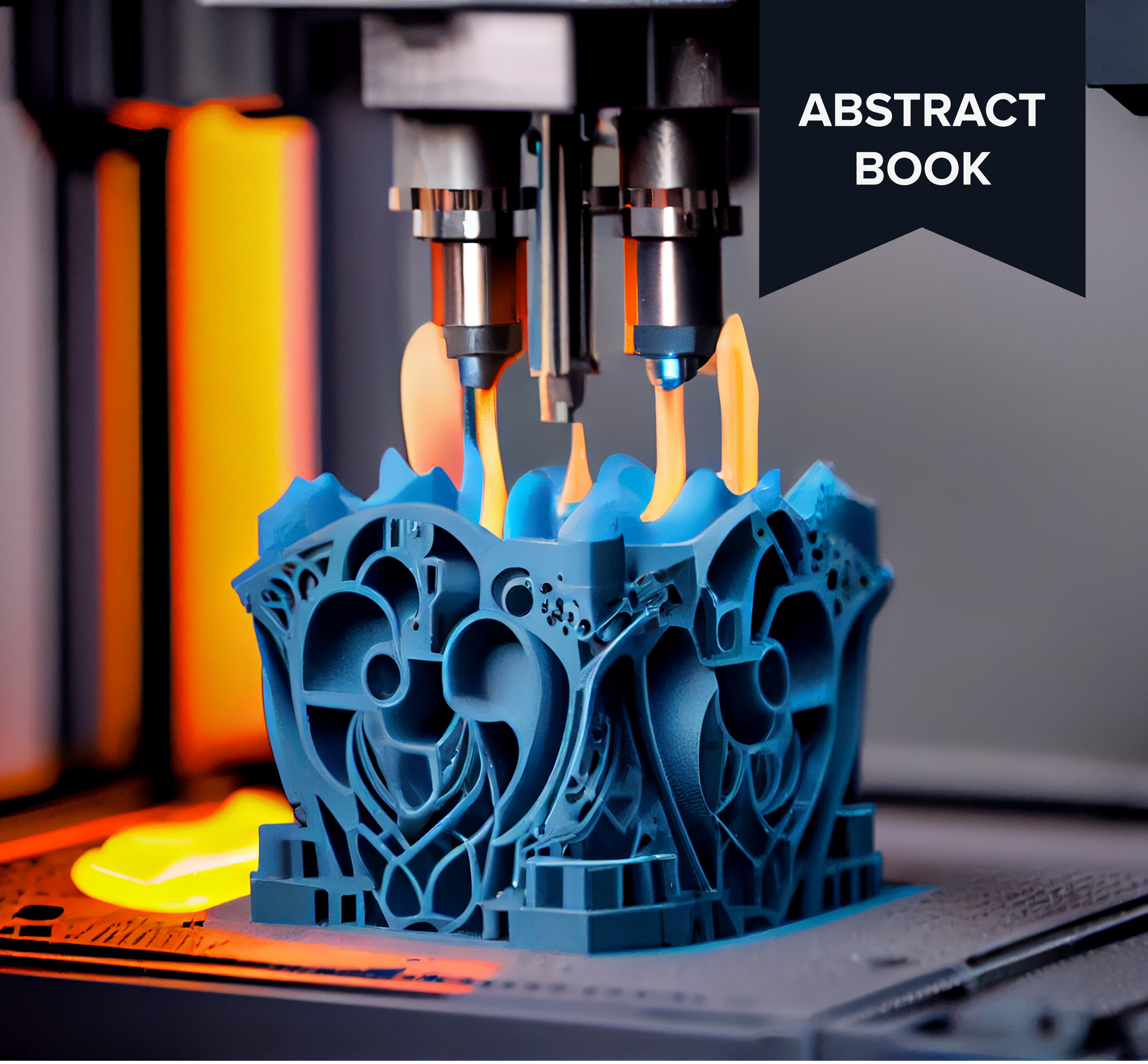

SCIENTIFIC SUMMITS

WSE3DPAM-2024

December 02-04, 2024 | Prague, Czech Republic

WORLD SUMMIT AND EXPO ON

3D PRINTING AND ADDITIVE MANUFACTURING

FOREWORD

Welcome to the 3D Printing and Additive Manufacturing

Join us at the forefront of technological innovation and exploration at the annual 3D Printing and Additive Manufacturing. As a pioneering platform for global experts, enthusiasts, and industry leaders, our conference serves as a catalyst for advancing the frontiers of 3D Printing and Additive Manufacturing.

At the 3D Printing and Additive Manufacturing Conference, we are committed to fostering a collaborative ecosystem that drives groundbreaking research, promotes technological advancement, and sparks revolutionary ideas within the realm of 3D Printing. Our mission is to facilitate meaningful dialogue and knowledge exchange that propels the industry forward and shapes the future of 3D Printing and Additive Manufacturing.

Through thought-provoking discussions, hands-on workshops, and networking opportunities, our conference aims to inspire creativity, foster interdisciplinary collaborations, and cultivate a vibrant community of robotics enthusiasts. Join us as we explore the latest trends, developments, and applications in the dynamic world of 3D Printing and Additive Manufacturing.

Together, let's unlock the boundless potential of 3D Printing and pave the way for a future defined by innovation and automation.

ORGANIZING COMMITTEE

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Giovanni Biglino	Bristol Medical School, UK
Allison, Paul	Baylor University, USA

KEYNOTE ABSTRACTS

Title: Innovation in Metal Additive Manufacturing with Wayland Additive's Neubeamr Process

Peter Hansford

Wayland Additive Limited, UK

ABSTRACT

Wayland Additive is driving innovation in metal additive manufacturing (AM) through its proprietary NeuBeam® process, designed for diverse production applications across industries. NeuBeam represents a groundbreaking advancement in metal AM, utilizing an advanced electron beam (eBeam) powder bed fusion (PBF) technique. Unlike traditional eBeam systems, NeuBeam neutralizes common stability challenges and provides greater flexibility than laser-based AM methods. This innovative process allows for metallurgical properties to be precisely tailored to specific application needs, enabling optimized production outcomes previously unattainable with conventional methods.

BIOGRAPHY

Peter has more than 23 years of experience working in the global Additive Manufacturing technology sector. Peter's expertise is in machine sales, marketing and channel development. He has worked with some of the pioneers of the additive manufacturing industry, including 3D Systems, Z-Corporation, Blueprinter and UnionTech among others. Peter has a proven ability within start-up companies working through 3 acquisitions and launching numerous new products with direct sales, management and recruitment for high tech hardware.

Title: SLA by 3DCERAM: Industrial Integration in Ceramic Additive Manufacturing

Rouslan Svintsitski

3D Ceram, France

ABSTRACT

3D printing, a hallmark technology of the fourth industrial revolution, is revolutionizing the ceramics industry by merging diverse technologies and blurring the boundaries between physics, digital technology, and biology. This additive manufacturing technique offers unprecedented opportunities for developing and producing.

The growing demand for intricate and large-scale ceramic products has positioned Stereolithography (SLA) 3D printing as a solution, gradually establishing itself as a new standard in shaping processes. This technology is particularly impactful in biomedical, aerospace, and semiconductor industries, where the unique properties of 3D-printed ceramics are leveraged for demanding applications.

While 3D printing has existed for decades, its recent acceleration in innovation raises a crucial question: Will it transition from laboratory experiments to widespread industrial adoption? Companies like 3D Ceram exemplify this potential shift, offering pathways from traditional production to advanced 3D manufacturing.

This presentation explores the multifaceted impact of 3D printing on ceramics, from unleashing creativity in research to enabling flexible production and new business models in manufacturing. It also addresses the environmental implications and emerging horizons, particularly through automation and Artificial Intelligence. The central role of process providers in supporting global customers and driving the sector's development is emphasized, highlighting their responsibility in facilitating the transition to additive manufacturing at an industrial scale.

BIOGRAPHY

Rouslan Svintsitski, 3DCeram Area Sales Manager, MBA graduated from ISCV of Conservatoire National des Arts et Métiers (France). More than 25 years of experience in ceramic process and technologies.

Title: Functional and Hierarchical 3D Printed Scaffolds for Bone Tissue Engineering using 3Y-TZP/HAp Composites

Elsa Dos Santos Antunes

James Cook University, Australia

ABSTRACT

Bone tissue engineering (BTE) is an exciting and rapidly evolving field of research that holds immense promise for patients suffering from bone injuries or diseases. Recently, advances in materials science and our understanding of the bone healing process have opened up new possibilities for creating effective BTE scaffolds.The key challenge in designing synthetic scaffolds for BTE is balancing the need for load-bearing capability with the requirement for promoting interaction with the local extracellular matrix (ECM) to facilitate bone healing. However, by leveraging the power of additive manufacturing (AM) techniques, complex scaffold designs can be designed to meet these dual responsibilities.

In this paper, we take a closer look at the potential of bioceramics in AM strategies for BTE applications. We will introduce strategies to process multiple materials using ceramic 3D printing. In-vitro performance of composite BTE scaffolds of 3Y-TZP – Hydroxyapatite with triply modified minimal structures (TPMS) will be studied. Relationships between the scaffold architecture (TPMS structure and porosity), mechanical performance and bone healing ability will provide a framework for development of personalized scaffolds that are tailored to the specific needs of individual patients, offering better outcomes, and reducing the risk of complications.

The high resolution of stereolithography-based ceramic printing allows for the introduction of hierarchical structures that meet the mechanical requirements of the patient. By combining different materials and structural features, engineers can create unique scaffolds that possess specific bone healing and structural capacities, moving away from the traditional one-size-fits-all approach to a more personalized approach to BTE.

Keywords: Additive manufacturing, Bioceramics, Composites, Bone tissue engineering

BIOGRAPHY

Elsa Antunes is a Senior Lecturer in Mechanical Engineering in the College of Science & Engineering, James Cook University. She obtained her PhD degree in Engineering from James Cook University in 2018. Since 2018, Dr Antunes has attracted more than >$2M in competitive research funding as a Chief Investigator. Dr Antunes received the 2023 Women in Industry award for Excellence in Engineering.

Dr Antunes research is focused on the field of Materials Engineering and Advanced Manufacturing, developing new materials and fabrication techniques for biomedical implants, aerospace and catalysis applications.

Title: X-Ray Computed Tomography (XCT) and Resonant Ultrasound Spectroscopy (RUS) Techniques for Quality Inspection of Additively Manufactured Parts

Obaton Anne Francoise

French National Metrology Institute (NMI), France

ABSTRACT

Additive manufacturing (AM) is becoming increasingly widespread in industry due to its ability to produce, within a short time, parts with complex geometric shapes, including lattice and internal structures, which could not be producedusing conventional manufacturing methods. This complexity of geometric shapes makes it difficult to inspect the quality of these parts using conventional non-destructive evaluation (NDE) techniques. The NDE techniques need to be volumetric and capable of accommodating complex geometric shapes as well as rough surfaces.

Among existing NDE methods, up to now, X-ray computed tomography (XCT) and resonant ultrasound spectroscopy (RUS) are the most suitable techniques to date.

XCT enables to image in three-dimensional (3D) the inside and outside of partsenabling a complete characterisation of the parts and even dimensional measurements. However, this technique is costly, requires skilled technician and reaches its limit for dense and large parts. Higher energy X-rays, not readily available on the market today, are required for such parts.

RUS fills theXCT gaps. Indeed, this technique is less costly, easy to use and suitable with large parts provided they resonate. In fact, its principle is based on exciting the vibrational modes of the parts. Any shift in frequencyof the vibrational modes between two parts will be the signature of a difference in geometry, density, elasticity or structural integrity (defects) of the two parts. However, this is a global (defects cannot be localized, unlike XCT) and comparative technique that requires a set ofteaching parts(the method cannot be applied to a single part, unlike XCT).

Thus, XCT and RUS have both advantages and disadvantages.

The talk will focus the on the advantages and disadvantages of XCT and RUS techniques for the quality inspection of AM parts.

BIOGRAPHY

Dr. habil. Anne-Françoise Obaton has been involved in metrology at the French National Metrology Institute (NMI): Laboratoire National de Métrologie et d'Essais (LNE) in Paris since 2000. Her research focused on optical metrology until December 2013, and then on metrology for additive manufacturing (AM) since January 2014. She is conducting research on the investigation and qualification of volumetric non-destructive testing (NDT) methods for quality insurance of AM parts. She is currently focusing on X-ray computed tomography (XCT) and resonant ultrasound spectroscopy (RUS). Related to this topic, she has been staying abroad, as guest researcher, in several organizations (BAM and PTB in Germany, DTU in Denmark and NIST in USA, for one year in 2018). From May 2023, for one year, she was a visiting researcher at Lawrence Livermore National Laboratory (LLNL) in California, USA, to be involved only in XCT.

Since 2014, she is involved in standardization on AM: ISO/TC261-ASTM/F42, joint group JG59 on “NDT for AM parts”. In addition, since 2022, she is involved in ASTM E07.01 Radiology (X and Gamma) Method specifically on XCT and E07.06 Ultrasonic Method specifically on RUS. In parallel, she is strongly involved in the XCT and AM working groups of the French Confederation for Non-destructive Testing (COFREND).

Title: 3D Printing in Medical Education, Patient Care, and Beyond

Getaw Worku Hassen
New York Medical College, Metropolitan Hospital Center, USA

ABSTRACT

3D printing is gaining popularity in healthcare. The area of application is Invasive procedures, which are part of emergency management. Healthcare providers need to acquire skills in invasive procedures. Being comfortable, confident, and competent when performing procedures is essential. Low-volume/rare procedures require pre-training.

Some of the challenges with performing procedures are anxiety of failure and anxiety of causing complications. Other challenges are problems with manual dexterity, difficulty handling instruments, and executing the procedure.

Some challenges can be overcome through experience, repeated practice, and real-life simulation. One option is to participate in medical simulation. Simulations area resource that provides opportunities to practice, learn, and improve, internalize the process of procedures, and help master the skills. With repeated practice, one develops insight into potential complications and will anticipate and prepare. Will know how to control complications.

Medical simulation is a widely used training modality for procedures. Emergency medicine programs primarily use mannequin- and video-based simulations, and surgeons have advanced simulation models.

Do you have to purchase expensive equipment?What should the cheaper alternative offer?

An ideal simulation model will have organs in the proper anatomical location and be comparable in size to the patient's organs. The relationships among different structures should be maintained, and the texture of organs should be similar to that of the patient's organs. Pathological/Physiological changes should be reflected, and the models should be affordable and not require experts!

On average, the printers required for creating models for medical simulationsare affordable ($100-2000). Printing requires minimum training. The filaments for the printer are cheap (cost per 1 kilogram material $20-40). This allows for the production of as many models as possible with variation and allows for repeated practices with easily reproducible parts.

Another advantage of 3D-printing technology is the possibility of presurgical practice and the production of prosthetics and other materials and devices. Neurosurgeryteams

can create skull flap replacements after a decompressive craniotomy to replace the missing gone with biocompatible resins, and Orthopedics can produce limb prosthetics in resource-limited settings. Critical care physicians can produce small accessories for their unavailable machines, which cannot be acquired due to financial issues in remote hospitals.

For example, the removal of a complicated brain tumor can be approached in a preoperative printed patient's skull and brain with the tumor. The approach can be practiced so the procedure does not cause significant complications by injuring vital structures around the tumor.

Future applications would include the production of organs for transplant.

BIOGRAPHY

Dr. Getaw Worku Hassen is a professor of Emergency Medicine at New York Medical College, Metropolitan Hospital Center. He is the research director and leads the department's 3D-printed medical simulation. Dr. Hassen studied medicine in Germany and has a PhD in Neural and Behavioral Science from the State University of New York. He is an emergency physician who conducts research in neurodegenerative diseases and clinical research on various emergency medicine topics. using 3D-printed technology, he has been involved in teaching and conducting research. Dr. Hassen has been preparing workshops in different hospitals in Osaka, Japan, and various cities and hospitals in Ethiopia.

Title: 3D Printing Ceramic Substrates for Coral Larvae Settlement and Growth

ABSTRACT

The health of coral reefs around the world are progressively declining as a direct result of anthropogenic activities which increase the stress experienced by reefs. Specifically, The Great Barrier Reef is becoming severely damaged as presented through ocean warming, acidification, and deoxygenation, resulting in widespread coral bleaching and mortality rates that are irreversible by natural processes. Active restoration through the deployment of artificial substrates onto degraded portions of the reef is the current method being proposed to improve social, economic, biological, and environmental functions of the reef.

In this research, a two-month experiment was performed to capture two out-of-season spawning events across three species of coral, completed at both a 10 mL and 15 L scale at the Australian Institute of Marine Science (AIMS) SeaSimulator research laboratory. The three sexually reproduced species tested include Montipora aequituberculata (Maeq), Mycedium elephantotus (Mele), and Acropora loripes (Alor). Two ceramic materials, Alumina and Hydroxyapatite, were used to form the basis of comparison, with pore sizes ranging from 0 μm to 900 μm examined to determine the preferred porosity.

Key findings identified that all three coral species showed preferential selection to conditioned Hydroxyapatite tabs with 800 μm pore sizes. The higher porosities tested between 600 μm and 900 μm had much greater settlement success compared with the lower pore sizes that were closer in diameter to that of the larvae at time of settlement. Finally, CCA conditioned tabs recorded much higher settlement rates than unconditioned as predicted from previous literature. This research was indicative in determining future works with focus needing to be granted to the physical application of surface roughness onto the 3D printed substrates.

Keywords: Additive manufacturing, Ceramics, Coral restoration, Coral reef

BIOGRAPHY

Matthew Drane is a researcher in the field of materials and advanced manufacturing in the College of Science & Engineering at James Cook University. Obtaining his degree in Mechanical engineering at JCU in 2023, Matthew is passionate about advanced manufacturing processes and his research is mainly focused on SLA ceramic manufacturing and materials engineering within the fields of biomedical implants, aerospace and marine applications such as sustainable rehabilitation of the Great Barrier Reef.

INVITED ABSTRACTS

Title: Revolutionizing Manufacturing: The Power of Industrial 3D Printing

Markus Glasser
EOS GmbH, Germany

ABSTRACT

This presentation will focus on the transformative impact of industrial 3D printing on today's manufacturing processes and how automation is critical to unlocking the technology's full potential. EOS, a pioneer in additive manufacturing (AM) since 1989, offers advanced solutions that combine high-quality production with innovation and sustainability. Our approach includes 3D printing of metals and plastics, supported by a comprehensive portfolio of services, materials, and processes to enhance manufacturing capabilities.

Today's industrial companies face multiple challenges, including pressure to reduce time- to-market, shorten product lifecycles, increase productivity, and lower costs. AM addresses these challenges through its flexibility, customization, and on-demand Production capabilities, offering significant advantages over conventional manufacturing methods. We will explore four fundamental pillars of AM: purpose-driven design, customization, on-demand and decentralized production, and circularity.

Through various customer use cases, we will illustrate how 3D printing can transform traditional manufacturing methods, delivering benefits such as high-strength, lightweight structures with minimal waste. These advances not only improve efficiency and design freedom but also align with sustainability goals. A key takeaway is that the full potential of AM is realized through automation. Automation increases the efficiency, scalability, and overall impact of AM processes, enabling transformative changes in manufacturing practices and supply chains. This underscores the critical need for integrated automation to overcome the limitations of traditional manufacturing and create a more agile, responsive, and sustainable manufacturing future.

Title: Additive Manufacturing for Biomedical Applications

Fengyuan Liu
University of Bristol, UK

ABSTRACT

Additive manufacturing, a revolutionary technology, is transforming biomedical applications. This innovative approach enables the precise, layer-by-layer fabrication of complex structures and patient-specific implants with exceptional accuracy. From customized prosthetics to heart stents, additive manufacturing offers tailored solutions for various healthcare needs. It enhances patient outcomes, reduces surgery times, and promotes cost-efficiency. This talk highlights the remarkable potential of additive manufacturing in patient-specific prothesis development and heart stents, offering personalized treatments and pioneering advancements that hold immense promise for the future of healthcare.

BIOGRAPHY

Fengyuan Liu is a Lecturer in Advanced Manufacturing Technologies at the University of Bristol, specializing in 3D/4D printing for biomedical applications. She is also a member of the Engineering Systems and Design Institute, member of Design & Manufacturing Futures Laboratory. Her research focuses on biomanufacturing systems, bone tissue regeneration, and heart stent regeneration using innovative materials. Previously, she worked as a Postdoctoral Research Associate at the University of Manchester, developing an affordable osseointegrated prosthetic solution through hybrid bio-additive manufacturing. Fengyuan's pioneering work includes inventing a hybrid biomedical additive manufacturing system for multi-material scaffolds. She's affiliated with the International Academy for Production Engineering (CIRP) and serves as a Guest Editor for the International Journal of Bioprinting. Her decade-long experience in additive manufacturing has yielded high-impact research and awards, such as the Best Macromolecules award in 2019.

Title: : Towards Personalized Medicine: Empowering the Application of 3D-Printing in Healthcare Using Functional and Advanced Excipients

Sharareh Salar-Behzadi
GmbH, Austria

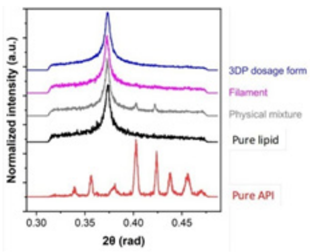
ABSTRACT

The rise of additive manufacturing technologies to become one of the most important topics in the pharmaceutical product development can be attributed to their inherent advantages, such as the patient- oriented, customized nature of these techniques, and the ability to create complex geometrical forms with high precision. The recent application of various 3D-printing methodologies expands from manufacturing oral formulations to implantable systems. The restriction is, however, the narrow spectrum of advanced and functional excipients, limited to the use of specific polymers.

This talk presents the successful expansion of the limited portfolio of 3D-printing excipients by application of lipids for filament-based 3D-printing of tailored oral dosage forms. The audience will be introduced to the challenging properties of lipids such as high degree of crystallinity, and unstable solid state, as well as how to modify lipids' properties and the process to fit together, accomplishing a novel patient-centric manufacturing platform. Case studies will be presented to show the API-loading, improved API solubility based on proper selection of lipids and understanding the extrusion process, tailoring the filaments physical properties, and 3D-printed forms.

The amorphous state of loaded API in filaments and 3D-printed forms is illustrated in figure 1. Filaments with suitable mechanical property and 3D-printed forms with different geometry are shown in figures 2 & 3.

Successful application of lipids as 3D-printing excipients can empower the development of patient-driven and point-of-care manufacturing platforms, which have proven paramount for future healthcare.



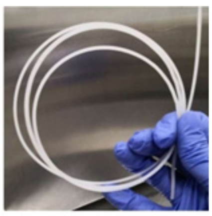


Figure 1- Wide-angle x-ray diffractograms of pure API and lipid, their physical mixture, as well as filaments and 3D-printed form

Figure 2- Lipid-based filaments with advanced mechanical properties.

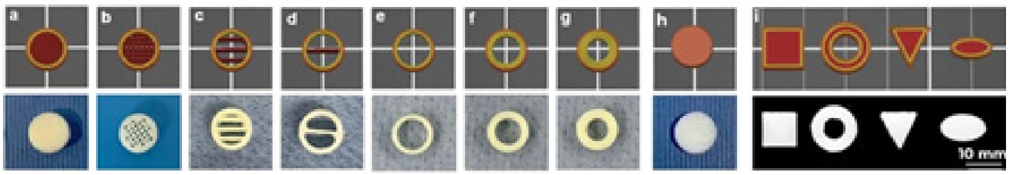


Figure 3- Lipid-based 3D-printed forms with different geometry

BIOGRAPHY

Sharareh Salar-Behzadi is Assoc. Professor at the department of pharmaceutical technology and biopharmacy, University of Graz, and key researcher at Research Center Pharmaceutical Engineering (RCPE) GmbH (http://www.rcpe.at/), Graz, Austria. She studied pharmacy and received her PhD from University of Vienna in pharmaceutical formulation and process development. She was afterwards a post-doctoral fellow at the same university for 6 years. She joined RCPE GmbH in 2011 and the University of Graz as lecturer in 2014, and later as Assoc. Professor in 2020.
Her interest is in pharmaceutical material science, solid state, structure-function analysis of pharmaceutical excipients, with a focus on lipid-based drug delivery systems, and their application in additive manufacturing for patient-centric product development.
Sharareh has worked with a large number of pharmaceutical, excipient, and equipment companies and received significant funding for her work in lipid-based drug delivery systems. Her publication record encompasses over 60 peer-reviewed publications and 5 patents in this field.

Title: 3D Printing to Create Surface Patterns on Textile Fabrics

Jinsong Shen
De Montfort University, UK

ABSTRACT

3D printing technology has been developing rapidly in recent years.The Fused Deposition Modelling (FDM) process uses the extrusion of molten thermoplastic materials through heated printing nozzle to create design objects layer by layer. The current research was to develop 3D printing technology on textile fabrics to create surface design based on FDM process using the Ultimake 3D printer. Printing parameters play an important role for printing on fabrics especiallyto achieve strong adhesion between the printed patterns and the surface of the fabrics. This research developed a method for assessing the attachment strength in the interface between the printed objects and the surface of fabrics. The effect of the initial setting distance between the printing nozzle and the printing platform on the performance of 3D printed fabrics was investigated. The strong attachment of printed patterns on the fabrics can beachieved through the fuse of printed filament polymer into the surface structure of fabric. The chemical finishing could change the surface properties of the fabrics such as hydrophobicity and smoothness. The water-repellent finishing can improve the quality of 3D print on textile fabrics with stronger attachment.The research work demonstrated the ability to create different design patterns in 3D on the fabrics with excellent durability to washing, which shows potential for the commercial application in fashion industry.

Keywords: 3D printing, textile patterns, rapid prototyping, material extrusion, fused deposition modelling

Title: Volumetric 3D Printing of Viscous Photopolymers with Xolography

Arpita Roy Choudhury

Xolo GmbH, Germany

ABSTRACT

Xolography as novel volumetric 3D printing technology rapidly produces objects from subcentimeter scale up to the size of dental models within a matter of minutes.1 The technology exploits dual-color photoinitiatiors, which molecularly combined type II photoinitiation motifs with a photoswitching function. This makes the dual-color photoinitiator responsive to light of two differing wavelengths, in a way that light of the first wavelength pre-activates the dormant initiator A, while light of the second wavelength transforms the pre-activated form B into the initiating species C, which induces curing of the photopolymer. Thus, with dual-color photoinitiation the zone of polymerization is restricted to regions, where light of both wavelength is present at the same time.

In Xolography we intersect a thin UV light sheet plane with a visible light projection within the volume of a photopolymer-containing vat. Only at the intersection points curing of the photopolymer is induced, generating a freely floating object within the resin. The technology fundamentally differs from other layer-based 3D printing methods allowing new perspectives for object design, material selection and fabrication processes2, e.g. the use of highly viscous resins and the 3D-printing of layer-less objects with isotropic material properties and optical grade surfaces.

In this presentation we will discuss the basic working principles of dual-color photoinitiation and the uniqueness of Xolography in terms of fabrication speed, material selection and its application for optics printing and biofabrication.

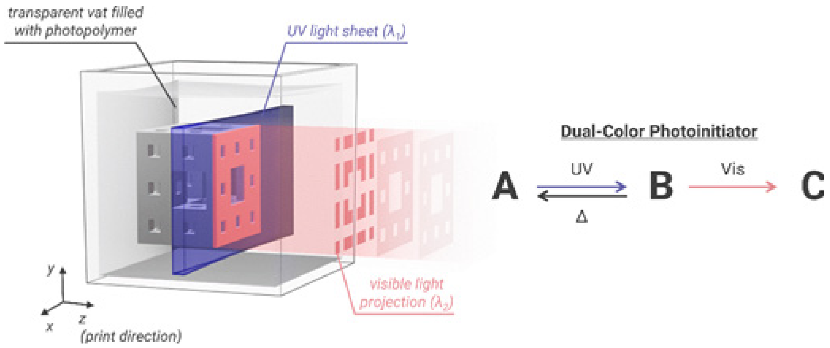


Figure 1. Principles of dual-color photoinitiation and volumetric 3D printing with Xolography.

Title: Non-Destructive Detection of Porous Defects in Additively Manufactured Samples using Ultrasonic Waves

Erwin Wojtczak

Gdańsk University of Technology, Poland

ABSTRACT

Additive manufacturing (AM) is a promising approach for production of lightweight, strong, andcomplex-shaped structures in many branches of industry, e.g., in dentistry and orthopaedics. There are a lot of filament types with different mechanical properties that can be used to produce 3D printed structures, among many polymers, metals or ceramics. Thanks to the simplicity ofthe production process, a wide use of biodegradable polymers, e.g., polylactic acid (polylactide – PLA), is observed. The studydealt with the application of ultrasonic waves for non-invasive diagnostics of AM elements. The main goal was damage detection and imaging of porous defects intentionally introduced to 3D printed plates produced from PLA filament. Areas with different porosity, modelled as pseudo-randomly placed voids, were considered. The specimens weretested using the guided wave propagation technique. The waveexcitation was providedby a PZTactuator and the signals of propagating waves were collected by the scanning laser Doppler vibrometry (SLDV) technique in a number of points organized in a regular grid at one surface of the sample. Additionally, in order to verify the experimental results, numerical simulations reflecting the measurements were conducted using finite element method in Abaqus/Explicit. The signals recorded with two approaches were processed using wavefield curvature imaging (WCI) technique which allowedthe imaging of damage areas based on the sensitivity of the wavefront curvature to structural discontinuities. The compensationof attenuation in wave signals was conducted to enhance the quality of damage maps. Based on the results, it was stated that the level of porosity strongly affects the efficiency of imaging. The possibilities and limitations of the proposed diagnostic algorithm were characterized. The presented results confirmed that ultrasonic guidedwaves can be successfully used for non-destructive damage detection and imaging in AM elements.

BIOGRAPHY

Dr. Erwin Wojtczak is an assistant professor at the Department of Mechanics of Materials and Structures, Faculty of Civil and Environmental Engineering, Gdańsk University of Technology. His research interests are focused on non-destructive diagnostics of engineering structures, especially using ultrasonic wave-based methods and ground penetrating radar. His latest works deal with the issue of damage identification and imaging in additively manufactured samples using elastic waves.

Title: Dynamic Analysis of Mechanical Metamaterials Produced with Additive Manufacturing Techniques

Tomasz Ciborowski

Gdańsk University of Technology, Poland

ABSTRACT

The study focuses on the modal analysis of 3D printed cantilever beams containing segments made in the front of mechanical metamaterials. Two beam variantswere analysed, differing in the orientation of their metamaterial segments and thus in the direction of printing. The research aimed to analyse how these differences, together with variations in the internal geometry such as the internal angles and wall thicknesses of the metamaterial segments, affect the dynamic characteristics of beam structures, in particular their natural frequencies and mode shapes. Following the parametric analysis, a three-point bending test was conducted on a testing machine to experimentally identify the bending behaviour of both beam variants. Corresponding numerical simulations were carried out to determine the effective modulus of elasticity in bending for both beam variants. The numerical results were validated experimentally for selected configurations. Additionally, an elastic boundary conditions were introduced in the numerical model to take into account the actual mounting conditions. The research findings highlight the potential of tailored metamaterial segments to tune and optimise the dynamic response and stiffness of beam structures, with applications in engineering fields requiring vibration control and structural adaptability.

BIOGRAPHY

Tomasz Ciborowski graduated with his bachelor's degree in civil engineering and is currently completing master studies at Gdańsk University of Technology. In his master thesis he analyses the dynamic behaviour of mechanical metamaterials produced using additive manufacturing technology. He plans to continue his research during PhD studies.

Title: Development of Hydrogels for 3D Printing Formed from Whey Protein and Pectin

Magdalena Trusinska, Katarzyna Rybak, Ewa Jakubczyk, Katarzyna Pobiega, Lilia Ahrné, Małgorzata Nowacka

Department of Food Engineering and Process Management, Institute of Food Sciences, Warsaw University of Life Sciences, Nowoursynowska 159c, 02-776 Warsaw, Poland

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Department of Food Science, University of Copenhagen, Rolighedsvej 26, 1958, Frederiksberg C, Denmark

ABSTRACT

The increasing number of consumers with special dietary requirements, including elderly individuals and hospitalized patients, createsthe need for innovative nutritional products that arenot only energy-dense and protein-rich but also visually appealing and tailored to their individual preferences. Taking this into consideration, three-dimensional printing emerges as a highly promising technology for foods as it allows for the creation of small batches of customized food items. To ensure proper printability, the food material should have suitable mechanical and rheological properties. Whey proteins can form gels, enabling the development of complex shapes through 3D printing, whereas pectin is commonly used to stabilize dairy products by modifying rheological properties during processing and enhancing the texture of the final products.

Therefore, the study aimed to investigate the impact of the addition of pectin to heat-induced whey protein gels on their printability. In particular, the effects ofdegree of esterification of pectin and its concentration was investigated.Firstly, the stock solutions of whey protein isolate (WPI), low methoxyl pectin (LMP) and high methoxyl pectin (HMP) were prepared and then they were mixed to obtain the desired compositions. Before printing, the samples were subjected to heat treatment to induce a fully developed gel network.

The 3D printing process was performed using the extrusion-based 3D printer. The sample characterisation was performed based on macroscopic photographs, texture analysis, rheological measurements, protein content, FT-IR spectroscopy and thermo-gravimetric analysis. The study showed that there are substantial differences between the properties of gels containingLMP and HMP, with the WPI-LMP gels being much more relevant for 3D printing.

Title: Additive Construction (3DPrintingofConcrete)

Tara Bisharat

B.Arch, OAA, MS. Space Architecture (Extreme and extra terrestrial habitats and systems engineering), Canada

ABSTRACT

Description

Additive construction (AC), also known as 3D Printing of Concrete, is a ground breaking technology that is redefining construction and reshaping how architects and engineers approach architecture, structures, and design of the built environment.

Despite AC being in its early stages, AC has already demonstrated significant advantages of traditional construction methods. Speed, cost efficiency and ability to maintain quality make AC a viable alternative, particularly when adopted at scale. The applications of AC are wide-ranging; from solving small-scale structural challenges and enabling construction of complex, intricate geometries that would otherwise be prohibitively expensive to building affordable housing and providing rapid shelter relief in post-disaster or post-war scenarios. AC also holds great potential for constructing habitats in extreme, remote, or extraterrestrial environments.

A key feature of AC is its potential for In Situ Resource Utilization (ISRU) which can address logistical challenges especially in remote and hazardous locations, reduce waste, and create more harmonious structures with their surroundings. This paves the way for more vernacular and sustainable architecture. Furthermore, by increasing safety and simplifying supply chains automation, AC presents an environmentally friendly solution that also facilitates innovative designs.

This session will explore the foundations of additive construction, technical aspects, limitations, and opportunities of AC. It will also highlight key applications and concepts, culminating in a case study of CONCAVE, my award-winning project in ICON Initiative 99 Competition. As a proof-of-concept for affordable housing, ConCave is set to be realized next year in Community First! Village in Austin, Texas.

Content Outline

1. Overview of Additive construction: Foundations, technology, processes, limitations, opportunities.
2. Applications and Concepts of Additive Construction: Key use cases and innovations.
3. Case Study: CONCAVE: An award-winning affordable housing project

Learning Objectives

1. Understand the technology and processes behind 3DPrinting of Concrete.
2. Explore the limitations and challenges of additive construction.
3. Discover how AC can unlock creativity in architecture and engineering.
4. Analyze CONCAVE, an award-winning project from the ICON Initiative 99 Competition.

BIOGRAPHY

An Earth and Space Architect, Tara is a Licensed OAA Architect with experience in Germany and Canada. Tara's project experience includes science and research centers, educational campuses, condominiums, and high-rise projects. Tara completed a Bachelor of Science in Architecture and a Master of Science in Space Architecture. She has a passion for designing and engineering habitats for extreme and extraterrestrial environments. Her field of study and research is in additive construction, both for Earth and beyond, focusing on systems engineering and mission planning for habitats that can be built in-situ using local materials and resources.

Tara recently built a talented team with the aim to participate in architectural competitions and push the boundaries of creativity and design in the innovative world of construction. The team recently won an honorable mention award in the Initiative 99 by ICON for designing affordable housing using additive construction.
[Website: www.concaveproject.com]

Tara's Master Thesis was on MAERAL, Scalable, Versatile & Intelligent Swarm Robotic Systems for Mars Surface Operations. This research explored the use of swarm robotic systems to construct habitats on Mars, which could greatly reduce the time and cost of building structures on the planet's surface.

She is an active member of the Space Architecture Technical Committee at the American Institute of Aeronautics and Astronautics (AIAA), SpaceArchitect.org, the Canadian Aeronautics and Space Institute (CASI), and the ASTM.org Technical Committee on Additive Manufacturing Technologies. Tara also hosts the podcast "From the Outpost," featuring conversations with experts on subjects related to architecture, science, and space.

Title: : Numerical Simulation for Geometry Prediction in Laser Cladding Process Based on a Dynamic Catchment Efficiency Approach

Yajie Hu
McGill University, Canada

ABSTRACT

The current research focused on using Finite Element Analysis (FEA) for constructing a prediction model of the cladding geometry for a powder-fed direct energy deposition (DED) process. It augments existing analytical solutions and investigate the sensitivity of processing parameters set and the dynamic aspect of the catchment efficiency by utilizing carbide alloys (Ni-WC) on a 4145-MOD Steel substrate. Backing by 13 sets experimentally available WC single file cladding data and with the comparison of the analytical solution, the confidence in its predictions is enhanced for the model. This model offers a quick reference tool for understanding the effects of process parameters on the built part's properties, reducing the need for repetitive experiments. The comparison with experiments yields to 6.2% average deviation, which highlights the model's reliability.

BIOGRAPHY

Yajie holds two Master's degrees from the University of Ottawa in Engineering Management and Mechanical Engineering, with a specialization in Thermal Barrier Coating finite element simulation. She has extensive experience in numerical simulation across thermal, mechanical, and various other disciplines. Currently, Yajie is pursuing her PhD at McGill University, working on a Direct Energy Deposition cladding simulation project for the mining industry.

Title: Implementation of 3D-Printed Conic Reference Structures for the Correlation of Microscopic and Microct Imaging

Philipp Nolte
HAWK Goettingen, Germany

ABSTRACT

Introduction

Hard tissue histology is often challenging because specimens are opaque, making it difficult to target specific areas of interest during the cutting process. As a result, key structures may be missed, and it becomes difficult to assess 3D parameters. In this work, we introduce a novel workflow that incorporates microCT scans of specimens before cutting, allowing for the precise targeting of regions of interest and the evaluation of 3D features. Additionally, we embed 3D-printed conic reference structures with the specimen, which enables the accurate registration of histological sections within the microCT context.

Objectives

Our goal is to enhance traditional histological methods by integrating 3D-printed reference structures to support correlative imaging. These structures assist in aligning histological sec-tions with the 3D microCT data, bridging the gap between 2D and 3D visualization.

Materials and Methods

In our workflow, we embed three 3D-printed, cone-shaped reference structures—created us-ing binder-jetting and digital light processing (DLP) printing—alongside tissue specimens in resin blocks. Once hardened, these blocks are scanned using microCT. A priming cut is made with a diamond bandsaw, followed by precise sectioning using a laser microtome. The histo-logical sections are then imaged with a microscope, and the resulting 2D images are fused with the microCT volume.

Results

We developed a microCT-aided workflow for hard tissue histology that incorporates external markers—specifically, 3D-printed cone-shaped reference structures—visible in both micro-scopic and CT imaging. After sectioning, the histological slice includes not only the tissue specimen but also elliptical representations of the cones. By analyzing

the geometric properties of these ellipses (e.g., major and minor axes), we iteratively matched them to corresponding regions in the 3D microCT scan. This method was successfully applied to all phantoms, enabling the reconstruction and extraction of a "digital twin" of the cutting plane from the CT data. Finally, we accurately registered both imaging modalities by aligning the intensity values of the histological and CT images.

Conclusion

Our novel CT-aided workflow offers a method to retroactively verify the accuracy of tissue cutting using embedded 3D-printed reference structures. This enables the fusion of histologi-cal data with microCT scans by overlaying corresponding CT slices and histological sections. By establishing a geometrical correspondence between the 2D histological images and the 3D microCT context, this approach can significantly enhance the traditional, color-coded histo-logical analysis by incorporating critical 3D information. The integration of 3D-printed struc-tures plays a key role in ensuring precision and improving the correlation between 2D histol-ogy and 3D imaging.

BIOGRAPHY

Philipp Nolte is a postdoctoral researcher and research manager at the Faculty of Engineering and Health at the University of Applied Sciences and Arts in Goettingen. His research primarily focuses on correlative imaging and the image registration of histological and micro-CT data. Previously, at the University Medical Center Goettingen, his work involved integrating 3D-printed phantoms into histological workflows, ensuring compatibility with common tissue embedding media. His latest research aims to enhance these methods, with a particular emphasis on improving resolution and X-ray contrast.

Title: Multi-Scale Optimal Design For Ultra-Lightweight And High-Stiffness Porous Stiffeners Using Variable Design Domain Topology Optimization

Daiki Yamane
Toyota Technological Institute, Japan

ABSTRACT

Stiffeners are structural elements with superior mass-to-stiffness ratio and are widely utilized in the engineering structures. Determining the optimal layout and shape of stiffeners without relying solely on the designer's intuition has attracted much attention in recent years. In this study, we propose an optimal design method for ultra-lightweight, high-stiffness porous stiffener structures by incorporating a porous structure within the stiffener structure.

In this method, we first determine the optimal macrostructure, including stiffeners, using the variable design domain topology optimization proposed by authors[1]. This method involves varying the design domain through shape optimization while seeking the optimal stiffener layout using topology optimization based on the SIMP (Solid Isotropic Material with Penalization) method. Subsequently, the stiffened structure is divided into arbitrary sub-domain, and independent periodic microstructures are applied to each sub-domain. The homogenized elastic tensors of each microstructure are calculated using the homogenization method and applied to the corresponding sub-domain of the entire stiffened structure. The optimization problem is formulated as a distributed-parameter optimization problem for both macro and micro optimization problem with compliance as the objective function. Following the formulation, the Lagrange multiplier method, the adjoint method and material derivative are used to derive the shape gradient function and the density gradient function. These gradient functions are then applied to the vector-type H1 gradient method for shape optimization and the scalar-type H1 gradient method for topology optimization. The introduction of the both types of H1 gradient method serves a dual purpose, enabling to obtain a smooth optimal shape of macro and micro structures and optimal topology without the checkerboard and grayscale issues, as well as reducing the objective function. Several numerical examples prove the effectiveness of the proposed method.

Keywords: Porous stiffeners, Design Optimization, Variable design domain topology optimization, H1 gradient method

Title: Optimal Design of Fiber Placement for CFRP Structures and its Path Design for 3D Printing

Makito Kato

Toyota Technological Institute, Japan

ABSTRACT

Carbon fiber reinforced plastics (CFRP) are used in many industrial products because of their superior specific strength and specific stiffness. CFRP has been attracting attention in recent years because of its curvilinear arrangement of fiber bundles in the optimum direction, which has become possible due to advances in manufacturing methods.

In this study, we propose the optimal fiber placement design method and the printing path generation method for designing and manufacturing CFRP using a continuous fiber 3D printer, which is a relatively inexpensive manufacturing method. The optimization problem minimizes the objective function which is the squared error between the displacement and the target displacement, under the constraints required for CFRP manufacturing on a 3D printer and the equilibrium equation. After formulating this optimal design problem, the sensitivity function is derived using the method of Lagrange multiplier and the adjoint method, and the H1 gradient method is used to determine the optimal fiber path that is smooth and manufacturable.

In addition to the optimal fiber path obtained by the optimal design method, the printing path generation method finds plastic paths to match it. By creating a plastic path, it is possible to fill in gaps between fibers with different curvatures, and to create areas composed entirely of plastic that do not require strength. In other words, it is possible to produce optimal fiber placement CFRP that has a freer structure.

The effectiveness of these methods was confirmed by actually performing the optimal design of CFRP and the printing path design, manufacturing, and conducting experiments.

Keywords: 3D printer, CFRP, fiber placement, printing path, H1 gradient method

POSTER PRESENTATION ABSTRACTS

Title: Using thePrinciples of Generative Design in theCreation of Manipulative Robotic Elements for Dental Applications

Samuel Mikuláško
Technical University of Košice, Slovakia

ABSTRACT

This study discusses the use of generative design principles in the design of a robotic gripper for dental applications. Generative design, supported by modern computational tools such as advanced simulation, topological optimization, and artificial intelligence algorithms, represents an innovative approach to solving complex design challenges. The main objective of the conducted study is the design and optimization of a gripper that can safely, accurately and efficiently manipulate dental materials used in the fabrication of prosthetic restorations. The design process involved several key steps: analysis of the technical requirements for handling dental discs, identification of mechanical and geometric constraints, and application of generative algorithms to design a prototype gripper. Load, gripping force, mechanical stability, and customizability analyses were implemented in the design process. Weight reduction was a fundamental constraint for the final design solution. The resulting solution provides high mechanical efficiency, the ability to adapt to different shapes and sizes of the objects to be handled, in accordance with the 70% reduction achieved using generative design methods. The developed design is also prototyped using additive FDM technology on a uPrint SE printer and reflects the requirements for easy integration into existing robotic systems. Experimental tests and validation of the prototype, made from ABSplus P430 material, have shown an increase in productivity and reliability of the overall system, while significant improvements in handling accuracy have also been achieved. This work demonstrates that generative design has significant potential for the development of robotic manipulators also in the field of dental manufacturing. The conclusions show that this approach can not only increase manufacturing efficiency, but also foster innovation in the design of robotic systems that meet the specific requirements of modern dental applications.

This work was supported by the Slovak Research and Development Agency under contract No. APVV-21-0293.This work was also supported by Cultural and Educational Grant Agency Ministry of Education, Science, Research and Sport of the Slovak Republic, grant KEGA 004TUKE-4/2022, Scientific Grant Agency Ministry of Education, Science, Research and Sport of the Slovak Republic and Slovak Academy of Sciences, grant VEGA 1/0258/24.

BIOGRAPHY

Samuel Mikuláško is a doctoral student at theTechnical University of Košice - Faculty of Manufacturing Technologies with the seat in Prešov. His dissertation focuses on researching thetechnological aspects of machining biomaterials, with his work encompassing process analysis, optimization of machining parameters, and evaluation of material properties used primarily in dental applications. His research is centered on identifying innovative procedures and technologies that could contribute to more efficient manufacturing processes and improve the quality of components intended for dental applications

Title: Possibilities of Using Additive Technologies in Creating a Robotized Workplace for Dental Production

Maryna Yerominais

Technical University of Košice, Slovakia

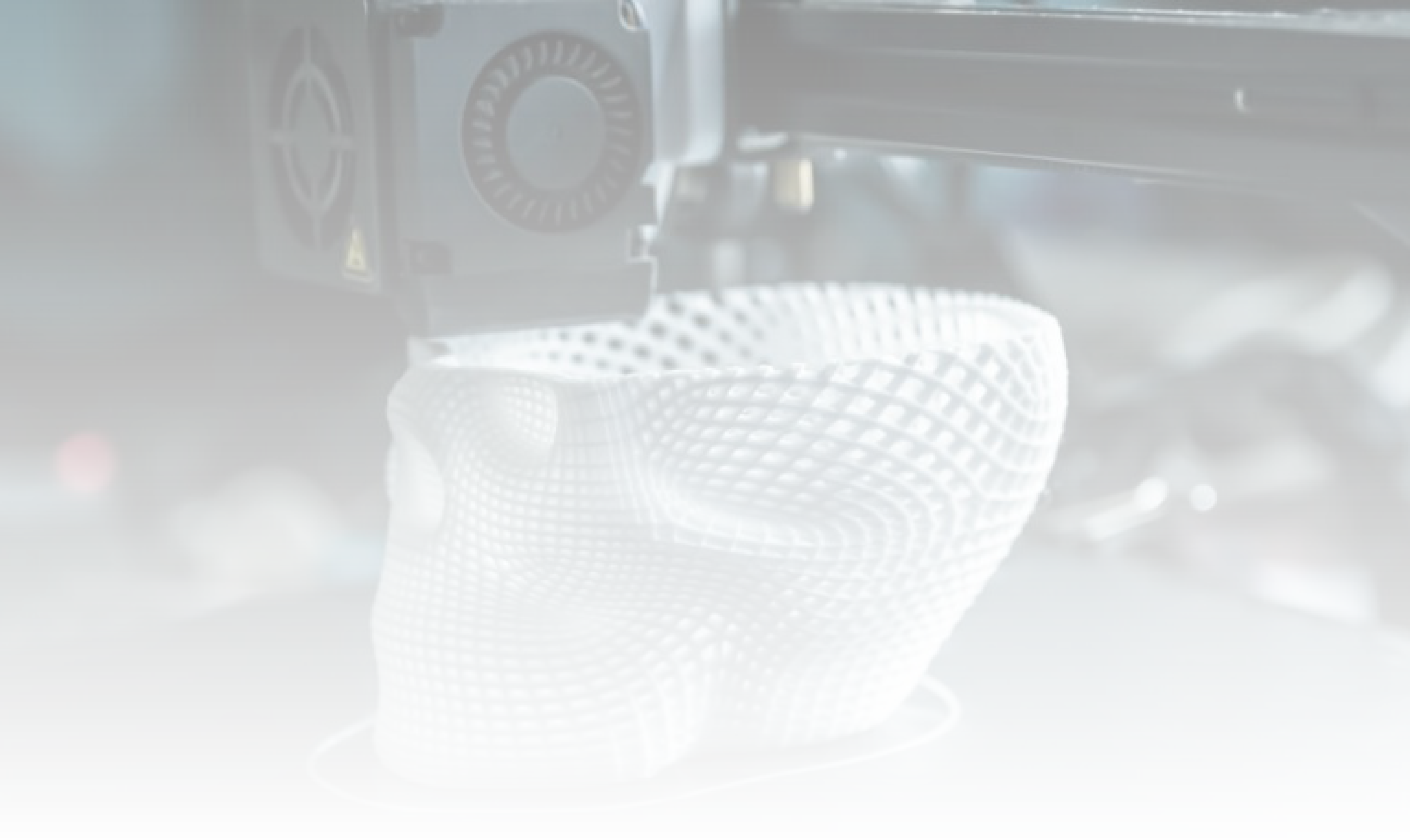
ABSTRACT

This study explores the possibilities of using additive technologies in the creation of a robotic workplace for dental manufacturing, with an emphasis on process optimization and the use of modern materials and 3D printing technologies. Additive technologies, offer unique solutions in the design and manufacture of complex components and are increasingly being applied in the dental industry. The main focus is to analyse the ways in which additive technologies can contribute to the production of implants, restorations, and other dental products, while providing a basis for integrating these technologies into a fully robotic workplace. This study describes the materials used in additive manufacturing, including biocompatible polymers, metals and ceramic materials that meet stringent requirements for mechanical strength, precision, and biocompatibility. Also, there are described the advanced printing technologies such as Stereolithography (SLA), Selective Laser Soldering (SLS), and Fused Deposition Printing (FDM) and Digital Light Processing (DLP) technologies, analysing their advantages, disadvantages, and suitability for various applications in the dental industry. An important part of this contribution is also a review of the available 3D printers, which vary in technology, accuracy and ability to integrate into automated systems. Finally, proposals for the integration of 3D printing into robotic workplaces are presented, which include automated processes from material preparation through the printing itself to post-processing and final inspection. This work underscores the growing importance of 3D printing and automation in transforming traditional manufacturing practices in dentistry and provides a vision for future developments in this field.

This work was supported by the Slovak Research and Development Agency under contract No. APVV-21-0293. This work was also supported by Cultural and Educational Grant Agency Ministry of Education, Science, Research and Sport of the Slovak Republic, grant KEGA 004TUKE-4/2022, Scientific Grant Agency Ministry of Education, Science, Research and Sport of the Slovak Republic and Slovak Academy of Sciences, grant VEGA 1/0258/24.

BIOGRAPHY

Maryna Yeromina is a doctoral student at theTechnical University of Košice - Faculty of Manufacturing Technologies withtheseat in Prešov. Her dissertation focuses on research in the field of implementing robotic workstations in the machining processes of dental implants. The main goal of her research is to identify and develop innovative solutions for the efficient use of robotic systems in the production of dental implants, including the optimization of manufacturing processes, enhancement of machining precision, and improvement of overall productivity.



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