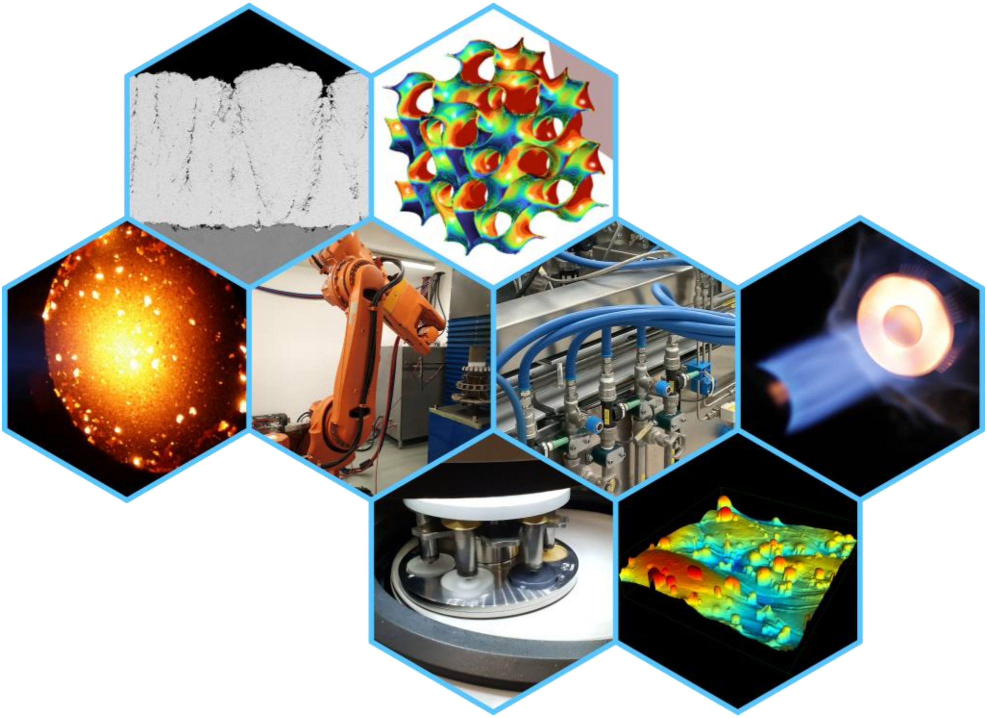
CLiCAM

Cultivating Leaders for Innovative Coatings and Additive Manufacturing Applications

Funded by the European Union



Virtual Test Beds

Materials & Coatings Area01

Material Preparation & Additive Manufacturing Area02

RESEARCH INFRASTRUCTURE.
EXPERTS. REAL SOLUTIONS.

www.clicam.eu

ABOUT

CLiCAM Virtual Test Beds

EXPERTISE
TECHNOLOGY
COLLABORATION
INNOVATION

MATERIALS
COATINGS
ADDITIVE
MANUFACTURING
REAL IMPACT

Connecting research capabilities with industrial challenges.

CLiCAM Virtual Test Beds connect companies with advanced infrastructure, specialised experts, and technologies from four European research institutions.

Together, we help companies find the right expertise and capabilities to address their specific materials and technological challenges – from material and process development to characterisation, testing, and experimental validation.

Our activities focus primarily on research, development, and experimental validation up to TRL 4–5.

EXPERTISE

Access specialised knowledge across four European research institutions.

INFRASTRUCTURE

Use advanced research equipment and technologies without building your own facilities.

CONNECTED SOLUTIONS

Combine complementary capabilities to address complex industrial challenges.

Have a technical challenge?

Describe your challenge and we will help you find the right experts and capabilities.

Bridging Research and Industry for a Sustainable Future.

Funded by the European Union

Two Areas. One Network of Capabilities.

The CLiCAM Virtual Test Beds are organised into two complementary areas, covering a wide range of materials, coatings and additive manufacturing capabilities.

Area 01

Materials & Coatings

Advanced materials, functional coatings and surface treatments supported by thin-film, plasma, PVD/PECVD, electrochemistry, and thermal spray technologies.

Area 02

Material Preparation & Additive Manufacturing (AM)

Material and feedstock preparation for additive manufacturing, from process development to component production and testing.

Explore the capabilities and case studies in our online catalogue →

CLiCAM TEST BEDS

What Can You Use the Virtual Test Beds for?

FROM RESEARCH TO INDUSTRY

FROM MATERIALS TO COMPONENTS

DEVELOP ADVANCED MATERIALS
Metallic, ceramic, glass and other advanced materials and powders.

DEVELOP AND APPLY FUNCTIONAL COATINGS
Surface engineering, protective and functional coatings tailored to specific applications.

ADVANCED ADDITIVE MANUFACTURING
Development and optimisation of materials, processes and components for additive manufacturing.

CHARACTERISE MATERIALS AND COMPONENTS
Microstructure, chemical and phase composition, mechanical properties and comprehensive material analysis.

TEST MATERIAL PERFORMANCE
Hardness, strength, wear resistance and other properties under relevant operational conditions.

INVESTIGATE FAILURES AND DEGRADATION
Analysis of fractures, wear, degradation mechanisms and root cause of component failure.

VALIDATE NEW TECHNOLOGIES
Experimental development, testing and validation of materials, processes and technologies for industrial applications.

Have a technical challenge?

Describe your challenge and we will help you find the right experts and capabilities.

Bridging Research and Industry through Innovation.

Academic Partners

Four European institutions. Connected research infrastructure.

FunGlass

Alexandr Dubček University of Trenčín, Slovakia

FunGlass is a leading research centre specialising in **glass, ceramic materials and advanced technologies**. It develops and characterises **innovative materials, processing technologies and solutions** with strong potential for **industrial application**. By combining cutting-edge scientific expertise with practical research, the centre strengthens **collaboration between academia and industry**. FunGlass also promotes **innovation, knowledge transfer and international cooperation**, as well as supporting the **education and professional development** of young researchers and future materials scientists.

CEITEC

Brno University of Technology

CEITEC BUT is a leading research centre specialising in **advanced materials, nanotechnology and engineering**. The **HPMC4I research group** focuses on the development of **advanced materials, functional coatings and innovative processing technologies** for industrial applications. Its research combines **thermal spraying, additive manufacturing, powder processing** and comprehensive material characterisation with the aim of developing solutions tailored to practical industrial needs. The group bridges the gap between cutting-edge scientific knowledge and real-world applications, thereby strengthening **collaboration between academia and industry**.

Academic Partners

Four European institutions. Connected research infrastructure.

WUST

Wroclaw University of Science and Technology, Poland

Wroclaw University of Science and Technology – Faculty of Mechanical Engineering focuses on research and teaching in the fields of **mechanical engineering, manufacturing and materials processing.** Its **Department of Metal Forming, Welding and Metrology** specialises in metal forming, welding technology and **advanced methods of measuring and characterising materials** for technical and industrial applications.

IPP

Institute of Plasma Physics of the Czech Academy of Sciences, Czech Republic

The **Institute of Plasma Physics of the Czech Academy of Sciences** is a leading research institute specialising in **high-temperature plasma and nuclear fusion, laser plasma, low-temperature plasma and plasma chemistry**. Its activities also cover **materials engineering, optical diagnostics and plasma-material interactions**, with applications in the energy sector and industry. The IPP provides research infrastructure and promotes education, knowledge transfer and **international cooperation**.

Industrial Partners

Collaborating for real-world impact.

AGC INTERPANE

ADVANCED COATINGS & SURFACE ENGINEERING

AGC Interpane specialises in **advanced coating technologies and surface engineering**. Its expertise includes PVD, PECVD, magnetron sputtering, and the development of functional thin-film coatings. The company combines materials development, coating process optimisation, coater machine manufacturing, and industrial-scale coating technologies for advanced applications.

CASTOLIN EUTECTIC

SURFACE ENGINEERING, WEAR PROTECTION & REPAIR

Castolin Eutectic specialises in **surface engineering, wear protection, repair, and joining technologies**. Its expertise includes thermal spraying, hardfacing, welding, brazing, and laser cladding. The company develops material and coating solutions designed to improve component durability, service life, and performance in demanding industrial environments.

LITHOZ GmbH

ADDITIVE MANUFACTURING OF HIGH PERFORMANCE CERAMICS

Lithoz GmbH is a technology company specialising in the **additive manufacturing of high-performance ceramics**. Its expertise includes lithography-based ceramic manufacturing, advanced ceramic materials, and the production of complex, high-precision components. Lithoz develops innovative ceramic 3D printing technologies for demanding industrial, medical, and research applications.

Industrial Partners

Collaborating for real-world impact.

OUEST COATING

THERMAL SPRAY & SURFACE ENGINEERING

Ouest Coating specialises in **thermal spray coatings and advanced surface treatments**. Its expertise includes HVOF, plasma spraying, cold spraying, and arc spraying, as well as complementary surface finishing technologies. The company develops coating solutions that improve resistance to wear, corrosion, erosion, and high temperatures.

TREIBACHER

ADVANCED CERAMICS & FUNCTIONAL MATERIALS

Treibacher Industrie AG is a leading materials company specialising in **advanced ceramics, ceramic powders, and functional materials**. Its expertise covers the development and processing of materials based on zirconia, rare earths, and other high-performance compounds. The company develops material solutions for demanding applications, including thermal spraying and wear-resistant coatings.

Zoz GROUP

POWDER PROCESSING & MECHANICAL ALLOYING

Zoz Group specialises in **mechanical alloying, high-energy milling, and advanced powder processing technologies**. Its expertise includes developing novel metallic, ceramic, and composite materials with tailored microstructures and properties. The company develops processing technologies and material solutions for advanced manufacturing and coating applications.

CLiCAM TEST BEDS

Industrial Partners

Collaborating for real-world impact.

3D CENTER

ADDITIVE MANUFACTURING & 3D PRINTING

3D Center focuses on **additive manufacturing and advanced 3D printing technologies**. Its expertise includes developing and applying innovative manufacturing processes and materials to produce complex components. The company works on transferring additive manufacturing technologies from research and development into practical industrial applications.

About

CliCAM ERA Talents

RESEARCHERS FROM 4 EUROPEAN PARTNER UNIVERSITIES

MATERIALS
COATINGS
ADDITIVE MANUFACTURING
ANALYSIS

Expertise. Knowledge transfer. Innovation. Industry collaboration.

ERA Talents are researchers from CLiCAM partner universities bringing specialised expertise in advanced materials, coatings, additive manufacturing, and materials characterisation. Through collaboration with industrial partners, they combine scientific knowledge with practical experience and contribute to the analyses, experiments, and technological solutions available within the CLiCAM Virtual Test Beds.

OUR EXPERTS

Assoc. Prof. Ladislav Čelko, PhD.

CEITEC, Brno University of Technology, Czech Republic

Advanced Coatings & Materials Engineering

Failure Analysis · Thermal Spray · Coating Testing · Surface Engineering · Materials Characterisation

Assoc. Prof. Amirhossein Pakseresht

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Coatings & Materials Engineering

Thermal Spray · Thermal Barrier Coatings · Tribology · High Entropy Oxides · Materials Characterisation

Pawel Sokolowski, PhD.

Wroclaw University of Science and Technology, Poland

Advanced Coatings, Welding & Additive Manufacturing

Welding · Thermal Spray · Powders · Surface Engineering · Additive Manufacturing

Tomáš Tesař, PhD.

IPP, Institute of Plasma Physics of the Czech Academy of Sciences, Czech Republic

Advanced Coatings & Materials Engineering

Coating Analysis · Thermal Spray · Feedstock Development · Applied R&D

Edgar B. Montufar, PhD.

CEITEC, Brno University of Technology, Czech Republic

Materials & Additive Manufacturing for Medical Applications

Biodegradable metals · Bioceramics · 3D Printing · Extrusive Additive Manufacturing · Biofabrication

Aleksandra Malachowska, PhD.

Wroclaw University of Science and Technology, Poland

Advanced Coatings & Materials Engineering

Cold Spray · Thermal Spray · Coating Testing · Surface Engineering · Materials Characterisation

About

CliCAM ERA Talents

Diana Lago, PhD.
FunGlass, Alexander Dubček University of Trenčín, Slovakia

Additive Manufacturing of Glasses & Ceramics

Advanced composites | Functional structures | Magnetic glasses | Environmental applications

Pavel Gejdoš, PhD.
CEITEC, Brno University of Technology, Czech Republic

Advanced Coatings & Materials Engineering

Metallography | Coating testing | Failure Analysis | Hardness Testing | Materials Characterisation

Omid Sharifahmadian, PhD.
FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Coatings & Materials Engineering

Thin Films | Plasma Deposition | PVD & PECVD | Antireflective & Low-E Coatings | Powder Synthesis

Anastasiia Novokhatska, PhD.
FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Coatings & Materials Engineering

Surface Engineering | Thermal Spray | Coating Testing | Microstructure Design | Materials Characterisation

Serhii Tkachenko, PhD.
CEITEC, Brno University of Technology, Czech Republic

Advanced Coatings & Materials Engineering

Sintering Technologies | Powder Metallurgy | Coating Testing | Surface Engineering | Materials Characterisation

Akansha Mehta, PhD.
FunGlass, Alexander Dubček University of Trenčín, Slovakia

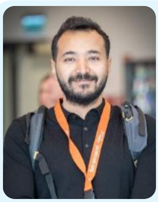
Advanced Materials & Materials Chemistry

Electrocatalysis | 3D printing | Nanomaterials | Photocatalysis | Functional Glass-Ceramics

Mateusz Skwarski, PhD.
Wroclaw University of Science and Technology, Poland

Modern Technologies & Mechanical Engineering

Hot Forming | Protective Coatings | Mechanical Testing | 3D Metal Printing | Crashworthiness



Mokhtar Mahmoud, PhD.
FunGlass, Alexander Dubček University of Trenčín, Slovakia

Additive Manufacturing & Materials Engineering

Glass & Ceramic Materials | Additive Manufacturing | Sustainable Materials | Materials Characterisation

CliCAM ERA Talents

Michaela Remešová, PhD.

CEITEC, Brno University of Technology, Czech Republic

Advanced Coatings & Materials Engineering

Electrochemistry | Chemical Deposition | Degradation | Surface Engineering | Materials Characterisation

Kamalan Mosas, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Optical & Functional Coatings

Thin Films | Functional Coatings | PVD/PECVD | Surface Engineering | Coatings Characterisation

Tomasz Kielczawa

Wroclaw University of Science and Technology, Poland

Advanced Coatings & Numerical Modelling

Microstructure | Thermal Spray | FEM modelling | Surface Engineering | Deposition Efficiency

Anusha Sekar, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Coatings & Materials Engineering

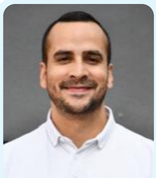
Surface Engineering | Thermal Spray | Coating Testing | Thermal Barrier Coatings | Materials Characterisation

Si Chen, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Biomaterials

Digital Light Processing | Composites | Bioactive Glasses | Surface Modification | Electrospinning



Germán A. Clavijo Mejía, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Multifunctional Coatings & Materials Engineering

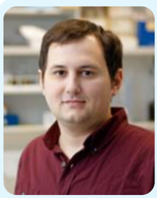
Thermal Spray | Process Optimisation and DoE | Bioactive and Functional Materials | Surface Engineering

Vojtěch Mařák, PhD.

CEITEC, Brno University of Technology, Czech Republic

Advanced Multifunctional Ceramics

Additive Manufacturing | Piezoceramics | Rapid Sintering | Materials Characterisation



Fatih Kurtuldu, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Materials Engineering & Additive Manufacturing

3D Printing | VAT Polymerisation | Digital Processing | Materials Characterisation

About

CliCAM ERA Talents

Rajesh Mundotia, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Advanced Coatings & Materials Engineering

Thin Films | Plasma Deposition | PVD & PECVD

Surface Engineering | Antireflective and Low-E coatings

Abel W. Ourgessa, PhD.

FunGlass, Alexander Dubček University of Trenčín, Slovakia

Chemical & Material Engineering

Thermal Spray | Inorganic Waste Upcycling

Additive Manufacturing | Materials Characterisation

We push the boundaries of materials.

We turn research into real-world solutions.

We help industry innovate.

We connect expertise with industrial needs.

We bring ideas from the laboratory to practical application.

Collaboration Opportunities

EXPERTISE

INFRASTRUCTURE

KNOW-HOW

Connecting expertise, infrastructure, and know-how to address real materials and technology challenges.

CLiCAM Virtual Test Beds bring together complementary research expertise, capabilities, and advanced infrastructure across four European institutions. They provide industrial and research partners with access to expertise and technologies in advanced materials, coatings, additive manufacturing, characterisation, testing, and related fields.

Collaboration can range from a single analysis or experiment to a multidisciplinary research approach combining capabilities from several institutions.

More than access to equipment

Collaboration through the Virtual Test Beds is not simply about accessing individual research equipment.

The key advantage is the ability to connect the right experts, infrastructure, and know-how to build a research approach tailored to a specific materials or technology challenge.

Key areas of collaboration

01 MATERIALS & COATINGS

Development and optimisation of advanced materials, powders, coatings, and surface treatment technologies.

02 MATERIAL PREPARATION & ADDITIVE MANUFACTURING

Preparation and modification of materials and feedstocks for advanced manufacturing and additive processes.

03 TESTING & VALIDATION

Testing and experimental validation of materials, coatings, components, and processes under relevant conditions.

04 CHARACTERISATION & ANALYSIS

Advanced analysis of material composition, microstructure, surfaces, coatings, defects, and properties.

Explore the capabilities and case studies →

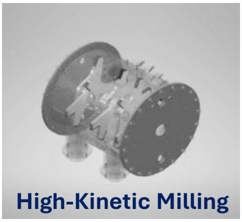
Area 01

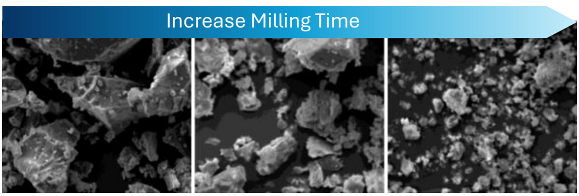
Materials and Coatings

Synthesis of Advanced Nanostructured Powders

To develop and optimise nanostructured powders by high-kinetic milling for the preparation of advanced PVD targets.

Design of Experiment → Powder Preparation → High-Kinetic Milling → Characterisation & Analysis → Validation





THE CHALLENGE

The geometry and size of the particles can be influenced by parameters of the milling process.

KEY RESULTS

- **Synthesis of fine metallic and ceramic powders with controlled particle size**
- **Optimisation of milling parameters to control powder morphology**
- **Enhanced alloying, diffusion, and powder refinement through optimised milling conditions**
- **Process control agents prevent cold welding and metal flake formation**
- **Particle analysis and structural characterisation**

Production of powders suitable for improved PVD target sintering and fabrication.

Partners involved

Zoz GmbH

FunGlass

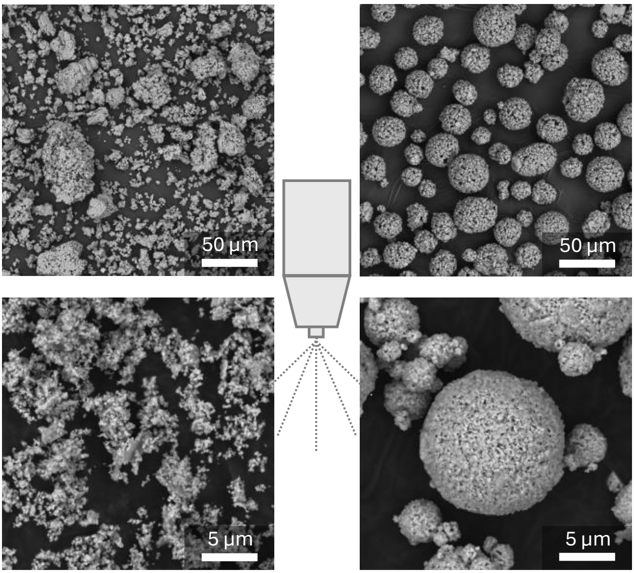
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

Powder Modification by Spray Drying

Transforming fine powders into spherical, flowable particles.

Powder Selection/Production → Suspension Preparation → Spray Drying → Powder Characterisation → Validation

BEFORE | **AFTER**



From fine powders to engineered particles - morphology matters.

THE CHALLENGE

Improve powder flowability, particle size distribution, and morphology for subsequent processing.

KEY RESULTS

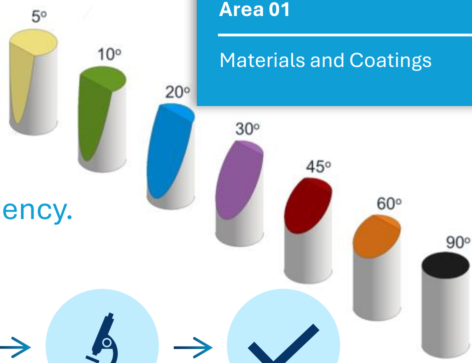
- Spherical particle morphology
- Increased particle size
- Improved powder flowability
- Controlled particle size distribution
- Reduced powder agglomeration
- Optimised spray drying parameters

Controlled particle size and morphology for improved flowability and processability.

Partners involved

CEITEC
Brno University of Technology
FunGlass
Alexander Dubček University of Trenčín

Deposition Efficiency of Thermal Spray Coatings

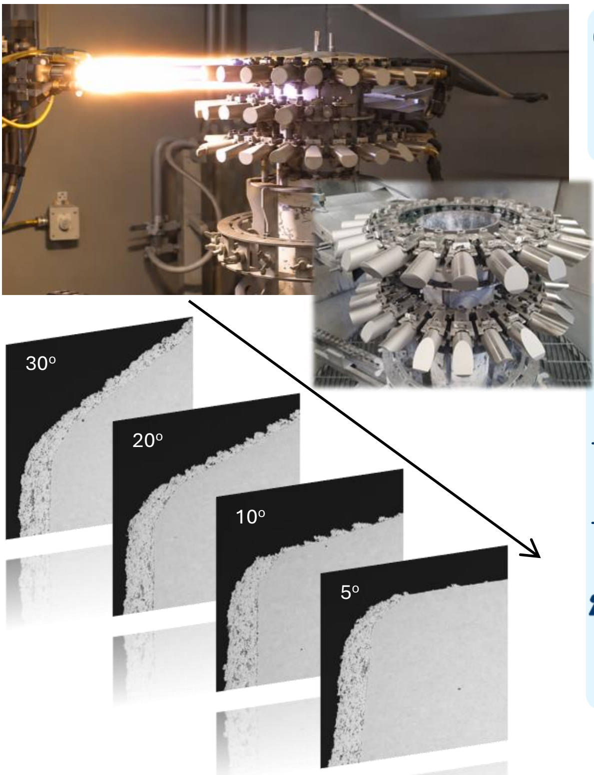


Area 01

Materials and Coatings

Relationship between thermal coating microstructure and its deposition efficiency.

Design of Experiment → Samples Manufacturing → Atmospheric Plasma Spraying (APS) → Characterisation & Analysis → Validation



THE CHALLENGE

Understanding the physics of thermal spray processes for reproducible production of ceramic coatings.

KEY RESULTS

- **Spraying angle influences coating deposition efficiency**
- **Formation of oriented microstructure at angles below 30°**
- **A small number of coating spots remain on the perpendicular surface**
- **Not only the angle but also the distance affects deposition efficiency**
- **Coating microstructure consists of characteristic splat structure**

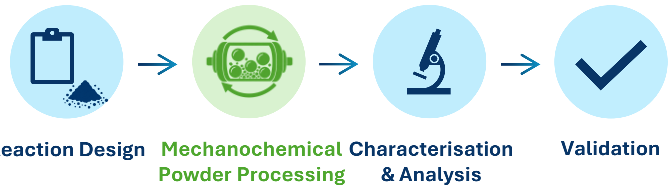
Sample angle significantly influences coating formation, microstructure, and deposition efficiency.

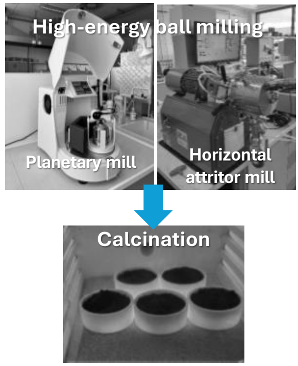
Partners involved

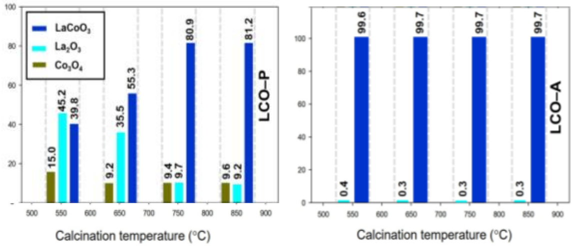
TREIBACHER
CEITEC
BRNO UNIVERSITY OF TECHNOLOGY
FunGlass
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

Mechanochemical Activation of Synthesis of Perovskite Powders

Relationship between the parameters of high kinetic processing of powders and their microstructure, phase composition, and morphology.

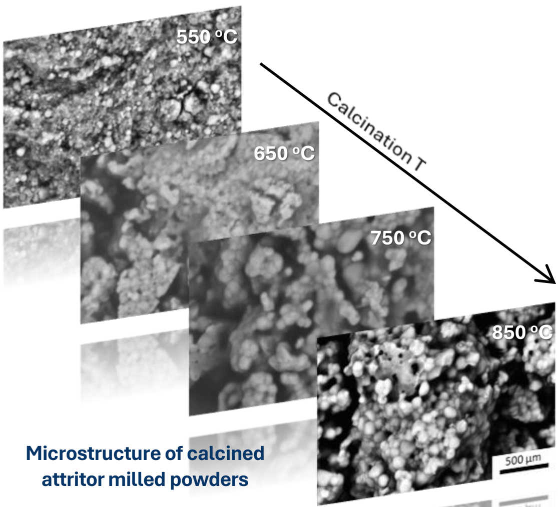






THE CHALLENGE

Understanding the effect of mechanochemical treatment on the microstructure and functional properties of catalytically active materials.



Microstructure of calcined attritor milled powders

KEY RESULTS

- **Direct mechanochemical synthesis of $LaCoO_3$ perovskite is achieved using a higher mechanical energy input in a horizontal attritor**
- **Powder purity is directly proportional to the calcination temperature**
- **Nearly single-phase $LaCoO_3$ of 99.6 wt.% is obtained from attritor-milled powders already at a temperature as low as 550 °C**
- **Powders have nanocrystalline microstructure**

High-energy ball milling parameters strongly affect perovskite formation, powder microstructure, and textural properties.

Partners involved

Zoz GmbH

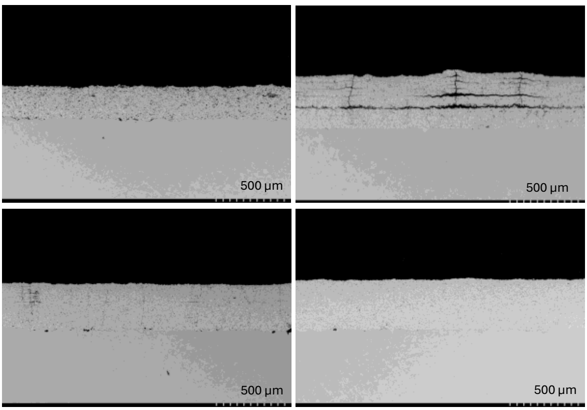
CEITEC

Brno University of Technology

Spraying of Fine Dry Powders

Finding ways how to spray fine dry powders,
i.e., without a liquid carrier for novel microstructures.

Design of Experiment → Powder Characterisation → Atmospheric Plasma Spraying (APS) → Characterisation & Analysis → Powder to Coating Relation



THE CHALLENGE

Finding the limits of current thermal spraying equipment to spray fine powders without the need for a liquid carrier.

KEY RESULTS

- Powders with PSD 5–15 µm are feedable and sprayable
- Powders finer than 5 µm still pose a significant feeding challenge
- Regular hose cleaning is essential to avoid clogging
- Fine powders tend to sinter and form DVC structure
- Tumbling drum flow meter can be used to predict sprayability

Fine powders in the 5–15 µm range can be sprayed using a relatively short stand-off distance and high relative torch-substrate velocity.

Partners involved

TREIBACHER

IPP

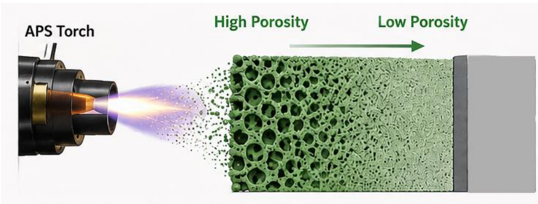
FunGlass

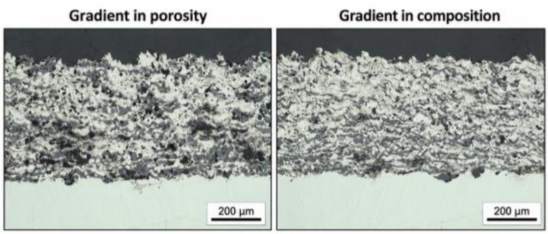
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

Functionally Graded Coatings by Thermal Spray Coating

Controlled porosity/composition through feedstock design, spray parameters, and layer-by-layer optimisation.

Microstructure Design → **Feedstock Preparation** → **Atmospheric Plasma Spraying (APS)** → **Characterisation & Analysis** → **Parameter Optimisation**





THE CHALLENGE

The development of a thermal spray processing strategy to create thin, functionally graded coatings with controlled porosity and composition.

KEY RESULTS

- **Particle size distribution influences coating formation and final porosity**
- **Spray distance strongly affects microstructure and coating quality**
- **Layer-by-layer APS deposition enabled controlled gradients through the coating thickness**
- **Thin graded coatings were successfully produced**
- **The coating showed good structural integrity and continuous graded architecture**
- **Process optimisation improved reproducibility and control of the deposited structure**

APS parameter optimisation enables controlled gradients in porosity and composition for thin functional coatings.

Partners involved

Ouest Coating
Thermal spray coatings

FunGlass

ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

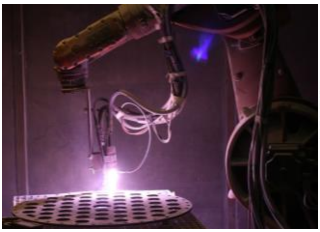
Development of Functional Ceramic Coatings

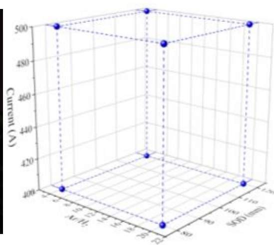
Area 01

Materials and Coatings

Fabrication of anti-sticking ceramic coatings.

Preliminary Study → Fabrication and Characterisation → Atmospheric Plasma Spraying Wettability Optimisation → Transfer to Cylindrical Rollers → Optimised Coating on Roller





THE CHALLENGE

Develop an anti-sticking ceramic surface that meets industrial roller requirements and can be transferred from flat laboratory substrates to cylindrical components.

KEY RESULTS

- **Selection and evaluation of ceramic feedstocks for APS based on phase composition, particle characteristics and application requirements**
- **Selection and evaluation of polymeric resin to modify the coating surface properties**
- **APS parameter development and structured experimentation to tune coating structure and functional surface properties**
- **Microstructure, phase analysis, surface roughness, wettability and adhesion assessment to connect process with performance**

**Functional ceramic coatings. Process optimisation.
Industrial scale-up and transfer.**

Partners involved

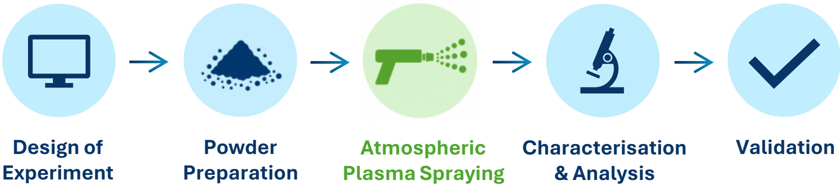
Ouest Coating — Thermal spray coatings

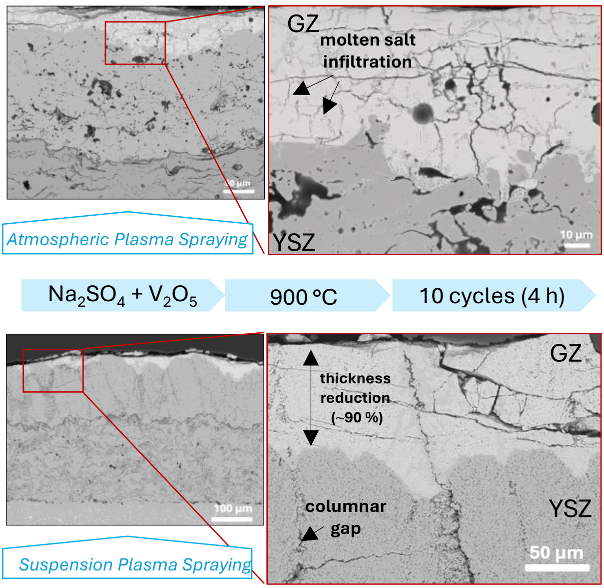
FunGlass

Alexander Dubček University of Trenčín

Development of Next-Generation of Thermal Barrier Coatings (TBC)

Effect of deposition technique and resulting microstructure on the hot-corrosion resistance of TBC coatings.





THE CHALLENGE

Understanding the hot-corrosion behaviour of double-layer $Gd_2Zr_2O_7$/YSZ TBCs deposited with two different deposition techniques.

KEY RESULTS

- **APS formed porous lamellar coatings, while SPS produced coarse columnar structures**
- **Precipitation of corrosion products caused micro-cracking and embrittlement of the top zone**
- **Hot-corroded samples exhibited severe thickness reduction compared to the as-sprayed state**
- **Fully melted zones at the APS-deposited upper layer acted as barriers for molten salt infiltration**
- **Columnar gaps served as the direct pathways for molten salt infiltration**

The double-layer GZ/YSZ TBC system showed significantly improved hot corrosion resistance and lower TGO growth rates than single-layer YSZ TBC.

Partners involved

TREIBACHER

FunGlass

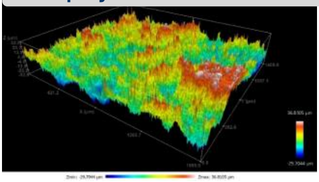
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

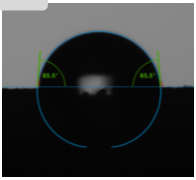
Development of Anti-Sticking Plasma-Sprayed Ceramic Coatings

Effect of composition, surface roughness, and wettability on the anti-adhesion performance of ceramic coatings for industrial rollers.

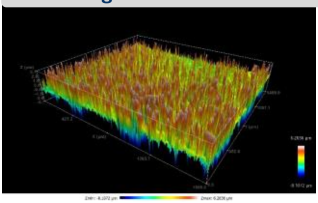
Design of Experiment → Sample Preparation → Atmospheric Plasma Spraying → Characterisation & Analysis → Validation

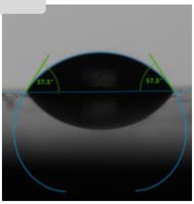
As-sprayed



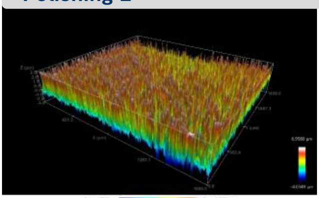


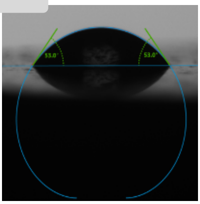
Polishing-1





Polishing-2





THE CHALLENGE

Evaluation of the wettability of a plasma-sprayed Al_2O_3–13 wt.% TiO_2 ceramic coating after finishing to Ra < 0.2 µm → potential reduction of film sticking on industrial rollers.

SELECTED PARAMETERS

- **Final surface roughness**
- **Coating porosity**
- **Powder granulometry**
- **TiO_2 content in Al_2O_3–TiO_2 coatings**
- **Replacement of Al_2O_3 by Cr_2O_3**
- **Post-treatments: epoxy impregnation, laser engraving**

The reduction in surface roughness achieved by polishing resulted in a lower water contact angle.

Partners involved

Ouest Coating Thermal spray coatings

FunGlass

ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

In-Flight Particle Diagnostics for Cold Spray

Area 01

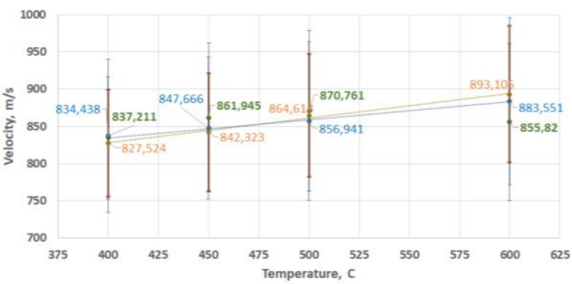
Materials and Coatings

What really controls particle velocity when metal powders are blended with ceramics?

8 feedstock powders · gas temperature 400–800 °C

Powder Selection → **Cold Spray Deposition** → **High-Speed Diagnostic** → **Data Analysis** → **Parameter Validation**

Robot-guided cold spray gun in the deposition cell



THE CHALLENGE

How does ceramic addition affect the critical particle velocity in cold spraying?

For metal–ceramic powder blends, this relationship was unclear, making spray parameter selection dependent on trial and error and leading to increased powder consumption, machine time, and inconsistent coating quality.

KEY RESULTS

- **Al + Al_2O_3 converges at 600 °C** – all five feedstocks land within 848–860 m/s - one parameter window for the whole family
- **Al + Al_2O_3 converges at 600 °C** – all five feedstocks land within 848–860 m/s - one parameter window for the whole family
- **The ceramic is the fast fraction** – with rising Al_2O_3 content the median moves 853 → 875 m/s and Q3 887 → 914 m/s
- **SiC blends keep accelerating** – 893 m/s at 600 °C vs 856 m/s for pure Al1050, which drops above 500 °C (clogging)

Measured in-flight data replaces guesswork: one parameter window now covers aluminium and its ceramic-reinforced blends.

Partners involved

Ouest Coating
Thermal spray coatings

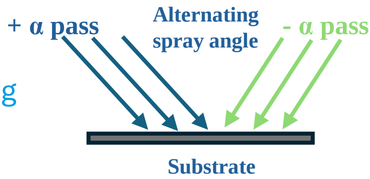
Wrocław University of Science and Technology

Development of Zig-Zag Columnar Thermal Barrier Coatings

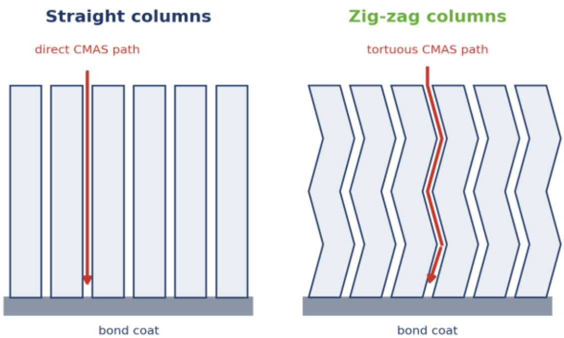
Area 01

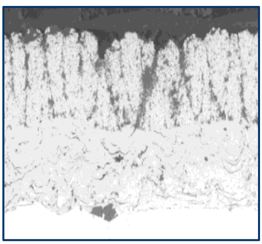
Materials and Coatings

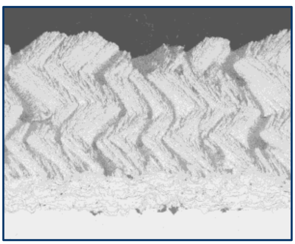
Tailoring column architecture through alternating spray angle in suspension plasma spraying.



Design → SPS with Switching → Zig-Zag Architecture → CMAS & Cyclic Analysis → Characterisation & Validation







THE CHALLENGE

Straight SPS columns give strain tolerance, but their vertical gaps open a direct path for molten CMAS and heat towards the bond coat.

KEY RESULTS

- Zig-Zag columns were achieved by reversing the spray angle
- Tuneable zig-zag angle and period
- Tortuous gaps to slow CMAS infiltration
- Zig-Zag vs straight under CMAS and cyclic testing conditions

Spray angle becomes a design tool for CMAS-resistant, low-conductivity TBCs.

Partners involved

TREIBACHER

FunGlass

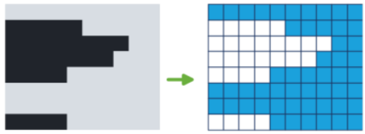
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

Development of Image-Based Thermal Conductivity Prediction

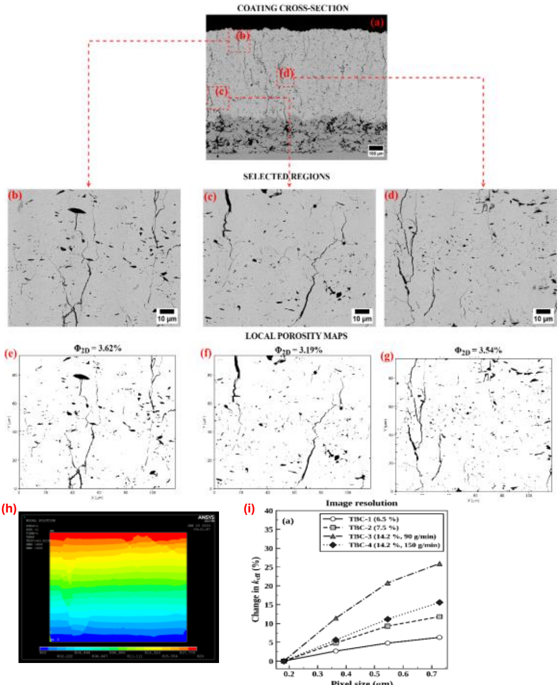
Area 01

Materials and Coatings

Predicting coating thermal conductivity from actual scanning electron microscope microstructure to reduce the need for laser flash analysis.



SEM Imaging → **Segmentation (Pore/Matrix)** → **Pixel-to Element Mesh** → **FEA 25-1200 °C** → **Validation**



TBC – 6.5% porosity: (a) coating cross-section; (b-d) selected regions microstructures; (e-g) segmented pore maps obtained from Python used as an input for the modelling; (h) thermal flux field; (i) effect of image resolution in predicted k_{eff}.

THE CHALLENGE

Laser flash testing to determine thermal conductivity is expensive, and preparing freestanding samples is time-consuming and material-intensive. A numerical screening tool is needed to reduce the number of samples that require testing.

KEY RESULTS

- **SEM pixels meshed as FE elements using a custom-built Python code**
- **k_{eff} was calculated from 25–1200 °C for microstructures with porosity between 6.5–14.3%**
- **Mesh refinement changes k_{eff} by < 2%**
- **Experimental data agreement ≈ 8% error (for dense coatings)**

Image-based FEA predicts thermal conductivity from SEM images, serving as an effective screening tool in the early stages of material development.

Partners involved

TREIBACHER

FunGlass

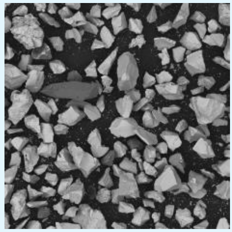
ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

Welding and Hardfacing for Harsh Abrasive and Erosive Wear Applications

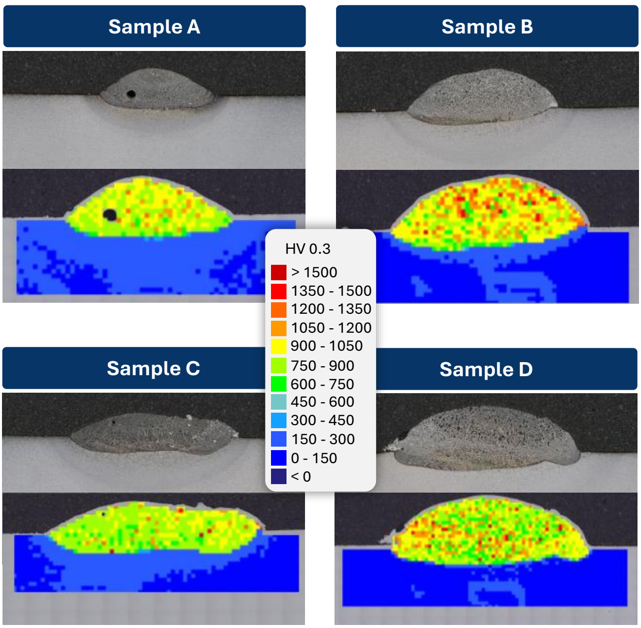
Comparative evaluation of the microstructure and microhardness distribution in weld overlays.

Powder Sieving → Weld Overlay Processing → Microstructure Analysis → Hardness Mapping → Results Evaluation

Initial Powder Feedstock



SEM powder morphology



Various processing parameters result in different microstructures and hardness distributions.

THE CHALLENGE

Optimising weld overlays to achieve controlled geometry, microstructure and microhardness distribution for components exposed to severe abrasive and erosive wear.

KEY RESULTS

- **Powder sieving**
- **Material characterisation (powder, weld overlays, microstructure, chemical and phase composition)**
- **Hardness measurement and mapping**
- **Technical consulting**
- **Results evaluation and interpretation**
- **Process and material optimisation recommendations**

From powder to high-performance weld overlays by manufacturing process optimisation for highly demanding wear applications.

Partners involved

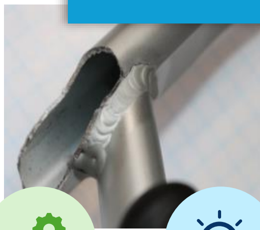
CEITEC, Brno University of Technology, Castolin Eutectic

Area 01

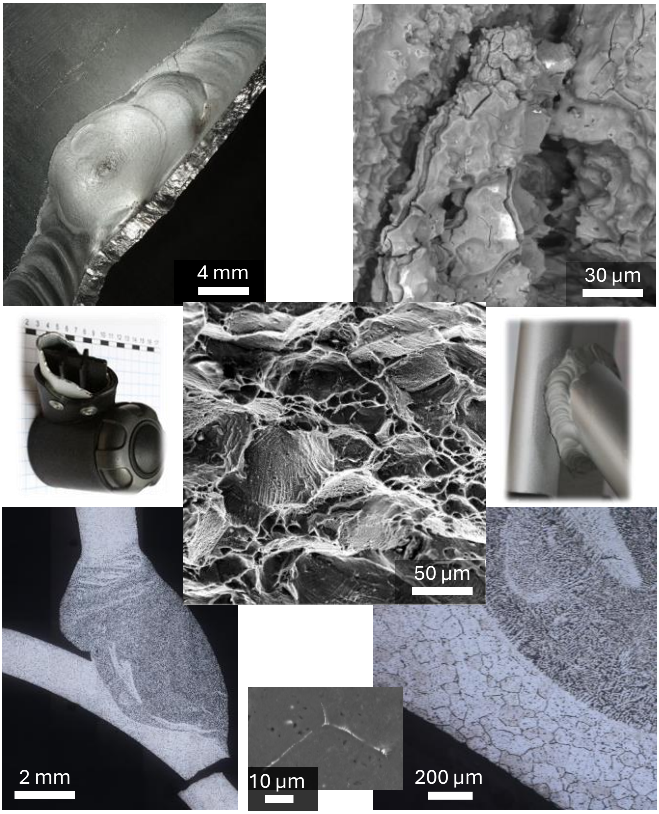
Materials and Coatings

Analysis of Causes of Baby Stroller Construction Damage

AlMgSi alloy thin-walled weldment profiles. Surface finish via anodic oxidation.



Problem Definition → Microstructural Analysis → Fractographic Analysis → Data Analysis and Processing → Damage Cause Identification



THE CHALLENGE

Identifying the cause of the damage.

Whose fault is it?

- Material
- Manufacturing technology
- Incorrect use

KEY RESULTS

Clear evidence of an error in production technology

Inappropriate welding parameters

Material embrittlement

Residual stress after welding

Anodic oxidation products on the crack surface confirm that cracking occurred before anodising

Sample angle significantly influences coating formation, microstructure, and deposition efficiency.

Partners involved

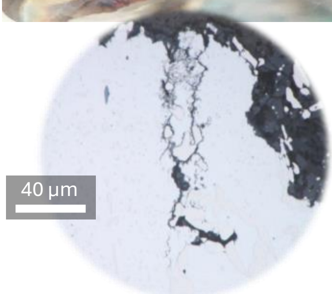
CEITEC

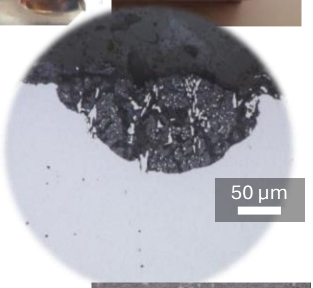
BRNO UNIVERSITY OF TECHNOLOGY

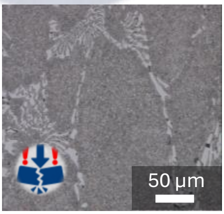
Causes of Injection Mould Insert Block Damage

Identification of the main causes of premature wear in a repaired insert block of an injection mould.

Problem Definition → Microstructural Analysis → Fractographic Analysis → Data Analysis and Processing → Damage Cause Identification







ASSUMED MATERIAL X40CrMoV5-1		ACTUAL MATERIAL X165CrMoV12
37 – 51 HRC	→ MATERIAL MISMATCH	57 – 63 HRC

THE CHALLENGE

Identifying the cause of the damage.

Whose fault is it?

- Material
- Mould insert block construction
- Repair technology
- Incorrect use

KEY RESULTS

- **Material mismatch identified**
- **Unsuitable microstructure**
- **Completely inappropriate design modification of the mould insert**
- **Incorrect welding repair procedure**
- **Insufficient corrosion resistance of the material**

Incorrect design modification, unsuitable welding parameters, and a suboptimal microstructure led to premature failure.

Partners involved

CEITEC

BRNO UNIVERSITY OF TECHNOLOGY

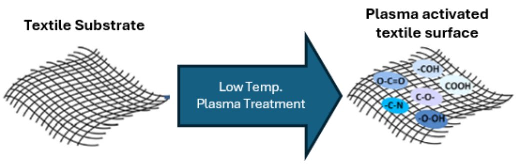
Metallisation of Textiles Using PVD and PE-CVD Technique for Low-E Applications

To develop durable Low-E coatings on textiles with superior adhesion and washability for technical textile applications.

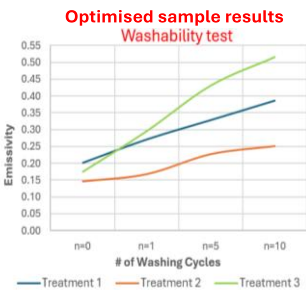
Design of Experiment → In-Situ Plasma Pretreatment → Coating Deposition → Characterisation & Analysis → Validation

Roll to Roll Coater

Optimisation of Plasma Treatment



Coated Textile Durability



THE CHALLENGE

- Coating wear and delamination during laundry cycles.
- Loss of electrical conductivity and Low-E thermal properties.
- Inconsistent surface coverage on flexible textile substrates.

KEY RESULTS

- Deposition of uniform Low-E coatings on Textiles by PVD and Hollow Cathode – PECVD
- Enhanced adhesion via low-temperature plasma activation
- High washability retaining low emissivity over 10+ wash cycles
- Wear- and environment resistant for superior durability
- Scalable roll-to-roll (R2R) processing for technical textiles
- Advanced structural characterisation, analysis and process validation

Developed an optimised process for depositing durable, low-emissivity conductive coatings on technical textiles.

Partners involved

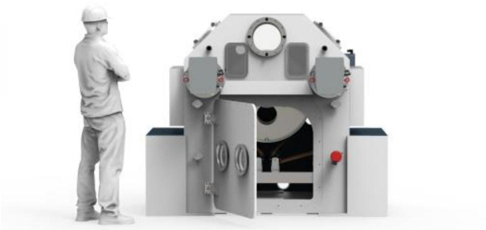
AGC Interpane · FunGlass · AGC Plasma Technology Solutions

Sustainable Low-E Coatings for Smart Textiles

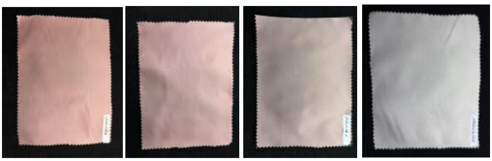
To develop durable and conductive multilayer coatings with controlled emissivity for advanced smart textile applications.

Design of Experiment → Substrate Preparation → Plasma Deposition → Characterisation & Analysis → Validation

Roll to Roll Coater



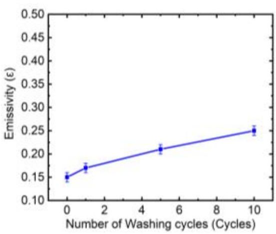
Adjusting Textile Colour



Coated Textile Durability

As-deposited

After 10 washes



THE CHALLENGE

Enhanced adhesion and durability of Low-E coatings after multiple washing cycles.

KEY RESULTS

- **Development of conductive coatings on Textiles by PVD and PECVD**
- **Optimisation of deposition parameters to enhance adhesion of Low-E coatings**
- **Enhanced washability and low emissivity after 10 washing cycles, with excellent visual appearance**
- **Wear and Environment resistant for better durability**
- **Development of Low-E coatings on different textiles for large-scale production and prototyping**
- **Surface analysis and structural characterisation**

Engineered conductive multilayer coatings with low emissivity and excellent durability for advanced technical textile applications.

Partners involved

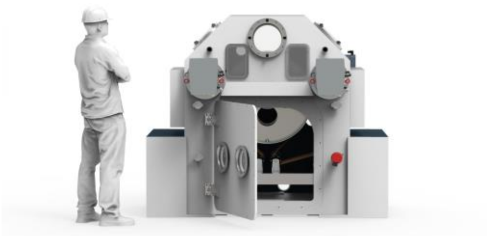
AGC INTERPANE
FunGlass
AGC Plasma Technology Solutions

Diamond-Like Carbon (DLC) Coating Deposition via PECVD and PVD: Gas Flow & Power Effect on Film Properties

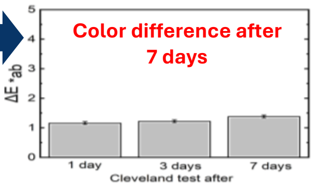
To investigate the influence of deposition conditions on the structural, optical, and mechanical properties of DLC coatings.

Design of Experiment → In-Situ Plasma Pretreatment → Coating Deposition → Characterisation & Analysis → Validation

Roll to Roll Coater



Coated Glass Durability



THE CHALLENGE

- Development of wear and environment-resistant DLC coatings for anti-reflective applications.
- Deposition of a uniform coating on a pilot-scale web coater.
- Understanding the influence of process parameters on the pilot-scale web coater.

KEY RESULTS

- **Optimisation of deposition parameters to enhance wear resistance**
- **Developed DLC thin films to improve the durability of optical coatings**
- **DLC deposited on glass substrates using PVD and Hollow Cathode – PECVD**
- **Superior protective performance under environmental and mechanical abrasion tests.**
- **Surface analysis and structural characterisation**

Developed durable, environmentally resistant transparent DLC coatings for advanced optical applications.

Partners involved

AGC Interpane

FunGlass

AGC Plasma Technology Solutions

Diamond-Like Carbon (DLC) Coatings: PECVD and PVD Deposition

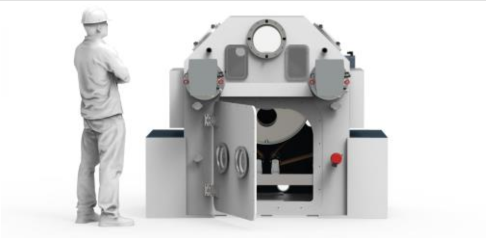
Area 01

Materials and Coatings

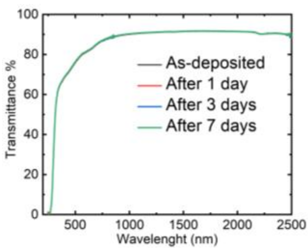
To investigate the influence of deposition conditions on the structural, optical, and mechanical properties of DLC coatings.

Design of Experiment → Substrate Preparation → Plasma Deposition → Characterisation & Analysis → Validation

Roll to Roll Coater



Cleveland test



Automated Wet Rub Test (AWRT)

THE CHALLENGE

Development of transparent DLC coatings for antireflective applications while maintaining their protective properties.

KEY RESULTS

- **Optimisation of deposition parameters to enhance wear resistance**
- **Development of DLC thin films to improve transparency**
- **DLC deposited on glass and textile substrates by PVD and PECVD**
- **Excellent protective performance under high humidity and UV exposure**
- **Surface analysis and structural characterisation**

Developed DLC coatings combine durability, transparency and excellent protective performance for advanced optical applications.

Partners involved

AGC INTERPANE

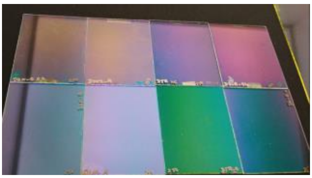
FunGlass

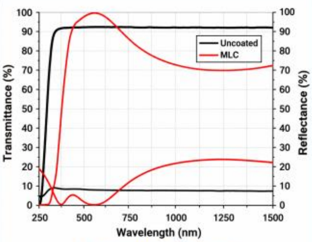
AGC Plasma Technology Solutions

Design & Development of Multifunctional Antireflective Coatings

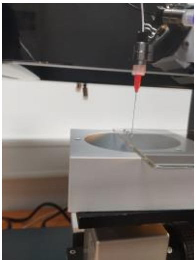
Improving light transmission through durable multilayer coatings.

Optical Design → Coating Deposition → Characterisation → Durability Assessment → Validation





Measured T / R spectrum



THE CHALLENGE

Developing a multifunctional multilayer coating that combines high optical transmission, tailored surface wettability, and long-term durability.

KEY RESULTS

- **Functional silica top layer with tailored hydrophobic ↔ superhydrophilic properties**
- **High visible transparency with up to 99% UVB blocking and IR reflection up to 25%**
- **Improved mechanical, chemical and environmental durability**
- **Layer thickness experimentally achieved within ±5% of the target**
- **Coating temperability tested up to 680 °C on low-iron float glass substrates**

Tailored multilayer design provides a pathway to multifunctional, durable, and thermally stable optical coatings.

Partners involved

AGC Interpane
FunGlass
Alexander Dubček University of Trenčín

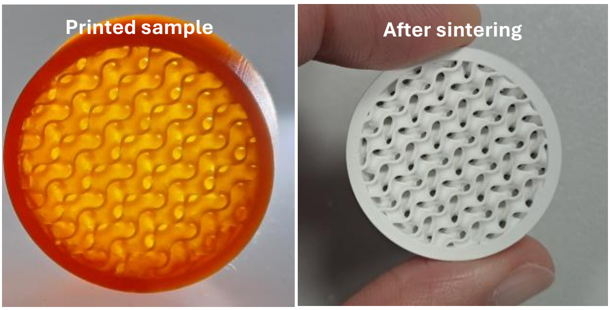
Additive Manufacturing of Functional Glass Architectures

Area 02

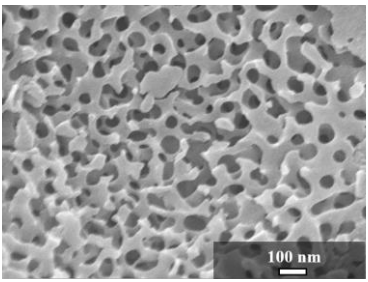
Materials Preparation and Additive Manufacturing

Development of complex glass porous structures by stereolithography and their processing towards application-oriented functionalities.

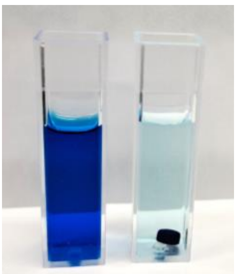
Glass Formulation → **SLA Printing** → **Thermal Treatment** → **Porous Glass Architecture** → **Adsorption / Resource Recovery**



3D-printed glass architectures



Internal nanoporous structure



MB adsorption test

THE CHALLENGE

Fabricating porous glass architectures with specific surface properties for environmental and energy applications.

KEY RESULTS

- **SLA enables the fabrication of complex glass architectures**
- **Specifically designed thermal treatment provides a route to controlled nanoporous structures**
- **The approach avoids the use of additional pore-forming agents**
- **Porous architectures can be tailored for adsorption and resource recovery**
- **AM combines structural design freedom with intrinsic functionality of borosilicate glasses**

Controlled processing enables the fabrication of porous glass architectures with tailored properties for environmental and energy applications.

Partners involved

LITHOZ

FunGlass

ALEXANDER DUBČEK UNIVERSITY OF TRENČÍN

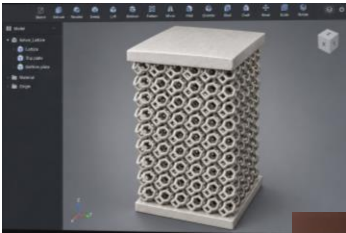
3D Printing of Lead-Free Piezoceramic Materials

Area 02

Materials Preparation and Additive Manufacturing

Removing shape limitations and overcoming new challenges in piezoelectric ceramics.

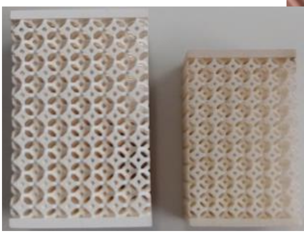
Design of Experiment → **Slurry Preparation** → **SLA Printing** → **Heat Treatment** → **Characterisation & Analysis** → **Validation**



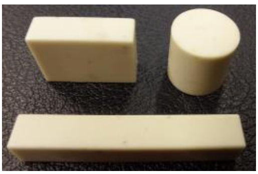
Digital design

Ceramic powder

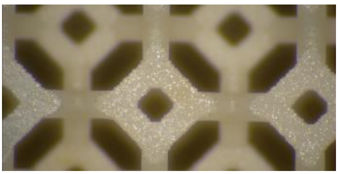
Printed parts



Sintering



Bulky parts



Fine lattice features

MATERIAL SYSTEMS

$BaTiO_3$

$Ba_{0.85}Ca_{0.15}Zr_{0.1}Ti_{0.9}O_3$

THE CHALLENGE

Produce printable slurries from ceramic materials with a higher refractive index while maintaining their functional properties.

KEY RESULTS

- **Stable slurries with high solids loading even from nanopowders**
- **Both bulky and fine structures survive printing and sintering**
- **Functional properties comparable to conventional samples**
- **Suitable for multimaterial printing for fabrication of metamaterials**

Complex lead-free piezoceramic components, from printable slurries to sintered structures. A basis for developing custom sensors, actuators, and architected functional ceramics.

Partners involved

LITHOZ® CEITEC BRNO UNIVERSITY OF TECHNOLOGY

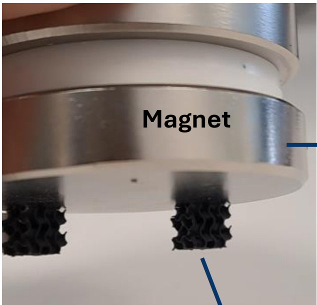
Magnetically Responsive Glass Architectures

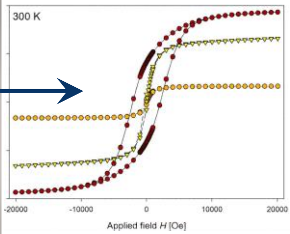
Area 02

Materials Preparation and Additive Manufacturing

Development of glass architectures incorporating magnetic phases for remotely controlled and bioinspired applications.

Glass Formulation → **Fe-based materials** → **SLA Printing** → **Thermal Treatment** → **Magnetic Behaviour**





Magnetisation vs Field dependences

THE CHALLENGE

Achieving high-resolution printing of dark, magnetically active glass materials while preserving their functionality and the geometrical complexity enabled by stereolithography.

KEY RESULTS

- **High-resolution SLA printing of completely dark, active glasses**
- **Fe-based materials impart magnetic response even after thermal treatment.**
- **Magnetic properties depend on the concentration and type of incorporated phase**
- **Printing and sintering parameters influence the final microstructure and properties**
- **The approach provides a route towards magnetically responsive glass architectures**

Additive manufacturing enables the integration of magnetic functionality into complex glass architectures for remotely controlled and bioinspired applications.

Partners involved

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Glass Architectures for Radiation Shielding

Area 02

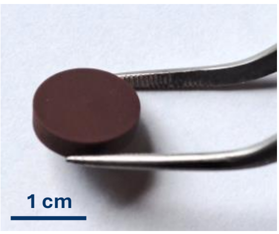
Materials Preparation and Additive Manufacturing

Development of complex glass structures incorporating shielding elements for advanced nuclear applications.

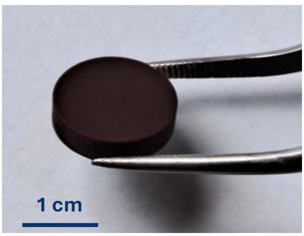
Design of Experiment → **High-Density Glass** → **SLA Printing** → **Thermal Treatment** → **Shielding**

THE CHALLENGE

Achieving high-density glass architectures for enhanced radiation attenuation while maintaining the resolution and geometrical complexity enabled by stereolithography.



3D-printed glass architectures incorporating different functional phases.



KEY RESULTS

- **High-resolution SLA printing of dark, high-density glass materials**
- **Structural and mechanical stability after sintering**
- **Relative densities above 97% were achieved after thermal treatment**
- **Optimised suspension preparation prevents particle sedimentation during printing**
- **SLA of dense architectures provides a versatile basis for advanced shielding materials**

High-density glass architectures produced by stereolithography offer a promising platform for future EMI & radiation shielding applications.

Partners involved

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Electrochemical Polishing of 3D Printed Structures

Area 02

Materials Preparation and Additive Manufacturing

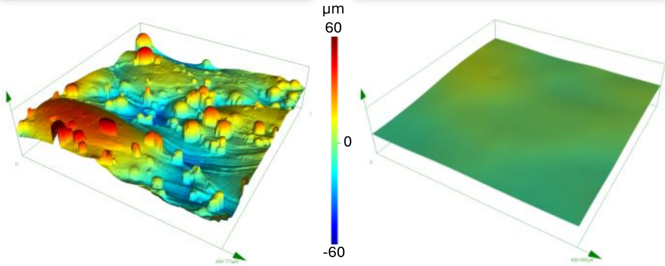
Improving the surface quality of complex additively manufactured components.

3D Modelling → **L-PBF 3D Printing** → **Electropolishing** → **Characterisation & Analysis** → **Validation**

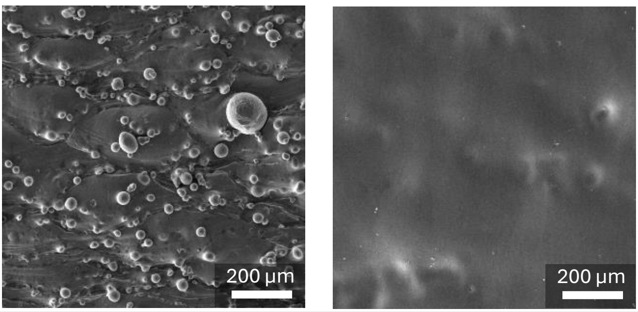
THE CHALLENGE

Reduce surface roughness, improve surface gloss, and preserve the complex geometry of 3D-printed structures.

BEFORE | **AFTER**



3D surface topography



Scanning electron image of the surface

KEY RESULTS

- **Reduced surface roughness**
- **Improve surface gloss**
- **Complex geometry preserved**
- **Optimised pre-treatment, electropolishing, and post-treatment processes**
- **Surface microstructure characterised**

Smoother surface with glossy finish. Experimentally validated.

Partners involved

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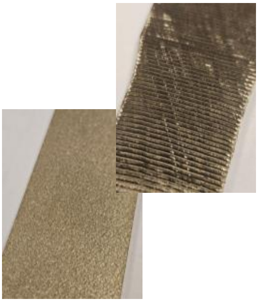
Thermal Spraying as Post-Process for Additive Manufacturing

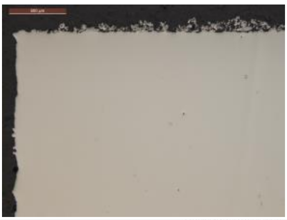
Area 02

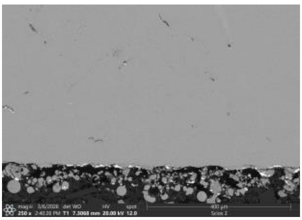
Materials Preparation and Additive Manufacturing

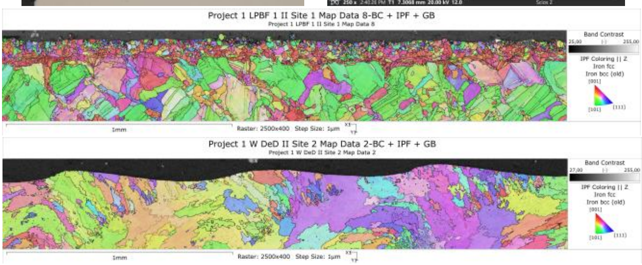
Characterisation of the sub-surface of AM elements.

Design of Experiment → **3D Printing** → **Characterisation & Analysis** → **Atmospheric Plasma Spraying** → **Validation**









THE CHALLENGE

To produce substrates by different AM processes and investigate the very sub-surface state of elements.

KEY RESULTS

- **Depending on the AM process, different surface features appear**
- **The surface structure depends strongly on the build-up direction**
- **LPBF yields the lowest porosity and finest grains but the highest stress/defect density, while EBM and Wire-LMD produce coarser structures with fewer defects**
- **Surface pre-treatment, such as grit blasting, machining, polishing, may be essential prior to spraying**

Depending on the additive manufacturing route, there is a different sub-surface state that should be considered before planning further post-processing.

Partners involved

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Wrocław University of Science and Technology

Castolin Eutectic

Multifunctional Multi-Ceramic Architectures (1)

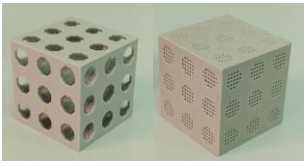
Area 02

Materials Preparation and Additive Manufacturing

Additive manufacturing of multi-material and multi-architectural highly complex cellular materials.

3D Design

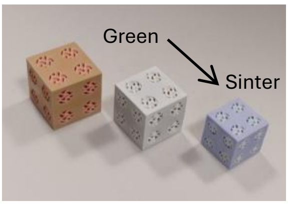
Lithography-based Ceramic Manufacturing

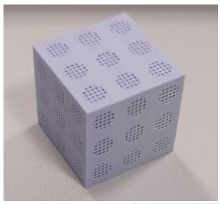


Single material (hydroxyapatite)

Multiple-material (hydroxyapatite-tricalcium phosphate)

Postprocessing

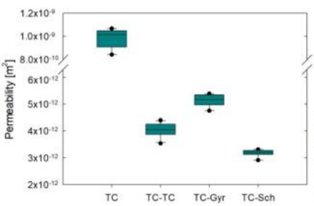


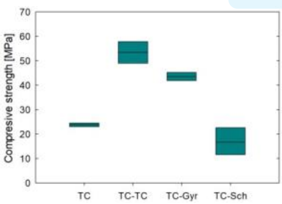


THE CHALLENGE

Co-sintering dissimilar materials and architectures.

Characterisation & Analysis





Porosity, pore size, permeability and strength can be controlled and tuned independently.

Partners involved

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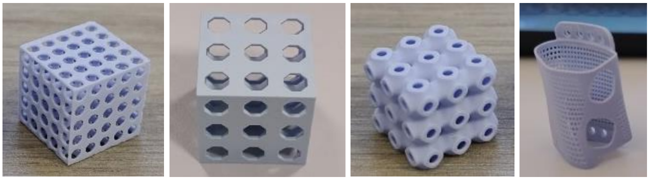
Multifunctional Multi-Ceramic Architectures (2)

Area 02

Materials Preparation and Additive Manufacturing

Hybrid manufacturing of osteogenic and personalised synthetic bone grafts and bone reconstruction implants.

Lithography-based Ceramic Manufacturing



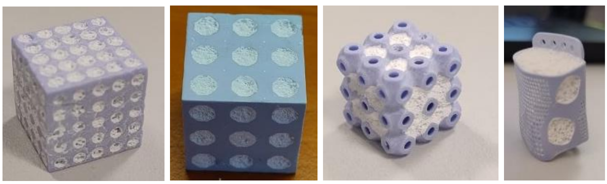
Customised, high-strength, additively manufactured architectures

Foam Infiltration

THE CHALLENGE

Co-sintering is overcome by the self-hardening capacity of the hydroxyapatite foam.

Multi-Ceramic Architecture



Porosity with the optimal geometry and size for osteogenesis.

Hydroxyapatite foams have the ideal nano-, micro-, and macrostructure for bone healing, while additive manufacturing allows implant customisation and personalisation.

Partners involved

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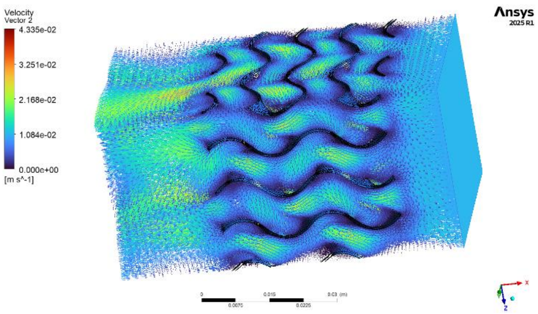
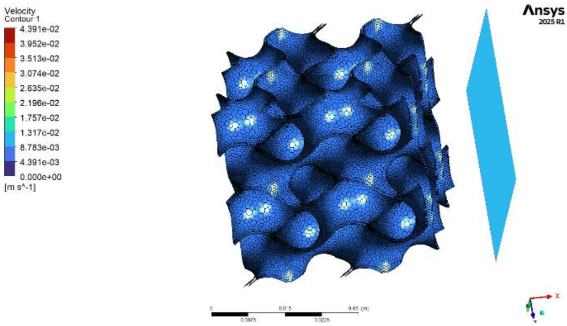
Design and Development of 3D Structures for Additive Manufacturing

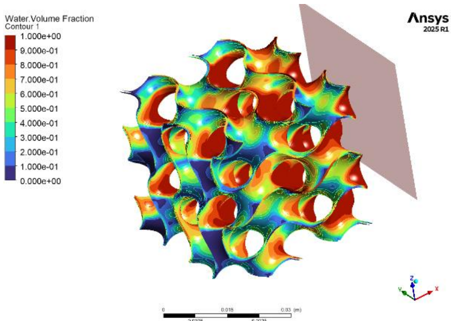
Area 02

Materials Preparation and Additive Manufacturing

Developing proficiency in CAD/CAM tools for 3D design. Optimising design parameters for various materials using ANSYS software.







THE CHALLENGE

Analysis of fluid dynamics within a 3D gyroid structure (20 mm, flow velocity = 0.01 m/s).

KEY RESULTS

- **Uniform flow through the gyroid channels confirms smooth transport and minimal dead zones**
- **Before contact and after 2 seconds, the structure shows effective fluid contact**
- **Red regions are highly wetted and activated; blue regions are minimally hydrated**
- **Average fluid residence time is approximately 2 seconds**
- **High porosity and efficient fluid transport support applications in water filtration, mass transfer, and heat exchange**

ANSYS-based simulations support the design, optimisation, and performance evaluation of complex 3D porous geometries.

Partners involved

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1393B3 Borate Bioactive Glass/Mesoporous Bioactive Glass Nanoparticle Composite Scaffolds

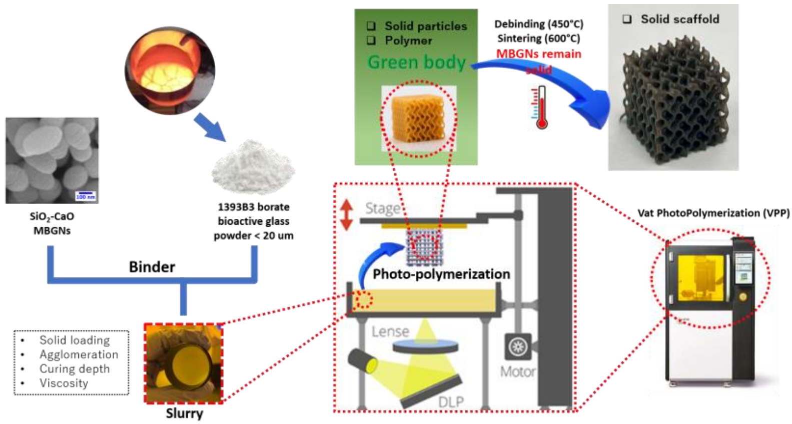
Area 02

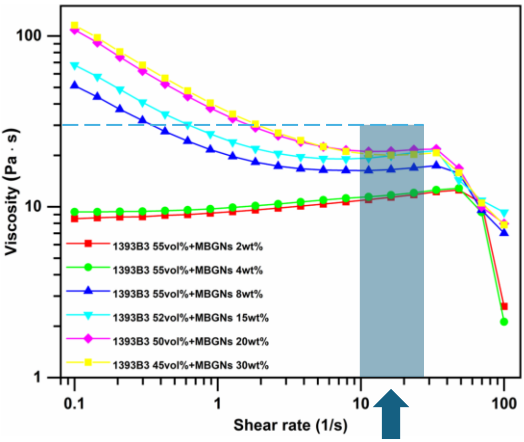
Materials Preparation and Additive Manufacturing

Slurry optimisation for DLP 3D printing.

THE CHALLENGE

Nanoparticle aggregation and increased slurry viscosity at higher nanoparticle contents.

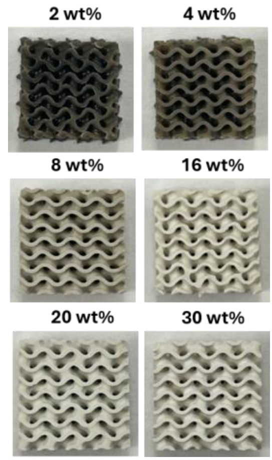




Printable zone

Gyroid Geometry Designed Textural Properties:
Pore size: **1000 µm**
Porosity: **70%**

2–30 wt% relative to 1393B3



The incorporation of MBGNs can promote hydroxyapatite formation. In addition, nanoparticles can serve as carriers for therapeutic ions, providing additional biofunctions.

Partners involved

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DLP Manufacturing of 1393B3 Borate Bioactive Glass Scaffolds with Bone–Mimicking Designs

Area 02

Materials Preparation and Additive Manufacturing

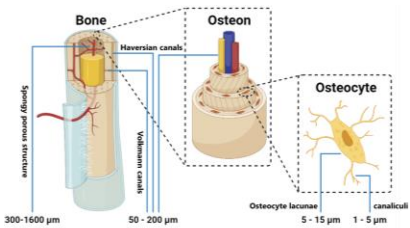
Optimisation of printing parameters to achieve finer structural features in the scaffolds.

THE CHALLENGE

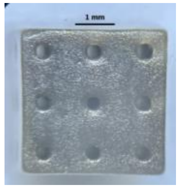
1. Detachment of printed parts from the build platform during printing.
2. Minimising scaffold strut thickness/diameter.

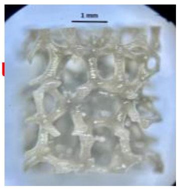
1393B3 Borate Bioactive Glass (BG)

Digital light processing (DLP)



Bone–mimicking scaffolds

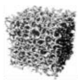




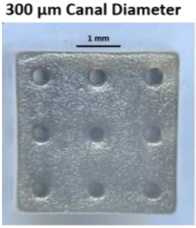
- ✓ **Full control of textural and structural properties**
- ✓ **Customisation for specific patients**

4 × 4 × 4 mm Cube
Cortical Bone-Mimicking
300 μm Canal Diameter

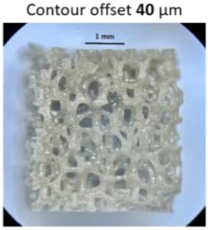
4 × 4 × 4 mm Cube
Cancellous Bone-Mimicking
1200 μm Pore Size/80% Porosity



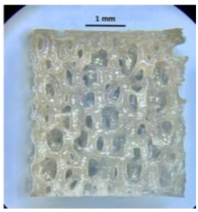
4 × 4 × 4 mm Cube
Cancellous Bone-Mimicking
600 μm Pore Size/90% Porosity



Contour offset **40** μm



Contour offset **80** μm



Successful DLP fabrication of 1393B3 Borate BG Scaffolds mimicking cortical and cancellous bone, with minimised strut size and fine structural features.

Partners involved

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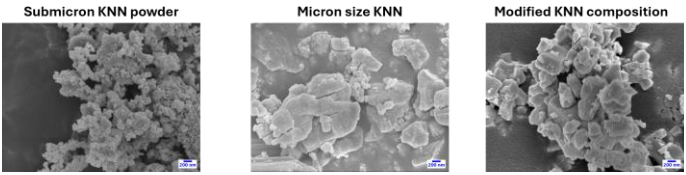
Università degli Studi di Padova

3D Printing of Lead-Free Potassium Sodium Niobate (KNN)

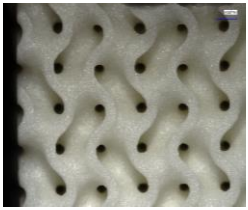
The effect of different particle sizes and compositions on the 3D printing and sintering behaviour of KNN.

THE CHALLENGE

Despite offering an eco-friendly, lead-free alternative with competitive electromechanical properties, additive manufacturing of KNN piezoceramics remains challenged by achieving high densification, controlling grain-oriented microstructures, and preserving stoichiometric homogeneity during printing and post-processing, all of which critically govern the final piezoelectric performance.



Sintered KNN samples with gyroid structure



KEY RESULTS

- **Using optimised shear-thinning slurries with 40–44 vol% solid loading, the DLP method successfully produced both simple cylindrical shapes and complex, crack-free gyroid structures**
- **TMA analysis established a narrow thermal processing window for KNN piezoceramics, achieving ideal densification and crack-free components between 1080 and 1100 °C**
- **While unwanted interactions occurred between KNN and Al_2O_3 during sintering, zirconia substrates proved to be a fully compatible alternative**

Particle size and compositional homogeneity of KNN powders critically affect printability and sinterability, which ultimately degrade the piezoelectric and electromechanical performance of 3D-printed KNN ceramics.

Partners involved

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