities and limitations of binder jetting and material extrusion will be presented comparatively and discussed in the context of industrial applications.

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Education
1974–1979 RWTH Aachen, Mineralogy
1984 RWTH Aachen, PhD (Dr. rer. nat.)
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Work Experience
1979–1987 RWTH Aachen, Research Scientist
1987–1990 Forschungszentrum Jülich, Research Scientist
1990–1996 DIFK (German Institute of Refectories and Ceramics), Bonn, Vice Managing Director
Since 1996 WZR ceramic solutions GmbH, Founder and Managing Director
Since 2005 Honorary Professor at University of Applied Sciences Bonn-Rhein-Sieg, Germany

Design, Additive Manufacturing and Testing of a 500 000 rpm Rotor for Micro-Turbine Applications

Owing to the high energy density of hydrocarbon fuels, ultra-micro gas turbines with power outputs below 1 kW have clear potential as battery replacement in drones. However, previous works on gas turbines of this scale revealed severe challenges due to air bearing failures, heat transfer from turbine to compressor, rotordynamic instability and manufacturing limitations. To overcome these obstacles, a novel gas turbine architecture is proposed based on conventional roller bearing technology that operates at up to 500 000 rpm and an additively manufactured monolithic rotor in cantilevered configuration, equipped with internal cooling blades. A preliminary rotor has been designed based on an interdisciplinary approach considering thermodynamic analysis, compressor and turbine design, structural design, heat transfer management, generator design and rotordynamic constraints. In this scope, clear advantages of ceramic additive manufacturing could be highlighted. Subsequently, monolithic rotor prototypes containing shaft, turbine and compressor have been manufactured using lithographic ceramic manufacturing technology and subsequent precision grinding. Additionally, the same geometries were manufactured from Inconel 718 using more conventional selective laser sintering technology. Following high-precision rotor balancing, high-speed tests are on-going reaching up to 500 000 rpm and yielding valuable performance data of compressor and turbine. The goal of this project is to demonstrate the feasibility of additive manufactured monolithic rotors for micro turbine applications.

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Lukas Badum
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Lukas Badum received his Bachelor and Master degrees in mechanical engineering from University of Stuttgart/DE.
Since 2019 he is working towards a PhD degree at the Turbomachinery and Heat Transfer Laboratory of Technion/IL, where he is involved in the field of Additive Manufactured micro-gas turbines.

Lithoz CeraFab 8500 at Sandia National Laboratories – a Year in Review

Join Dale Cillessen of Sandia National Laboratories for a Ceramic Additive presentation highlighting a year in review of using a Lithoz CeraFab 8500. This presentation will cover SNL and Lithoz America teaming together to develop custom slurries, mechanical characterization, sintering, shrinkage, and the impacts of having access to ceramic additive manufacturing.

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Dale Cillessen
Sandia National Laboratories

Additive Manufacturing at JPL: Research and Applications

Samad Firdosy and R. Peter Dillon
NASA Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA 91109

Metal, ceramic and polymer additive manufacturing processes are currently being developed at JPL for enabling and critical applications in support of robotic space exploration missions. Additive processes allow for the possibility of fabricating complex geometries with functional and structural materials that have been traditionally difficult to manufacture by traditional means. Selected research and applications will be discussed for additively manufactured metals, ceramic and polymers in the context of JPL applications. In addition, the fabrication, post process and testing of laser powder bed fusion additively manufactured heat exchangers for the MOXIE technology demonstrator on NASA's Perseverance rover will be presented.

Samad Firdosi
NASA

Samad Firdosy is a materials and manufacturing technology development engineer at the NASA Jet Propulsion Laboratory. He is currently focused on the development and qualification of additive manufacturing materials and processes for space craft applications.

Data Management in Production of Ceramic Membranes

The industrial production of ceramic filters has a history which goes way back into the 40s of the last century. This industrialization was triggered by the need for the enrichment of uranium 235 used in the first atomic bombs and a technology capable to realize that. Although today, the use of ceramic membranes is solely focused on more peaceful applications like in the chemical industry, the major production processes are still handled in a similar and very often manually manner. As ceramic membranes were mostly used in niche market applications and thus manageable production capacities, the well-defined & monitored manual processes could easily handle the collected data and its management so far. In recent years that changed dramatically due to the larger demands for ceramic membranes in broader mass-market applications like waste water and drinking water treatment. As automation became a crucial part of the former manually driven production processes, data creation, collection, analysis, and its management were paramount to run the new production lines economically sound and safe. Although the production processes are well-known and understood and each individual process on its own is rather more simple than complex, the combination of all of them and their interaction to each other, especially on a significant larger production scale, had a major impact to the process control and the data management. This presentation will give an overview of the unexpected but not unsolvable challenges and how potential solutions may look like.

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Christian Goebbert
Managing Director, Nanostone Water GmbH/DE

- Christian Goebbert, born in Saarbruecken, Germany
- He received a master’s degree in Chemistry at the University of Saarland, Germany and the University of Surrey, UK in 1996
- In 2001 he received a PhD in material sciences. The thesis involved the development of transparent conductive coatings using dispersable ITO nano particles
- In 2001 he joint a young start-up company, ItN Nanovation in Saarbruecken, Germany. In his responsibility was the development and upscaling of a specific nano powder production process. Later he became the technical head of production, responsible for the production of ceramic coatings and ceramic membranes
- In 2010 he became the co-founder of a new company, majorly focusing on the development of a ceramic membrane for drinking water applications
- Today, he is the managing director of the production facility of Nanostone Water GmbH in Halberstadt, Germany and responsible for 110 employees. On the global Nanostone levele, he is also the Chief Science Ofiicer and Vice President R&D
- His major focus activities are in the planning & supervision of all local and global R&D activities of Nanostone Water, the development of next generation products, IP management, field application support and customer support.

Transformation from Manufactory to Smart Production

Whether from the consumer side or from industrial customers - the expectations of the products are changing. In the days of manufactories it was still enough for them to be of high quality and individual, at the time of industrialization it was above all quality, price and availability. Many people wanted access to goods that were previously inaccessible to them. In the course of time, individuality was added, which one tried to achieve by means of a variety of variants. This is no longer enough. The essential new requirements from the market are real individuality, more customer benefits in existing products and more services. This requirement also affects production. Smart Production wants to meet these new requirements for production systems based on new customer needs and the corresponding business models using innovative technologies and methods. That's the theory. But how does this work in practice?

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Wolfgang Heining
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- Born in Eschenbach/DE
- He received his bachelor's degree in Applied Informatics from the OTH – Technical University of Applied Sciences
- In 2011 he joined the company UBH as Software Developer for Automation Technology, Amberg/DE
- In 2018 he joined the company Lippert GmbH & Co. KG as Software Developer for AuTomation Technology/DE
- In 2019 he started studying for his master's degree in Technology Management 4.0 at OTH – Technical University of Applied Sciences

His main focus is the creation of NET material flow applications in the field of conveyor technology.

Data-centric Smart Factory

Since the breakthrough of deep neural networks in image recognition, artificial intelligence has proven to be very successful in a wide range of industrial applications, bringing the concept of automation to a new level.
However, a full deployment of these technologies in a plant poses serious challenges.
In order to let the algorithms support the decision-making process of white and blue collars in a reliable way, one need to standardize the flux of data generated across the entire factory, from raw materials characterization to quality controls, from scheduling orders to warehouse management. That is the key to unlock the power of AI under the strict constraints imposed in a production environment.
In other words, we really need to acknowledge the central role played by data to make a factory smarter, as tech companies did to create the smart devices that changed our way of living.

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Born in Ravenna/IT.
M. Tellarini received the BA and MS in physics from the University of Ferrara/IT and the PhD from the University of Portsmouth. Since 2016, Matteo Tellarini is Data Scientist at the SACMI's Innovation Lab/IT, where he develops machine learning applications for controlling industrial processes, modeling the wear of components and predicting the machines' faults.
He is also involved in industrial research projects for the development and test of innovative IoT solutions."

Redefining Interactions with Machinery and Equipment. Unlock AR Empowered Processes in the Ceramics Industry

Industrial service processes often require travelling to bring technical expertise where it is needed. In addition, the Corona Virus makes personal contact amongst experts, technicians and machine operators on the shop floor more difficult. Modern Augmented Reality technology in combination with advanced mobile devices and fully adapted processes of machinery and equipment makes machine-relevant knowledge available anytime and anywhere. Immediate reduction of travel expenses and machine downtimes and increased efficiency of processes are some of the short-term benefits. Also explore the long-term value gained by the ability to establish digital business models for machine manufacturers and service providers.

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Daniel Mirbach
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He started his professional career in 2005 with a commercial apprenticeship at a renowned German telecommunications provider, which was later followed by a degree in Business Administration (BA). In the meantime, he changed to a leading company in the field of high-temperature technology up to 1800 °C in 2011. He was responsible for the worldwide sales of metallic-ceramic products, components and systems for the construction and operation of electrically and combustion-heated industrial and laboratory furnaces for sintering, firing, melting as well as heat treatments. In 2017, he took over the management of the marketing department and was responsible for the operational and strategic branding. After more than 11 years of experience in sales, 8 of them in sales of products requiring technical explanation and more than 6 years of experience in B2B marketing, 2 of them in management positions, Daniel Mirbach changed to oculavis GmbH/DE in September 2019. From now on he will be Head of Marketing. The core solution of oculavis GmbH is the modular Augmented Reality platform oculavis SHARE. With oculavis SHARE, service processes, customer service and maintenance procedures can be redefined and carried out more efficiently thanks to Augmented Reality powered remote expert support and standard work instructions. Digital business models in service become also possible for machinery and equipment manufacturers.

The Next Challenge in Digital Production with Powder Metal Presses

Since several years Dorst Technologies offers IoT functions that extract valuable data from the production process for the user of hydraulic and electric powder presses, refine them and make them available in the customer's own MES system, ready to use. Various satisfied customers are already successfully using the system in production.

The objectives are:

1. Part Quality – documentation of ongoing production by recording and consistently storing all relevant press parameters.
2. Productivity Overview – daily, weekly and long-term production overview, machine availability documentation
3. Machine Condition – monitoring of all relevant machine elements. Smart Maintenance, the innovative service, includes automated monitoring and predictive maintenance for presses.

In addition to the presentation of the IoT function packages and their topology in the production environment, the presentation will address the revolutionary opportunities opened up by the systematic application of Artificial Intelligence (AI) algorithms and machine learning in the context of part quality and machine availability.

In order to meet the diverse demands of digital services, Dorst has developed a modular IoT function library. An individual data model will be created based on the customer's requirements. The Dorst IoT system easily connects to higher-level enterprise systems through optimally adapted interfaces. The refined data are made available to the customer's MES system via this interface.

In addition to data refining, Dorst Analytics, – a SaS (Software as a Service) solution, offers advanced data analytics functions for Dorst customers in case of complex problems and questions in the production environment.

In addition to its competence in data analytics, Dorst Technologies is mainly a valuable partner for successful digital production thanks to its technological and machine-specific know-how.

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Herbert Gröbl
Competence Team IoT,
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After completing a dual study program in radio frequency technology in combination with a few years of experience at a satellite earth station, he started his career at DORST Technologies in 1989.

After working as a service engineer and software developer, he headed the control engineering development department for more than 10 years. Since 2017 he performs as CIO and CDO for IT and IoT at DORST Technologies.

Keynote

As a hidden champion in the development of production equipment for metal powder, technical ceramics and traditional ceramic products, DORST Technologies expands its portfolio to include functions for the digitalization of powder presses, spray dryers and pressure casting machines. The focus of the development is to increase the Overall Equipment Effectiveness (OEE) of DORST production machines. Using methods from current international research achievements in the field of Artificial Intelligence (AI) and Data Analytics, functions are being developed to improve the quality of the manufactured products and to avoid unplanned machine downtime.

Silicon Nitride Speciality Materials for Product and Process Innovation in Semiconductor and Analysis Technology

High-performance ceramic components on the basis of silicon nitride are used for the optimization of structures and processes (for instance, for reducing wear, increasing process temperatures, avoiding corrosion or cross-contamination to lightweight engineering or reducing accelerated masses. However, the established standard silicon nitride grades available on the market are now reaching their limits. One solution may be speciality grades with a properties profile that has been selectively changed based on modification of the composition and/or microstructure compared to established gas-pressure-sintered silicon nitride (GPSN). On account of the high technological challenges involved, however, such special variations developed in laboratories in recent decades are only slowly finding their way into production. As a specialist in silicon-nitride-based materials and niche supplier, FCT Ingenieurkeramik recognized the sign of the times early on and has therefore been offering speciality Si_3N_4 material variants for several years now. The technological benefit can be shown very clearly with the example of semi-conductor technology: For example, for the lining of coating equipment or handling systems for wafers, speciality ceramics are sought that contain the lowest possible quantities of sintering additives and impurities in their composition in order to minimize the effects of cross-contamination. In other cases, a thermal expansion coefficient identical to that of the silicon or SiC wafers is required to structure semi-conductors as finely and precisely as possible and then test them accordingly. For the perfect tempering of wafers, on the other hand, speciality Si_3N_4 grades with increased thermal conductivity are useful. These are also used increasingly as substrates for high-power circuits – e. g. in wind power and electric mobility applications, as, besides good heat dissipation, higher application temperatures, thermal shock resistance and strength or damage tolerance are becoming increasingly important for these components. For measurement and analysis systems, tailored Si3N4 ceramics offer crucial advantages: e. g.crucible holders in smelters for XRF specimens – made of Hastelloy up to now – are now being replaced with a special Si_3N_4 grade. Thanks to high-temperature strength and corrosion resistance, Si_3N_4 offers not only a longer lifetime, it also reduces cross-contamination in XRF analysis specimens.

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Dr Ulrich Degenhardt,
Head of R&D, FCT Ingenieurkeramik/DE

He is Head of Research and Development at FCT Ingenieurkeramik GmbH/DE, a manufacturer of high end components made of non-oxide ceramics. He first studied Material Science and Engineering at the University of Bayreuth/DE.
In 2005, he received the German Hans-Walter-Hennicke Award for his master thesis. Prior to joining FCT, he made his PhD at the Department of Ceramic Materials Engineering in Bayreuth, with research focus on precursor-derived ceramics. In his actual work at FCT, he advances the material development and tailoring of special silicon nitride grades.

Development of Custom-made Silicon Carbide RTP Powders

Industry is always looking for efficiency and a better utilization of resources. An efficient molding process needs to maintain continuous feeding and reduce cleaning pauses. To achieve this, improvements on the machinery and materials have been developed in the last years.

"Ready to Press" (RTP) powders are a response of the material suppliers to the need to adapt and fulfill to the industry's requirements.

RTP powders are uniquely formulated to aid in the manufacturing of pressed ceramic parts. RTP are spray dried, high surface area powders held together by a binder premix that includes the necessary additives to press and sinter directly into a variety of green ceramic bodies. Due to their relatively round shape, they easily "flow" into pressing tools for further processing into preforms.

During the development with the customer, powder-specific data are evaluated in the first step in order to be adapted to the production requirements. After the components have been successfully manufactured, tests are carried out to optimize downstream process steps such as pressing parameters and sintering.

Using two SiC powder developments for different applications, the development and material properties are presented up to the finished component.

Industriekeramik Hochrhein GmbH/DE
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Ceramic Filters for Advanced Process Technologies

Due to their specific advantages, the demand for ceramic filters is increasing worldwide. As a consequence of the rapid spread and development, the quantitative and qualitative requirements for the
demands on the extrusion of these filters as the dominating shaping method are growing in concept and detail. Which requirements have to be met in extrusion?
Which perspectives and drivers are to be expected?
Are there new developments in the geometry or the coating of the filters?
All this will be explained in a practice-oriented way by

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Martin Simon, Head of Design and Project Management, ETC-Kema, Schöpstal/DE

- 26.07.1985
  Born in Görlitz, Germany
- 2004
  Abitur at Annengymnasium Görlitz
- 2005–2008
  Vocational training as an industrial mechanic at Siemens Power Generation Görlitz
- 2008–2011
  Dual mechanical engineering studies (specialising in design) at DHBW Mosbach and Wacker Neuson SE Munich
- 2011–2018
  Development engineer and project manager at Wacker Neuson SE Munich
- 2018–
  Head of design and project manager at ECT KEMA GmbH

Tailoring Natural Fertilizer

The situation is coming to a head. Agriculture is blamed for being the sole culprit for too high nitrate concentrations in the ground water. Farmers are asked to reduce the spreading of manure and digestate, accepting the loss of earning. Of course, this leads to protests from the agricultural sector. The origin of this issue is, that manure and digestate contain too less essential phosphate or too much ammonium, respectively, to sufficiently supply the highly bred crops with nutrients. To provide the plants with ideal growing conditions, either phosphate can be added (Morocco and China are the only countries with noteworthy deposits) or the volume of the untreated natural fertilizers is adjusted to the phosphate need (which leads to the nitration of unused ammonium).

A well-working solution to the dilemma is to separate the raw material into different fractions by ultrafiltration. The possibility results from the comparatively large size of phosphate ions. This process should of course be ideally run continuously, at low energy consumption and in high yield (heavily concentrated). Dynamic crossflow filtration is a separation technique that fulfills all these requirements. Disc-shaped membranes are assembled onto a hollow shaft which is rotated by a motor. The transmembrane pressure generated in a pressurized housing. The filtrate passes the membrane from the outside to the inside and is removed through the shaft, while the retentate is constantly removed from the membrane surface and re-dispersed. Continuous cleaning through tangentially flow ("crossflow effect") is thus not reached by pumps like in conventional setups (moving liquid, static membrane), but by the rotation of the filter stack (moving membrane, static liquid). This ensures significant energy savings during operation. Beyond that, the values transmembrane pressure and cross flow velocity are preserved as individual parameters. This allows both the cleaning effect to be increased many times over (higher flux) and the processing of high concentrations (savings in volume of the tailored material). The filtration using KERAFOL's alumina membrane disc with 5 nm coating leads to a phosphorous-enriched fraction, while a subsequent reverse osmosis gives a potassium- and nitrogen-rich concentrate as well as pure demineralized water. All in all, this procedure can reduce the nitrogen content in natural fertilizers as well as significantly save volume for storage and transport.

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Silicon Carbide Material: Solutions for Laser Processes, Semiconductor and Opto-Mechanics OEMs and Chemical Industries

Boostec® SiC is a technical ceramic obtained by pressureless sintering. This process leads to a silicon carbide that is completely free of non-combined silicon.
Our material is well known for its outstanding properties specifically for harsh environments uses. Boostec® SiC is commercially available since the 90's for mechanical seals and bears (automotive and chemical industries). Its uses have been enlarged to other industrial sectors with the capacity to produce large and complex full SiC parts and assemblies until 3,5 m class to offer new solutions for semiconductor and opto-mechanics OEMs.
These 30 years old background allows us to develop new innovative applications based on collaborative programs with end users. From the manufacturing of monolith ceramics to the production of complex solutions, Mersen Boostec has developed over the years a unique expertise.
Presentation will begin with a short description of the company inside Mersen, a large and worldwide industrial group. Process and material properties will be described within a second part. Final focus on four of our main current commercial activities will be overviewed as following:

- Laser processes: Mersen Boostec provides standard and custom active mirrors from 10–500 mm aperture, with a range of high reflective coatings. Market segments for high end scanning mirrors are for laser material processing and for instrumentation. Key advantages will be discussed (fast thermal stabilization, low moment of inertia, lightweight…).
- Semiconductor and optomechanics OEMs: Mersen Boostec provides SiC ultra-stable structures thank to high specific stiffness and high thermal stability of the material.
- Continuous flow reactors for the chemical industry: Mersen Boostec develops and manufactures high technology chemical reactors for continuous flow systems in cooperation with Corning SAS.
- Heat exchangers for the chemical industry: It is a key solution for processes with high corrosion and for processes with high service rates (less maintenance).

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Marc Ferrato
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1990–1994
Non-oxide ceramic expertises for ceramics and composites private company. Joined Mersen Boostec at the creation 1999.
2004–2004
BraSiC braze technology development Tests, qualification and validation for ESA HERSCHEL program
2004–2012
Collaborative programs
- INPAC (SiC for chemistry) – FUI/FEDER
- HEXOSiC (SiC for chemistry) – ANR
- GRAWITON (SiC for optics) – 7 PCRD
- HYCYCLES (SiC for energy) 7 PCRD

2012–2016
R&D Manager within Mersen BOOOSTEC
- New product developments from R&D to markets.
  SiC Chemical reactor
  SiC heat exchanger
  SiC for space and industrial optics

Since 2016 R&D Manager within Mersen BOOOSTEC
- New product developments from R&D to markets
  SiC Chemical reactor
  SiC heat exchanger
  SiC for space and industrial optics

Water-Based Tape Casting Process: an Innovative Environmental Friendly Process for Mass Production of Thick and Thin Ceramic Substrates for Electronic Applications

Towards the commitment to the environment by introducing a cleaner process within the mass production, Sedal has been involved for the last years in the optimization of the water-based tape casting process to produce high quality ceramic substrates for electronic applications. It is well known that water-based tape casting is a low- cost and especially an environmentally friendly process. But its main difficulty relies on the drying conditions and controlling the thickness of the tapes obtained, among others. That is why, its mass production introduction is being a difficult task for the ceramic substrate´s industry and is the main reason for which the organic solvent-based tape casting process predominates, even its complex installations, high cost and harmful effect for the environment.
Despite this, Sedal has optimized the water-based process for different thicknesses of alumina 96 substrates for mass production: from 0,3 mm to 1mm. Slurry formulation, tape casting process conditions, densification and post sintering processes, all have influence on the final quality of the substrate, but also are conditioning the continuity of the process. Using the optimized process, Sedal can produce high quality ceramic substrates that accomplish state of the art standards required by electronic applications. Physical, mechanical, electrical, thermal and surface properties are showing that this process can be used industrially in continuous production, gaining a cleaner process without losing performance of the substrates. Some results of our ceramic substrates obtained in the mass production by water-based tape casting process are shown in this paper.

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Advanced Ceramics for Healthcare – Materials, Properties, Applications

The most important properties of advanced ceramics in the field of medical technology are hardness, electrical insulation, stiffness and, of course, biocompatibility. Ceramics are therefore indispensable in this field; they play a decisive role in many areas, including implants, dental prostheses and medical instruments.
In this lecture, the most common ceramic materials for applications in surgical instruments, their specific properties and typical areas of use in this application will be shown. In addition to solid ceramics, ceramic coatings will be presented, which are also suitable for such applications and in some cases can represent an interesting alternative.

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Ulrich Werr
Area Sales Manager, Rauschert/DE

Ulrich Werr was born and raised near Cologne, Germany.
After a three-year apprenticeship as a potter, he studied Metallurgy and Materials Engineering with focus in ceramics at RWTH Aachen University from 1992 to 1997. His degree was awarded with the Springorum Denkmünze (Springorium Commemorative Coin) and the Friedrich Wilhelm Prize by the RWTH Aachen University.
He then worked as a project manager at the Research Institute for Inorganic Materials Glass/Ceramics in Höhr-Grenzhausen, Germany from 1997 to 2002. Here he carried out process optimisation and publicly funded projects in the ceramics industry.
In 2002, Ulrich Werr moved to Rauschert in Pressig (Upper Franconia, Germany). To date, he has already held a wide variety of positions in the company: from laboratory engineer to production manager extrusion and injection moulding to technical sales USA. Since 2015, he has been in charge of sales for ceramics in medical technology, electrical heat technology and various special applications.
In 2018, he was also appointed Sales Manager of the Pressig-Heinersdorf site of the Rauschert group.

Consequences of Stretching Ceramic Mechanical Properties to their Limits for Technologically Challenging Applications

The mechanical performance of ceramic materials are typically characterized according to various standards, which mainly focus on final test geometry and surface roughness of the samples. However, it is common knowledge that also the manufacturing route plays a crucial role in the final performance of a ceramic monolith, for given pressing and sintering conditions. This is even more relevant for zirconia were the different manufacturing steps could significantly influence its crystallographic phase composition. So far, this was not critical for most of the applications as the safety factors for design were very large. Today in applications, such as dental implants, the components are designed at the limit of what the material can deliver in controlled conditions. The intrinsic statistical distribution as well as the process variability of the mechanical resistance of ceramics, such as zirconia, needs to be addressed when designing sensitive components, such as medical implants. This talk aims at raising the questions of ceramic mechanical characterization and its implications on materials selection. Finally, it will address the importance of product characterization for sensitive applications

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Vice President Innovation & Development, Ceramaret/CH

- Senad Hasanovic was born in Bosnia and Herzegovina, lives works now in Switzerland.
- He received his master's degree in materials science and engineering from Ecole Polytechnique Fédérale de Lausane (EPFL)
- He worked as research engineer at EPFL on Metal Matrix Composites and joined a high-end watch company as first step his industrial career
- He joined the management team at Ceramaret in 2015, where he's in charge of Busi-ness Development through innovation and R&D programs

Highly Leak-tight Ceramic-metal Assembly for a Novel, Three-dimensional Imaging X-ray Process

The presentation is intended to provide an overview of the ongoing bilateral 4-year development work by Adapter Imaging LTD and Alumina Systems GmbH in the context of the production of a new, three-dimensional imaging X-ray process. The main focus of the work presented here is the evolution of the vacuum-tight brazed ceramic-metal component to generate the required X-ray radiation. In this case, the ceramic-metal brazed part is one of the core components for the patented process.

Selected evolutionary steps (from the first idea to the implemented solution) and the corresponding joining technology will be presented and discussed. Advantages and disadvantages concerning the required production steps will be presented, including the design decisions derived from them.

Finally, the advantages of the novel process are presented showing first examples from tests conducted by Adaptix Imaging LTD.

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Dr Kai Sauerzapfe, Head of Business Unit Battery Systems, Alumina Systems/DE

- 9/1997–9/2004 Study of mechanical engineering with specialisation in space tech-nology at RWTH-Aachen
- 9/2004–1/2010 Research assistant at the Institute for Ceramic Components in Me-chanical Engineering, later renamed Materials Applications in Mechanical Engineer-ing at RWTH Aachen University (PhD)
- 3/2010–1/2013 Research associate at the Project Management Organisation Jülich
- 2/2013–9/2014 Head of FEM at Lapp Insulators Alumina GmbH
- 9/2014–1/2019 Head of Product and Process Development Lapp Insulators Alumina GmbH (Alumina Systems GmbH)
- 1/2019 Head of BU Battery Systems at Alumina Systems GmbH

Material Performance and High Functional Integration – Economic Solutions for Many User Industries

Panel Discussion
Organized by Expert Group CIM/DE
Moderator Dr Moritz von Witzleben,
Managing Director, INMATEC Technologies GmbH/DE

Participants
Dr Karin Hajek, Sales Director,
INMATEC Technologies GmbH/DE
Marko Maetzig, Process Development PIM, ARBURG/DE
Harrie Sneijers, Sales Director,
Formatec Technical Ceramics/NL
Phillip Ninz, Scientist, IFKB University Stuttgart/DE

Moderator

Dr Moritz von Witzleben,
Managing Director INMATEC Technologies GmbH
INMATEC Technologies GmbH is the world's leading producer of feedstocks for ceramic injection moulding. Since 1998, INMATEC has been developing and producing ceramic feedstocks.
Besides a wide range of standard feedstocks that are based on different ceramic powers and already meet many requirements, customized solutions are developed and feedstocks produced on production scale. INMATEC has significantly widened its product portfolio in respect of binder systems for ceramic injection moulding. INMATEC is a development partner, service provider and producer at the same time. Moritz von Witzleben is a graduate mineralogist and has been managing director at INMATEC Technologies GmbH for over 20 years. As deputy chairman of the Injection Moulding Expert Group, he is driving the further development of ceramic injection moulding; with his teaching at Bonn-Rhein-Sieg University of Applied Sciences and at the University of Koblenz, he has inspired students' keen interest in ceramics as a material and ceramic injection moulding as a shaping method.

Panel members

Dr Karin Hajek
Sales Director INMATEC TECHNOLOGIES.
Karin Hajek has been with INMATEC Technologies GmbH for 20 years, and as sales manager she can draw on a wealth of experience in advising customers on the selection of ceramic raw materials and feedstocks prepared from these.

Dipl.-Ing. Marko Mätzig,
Responsible for Process Development PIM at
ARBURG GmbH & Co. KG.
He joined Arburg in 2000. He studied Materials Science at TU Dresden and went then to University of Nottingham to deepen his knowledge in Materials Engineering.
For over 50 years, ARBURG has working on ceramic and metal injection moulding and is therefore one of the pioneers in this technology. During these years, ARBURG has been supplying injection moulding machines to manufacturers of CIM and MIM components. To support customers over the entire process chain, a PIM laboratory was set up in 1991.

Harrie Sneijers,
Sales Director Formatec Technical Ceramics BV
In 1996, Formatec was started up as a CIM development company, involved in product-specific process developments for companies such as Philips, Samsung, Vertu, etc. Subsequently, besides development, the company took over the production of components. The still strong development DNA is applied by Formatec to meet customer-specific challenges in ceramics, like ZrO_2, Al_2O_3, but also for special in-house developments like ESD-qualified ZRO_2. Formatec offers a wide range of services; ceramic injection moulding, green machining, grinding, polishing and additive manufacturing with its own systems developed inhouse. Harrie Sneijers has been working in the injection moulding industry for 40 years and has extensive experience as a manufacturer of moulds for injection moulding, process developer and technical consultant for ceramic injection moulded components as well as 3D printing.

Phillip Ninz,
Scientist at IFKB Institute of Ceramic Components, Uni Stuttgart
Under the direction of apl. Prof. Dr Frank Kern, the Department of High-Performance Ceramics at the IFKB has focused for over 20 years on research and teaching with oxide ceramic materials and their fabrication methods for demanding applications in mechanical engineering, medical systems and electronics. The findings of fundamental material-related research are transferred in the scope of mainly publicly funded projects to industrial applications. To this end, the IFKB is researching the entire process chain of ceramic injection moulding from raw powder selection and preparation, through feedstock production, CIM, debinding to the sintering process. With this integrated approach to the manufacturing chain from material to the application, the department has gained valuable expertise to solve industrial problems. Philipp Ninz is a PhD student and long-serving research assistant at the IFKB, focussing primarily on the research and development of ceramic materials for laser direct structuring. Moreover, he is working on the transfer of these materials to industrial production by means of ceramic injection moulding and additive processes.

Accelerating the LPBF Process by the Combination of AM and HIP

Additive manufacturing (AM) processes are of great interest and are the subject of extensive research. Nevertheless, there are still limitations. For laser powder bed fusion (LPBF) the process duration for large components is long, and in addition, the reliability of manufactured components is often not sufficient due to manufacturing-related defects and an anisotropic microstructure. A popular way to optimize the mechanical properties is hot isostatic post-processing of additively manufactured components. Hot isostatic pressing (HIP) is an established method in powder metallurgy, which enables materials of the highest quality to be manufactured. The structure achieved is homogeneous and pore-free. Thus, additively manufactured components can be optimized enormously, in particular concerning their fatigue strength. Additionally, by using a HIP post-treatment, the AM process can be greatly accelerated by increasing the scanning speed or the hatch distance because HIP is able to densify large porosities if the samples are built with a dense shell.

IAPK
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Dr Anke Kaletsch
Deputy Managing Director, IAPK/DE

Dr Anke Kaletsch is Head of the Division Powder Technology at the Institute for Materials Applications in Mechanical Engineering (IWM) at RWTH Aachen University. In addition, she is the Deputy Head of the Institute of Applied Powder Metallurgy and Ceramics (IAPK), which is an associated institute of RWTH Aachen University. Anke Kaletsch studied Mechanical Engineering in Aachen and received her doctoral degree from RWTH Aachen University in 2016. At IWM and IAPK she coordinates research activities and projects in the field of powder metallurgy and ceramics. The main research areas in her department are Additive Manufacturing (AM), hot isostatic pressing (HIP), and sinter simulation for different production processes like HIP, FAST/SPS, or sintering of parts, produced by binder jetting. Her own scientific focus is the combination of AM technologies with hot isostatic pressing. The combination of AM and HIP enables, on the one hand, the improvement of fatigue performance for AM-materials, and opens on the other hand new opportunities for design-free HIP capsule production for net-shape components and functional composite-components.

Efficient Production and Qualification of New Materials for the LPBF Process

A major issue for today's metal additive manufacturing industry is the low number of commercially available and qualified materials. This slows down the development of new applications and inhibits the use AM in new industrial areas. To take on this problem Rosswag introduced a holistic process chain beginning with the powder production up to the final part qualification. This process chain is presented with a focus on powder production and the necessary subsequent material and process investigations to achieve predefined technical readiness levels. For the powder production, a typical production process is introduced and important powder and particle characteristics are discussed as well as how to transfer the as-sprayed powder into an LPBF-ready state. Afterwards, the material qualification route for the LPBF process together with target benchmark values for an initial qualification is shown.

Daniel Beckers,
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Lithography-Based Metal Manufacturing (LMM)

Lithography-based Metal Manufacturing is an additive manufacturing technology for the production of functional metal components with superior surface aesthetics compared to other AM technologies. LMM is based on the concept of photopolymerization, where metal powder is homogeneously dispersed in a light-sensitive resin and selectively polymerized layer-by-layer by exposure with light. The printed green parts undergo a debinding step to burn off the photopolymer-based binder system. With a subsequent sintering step, mechanical properties, and microstructure equivalent to Metal Injection Molding (MIM) can be achieved. Sintered parts made of 316 L stainless steel can achieve 98,5 % of the relative density and a tensile strength >500 MPa. The LMM approach enables production of complex part sizes <200 g with low surface roughness, high accuracy of the details, mechanical properties, and feature resolution. LMM is developed as a complementary technology for the MIM mass production for prototyping and small-scale production. Using LMM, MIM producers can support their customers more efficiently in the prototyping phase and provide functional parts in hours instead of months.

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Dr Gerald Mitteramskogler
Managing Director, Incus/AT

- Gerald Mitteramskogler was born in Steyr, Austria.
- He received his M.S. and Ph.D. in Mechanical Engineering from Vienna University of Technology. His research was focused on the developing of materials and systems for the AM of dental ceramics
- In 2015–2019 he worked as a Head of research and development of metal-based materials for lithography-based printing at Lithoz, expert in 3D printing of bone replacement material and high-performance ceramics
- Since 2019 Gerald is CEO at Incus, Austrian system provider for an innovative lithography-based Metal Manufacturing (LMM)

Gerald Mitteramskogler is a mechanical engineering professional with 11+ years of experience in AM of metals and ceramics. Understanding the challenges of metal manufacturing, he founded Incus to introduce a novel 3D printing technology for producing complex parts.

Potential of HIP Postprocessing as Part of Additive Manufacturing Production Process to Ensure High Quality Parts

Ceramic and Metallic sintered parts, regardless of the actual manufacturing process, generally tend to show residual porosity and defects. In most cases, both phenomena are unwanted as among others, they decrease fatigue strength and polishability. Furthermore, pores may be a spot for bacteria.

Of course, the grade of residual porosity always depends on various parameters of the individual manufacturing process. But it can be assumed, that in conventional sintering processes of mass production residual porosity can be minimized more efficiently compared to innovative and flexible manufacturing processes such as Additive Manufacturing (AM).

HIP, hot isostatic pressing, as a post-treatment can eliminate residual porosity in all kinds of sintered parts. A high-pressure inert gas atmosphere creates high isostatic forces on the parts while sintering temperatures induce diffusion processes which close and seal all pores and defects reliably. Even though HIP technology is ambitious, the process itself is considered as highly reliable and repeatable if the parts have a gas tight surface where the process gas pressure can work on.

In a simplified comparison, AM parts tend to create more residual pores and defects than conventionally sintered parts. The reasons may be diverse but from our point of view, the main reason is that on principal, optimizing the AM process is incomparably more challenging than optimizing the process of conventional sintering processes. While in conventional sintering of mass production the process could be adapted and optimized over countless cycles, this is not possible in the same way for AM for a few reasons. In AM it is not possible to produce hundreds of parts in a first series with slight variations in e.g. powder composition, geometry and support structures, print/laser parameters, sintering conditions, etc. just to find out which part shows lowest porosity.

The Idea of AM is to make single individual parts in a very short time without any additional costs for special tools, or an any optimizations in several iterative cycles. Changing the geometry of the parts is also no adequate method for optimization because this would reduce the main strength of AM, the possibility to design highly complex shapes.

Here, HIP can be a solution. HIP can close pores and heal defects very efficiently to make AM material mechanically reliable. By doing so, AM can concentrate on its main strength, the rapid manufacturing of highly complex shapes and individually designed parts.

This presentation will concentrate on the question how a HIP for AM may look like, from our perspective. CREMER wants to put not only technical but also commercial aspects into discussion due to the experiences we made with AM during the last years. We are looking forward for a vital discussion about the opportunities of AM + HIP with the audience.

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100 Years of Hard Metals and not an End

In 1923, almost 100 years ago, a material made of hard tungsten carbide and tough cobalt metal was patented, which laid the foundation for modern hard materials. From the beginning, further development was aimed at increasing material quality ("minimizing the defect density") and performance. Today, hard metal is a material on which both users and manufacturers place extremely high demands. Selected examples will be used to show how these can be met in the future. In an overview, aspects of the raw materials, the processing, the hard metal itself, and the life cycle will be addressed.

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- 2002–2007 Studies of Technical Chemistry at TU Wien /AT. Diploma Subject "Production of Orientated Carbon-Nanotube-Layers"; Supervisor: R. Haubner; Institut for Chemical Technologies and Analytics, 2007; Diploma: 19.11.2007.
- 2008–2010 Doctorate in techn. sciences at TU Wien / AT. Thesis: "Plasma-CVD of SiOCN-layers on Nitride-bonded and Post-oxidized steels"; Supervisor: J. Laimer, R. Haubner; Institut of Applied Physics, 2010; Rigorosum: 20.01.2010.
- 2010: Post-Doc at Faculty of Physics TU Wien / AT
- 2010–2011 HSE-Manager at Habich GmbH, Weiten/AT
- 2011–2015 Material Technology at Andritz AG, Graz / AT
- 2015–2017 QM and R&D Manager at BVT GmbH, Lannach / AT
- since 2017 member of R&D at Boehlerit GmbH & CO KG, Kapfenberg / AT
- since January 2020 Group Manager Development of Cutting Materials at Boehlerit GmbH & CO KG, Kapfenberg / AT

Current Trends in the Development of Hard Metals

Hardmetals or cemented carbides are a widely used material for a wide range of applications such as cutting and drilling tools, mining tools and wear resistant parts. The excellent mechanical properties result from the combination of a ceramic hard phase, usually tungsten carbide (WC) and a ductile metallic binder phase, usually cobalt (Co). While this combination of WC and Co is most common since its initial development in the 1920s, there is an increasing need for both alternative hard phases and alternative binder phases. This is on the one hand due to increasing demands in regard to material performance and on the other hand due to the fact that Cobalt is classified as both a critical raw material and also as a toxic CMR material. This talk includes current research trends on novel compositions in regard to alternative hard phases and binder metals as well as on additive manufacturing technologies for complex shaped hardmetal tools.

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Dr Johannes Pötschke, Group Leader Hardmetals and Cermet Fraunhofer IKTS

Dr Johannes Pötschke is Group Leader of the Research Group Hardmetals and Cermets at the Fraunhofer Institute IKTS in Dresden/DE. He studied material science in Bayreuth and Dresden and did his PhD thesis on binderless hardmetals at the Technische Universität Dresden. He is in charge of many national as well as international public and industrial funded research projects in the field of hard materials development and processing, including additive manufacturing.

AM of WC–Co Hard Metals Using Laser Powder Bed Fusion

The production of WC–Co carbides requires considerable know-how. The starting powders, the furnace atmosphere have a significant influence on the microstructure and the mechanical properties of hard metals. The potential of additive manufacturing and especially beam-based processes cannot yet be unleashed. Beforehand, questions regarding the starting powders, the process parameters, and the possible post-treatment must be clarified. Researchers from all over the world are working on this issue. The currently published studies will be summarized in this presentation. Results from recent work carried out in collaboration with Fraunhofer ILT and the Machine Tool Laboratory WZL at RWTH Aachen University will be presented.

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Sofia Fries, Team Leader Hard Metals and Cermets, IWM, RWTH Aachen University/DE

Sofia Fries studied Nanotechnology at the Friedrich-Alexander-Universität Erlangen-Nürnberg. She completed her master's degree in materials science at RWTH Aachen University.
She has worked as a research assistant in the Powder Technology Division at the Insititute for Materials Application (IWM) since 2016. Her research interest lies on microstructure of ceramic-metal joints and properties of cemented carbides. In particular, her research focuses on laser-based additive manufacturing of cemented carbides.

The Potential of Innovative Furnace Technology for the Development of Hard Metal Products for Specific Applications

The wide spectrum of hard metal applications is reflected by an equally large spectrum of grades differentiated according to chemical composition and microstructure. The required properties depend strongly on the application. The material characteristics must be tailored to fit these requirements. Intense research is ongoing to increase the understanding of influence parameters on achievable properties and failure mechanisms in practice. In addition, the establishment of AM has opened up new possibilities concerning the versatility of hard metal design options. To facilitate the production of new materials on an industrial scale, progress concerning furnace technology plays an important role. An overview of a selection of furnace technology currently in use along the production chain is considered. The application field of the CREMER CARBIDE2500 furnace type is carburization of tungsten or tantalum on an industrial scale. This innovative technology has increased the possible carburizing temperature range to 1400–2500 °C. The temperature and dwell time directly influence the grain size of the powder produced. A wide range of hard metal hardness, fracture toughness, and wear resistance can be achieved by varying the grain size and binder content. An increase in grain size range available opens up new possibilities for material design.

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- 1991 –1994 Mechanical Engineering, University of the Witwatersrand in Johannesburg, South Africa. Academic degree achieved: Bachelor of Science in Engineering
- 1995 –1999 Mechanical Engineering (Specialization: Thermal Engineering), RWTH Aachen, Germany. Academic degree achieved: Dipl.-Ing.
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Multimaterial Ceramic Additive Manufacturing for Medical Applications

This contribution will comprise a short survey of ceramic additive manufacturing applications in medicine followed by a presentation of current research and development activities performed within the research project "INK-plant" (Ink-based hybrid multimaterial fabrication of next generation implants). In this project multimaterial ceramics will be used for manufacturing subperiosteal implants. The medical background as well as the challenges of implant design and 3d-printing will be presented together with some remarks about what will be needed to move towards clinical trials and approval.

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Francesco Moscato received the PhD in Industrial Bioengineering from the University of Calabria (Italy) in 2008. He was Visiting Scholar at Columbia University (New York USA) in 2014. Since 2015 he is Associate Professor at the Medical University of Vienna.

The research of Francesco Moscato focuses on two main areas: Medical Additive Manufacturing: investigation of how 3d-printing can improve surgical and interventional procedures, medical device prototyping, tissue engineering and medical education. Cardiovascular Bioengineering: research and development of methods and devices improve diagnostics and provide support to a range of cardiovascular pathologies.

He is author of 59 original articles and more than 30 invited talks (twice at a Gordon Research Conference). He was Secretary General (2013–17) and President (2018–19) of the International Society for Mechanical Circulatory Support. Francesco Moscato has been Principal Investigator/Site Coordinator in 7 international and national research grants (for a cumulative funding of about 4 Mio EUR).

Ceramic Dental Implants – 3D-Printed Applications

Dental implants made of ZrO_2 have become a serious addition to the treatment spectrum to implants made of titanium. In addition to increased health awareness on the part of patients, the clinical advantages of the material ZrO_2 have also led to this development. However, the reliable use of these implant systems was only made possible by the consistent further development of materials and the optimization of manufacturing methods. For dental implants, not only aesthetics, comfort and biocompatible materials are of great importance - above all, they must also grow well into the bone and withstand the high daily loads in the long term. In this context, in addition to implant geometry and material selection, it is the manufacturing processes that play an important role in this stability and the long-term clinical success of the implants. Recently, new manufacturing methods such as additive manufacturing (AM, 3D-printing) for the production of dental implants from zirconium dioxide have increasingly become the focus of interest and research. The advantage of AM is that three-dimensional objects can be designed on the computer in an almost unlimited variety of shapes and complexity, and can thus be implemented cost-effectively with reduced material input. However, additive manufacturing is currently still in competition with conventional manufacturing methods such as CIM or hard machining and must be measured against these. In this context, two-piece implants, for example, also entail different clinical manufacturing requirements than one-piece implants. Furthermore, although a microrough surface design of a ceramic implant has an important influence on long-term clinical success, inadequate surface finishing can lead to loss of stability and implants. From a clinical point of view, does the advantage of AM "customized design" also apply to implants or does standardized manufacturing offer advantages after all? And last but not least...why should we deal with ceramic implants at all? With answers to these questions and with further clinical background on AM in connection with ceramic implants, this lecture addresses in particular developers and experts from the field of biomaterials and technology, as well as manufacturers of ceramic implants and research institutions. This is because knowledge of the background and actual clinical requirements for ceramic implants is an important prerequisite for the further development and establishment of AM. Only through intensive cooperation between research, technology and clinical application can successful products be created for the benefit of our patients.

Dr Jens Tartsch
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Dr. Jens Tartsch is an international well known expert for ceramic implantology in Switzerland. He graduated in 1992 at the „Free University of Berlin (Charite) /Germany". Today Dr. Tartsch is working in his private dental clinic in Zürich/Switzerland. His main emphasis is in ceramic implant dentistry, the biomaterial and immunological aspects in dentistry and material incompatibilities. Thus, he is an international educator, speaker and author for the topic ceramic implantology and immunology in dentistry. Dr. Tartsch is founder and President of the European Society for Ceramic Implantology - ESCI, chairman of the German Society for Environmental Dental Medicine - DEGUZ and Member Board of Directors of the Swiss Society for Anti Aging Medicine and Prevention - SSAAMP.

Bone Regeneration with 3D-Printed Biodegradable Ceramic Scaffold

Introduction: Availability and regeneration of bone are crucial topics in surgical field concerning the skeleton. Age and pathologies are major challenges in these fields. Therefore, there is a major effort to maximize healing and reduce complications by guiding scaffolds. 3D printed customized scaffolds are among the most advantageous artificial materials for bone regeneration. They can provide increased time efficiency, decreased complication risks, enhanced healing capabilities, and allow for complex scaffold architecture and patient specific geometry. To evaluate a novel biodegradable 3D printed β-TCP (LithaBone TCP 380 D, Lithoz GmbH, Austria, Vienna) scaffold in regard to biocompatibility and osteoconductivity we chose proximal tibiae and calvariae of rats. Goal is a possible use in guided bone regeneration in oral surgery and orthopaedics.

Method: Bilateral calvaria critical size defects (Ø 5 mm) together with mono cortical proximal tibia defects (Ø 1.5 mm, depth: 6 mm) were applied in 36 (12/group) adult male Sprague Dawley rats. Left side defects were sham control, were experimental. Experimental side was filled with on of the following bone substitutes: 1) a novel biodegradable 3D printed β-TCP (LithaBone TCP 380 D) by Lithoz, 2) a proven 3D printed β-TCP (LithaBone TCP 300) by Lithoz, and 3) Bio-Oss®Block by Geistlich Pharma AG (Wolhusen, Switzerland). For analyzing bone volume in the defect area and scaffold volume in vivo micro-CTs scans at wek 2 and 4 and ex vivo scans were performed. Assessing biocompatibility, newly formed bone area, penetration depth, vessel number, vessel area and bone apposition rate are done with histological undecalcified thin ground sections.

Results: Preliminary qualitative results showed a high bone regeneration and therefore high osteoconductivity after 4 weeks of time compared to the sham and no adverse effect for biocompatibility. We expect quantitative results to be ready for presentation on the congress.

Conclusion: Biodegradable 3D printed β-TCP scaffold could be a candidate for guided bone regeneration in implant placement, orthopaedics, traumatology, and neurosurgery to promote bone regeneration in flat and long bone defects in case of confirmation of the qualitative results.

Prof. Dr Annelie-Martina Weinberg
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Prof. Annelie-Martina Weinberg is the leader of the Musculo-skeletal Research Unit on Biomaterials at the Department of Orthopedics and Traumatology, MUG. She is an orthopaedic surgeon with a permanent staff position and who has highlighted her career in the development of bioresorbable materials for the application in orthopaedics, especially paediatric orthopaedics, by successful acquisition of the Laura Bassi Centre BRIC (Austrian funding program). 3-D printing is a further topic in her career. Furthermore she is a member of the CaMed Project (Austrian funding project) which focus on 3-D printing in clinics and medicine.

Ceramic Additive Manufacturing in Prosthetic Dentistry

Lithium disilicate ($LiSi_2$) is a unique dental ceramic due to its great optical characteristics, especially translucency in combination with good mechanical properties, such as strength and fracture toughness. The translucency of LiSi2 is on par with other glass ceramics such as feldspar, whereas it is exceeding them in mechanical strength. There it is only rivaled by oxide ceramics, such as Zirconia and Alumina, which in turn do not satisfy aesthetic requirements. Therefor $LiSi_2$ is favored for restorations especially in the anterior region.

Conventional processing of $LiSi_2$ is either by hot-pressing precrystallized blanks in the so-called lows wax technique or by milling of blocks or blanks. The former method is quite intricate, time and material consuming. Milling as a computer aided manufacturing method (CAM) is embedded in the digital workflow, where patient data is acquired by intraoral scanning and the model and restauration are designed by designated computer aided design (CAD) software. The milling process however is also material consuming, as it is a subtractive method, and furthermore it is limited in the freedom of design. Especially thin restorations, such as non-prep veneers with thicknesses below 1 mm cannot be easily produced by milling. Additive manufacturing (AM) technologies are promising approaches to overcome these limitations of the CAD-CAM production of LiSi2 restorations. Especially lithography based ceramic manufacturing, as developed by Lithoz, is an AM technology with high resolution and precision. We are showing a possible clinical application of LCM produced $LiSi_2$ restorations in the anterior region, which to the best of our knowledge has not been applied until now.

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Franziska Schmidt graduated as Diplom Ingenieur in Materials Science in 2007 and completed her Dr.-Ing. Degree in biomaterials science in 2013, both from the Technische Universität Berlin. During her time as PostDoc at the chair for advanced ceramic materials (TU Berlin) and subsequently at the Division Ceramic Processing and Biomaterials at the Bundesanstalt für Materialforschung und Prüfung (BAM, Berlin) she focused on material development for ceramics and composites for additive manufacturing and hard tissue regeneration. In 2020 she joined the department for prosthodontics at the Charité Universitaetsmedizin Berlin as head of the laboratory for Materials science and Biomaterials. Here she has been focusing on development and in-vitro characterization of dental implants, implant surfaces and restoration materials, with a strong focus on ceramic and composite materials and application of AM in dentistry.

New Possibilities Through Multi-Material Printing in Ceramics

The medical, electrical and aerospace fields are just some examples of industries that are using 3D printing to push past previously established applications. Multi-material 3D printing is garnering particularly widespread attention in this way due to the wide range of possibilities it offers to manufacture parts with improved functionalities and properties. New applications are just waiting to be discovered thanks to multi-material 3D printing and this technology is finding new uses in different industries every day.

In this lecture you will learn all about Lithoz's CeraFab Multi 2M30, a powerful multi-material 3D printer which utilizes the full capacity of additive manufacturing to combine ceramics, metals and polymers in one single component. This innovative machine enables complete freedom in design, allowing for the manufacture of parts and structures with combined material properties and thus opening the door to 3D printing in entirely new applications and industries. Powered by industry-leading Lithography-based Ceramic Manufacturing technology, the CeraFab Multi 2M30 creates multi-functional components for applications ranging from electronics and embedded sensors to biomedical implants and devices, as well as in the aerospace and automotive industries.

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Background in chemical engineering and material science from Technical University of Vienna.
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Exploring New Concepts to Design Damage Tolerant Ceramics Using AM

The combination of ceramics with other materials has enabled the fabrication of hybrid systems with exceptional structural and functional properties. However, a critical issue affecting the functionality, lifetime and reliability of these systems is the initiation and uncontrolled propagation of cracks in the brittle ceramic parts, yielding in some cases very high rejection rates of component production. In previous work, design concepts that combine different approaches used in current ceramics engineering have proved successful in obtaining highly reliable ceramic materials with enhanced fracture resistance. For instance tuning the location of "protective" layers within a ceramic multilayer architecture can significantly increase its fracture resistance, while retaining high strength. The use of tailored residual stresses in embedded layers can act as an effective barrier to the propagation of cracks from surface flaws, providing the material with a minimum design strength, below which no failure occurs. Moreover, by orienting (texturing) the grain structure, similar to the organized microstructure found in natural systems such as nacre, crack propagation can be controlled within the textured ceramic layers. Two examples show the potential of employing the LCM process to design multi-phase layered architectures is presented.

(i) A multi-material approach is employed to combine alumina-zirconia layers sandwiched between pure alumina layers, in order to introduce significant compressive residual stresses in the latter. A characteristic strength higher than 1 GPa was measured on the alumina multi-material system, compared to ~650 MPa in monolithic alumina, taken as a reference. This is the first report of employing AM to tailor the strength of alumina ceramics, taking advantage of the layer-by-layer printing process.

(ii) 3D-printed highly textured alumina is fabricated combining the LCM technology and Templated Grain Growth (TGG) during sintering. Relative densities of >93 % were reached for textured alumina, compared to 99 % on equiaxed reference samples. A high degree and quality of texture was achieved with 3D-printing. A characteristic strength of 640 MPa was measured for textured alumina, comparable to 570 MPa obtained in equiaxed alumina.

The aim are complex 3D ceramic-based multi-material geometries with tailored microstructures, with outstanding mechanical strength and reliability.

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AM of Alumina Ceramics for the Selective Laser Induced Metallization

Laser induced activation and autocatalytic metallization is a process enabling the selective and fully additive metallization of ceramic materials. Hereby a pulsed laser beam is used to structure and activate the surface. Subsequently the parts are immersed in an electroless metallisation bath in which the deposition of metal takes place selectively on the activated surface areas. The process is used for the application of conducting paths, antennas or other metallic structures on complex shaped three dimensional ceramic components. Thereby a high degree of design freedom is achieved and structural and electronic functionalities can be integrated. This enables miniaturisation and leads to reduced weight and volume of electronic components. Recent material related research on ceramic substrates of our own promises new application fields for three dimensional mechatronic integrated devices (3D-MID) by exploiting the beneficial properties of ceramics compared to state-of-the-art polymers.

The substrate material composition, its microstructure and surface properties are important factors for the effectivity of the metallization process besides the type of laser source and parameters and the composition of metallization bath. The metallization efficiency of alumina can by drastically increased by doping with few percent of oxides such as Cr_2O_3 or NiO. For the LCM process these intransparent dopant powders propose a challenge. The LCM process is relying on a certain amount of transparency of the powder loaded suspensions in order to solidify a suspension layer with a certain thickness and to reliably interconnect the layers to form a solid, defect free part. A different way to incorporate dopants into the ceramic substrate material is by a subsequent dip infiltration after the shaping process. Hereby a pure alumina part is shaped, debindered and pre-sintered. The resulting porous body is infiltrated with a precursor solution of the respective dopant. During drying the precursor is decomposed and the oxide dopant is deposited within the pore volume and then diffuses into the alumina during sintering. The drawback of this method is that the dopant concentration is inhomogeneous over the volume and leads toto a higher concentration on the surface.

The presentation addresses challenges connected to AM via LCM and shows first results of the successful selective metallization of doped alumina substrates doped.

Philip Ninz
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IFKB Institute for Ceramic Components at the University of Stuttgart

The Department of Advanced Ceramics at the IFKB, headed by Prof. Dr Frank Kern, has been involved in research and teaching of oxide ceramic materials and their manufacturing techniques for demanding applications in mechanical engineering, medical technology and electronics for more than 20 years. The findings of fundamental materials-related research activities are transferred to industrial applications within the framework of mostly publicly funded projects. To this end, the IFKB researches the entire process chain of ceramic injection moulding, from raw powder selection and preparation, feedstock production, CIM moulding, debinding to the sintering process. Due to this holistic view of the production chain from material to application, the department was able to develop valuable competences to solve industrial problems.

Philipp Ninz is a doctoral student and long-term research associate at the IFKB and is primarily involved in the research and development of ceramic materials for laser direct structuring. He is also involved in the transfer to industrial production of these materials using ceramic injection moulding and additive processes.

Characterisation of the Components as a Function of the Orientation in the Installation Space

AM components often have step-like surfaces due to the layer-by-layer structure. To be able to characterize their influence on the properties as a function of the component alignment, a special test method was developed at Fraunhofer IKTS, which is now being further developed within the CharAM project. In addition, the method is being validated by means of a round robin test with six partners.

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AM of Ceramic Porous Structures for Application to Combustion Systems

In Porous Media Burners (PMBs), a solid porous matrix embedded within the combustion chamber accumulates heat from the hot gaseous products and preheats incoming reactants. PMBs have been shown to achieve combustion properties superior to those of free-flame systems, including higher burning rates, reduced propensity for flame instabilities, decreased pollutant emissions, and lower lean-flammability rates. Furthermore, the large surface area-to-volume ratio of PMBs can be applied to facilitate effective adsorption and conversion of impurities.

The local porous structure of PMBs directly affects the total heat transfer across a porous material, reactivity, and flow behavior. However, conventional fabrication methods for the ceramic structures applied in PMBs produce locally random pore geometries and sizes within a range of global parameters. Architected porous materials, however, enable tuning of flame stability and pollutant formation, which can have significant impact on combustors prone to lean flame blow-out, e.g., gas turbine engines, or systems that require robust operation for a wide operating range, e.g., household boilers. In this research, we demonstrate the fabrication of architected porous ceramics with predefined and reproducible microstructures to enable advanced PMBs. Using Digital Light Processing ceramic additive manufacturing, five different mullite and alumina burners were designed, printed, and tested to characterize emissions, temperature, and structural properties.

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AM – Activities and Success Stories from the Ceramic Industry

The bavarian "Coordination Centre for Additive Manufacturing", at Bayern Innovativ, is a hub that links all experts and newcomers and all activities to 3D printing within Bavaria but also on an Germany-wide and international level, from and to Bavaria. Practical examples from partners and stakeholders provide insights in the successful work performed by the companies and research institutions.

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Uncovering the "Hows" and the "Whys" of Colloidal Stability in Ceramic Resins for Stereolithohgraphy

Polymeric dispersants are frequently used to provide steric and electrostatic stabilization of ceramic particles in photo-curable resins intended for digital light processing (DLP). However, the dispersant's type, functionality and concentration directly influence its effectiveness. This contribution is a characterization study of more than ten anionic, cationic, nonionic and amphoteric dispersants, with the goal of identifying the optimum polymeric dispersant for ceramic-filled photo-curable acrylate formulations. The compatibility and miscibility of the different dispersants were tested in a typical photo-curable acrylate monomer (methyl methacrylate). Two different ceramic powders, viz. Al_2O_3 and β-$Ca_3(PO_4)_2$, were functionalized with the selected dispersants using shear mixing and an agitator bead mill. Micrographs revealed that anionic dispersants offer a promising dispersibility in acrylate formulations, while different types of anionic ammonium polyacrylate dispersants showed varying levels of effectiveness. The operational pH of the suspensions was monitored for varying concentrations of the dispersants. This revealed the dissociation mechanism of the different dispersants. The concentration of each adsorbed dispersant on the surface of the ceramic particles was measured using centrifugation followed by UV/VIS spectroscopy. Moreover, flow curves generated on a modular rheometer were used to analyse the influence of the dispersant type and concentration on the flow and viscoelastic behaviour of the resins. The sedimentation stability was assessed using amplitude sweeps followed by frequency sweeps. The highest levels of adsorbed dispersant induced the lowest viscosity, storage and loss moduli. High levels of adsorbed dispersant, coupled with the right electro-chemical interaction, offered superior colloidal stability. This resulted in a more reliable feedstock for stereolithography.

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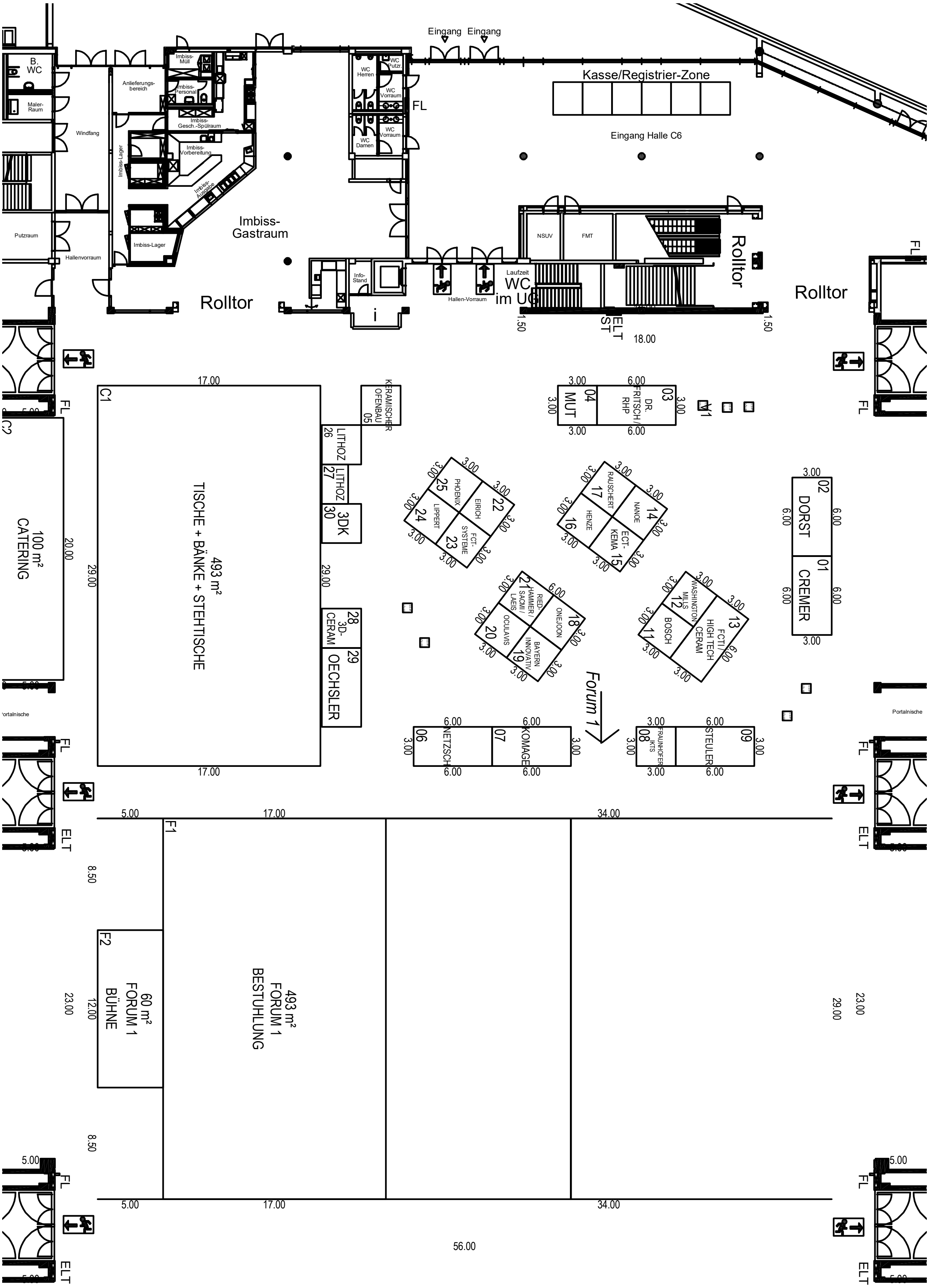
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B. WC
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18.00
C1
493 m²
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17.00
29.00
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100 m²
CATERING
20.00
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11 BOSCH
06 NETZSCH
07 KOMAGE
08 FRAUNHOFER IKTS
09 STEULER
Forum 1
F1
493 m²
FORUM 1
BESTUHLUNG
F2
60 m²
FORUM 1
BÜHNE
34.00
23.00
12.00
8.50
56.00
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