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9th European Congress on

3D PRINTING & ADDITIVE MANUFACTURING

October 07-08, 2024 | London, UK

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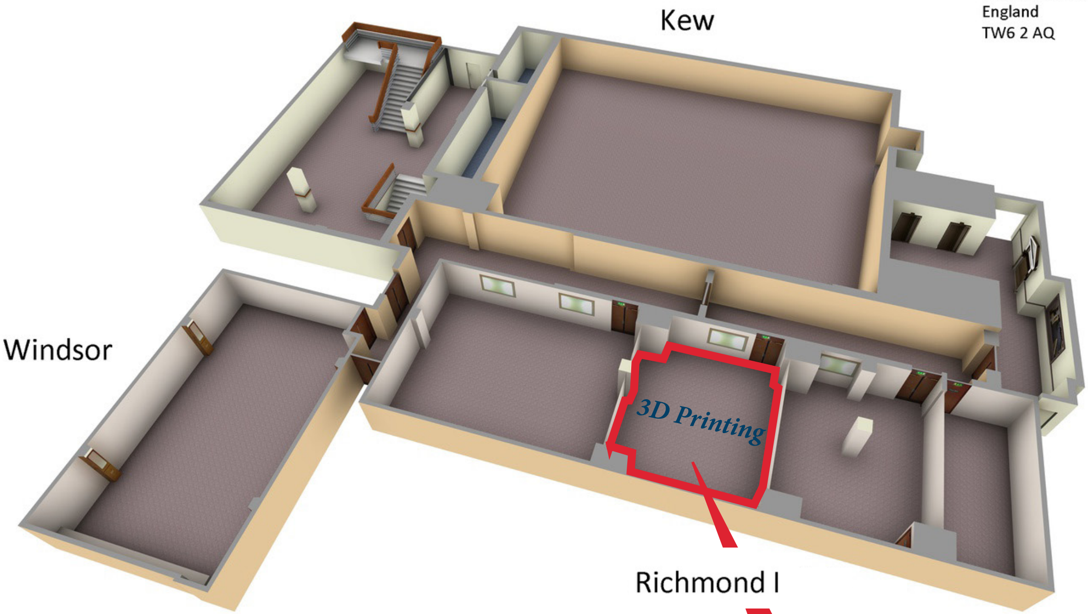

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Conference Hall

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Scientific Program

Scientific Program

Monday
October 07, 2024

9th European Congress on

3D Printing & Additive Manufacturing

Day 1 - October 07, 2024	
Meeting Hall: Richmond Suite I	
08:00 - 08:45	Registrations
08:45 - 09:00	Opening Ceremony and Introduction
Keynote Presentations	
9.00 - 9.40	Binder Jetting Powder Bed Additive Manufacturing followed by Reactive Infiltration Assisted Sintering of Metal/Ceramic Heating Elements
	Alexander Katz-Demyanetz, Israel Institute of Materials Manufacturing Technologies, Israel
9.40 - 10.20	3D Nanoprinting – Possibilities, Strategies and Applications
	Harald Plank, Graz University of Technology, Austria
Networking & Refreshments: 10.20 - 11.00 @ York Lobby	
11.00 - 11.40	Thixotropic Metal Processing and 3D Printing of Zinc and Magnesium Bio-Alloys for Biomedical Implant Applications
	Jack Zhou, Drexel University, USA
Oral Presentations	
Session Chair:	**Hamid Mehrabi,** University of Sunderland, UK
Session Chair:	**Jack Zhou,** Drexel University, USA
Sessions:	Metal 3D Printing | 3D Printing Materials | Polymers in 3D Printing | 3D Bio Printing | Clinical applications of 3D Printing in Orthopedics and Traumatology | 3D Printing | 3D Printing Future Technology | Challenges in 3D Printing | Innovations, Design & Future Technology in 3D Printing
11.40 - 12.05	A Construct To Perform *In situ* Deformation Measurement of Material Extrusion Fabricated Structures
	Daniel Nelson, United States Air Force Test Pilot School, USA
12.05 - 12.30	Mechanical Factors that affect the Stability and Sustainability of 3D Printed and 3D Bioprinted Objects
	Maria Mavri, University of the Aegean, Greece
12.30 - 12.55	Investigations into Polymer Bonding During the Fused Filament Fabrication Process and its Effect on Mechanical Properties
	Julian Klingenbeck, University of the Bundeswehr Munich, Germany
Group Photo: 12.55 - 13.10	
Lunch: 13.10 - 14:00 @ Market Garden Restaurant	
14.00 - 14.25	The Use of Fibers in the Production of Geopolymers using the 3D Printing Method
	Szymon Gadek, Cracow University of Technology, Poland
14.25 - 14.50	Experimental Analysis of Thermal Properties and Microstructural Evolution of Ti-6Al-4V during LPBF Printing
	Johannes Rottler, University of the Bundeswehr Munich, Germany
14.50 - 15.15	Numerical Investigation of Porous Structures for Additive Manufacturing in Biomedical Applications
	Babak Ziaie, Atlantic Technological University, Ireland

9th European Congress on

3D Printing & Additive Manufacturing

15.15 - 15.40	Processability of Aluminium Alloys by Pbf -Lb/M Additive Manufacturing **Ignacio González-Barba,** University of Seville, Spain
15.40 - 16.05	The Additive Manufacturing Transformation: Empowering Manufacturing with 3D Printing **Wilderich Heising,** Boston Consulting Group (BCG), Germany
Networking & Refreshments: 16:05 - 16:30 @ York Lobby	
Poster Presentations	
Poster Judges	**Alexander Katz-Demyanetz, Harald Plank, Hamid Ahmad Mehrabi and Jack Zhou**
3DP-01	A Structure-properties Assessment of Co-28Cr-6Mo Alloy Manufactured by Laser Powder Bed Fusion (LPBF) **Yuliia Chabak,** Institute of Materials Research of Slovak Academy of Science, Slovakia; Pryazovskyi State Technical University, Ukraine
3DP-02	Structure and Tribological Behaviour of "(TiC+WC)/Hardened Steel" Particulate Metallic Matrix Composite Additively Manufactured by Pulsed-plasma Spraying **Vadym Zurnadzhy,** Institute of Materials Research of Slovak Academy of Science, Slovakia; Pryazovskyi State Technical University, Ukraine
3DP-03	Marine Propellers Printed in Metal 3D Printing Technology **Joanna Kulasa,** Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland
3DP-04	Research on the Development of a Bearing Shells Production Technology by Applying a Sliding Layer in the 3D Printing Process using the Wire Arc Additive Manufacturing Method **Anna Brudny,** Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland
3DP-05	Development of The on-Line Reading Oxidative Potential System using Resin-Based 3D Printing Technology **Antonio Toto,** University of Lausanne, Switzerland
3DP-06	CFD Modeling of strand Deposition Flow in Robocasting for Geopolymer-Based Composites **Abrar Gasmi,** Laboratoire des Technologies Innovantes, France
3DP-07	Multiscale *In situ* Quantification of the Role of Surface Roughness and Contact Area using a Novel Mica-PVS triboelectric nanogenerator. **Jack Perris,** University of Glasgow, UK
3DP-08	Stereolithography Printing for the Fabrication of Flexural Ultrasonic Sensors with Significantly Enhanced Operational Bandwidth **Mahshid Hafezi,** University of Glasgow, UK
Day-1 Concludes followed by Award Certifications	

Scientific Program

Tuesday
October 08, 2024

9th European Congress on

3D Printing & Additive Manufacturing

Day 2 - October 08, 2024	
Meeting Hall: Richmond Suite I	
Keynote Presentations	
9.00 - 9.40	Comparative Analysis of Investment Cast Inconel 625 with Atomic Difusion Additive Manufacturing
	Hamid Ahmad Mehrabi, University of Sunderland, UK
9.40 - 10.20	Design, Simulation, and Experiments for Direct Thixotropic Metal 3D Printing
	Jack Zhou, Drexel University, USA
Networking & Refreshments: 10.20 - 10.45 @ York Lobby	
10.45 - 11.25	Development and Performance Evaluation of Cement Systems for Aerial Additive Manufacturing
	Richard J Ball, IMPS Bath University, UK
Oral Presentations	
Session Chair	**Alexander Katz-Demyanetz,** Israel Institute of Materials Manufacturing Technologies, Israel
Session Chair	**Harald Plank,** Graz University of Technology, Austria
Sessions:	Metal 3D Printing | 3D Printing Materials | Polymers in 3D Printing | 3D Bio Printing | Clinical applications of 3D Printing in Orthopedics and Traumatology | 3D Printing | 3D Printing Future Technology | Challenges in 3D Printing | Innovations, Design & Future Technology in 3D Printing
11.25 - 11.50	Effect of Pulsed Plasma/Laser Surface Modification on Structure and Tribological Behaviour of 316L Steel: Wrought vs. Laser Powder Bed Fusion
	Efremenko V, Institute of Materials Research of Slovak Academy of Science, Slovakia; Pryazovskyi State Technical University, Ukraine
11.50 - 12.15	3D Printing Parameters for Leakproof Capsules – Additive Encapsulation of PCM
	Miguel Moreira, University of Aveiro, Portugal
12.15 - 12.40	Advancements in 3D Printing of Ceramic-Like Geopolymers
	Abrar Gasmi, Laboratoire des Technologies Innovantes, France
12.40 - 13.05	Evaluation of Additive Manufacturing Feasibility in the Energy Eector: A Case Study on Gas-insulated High-voltage Switchgear
	Elham Haghighat Naeini, Hitachi Energy, Poland
Lunch: 13.05 - 14:00 @ Market Garden Restaurant	
14.00 - 14.25	Numerical Investigation of Inkjet Based Bioprinting of Viscoelastic Liquids
	Rahul Pundora, Indian Institute of Technology Jodhpur, India
14.25 - 14.50	3D Edible Printing: Food-grade Materials with Binder Jetting Printers
	Shahnaz Mansouri, Monash University, Australia
Networking & Refreshments: 16:00 - 16:30 @ York Lobby	
Day-2 Concludes followed by Vote of Thanks and Certificate Felicitations	

Virtual Program

Virtual Program

Monday
October 07, 2024

9th European Congress on

3D Printing & Additive Manufacturing

Virtual Program (British Summer Time Zone)	
Day-1 | October 07, 2024	
09:45 - 10:00	Introduction
Keynote Presentation	
10.00 - 10.40	Crystallographic Basis of Shape Reversibility in Shape Memory Alloys **Osman Adiguzel,** Firat University, Turkey
Oral Presentations	
10.40 - 11.05	Use of 3D Printed Bioscaffolds from Decellularized Umbilical Cord for Cartilage Regeneration **Tayyaba Bari,** Interdisciplinary Research Centre in Biomedical Materials (IRCBM), COMSATS University Islamabad, Pakistan
11.05 - 11.30	Innovative Redesign of Decorative Lighting Frames: Transitioning from Traditional Manufacturing to Additive Manufacturing for Enhanced Sustainability and Customization **Liyanage Hemal,** EPF Engineering School, Troyes, United Kingdom
11.30 - 11.55	3D Printing Technology and its Combination with Nanotechnology in Bone Tissue Engineering **R. Thiruchelvi,** St. Josephs College of Engineering Chennai, India
11.55 - 12.20	Effect of Selective Laser Melting (SLM) Process on Tribological Behavior of Ferrous and Non-ferrous Alloys **Omid Ashkani,** Islamic Azad University, Iran
12.20 - 12.55	Improving the Fatigue Design of Mechanical Systems such as Refrigerator **Seongwoo Woo,** Ethiopian Technical University, Ethiopia
12.55 - 13.20	Ultra Thin Metal Shell Structure: Big Data, Simulation and AI **Pablo Lorenzo-Eiroa,** New York Institute of Technology, USA.
Poster Presentations	
13.20 - 13.35	Using 3D Printed Cardiac Abnormality Models in Pre-Clinical Medical Education **Sthefon Tran,** California University of Science and Medicine, USA
13.35 - 13.50	The Design and Development of 3D-Printed Tablets for Neurological Disorders: Current Status, Challenges, and Future Trends **Jeevandeep Mishra,** Medi-Caps University, India

Day-1
Keynote Presentations

BINDER JETTING POWDER BED ADDITIVE MANUFACTURING FOLLOWED BY REACTIVE INFILTRATION ASSISTED SINTERING OF METAL/ CERAMIC HEATING ELEMENTS

Alexander Katz-Demyanetz[1], D. Zolotaryov[1], G. Muller[1], L. Rudnik[1] and M. Bamberger[2]

[1]*Israel Institute of Materials Manufacturing Technologies, Israel*
[2]*Faculty of Materials Science and Technology, Israel*

Abstract

Background: Nowadays, a demand for custom individualized complicative shaped ceramic-based composite heaters significantly increases. This is dictated by a necessity to find less energy-consuming heating technologies, and then especially adjusted heaters topology may be a good technical solution. Technological survey shows that currently, the market offers a wide variety of SiC and $MoSi_2$ made heaters, but the situation is different regarding the individually shaped heaters. The most promising technology potentially permitting to reach this task is additive manufacturing, in common, and binder jetting assisted additive technology, in particular.

Objective: The present research is aimed to establish a scientific and technological background for binder jetting assisted printing followed by reactive sintering of the mentioned ceramic-based composite heaters. The phase formation and interface reactions kinetics and densification mechanisms responsible for full-densification-aimed reactive sintering are studied. The main task of the research is to achieve the desired mechanical, thermal, and electrical properties of the finally produced material, which may be applicable for manufacturing of the most effective complicative shaped ceramic-based composite heaters.

Methods: Microstructure and properties of the obtained as-built and as-post-treated products have been characterized by means of Optical and Scanning Electron Microscopy (SEM), High-Resolution Scanning Electron Microscopy (HRSEM), Transmission Electron Microscopy (TEM), High-Resolution Transmission Electron Microscopy (HRTEM) and Scanning Transmission Electron Microscopy (STEM) combined with Energy Dispersive X-rays Spectroscopy (EDX), X-Rays Diffraction (XRD), microhardness and Archimedes density measurements, methods of thermal resistance and thermal conductivity measurement.

Biography

Alexander Katz-Demyanetz has done his PhD at Faculty of Materials Science and Engineering at Technion - Israel Institute of Technology. During last twenty years he has his professional expertise in phase transitions and reactive diffusion in metals, ceramics and composite materials, heat treatment of metals and alloys, powder technologies (including powders processing, consolidation, sintering and densification), additive technologies (including beam induced methods – EBM and SLM, and binder jetting methods). Dr. Katz-Demyanetz is a lecturer at Technion – Israel Institute of Technology in Haifa, Israel, and Braude Academic College in Karmiel, Israel.

3D NANOPRINTING – POSSIBILITIES, STRATEGIES AND APPLICATIONS

Harald Plank[1-3]

[1]*Graz University of Technology, Austria*
[2]*Christian Doppler Laboratory - DEFINE, Austria*
[3]*Graz Centre of Electron Microscopy, Austria*

Abstract

After the advent of 3D printing in the 1980s through polymer printers, the basic concept evolved dramatically and revolutionized numerous areas of research and development. This technology pool outperforms other approaches through its process simplicity, design flexibility and true 3D capabilities. Although increasingly matured for macro, meso, and even microscales, expansion to the true nanoscale has been and continues to be a major challenge. In the small pool of relevant techniques at this scale, additive nanomanufacturing with focused ion/electron beams are the most promising candidates as they offer the required resolution, 0D-3D design flexibility and – to some extent – material variability. Depending on the particles used, the technologies are called Focused Electron / Ion Beam Induced Deposition (FEBID / FIBID). Both are based on the highly local dissociation of surface-adsorbed precursor molecules injected into the vacuum chamber of scanning electron microscopes (SEM), focused ion beam systems (FIB) or SEM-FIB double beam systems. Consequently, there are only minor requirements for substrate materials (vacuum/beam compatibility) and surface morphologies (accessible to the beams). Together with the ability to produce even complex, free-standing 3D nano-objects in a single step and available software packages that enable reliable upfront design, both techniques occupy a leading role in the field of direct-write 3D additive manufacturing.

In this talk, we will introduce the audience to the applicability of both techniques, starting with advantages and disadvantages of both particle types. We then focus on the principles of 3D nanofabrication, including a look at technical and physical limitations. This also includes a view on application paths by breaking down the most relevant direct- and multi-stage-procedures. The contribution then presents several examples ranging from nano-optics/electronics/magnetics over advanced scanning nanoprobes towards sensing applications to demonstrate the broad applicability. The talk is rounded off with a future perspective at technologies, materials and research areas that have hardly been addressed so far.

Biography

Harald Plank has a background in physics and is a professor at the Institute for Electron Microscopy and Nanoanalysis at the Graz University of Technology in Graz, Austria. His research focus is in the area of additive, direct-writing nanofabrication using focused electron/ion beams with a major focus on additive 3D nanoprinting. Based on a long experience in this field, its activities range from fundamental aspects to real-world applications. While the former provides the basis for exploiting the technology's full potential, the latter leverages its unique advantages to generate novel scientific approaches as well as radically new concepts for industrially relevant applications. For that, predictability, precision and reliability are essential and are therefore a high priority. In short: Harald Plank's aspiration is to develop new 3D nano-concepts for transfer to industrial applications based on a fundamental understanding of the processes involved.

THIXOTROPIC METAL PROCESSING AND 3D PRINTING OF ZINC AND MAGNESIUM BIO-ALLOYS FOR BIOMEDICAL IMPLANT APPLICATIONS

Yifan Fei, Jie Xu, and Jack Zhou

Drexel University, USA

Abstract

This research is to explore a novel manufacturing system that is capable of thixotropically processing and 3D printing of zinc and magnesium bio-alloys. Zinc and magnesium bio-alloys are highly demanded in medical implanted devices for their biodegradability and high strength. However, current 3D printing techniques encounter a substantial difficulty in fusing powders from such bio-alloys owing to vaporization and oxidization under high power laser. Lack of a direct printing process greatly hampers the use of zinc and magnesium bio-alloys in customer-tailored treatment and cure. To overcome this hurdle, a new thixotropic 3D printing methodology is proposed to allow zinc and magnesium bio-alloys to be directly printed into accurate 3D shapes. The new technology is expected to dramatically impact skeletal and soft tissue fixation tools, vascular inflation stents, and bone tissue scaffolds. This would lead to a revolutionary improvement particularly in orthopedic, spinal and vascular surgery by providing patient-tailored medical devices that are strong and biodegradable/absorbable in vivo. The new process may also be adapted to fabrication of aluminum-based alloys for broad industrial applications.

Biography

Jack Zhou's current research is in additive manufacturing and 3D printing, biomedical design and manufacturing, and tissue engineering. He invented several new rapid prototyping machines and technologies for microstructures, bone scaffolds and soft-tissue fabrications. He published more than 150 journal and peer reviewed conference papers, and 20 patents; and organized various conferences/symposiums nationally and internationally. He has received more than 36 grants from government, industry and research institutions, and advised more than 40 Ph.D. & Master students and post doctors. He is a fellow of ASME, and received many awards from various societies, organizations, and institutes. Currently he teaches and directs research in the Department of Mechanical Engineering and Mechanics at Drexel University, Philadelphia, USA.

Day-1
Oral Presentations

A CONSTRUCT TO PERFORM IN SITU DEFORMATION MEASUREMENT OF MATERIAL EXTRUSION-FABRICATED STRUCTURES

Daniel Nelson and Valeria La Saponara

United States Air Force Test Pilot School, USA

Abstract

Background: Material extrusion is an additive manufacturing modality that continues to show great promise in the ability to create low-cost, highly intricate, and exceedingly useful structural elements. As more capable and versatile filament materials are devised and the resolution of manufacturing systems continues to increase, the need to understand and predict manufacturing-induced warping will gain ever greater importance.

Objective: To show the viability of adapting Digital Image Correlation (DIC)-based experimental methodologies to gather in situ surface displacement and thermal data of small-scale neat polymer structures during a Fused Filament Fabrication (FFF) build. Additionally, develop novel analysis techniques designed to gather insight into both the time- and location-dependence of developed displacements/deformations, as well as the print-to-print variation of realized deformations.

Methods: DIC sensing of residual stress induced surface displacements was employed alongside novel analysis methods to measure the creation, location, and magnitude of warping events resultant from the additive manufacturing process. Additionally, this project explores those analysis methods to understand the build parameter correlation driving the deformation of additively manufactured parts.

Results: The results showed that the proof-of-concept process was a success. The application of DIC monitoring during the course of a test structure creation allowed for the gathering of in-plane surface displacements as well as the statistical analysis/determination of the manufacturing parameters that led to the creation of the displacements within the test structure.

Conclusion: This research proved the utility of DIC to measure the surface displacements resultant from the buildup of thermally induced residual stresses, providing insight into when and where deformations are occurring. This experimental/analysis design also showed the value of pairing displacement and thermal monitoring as well as utilization of various data analysis techniques/products that can be employed to understand, explain, and display the data obtained through the experimentation.

Biography

Daniel Nelson currently serves as a Lieutenant Colonel in the United States Air Force and works as the Deputy Director of Education at the United States Air Force Test Pilot School. Past assignments have included the leading of testing and evaluation of F-35, and leading the Flight Test Engineering team in the development of a Presidentially Director flight test program. In addition to his expertise in the Test and Evaluation of aircraft and aircraft systems, Dr. Nelson's research focuses on the creation of Aerospace Structures and Additive Manufacturing. His research focuses on the use of non-contact inspection methods to quantify and analyze deformations developed during the construction of additively manufactured polymer structures.

MECHANICAL FACTORS THAT AFFECT THE STABILITY AND SUSTAINABILITY OF 3D PRINTED AND 3D BIO-PRINTED OBJECTS

Maria Fafaliou, Athanasia Kadrefi, Evgenia Fronimaki and Mavri Maria

University of the Aegean, Greece

Abstract

Background: Three-dimensional (3D) printing refers to a technological procedure that turns computer-based digital files into solid objects. Once the digital files are created, either by using computer design software or a 3D scanner, they are sliced into sections and a 3D printer stacks the raw material into layers.

3D Bioprinting technology utilizes 3D Printing technology and biofabrication technology in order to ‘print’ living cells into biomedical parts. Bioinks are used as ‘inks’ in 3D bioprinting. Most of them are hydrogels, loaded with cells, growth factors and all necessary substances for cell survival and growth.

The main question raised is whether 3D printing technology and 3D bioprinting are sustainable production processes. This study aims to review mechanical factors which affect the stability and the sustainability of a final 3D printed and 3d bio-printed object.

Objective: To review mechanical factors that affect the stability and the sustainability of a final 3D printed and 3d bio-printed objects.

Methods: Based on literature, we identify factors affects sustainability and group them to categories based on their characteristics and on their structure.

Results: Development of a list of factors that affect sustainability of objects of these two technologies under examination, identify common factors (i.e. environmental factors) and define which factors are controllable by humans and which are not.

Conclusion: The proposed factors belong to a wide range of mechanical factors that affect the sustainability of a final 3D object. Utilizing the results, future researchers can enrich the catalogue of these factors

Biography

Maria Fafaliou implements her research on bioprinting focusing on improving the mechanical properties and the quality of analysis of the bioprinting process. She holds a M. Sc. on Development, Quality Control, and Safety of New Cosmetic Products.

Athanasia Kadrefi implements her research on how different kinds of materials and technologies affect product life cycle in Additive Manufacturing (3D Printing). She also holds a BSc in Financial Management and Engineering, and a Master in Business Administration.

Evgenia Fronimaki Evgenia Fronimaki holds a Ph.D. on Operations Management in the field of Additive Manufacturing and Digital Technologies, a Master in Business Administration and a B.Sc. in Business Administration from the University of the Aegean. She is a Collaborating Faculty Member at the Hellenic Open University and she also teaches as an Adjunct lecturer in the University of the Aegean.

Prof. Maria Mavri is a Professor of Quantitative Methods at the Department of Business Administration, University of the Aegean, Chios, Greece. She holds a B.Sc in Mathematics from the University of Athens, a MSc degree in Decision Sciences from Athens University of Business & Economics and a PhD in Operational Research from the same University.

INVESTIGATIONS INTO POLYMER BONDING DURING THE FUSED FILAMENT FABRICATION PROCESS AND ITS EFFECT ON MECHANICAL PROPERTIES

J Klingenbeck, A Lion and M Johlitz

University of the Bundeswehr Munich, Germany

Abstract

Background: It is an established fact, that parts/samples manufactured with the Fused Filament Fabrication process can exhibit pronounced anisotropic mechanical behavior. The extent of such anisotropies varies by material and the chosen manufacturing parameters. In previous research, these observed anisotropies were associated with bonding phenomena between the individually deposited polymer lines during production. Based on the theory of polymer dynamics the mechanical properties of such polymer bonds are dependent on the temperature development in the bond region, i.e. the interface between the polymer lines. This correlation has been shown experimentally regarding the tensile strength of printed materials.

Objective: The goal of this contribution is to determine the influence of process temperature during the FFF process on the viscoelastic properties of the polymer bonds and determine if controlled variations in chamber temperature are an effective option to influence mechanical properties.

Methods: Custom tensile samples with a width of a single polymer line were manufactured at three different chamber temperatures (room temperature, 50°C, 60°C) and subsequently tested under uniaxial loading at laboratory conditions until failure (following DIN ISO 527-1), as well as in relaxation at a constant strain of 1% for 1 hour.

Results: The tensile tests showed an increase in tensile strength from 53 to 64 MPa and an increase in Young's modulus from approx. 2950 to 3150 MPa as chamber temperature increased. The relaxation tests continue this trend. With the relaxation modulus increasing with temperature.

Conclusion: The results showed, that the custom tensile samples delivered repeatable results and provided an alternative to standard tensile samples. Chamber temperature proved to be an effective parameter in controlling the mechanical behavior of the polymer bonds. Further, it could be shown that, in contrast to previous studies, the polymer bonds exhibit a change in viscoelastic properties.

Biography

Julian Klingenbeck graduated with a master's degree in mechanical engineering from the Technical University Munich and is currently employed as a research associate at the University of the Bundeswehr Munich at the Institute of Mechanics. His focus is the 3D printing process known as Fused Filament Fabrication. In particular, he specializes in various experimental techniques for characterizing the mechanical and thermal properties of parts/structures manufactured in this process. With the goal of establishing a connection between the process parameter dependent development of the polymer microstructure and the resultant material properties.

THE USE OF FIBERS IN THE PRODUCTION OF GEOPOLYMERS USING THE 3D PRINTING METHOD.

Szymon Gądek[1], Inna Oliinyk[2], Kinga Korniejenko[1] and Barbara Kozub[1]

[1]*Cracow University of Technology, Poland*
[2]*Pryazovsky State Technical University, Ukraine*

Abstract

Background: The continuous pursuit of developing innovative production methods is a paramount issue in modern materials engineering. Over the years, 3D printing has emerged as a dynamically evolving branch. It has also been noticed by the construction sector, where 3d print is increasingly being utilized. The use of this technology significantly contributes to cost reduction and acceleration of construction work. In construction, geopolymers have begun to be used more frequently as an alternative to elements made of concrete. Additionally, similar to concretes, geopolymers have started to be reinforced with various fiber additives.

Objective: Investigating the effect of adding cotton fibers to geopolymers on mechanical properties and thermal conductivity.

Methods: To produce geopolymers, fly ash was mixed with an alkali activator in the form of a 10-molar solution of sodium hydroxide combined with aqueous sodium silicate. 1% by weight of cotton fibers were added to some of the mixtures. The prepared mixture was then 3D printed to create plates. Some of the plates were cut into appropriate pieces, and the prepared samples were subjected to three-point bending and compression tests. Part of the plates underwent thermal conductivity tests and measurement of density.

Results: The cotton flock caused an increase in the density of printed samples by approximately 8%. The fibers used resulted in a reduction in the thermal conductivity coefficient across all investigated temperature ranges. Unfortunately, decreases in both compressive and flexural strengths were observed. The reduction in compressive strength amounted to approximately 20% and 23% for loads applied perpendicular and parallel to the printed sample layers, respectively. Regarding flexural strength, these decreases were approximately 14% and 24%, respectively.

Conclusion: Based on observations during printing and test outcomes, it appears that the decline in properties may be linked to the clustering of fibers, consequently affecting the printability of the material.

Biography

Szymon Gądek has knowledge in the field of 3D printing technology of various materials. Since being employed at the Cracow University of Technology, he has been conducting numerous didactic classes in the field of technological and material science subjects, including foundry, welding, 3D printing, and various computer simulations of processes occurring in materials during deformations and joining processes. He has worked not only at the University but also in other companies as a "3D Printing Specialist". Additionally, he collaborates with researchers from meany different countries on plentiful international projects. He actively participates in international conferences, where he delivers presentations on his scientific activities. He is a co-author of peer-reviewed scientific and technical publications. In his work, he deals with both polymer and geopolymer materials. His experience in this field allows him to formulate precise theses and draw logical conclusions.

EXPERIMENTAL ANALYSIS OF THERMAL PROPERTIES AND MICROSTRUCTURAL EVOLUTION OF TI-6AL-4V DURING LPBF PRINTING

J Rottler, TK Tetzlaff, A Lion and M Johlitz

University of the Bundeswehr Munich, Germany

Abstract

Background: In Laser Powder Bed Fusion (LPBF) the inhomogeneous heat fluxes caused by selective energy input and insufficient heat removal lead to process errors such as warping and inadequate component quality, especially by high-performance materials like Ti-6Al-4V. Hereby, the global temperature fields, apart from the melting zone, with cooling gradients, play the driving role and interact with the residual stress or deformation field and the microstructure state within the component. Within the LPBF process, the temperature history acts like an in-situ heat treatment on the solidified material, resulting in a distinct hierarchical α’ martensitic Ti-6Al-4V microstructure determining the component quality.

Objective: This investigation aims to gain a deeper understanding of the effect of Ti-6Al-4V material evolution driven by thermal history, achieving fundamental knowledge for thermal process tailoring. Our presented study focuses on the thermo-physical properties and the phase transformation of Ti-6Al-4V within the global temperature field range in the LPBF process.

Methods: Ti-6Al-4V is analyzed in both bulk and powder states according to its thermal properties (specific heat capacity, thermal diffusivity, thermal expansion behavior) via thermal analysis (DSC, LFA, TMA). We investigated the characteristics of temperature history as thermal load and the effect heat accumulations in case of insufficient heat removal on the microstructure (Vickers hardness).

Results: In total, the difference of thermal conductivity between powder and solidified material up to 850°C is shown. Vickers hardness test on heat treated specimens reveled hardening effects due to complex microstructural transformation mechanisms.

Conclusion: The findings demonstrate that printing with Ti-6Al-4V can lead to notable local variations in the microstructure of the material. Even short holding times at moderate temperatures (up to 500°C), which are not in close proximity to the laser-processed surface, can induce crucial differences in hardness. This can ultimately cause local embrittlement and the initiation of cracks within the component.

Biography

Johannes Rottler studied mechanical engineering at the University of Applied Science in Regensburg (bachelor’s degree) and the University of Applied Science in Munich (master’s degree). Since 2021, he has worked as a research associate at the University of the Bundeswehr Munich at the Institute of Mechanics at the Department of Aerospace Engineering. Together with our partners, the Technical University Dresden and the Bundeswehr Research Institute for Materials, fuels, and Lubricants, this study is focused on the effect of process heat conduction within Laser Powder Bed Fusion on Ti-6Al-4V microstructure. The aim is to gain fundamental knowledge in order to thermally tailor the process and improve process reliability and component quality through the use of an effective support structure.

NUMERICAL INVESTIGATION OF POROUS STRUCTURES FOR ADDITIVE MANUFACTURING IN BIOMEDICAL APPLICATIONS

Babak Ziaie, Xavier Velay and Waqas Saleem

Atlantic Technological University, Ireland

Abstract

Background: In the realm of biomedical device manufacturing, Additive Manufacturing methods, such as Selective Laser Melting (SLM) and Electron Beam Melting (EBM), have emerged as promising avenues. Their ability to fabricate bio-inspired and biocompatible porous structures makes them particularly attractive. These porous structures have garnered significant attention due to their potential for enhancing osseointegration and facilitating nutrient diffusion in biomedical implants.

Objective: The primary goal of this study is to comprehensively assess the mechanical properties of three prominent Triply Periodic Minimal Surface (TPMS) structures: Gyroid, Diamond, and Primitive. These structures are being evaluated as potential candidates for biomedical implants. By investigating their mechanical behavior, we aim to determine their suitability and efficacy in biomedical applications.

Methods: To achieve this objective, we conducted Finite Element Method (FEM) analyses on both solid and sheet network variations of the TPMS structures. Our analyses encompassed a range of unit cell sizes, from 1 to 2.5 mm, and porosities spanning from 50% to 85%. Through numerical analysis, we quantified crucial mechanical properties, such as elastic modulus and yield strength.

Results: Our findings revealed that TPMS structures within the unit cell size range of 1-2.5 mm possess pore sizes suitable for biomedical implants, ranging from 300-1000 µm. Elastic modulus values varied from 1.485 to 33.815 GPa, whilst yield strength ranged from 20 to 304.5 MPa across the 50%-85% porosity spectrum. Interestingly, alterations in unit cell size exhibited minimal impact on mechanical properties.

Conclusion: In conclusion, our study underscores the potential of TPMS structures for biomedical applications. Whilst unit cell size adjustments demonstrate limited influence on mechanical properties, careful consideration is warranted regarding porosity levels to mitigate structural defects. For optimal pore sizes in the 700-1000 µm range, adoption of a 2.5 mm unit cell size emerges as a prudent choice for effective implementation in biomedical implants.

Biography

Babak Ziaie is a PhD researcher in the Mechanical and Manufacturing Department at the Atlantic Technology University (Ireland), and a member of the Center for Mathematical Modelling and Intelligent Systems for Health and Environment (MISHE). He specializes in the development of porous biomedical devices, with expertise in numerical modeling simulations and Finite Element Method (FEM) analysis. Currently, he is focused on advancing porous biomedical devices through topology optimization and additive manufacturing techniques, employing a combination of numerical investigations and experimental studies. Prior to this, he conducted research on fatigue and thermal analysis of dental implants.

PROCESSABILITY OF ALUMINIUM ALLOYS BY PBF-LB/M ADDITIVE MANUFACTURING

Ignacio González-Barba, Antonio Periñán, Marcela Martínez and Fernando Lasagni

University of Seville, Spain

Abstract

The interest in aluminium alloys for Additive Manufacturing (AM) processes has increased significantly during the last years. Thanks to the freedom of design offered by AM technologies, specifically for Powder Bed Fusion – Laser/Metal (PBF-L/M), aluminium alloys have shown a high potential for their implementation in several industrial sectors. The combination of a reduced density together with high specific mechanical performance make AM Al-alloys a great choice for the production of several applications. Other materials properties, like a high thermal and electrical conductivity, or improved corrosion resistance, between others, make it interesting for the aerospace industry. There are currently available several commercial Al-alloys in the market, although their maturity for producing final Al-products with the high quality required for the aerospace industry still need to be investigated. This work explores the processability of different Al-alloys manufactured by PBF-L/M. This is analyzed by the development of a Design of Experiment (DoE) campaign for achieving the best processing parameters in order to produce full dense materials. There, bulk and surface density, void content and surface roughness are the main variables to be characterized at this initial step. Later, different thermal treatments are applied and evaluated for each alloy, aiming to produce the best mechanical characteristics, but also analysing other relevant aspects such the electrical resistivity and thermal conductivity.

Biography

Ignacio has his expertise in metal powder 3d printing process performance and their applicability in aerospace sector. His study based on the customization of material & process leads to launch new technology to real applications in the aerospace industry. This article iterates the design, manufacturing and testing of different aluminium alloys for the industrialization of aerospace final products. He has developed this study during his aerospace internship in a R&D centre and master´s degree in materials Science & Technology. Now this study is his preliminary phase for opening aerospace qualifications based on additive manufacturing.

THE ADDITIVE MANUFACTURING TRANSFORMATION: EMPOWERING MANUFACTURING WITH 3D PRINTING

Wilderich Heising

Boston Consulting Group (BCG), Germany

Abstract

In the recent years, we have seen strong technological advancements in additive manufacturing. Manufacturing companies can now build on the technology to create parts for serial manufacturing. This presentation will reflect on the transformatory challenges of the shift from prototyping to manufacturing 3D printing use cases and how to master this transition to the benefit of operations. The future of 3D printing will be driven by manufacturing applications. However, it is not trivial to identify the most suitable parts for additive manufacturing out of a portfolio of multiple parts that a manufacturing company has in its offering. This presentation will discuss a case study on how an electrical components company is leveraging an Additive Manufacturing Opportunity Screening Tool into which a set of SKUs/ parts is loaded into to identify not only the right parts for 3D printing but to also get a recommendation on which is the most appropriate technology to use. Moreover, manufacturing companies can now build on the technology to form distributed production networks to make their operations more efficient, more resilient, and more sustainable. We present a framework ensuring the right design choices and identify most suitable applications for distributed manufacturing. Moreover the presentation will dive into latest trends and market developments in additive manufacturing and highlight current challenges of the industry and strategies to overcome these challenges.

Biography

Wilderich Heising is a Partner and Associate Director at the Boston Consulting Group (BCG). He is a core member of BCG's Innovation Center for Operations and very active in BCG's Health Care, Industrial Goods and Consumer Products practice areas. His focus at BCG is on advanced manufacturing and supply chain topics such as additive manufacturing, 3D printing, digitalization, the factory of the future, Industry 4.0, supply chain of the future as well as on manufacturing and distribution strategy and network optimization. He leads the additive manufacturing topic as well as the network strategy and optimization topic for BCG globally. He holds a Ph.D. in engineering from the Technical University of Berlin.

Day-1
Poster Presentation

A STRUCTURE-PROPERTIES ASSESSMENT OF Co-28Cr-6Mo ALLOY MANUFACTURED BY LASER POWDER BED FUSION (LPBF)

Chabak Yu.G., Efremenko B.V., Lekatou A.G. and Efremenko V.G.

Institute of Materials Research of Slovak Academy of Science, Slovakia; Pryazovskyi State Technical University, Ukraine

Abstract

Background: Co-28Cr-6Mo alloy is among the first options as a material for the biomedical and dental implants. Additive manufacturing seems very perspective for the implant production though it should be well substantiated and confirmed relative to the alloy's performance.

Objective: To comparatively study the mechanical/corrosion/wear behaviour of the wrought and LPBF-manufactured Co-28Cr-6Mo alloys regarding the microstructure and elemental distribution.

Methods: Optical microscopy, SEM, energy-dispersive spectroscopy ("INCAx-sight" (Oxford Instruments)), nanoindentation ("G200 Nano Indenter" (Agilent Technologies)), electrochemical testing ("Gill AC" (ACM Instruments) galvanostat/potentiostat) in a 37°C simulated body fluid (SBF).

Results: The LPBF alloy has a γ(FCC)+ε(HCP) structure combining three main patterns: (a) "melt pools" and columnar grains, (b) a solidification cellular network, and (c) dislocations walls and strain-aged elemental segregations of Mo and Cr found in the cell boundaries. The hierarchical cellular structure of the LPBF alloy ensured its advantage in properties relative to the wrought alloy: in elastic modulus - by 6 GPa, hardness - by 0.93 GPa, SBF-wear rate - by 25%. Both alloys showed close electrochemical behaviour, presenting true passivation, low corrosion current densities (of the order about 10–4 mA/cm2), and a very high resistance to localized corrosion. The LPBF alloy presented even lower corrosion current density and passive current density despite of finer hierarchical microstructure.

Conclusion: The LPBF Co-28Cr-6Mo alloy performed similar to the wrought alloy corrosion behaviour while it outperforms the wrought analog in respect of the micromechanical and wear properties. That proves the applicability of LPBF technology for Co-28Cr-6Mo implant fabrication.

Biography

Yuliia Chabak graduated from Pryazovskyi State Technical University. She has the "PhD" and "Doctor of Science" degrees. Yuliia's expertise is in Materials Science, specifically in "structure-properties" evaluation, surface engineering (via plasma and laser treatment), design of alloys and coatings for tribological applications, etc. Her research in recent years is dedicated to the comparative study of 3D-printed biomedical alloys. She took part in many basic and R&D research projects funded by government bodies and industrial enterprises. She combines research activity with teaching in a university Professor position. In 2020 Yuliia Chabak was awarded the Prize of the Parliament of Ukraine for young researchers.

STRUCTURE AND TRIBOLOGICAL BEHAVIOUR OF "(TiC+WC)/HARDENED STEEL" PARTICULATE METALLIC MATRIX COMPOSITE ADDITIVELY MANUFACTURED BY PULSED-PLASMA SPRAYING

Zurnadzhy VI, Chabak Yu G, Efremenko VG and Petryshynets I

Institute of Materials Research of Slovak Academy of Science, Slovakia; Pryazovskyi State Technical University, Ukraine

Abstract

Background: Particulate metallic matrix composites (PMMCs) are specific materials that consist of dissimilar materials with different physical and mechanical properties intended for different engineering applications. In-situ additive manufacturing of PMMCs with advanced wear resistance is a challenging task.

Objective: To study the structure and wear performance of a "(TiC+WC)/Hardened Steel" PMMC additively consolidated on metallic surface using a high-energy pulsed-plasma spraying.

Methods: The research was performed using optical microscopy, scanning electron microscopy, EDX, X-ray diffraction, microhardness measurements, and dry-sliding testing ("Ball-on-Disc" scheme). Layer-by-layer deposition of PMMC was fulfilled in a repetitive-pulse regime using an electrothermal axial plasma accelerator (EAPA). Each plasma pulse was produced under the discharge voltage/current of 4.0 kV/18 kA. A consumable EAPA cathode (steel tube filled with the bakelite-bound TiC/WC powders) was used as a feedstock source.

Results: Due to easy binder evaporation, the carbides (25-30 vol. %) were directly plasma-sprayed on the substrate (1045 steel) without substantial melting. In the PMMC structure, carbides were uniformly distributed within a hard (500–1044 HV) steel matrix consisting of 57 vol.% austenite and 43 vol.% needle martensite. A synergy of hard matrix and carbides advanced a PMMC's wear performance.

Conclusion: Pulsed plasma spraying allows a layer-by-layer building of crack-free PMMC intended for tribological application. The dry-sliding wear resistance of PMMC increased by 4.4-16 times to the substrate depending on the counter ball material (100Cr6 bearing steel, SiC).

Biography

Vadym Zurnadzhy has a PhD degree in Materials Science. He graduated from Pryazovsky State Technical University (Ukraine) and specializes in steels and alloys mechanical/tribological performance; structure characterization; mechanisms and kinetics of phase transformations under heat treatment and stress/strain; high-strength steels: surface modification/coating depositions; structure/properties of 3D-printed metallic materials. He took part in basic research studies and R&D projects focused on metallurgical and machinery sectors.

MARINE PROPELLERS PRINTED IN METAL 3D PRINTING TECHNOLOGY

Joanna Kulasa, Anna Brudny, Wojciech Burian and Barbara Juszczyk
Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland

Abstract

Background: The 3D Printing technology of a propeller prototype using Cu-based materials is presented. The components were manufactured by means of the 3D Metal Printing (3DMP®) process which belongs to the Wire Arc Additive Manufacturing (WAAM). The main advantages of the WAAM technology are lower investment costs, as well as shortening the production time by reducing the number of stages. In addition, the significant advantages of this technology include high deposition rate of successive layers of material (high efficiency of the 3DMP® process), possible reduction of the weight of elements, low material losses, and the possibility of reusing post-production waste.

Methods: The 3D printing of the prototype of the propeller was performed with the complex machine systems from GEFERTEC GmbH. The 3DMP® process is considered as alternative, competitive, and more environmentally friendly to presently used conventional metal processing technologies. The principle of the 3DMP® process is to make the final product layer-by-layer from the wire as a feedstock material. As part of the work, feedstock materials were also produced in the form of a wire with a diameter of 1 mm made of a modified alloy based on aluminum bronze for applications in additive manufacturing technology for the production of spatial objects with improved mechanical properties intended for operation in the corrosive marine environment, which was successfully used to print a full-size propeller prototype. The wires for 3D printing technology were manufactured by melting and continuous casting as well as plastic working with intermediate heat treatment.

Results: A full-size five-blades prototype of the propeller was successfully printed and machined. The project proved that it is possible and viable to replace traditional manufacturing technologies with additive manufacturing successfully.

Biography

Joanna Kulasa has a PhD degree in the field of Metallurgy. Director of the Centre for Advanced Material Technologies in Łukasiewicz - Institute of Non-Ferrous Metals.

Her scientific and research work focuses on the development of, among others: modern manufacturing technologies, including additive manufacturing (WAAM), non-ferrous metals alloys and composites, plastic working and heat treatment of non-ferrous metals and their alloys, material testing (advanced methods of structure examination, tribological tests). Has experience as a manager and co-author of projects co-financed from structural and European funds. Author of more than 70 research and development works and more than 55 scientific publications, mainly in the field of additive manufacturing, foundry, composite materials, and tribological properties of these materials. Creator of patents and patent applications, as well as industrial implementations. Member of the Association of Engineers and Technicians of Non-Ferrous Metals, and the Polish Committee for Standardisation (for testing the properties of metals).

RESEARCH ON THE DEVELOPMENT OF A BEARING SHELLS PRODUCTION TECHNOLOGY BY APPLYING A SLIDING LAYER IN THE 3D PRINTING PROCESS USING THE WIRE ARC ADDITIVE MANUFACTURING METHOD

Anna Brudny, Joanna Kulasa and Marcin Maleta

Łukasiewicz Research Network – Institute of Non-Ferrous Metals, Poland

Abstract

Background: In the production of plain bearing shells for use in transport, especially railway transport, the dominant technology is still the classic casting of the bearing alloy into the shell, analogous to the one used over 100 years ago. Hence, new 3D printing technologies developed recently have great potential for use in this area of application. Due to its specification, 3D WAAM technology seems to be the most appropriate in this regard.

Objective: The aim of the project is to develop a technology for producing a wire from a tin-based bearing alloy with an optimized chemical composition for welding the sliding layer of bearing shells with the innovative WAAM 3D printing and to develop a technology for producing a sliding layer from the newly developed wire using the WAAM 3D printing. The research conducted as part of the work will be aimed at confirming the possibility of producing high-quality sliding layers of a quality comparable or higher than the quality obtained during classic processes of casting of these layers with a bearing alloy.

Methods: The project concerns two main, closely related issues. The first is the introduction of an innovative technology for producing sliding layers using WAAM 3D printing technology in the production of bearings. The second issue determining the introduction of WAAM 3D printing is the development of a production technology for a wire with a diameter of ≤1.2 mm from a tin-based bearing alloy with optimized chemical composition. The main problem is the very low ductility of these alloys, especially those containing larger amounts of antimony and copper additives, forming hard and brittle phases with tin, which in turn determine good bearing properties. This set of properties significantly complicates the production of wires.

Conclusion: The introduction of an innovative method of producing bearing shells for railway needs is related to the industry's great interest in new solutions, as well as relatively high demand. The solutions developed as part of this project can also be used in other industry sectors.

The research will be carried out as part of the LIDER project (LIDER14/0127/2023) financed by the National Centre for Research and Development.

Biography

Anna Brudny, MSc, a PhD student, young researcher, a senior specialist in Łukasiewicz Research Network - Institute of Non-Ferrous Metals. Author and co-author of 35 research and research and development projects both national and international mainly in the field of the development of modern technologies for the production of non-ferrous metal alloys and composite materials (WAAM additive manufacturing technology, casting processes, high-temperature pressure infiltration), plastic forming processes, non-ferrous metal recycling and material testing (advanced structural and tribological analysis). PhD student at the Doctoral School of the AGH University of Science and Technology, the discipline of materials engineering (implementation doctorate). Co-author of research works commissioned from the industry and patent applications. Participant of scientific conferences, internships, and training courses. Winner of numerous awards for completed and implemented R&D works. Member of the Association of Engineers and Technicians of Non-Ferrous Metals, the Supreme Technical Organization NOT, the Polish Society of Composite Materials, the Polish Committee for Standardization (No. 219).

DEVELOPMENT OF THE ON-LINE READING OXIDATIVE POTENTIAL SYSTEM USING RESIN-BASED 3D PRINTING TECHNOLOGY

A Toto[1], JJ Sauvain[1], N Concha-Lozano[2] and G Suarez[1]

[1]*Center for Primary Care and Public Health, University of Lausanne, Switzerland*

[2]*University Center of Legal Medicine, University of Lausanne, Switzerland*

Abstract

Background: Whereas PM mass concentration is associated in epidemiological studies to health effects, this indicator may underestimate the overall impact, as often a large amount of low-toxicity compounds contribute to the mass. The measure of OP (oxidative potential) of ambient aerosol appears as a more integrative metric than mass to evaluate their health effect.

Objective: To develop and characterize a direct-reading instrument based on the acellular ferrous-orange xylenol (FOX) assay allowing a continuous sensing of ambient oxidizing compounds.

Methods: The on-line measurement system, achieved using resin-based 3D printing technology, is based on i) the air sample is sprayed into clean water in order to maximize the air-liquid interface; ii) the water sample is transferred into the sensing chamber where FOX solution is added; iii) the kinetics of Fe(II) oxidation is followed with photonic measurements using orange LED (580 nm).

A series of post printing treatments were made to eliminate the reactivity due to the resin. The final printed prototype was 1) sonicated in water for over 1 hour; 2) dried in the air over night and in the oven for 2 hours; 3) cured with UV and 4) coated with epoxy resin.

Results: By combining the multiscattering-enhanced absorbance (MEA) strategy and the sensitive FOX assay, we developed a photonic device allowing an on-line measurement of the environmental OP with high sensitivity.

Conclusion: An original OP determination device was developed, characterized and tested on-site that enables continuous monitoring of the gas and particulate phases of the ambient aerosol. The preliminary results obtained from a measurement campaign conducted in an air quality station indicate that O3 strongly contributes to the OP. The possibility to perform continuous and long-term OP measurements along with the monitoring of standard air pollutants and meteorological conditions will help in refining our understanding of this emerging metric.

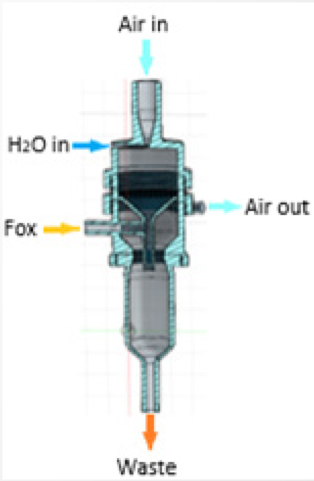

Fig.1 Schematics of the device.

Biography

Antonio G. Toto has a master's in chemical engineering at University of L`Aquila with one year exchange with the University College of London (UCL). He is a researcher at department of DTSE, Unisanté. He is responsible of the 3D design (Autodesk 360 fusion), focused on the fluid dynamic (liquid and gas), and printing, focused on the characteristic of different resins, new prototypes for the detection of the oxidative potential in ambient air. He is in change on developing a new post-cure resin process (Sonication, UV treatment, etc.) to reduce the reactivity of resins with different solvents. He coordinates the stability tests of the prototypes.

CFD MODELING OF STRAND DEPOSITION FLOW IN ROBOCASTING FOR GEOPOLYMER-BASED COMPOSITES

A Gasmi, M Guessasma, H Haddad, C Pelegris and R Davidovits

Laboratoire des Technologies Innovantes, France

Abstract

Background: 3D printing of geopolymer-based composites combines the sustainability of geopolymers,with the precision of additive manufacturing to create complex and eco-friendly structures. Computational Fluid Dynamics (CFD) optimizes this process by simulating the behavior of the geopolymer, addressing issues such as nozzle clogging and layer adhesion. This integration enhances the efficiency and performance of printed structures.

Objective: To investigate the impact of various parameters on strand deposition using CFD methods. Methods: The methodology involves characterizing the printed strand of geopolymer-based composites. We start by characterizing the rheological properties of the geopolymer formula to understand its flow behavior. Next, we identify the governing rheological law and incorporate it into the numerical model. By varying different parameters within this model, we analyze their effects on the final shape of the printed strand, allowing for optimization and improved control over the 3D printing process.

Results: The methodology involves characterizing the printed strand of geopolymer-based composites. We start by characterizing the rheological properties of the geopolymer formula to understand its flow behavior. Next, we identify the governing rheological law and incorporate it into the numerical model. By varying different parameters within this model, we analyze their effects on the final shape of the printed strand, allowing for optimization and improved control over the 3D printing process.

Biography

Abrar Gasmi is currently a second-year doctoral student at the Laboratory of Innovative Technologies, UPJV in Saint-Quentin, France. She earned a degree in mechanical engineering in 2022 and a master's degree in complex and intelligent systems in the same year. Her research focuses on the development of the 3D printing process for geopolymers. In her work, she is tasked with formulating a geopolymer that aligns with the company's specifications, designing a suitable 3D printing machine for the developed formula, and creating a digital decision support tool for simulating the entire printing process. Abrar is dedicated to advancing innovative technologies in materials science.

MULTISCALE IN-SITU QUANTIFICATION OF THE ROLE OF SURFACE ROUGHNESS AND CONTACT AREA USING A NOVEL MICA-PVS TRIBOELECTRIC NANOGENERATOR.

Charchit Kumar, Jack Perris, Satyaranjan Bairagi, Guanbo Min, Yang Xu, Nikolaj Gadegaard and Daniel M Mulvihill

University of Glasgow, UK

Abstract

Triboelectric nanogenerators (TENGs) are energy harvesters generating electricity via the triboelectric effect and electrostatic induction. However, the influence of interface mechanics on TENG performance requires attention. Here, we study the effect of random multiscale surface roughness on TENG performance using a novel in-situ optical technique to directly visualise the contact interface. To achieve this, a new type of TENG is developed based on transparent mica in contact with polyvinyl siloxane (PVS). A wide range of surface roughness instances were created on the PVS surface (Sq from 1.5 to 82.5 µm) by replicating 3D-printed masters developed from numerically generated rough surfaces. TENG output was found to be highly sensitive to surface roughness over a wide range of forces and frequencies. The dependence of real contact area on roughness was identified as the underlying cause. In this work, electrical output (and contact area) decreased significantly with increasing roughness. The highest output (smoothest PVS surface) gave open circuit voltage 222.8 V, short-circuit current density 53 mA/m^2 and peak-power density 4256 mW/m^2: a competitive output given the rapid and simple fabrication, low cost and long durability demonstrated. The new Mica-PVS TENG, the direct technique for TENG interface visualisation and the insights on the role of topography and contact area will be invaluable for future TENG design.

Biography

Jack Perris is a mechanical engineer with research and development experience in surface fabrication and advanced manufacturing focused on surface replication, interface design, and triboelectric nanogenerators. His areas of interest extend to materials science, mechanical design methodology, microfluidic design and production, metrology and materials analysis, experimental mechanics, MEMS device fabrication, clean room techniques, advanced and additive manufacturing, finite element analysis (FEA), and numerical modelling. His current work focuses on the fabrication of TENG devices and associated experimental analysis. This work aims at understanding, predicting, and optimising the contact area and charge transfer at TENG interfaces. Coupled with understanding how rough and structured interface mechanics affect electrical output of TENG devices.

STEREOLITHOGRAPHY PRINTING FOR THE FABRICATION OF FLEXURAL ULTRASONIC SENSORS WITH SIGNIFICANTLY ENHANCED OPERATIONAL BANDWIDTH

Alexander Hamilton, Sam Adams, Mahshid Hafezi and Andrew Feeney

University of Glasgow, UK

Abstract

Background: The flexural ultrasonic transducer (FUT) is an air-coupled transmitter and receiver, popular in automotive applications. Commercial variants comprise a circular metallic plate, usually aluminium, driven by a piezoelectric disc bonded to the underside. Axisymmetric vibration modes are generated within the plate by electrically driving the piezoelectric disc, thus producing ultrasound. Here, modal frequencies are governed by the plate's stiffness and geometrical parameters. The reliance on bulk metallic plates gives little freedom for tailoring device dynamics. Here, stereolithography is used for the first time to synthesise non-metallic FUT plates for kHz operation, retaining sufficiently high vibration amplitudes for practical measurements and providing enhanced bandwidth compared to a commercial transducer.

Objective: To successfully manufacture 3D-printed flexural ultrasonic transducers and subsequently characterise their dynamic performance relative to commercial transducers

Results: SLA-printed FUTs were successfully manufactured (Form3+, Formlabs) with results closely agreeing with finite element analysis predictions. Electrical impedance analysis (4294A, Keysight Technologies) and Laser Doppler Vibrometry (MSA-100–3D, Polytec), was performed to confirm the fundamental resonance modes, occurring around 23 kHz and 110 kHz respectively. High-frequency microphone testing (46DP-1, GRAS) was conducted with the FUT acting as transmitter. Results illustrated that the device exhibited a 6 dB bandwidth of 12.6% compared to 5.7% obtained for a commercial device. Significant signal stability has been reported over the entire operating range for the 3D-printed device respectively.

Conclusion: This study has demonstrated the potential of stereolithography for the fabrication of flexural ultrasonic transducers. It is anticipated that this research will lead to new applications for this transducer class, beyond conventional automotive proximity sensing.

Biography

Alex Hamilton is a Research Associate within the Centre for Medical and Industrial Ultrasonics (CMIU), James Watt School of Engineering, University of Glasgow, Glasgow, U.K. He was awarded his PhD degree in Mechanical Engineering in 2023. His research interests include mechanics of materials, advanced materials and novel manufacturing strategies for micro/nano-scale structures. His current research focusses on air-coupled ultrasound transducer design.

Day-2
Keynote Presentation

COMPARATIVE ANALYSIS OF INVESTMENT CAST INCONEL 625 WITH ATOMIC DIFUSION ADDITIVE MANUFACTURING

Hamid Mehrabi, Mark Armstrong, Nida Naveed

University of Sunderland, UK

Abstract

Background: Inconel 625, renowned for its remarkable resistance to high-temperature and corrosive environments, serves as a pivotal superalloy in industries with stringent performance demands.

Objectives: This study presents a comparative analysis of Inconel 625 components produced via two distinct methods: atomic diffusion additive manufacturing (ADAM) and investment casting (IC). The primary objective of this research is to assess the physical and mechanical properties of samples fabricated through both ADAM and IC.

Methods: Mechanical properits including tensile strength, yield strength, and elongation as well as surface quality of the parts are evaluated. A quantitative and insightful comparison between ADAM and IC, offer shedding light on their respective performance in meeting the mechanical requirements of industrial applications.

Results: The findings indicate that Inconel 625 components produced via ADAM exhibit comparable mechanical properties, with an ultimate tensile strength of 652 MPa, yield strength 298 MPa, elongation 42% and hardness of 7HRC. In comparison, Inconel 625 components produced through IC exhibit an ultimate tensile strength of 495 MPa, yield strength 283 MPa, elongation19%. and hardness of 20HRC. This direct comparison underscores the comparable mechanical properties achieved through ADAM.

Conclusion: Beyond the analysis of mechanical properties, this study highlights the practical advantages of ADAM, which offers unparalleled design flexibility, significantly reduces material waste, and enables the creation of intricate geometries tailored to the specific needs of diverse industries. These advantages position ADAM as an optimal choice for industries seeking, design flexibility, light-weighting and fast production.

Biography

Hamid Mehrabi is a mechanical engineer with an MSc in welding and PhD in heat treatment of steels. Over the years, he has developed an understanding of materials (metals, polymers and ceramics) and manufactutring processes (casting, welding, additive manufacturing and heat treatment) by working closely with various industries including automotive, aerospace and oil and gas. Majority of his research are based on the needs of industries, through partnerships with companies finding solutions to current standing issues, saving resources (materials and energy) ensuring a sustainable process. He strongly considers localized manufacturing and 3D printing are among the future environmental sustainability strategies, avoiding climate change.

DESIGN, SIMULATION, AND EXPERIMENTS FOR DIRECT THIXOTROPIC METAL 3D PRINTING

Yifan Fei, Jie Xu and Jack Zhou

Drexel University, USA

Abstract

Background: In current metal 3D printing, laser melting/sintering of powders is a typical additive manufacturing (AM) process. However, laser melting/sintering, not mentioning its slow and expensive process, is technically not suitable for chemically reactive metal powers such as Al, Mg and Zn powders because these powers under normal conditions are covered naturally by a passivated oxidation layer. Al, Zn and Mg are middle-melting-point metals (660°C, 519.5°C and 650°C, respectively), but their oxides have melting temperature close to 2000°C or even higher. The high laser energy needed to break the oxides leads to poor fusion quality caused by undesired metallurgical defects such as porosity, cracking, and evaporation of alloying elements. Compared with current powder-based 3D metal printing, thixotropic metal 3D printing has great potentials and advantages in equipment cost, product quality and process efficiency.

Objective: The main objective of this research is to explore a novel manufacturing system that is capable of thixotropically processing and 3D printing of light alloys such as Al, Mg, Zn alloys into various devices and products.

Methods: A thixotropic fluid is characterized with a high viscosity and a yield stress at a low strain rate, but the fluid thins at increasing strain rate. Inside the nozzle, the viscosity is low because of high shear rate, so flow is enabled. Outside the nozzle, the shear rate rapidly vanishes, so a yield stress is produced to counterbalance the surface tension. This thixotropy not only permits the printing fluid to form a stabilized paste-like filament during printing and furthermore allows the printed fluid not to sag in the absence of a mold, thus enabling direct 3D printing with high geometrical control.

Results: Metals and alloys may be thixotropically processed and printed by a properly designed extrusion-based 3D printing system, and the thixotropic properties can improve the metal printability. Direct thixotropic metal printing can help optimize the metal printing procedure to reduce post-printing treatments. Thixotropy as a time-dependent property for semi-solid metal processing has been investigated, and the major process parameter on printability has been examined.

Conclusion: A direct thixotropic metal 3D printing machine has been developed and a modeling and simulation process for the system has been conducted. The printability of this direct metal 3D printing machine has been studied.

Biography

Jack Zhou's current research is in additive manufacturing and 3D printing, biomedical design and manufacturing, and tissue engineering. He invented several new rapid prototyping machines and technologies for microstructures, bone scaffolds and soft-tissue fabrications. He published more than 150 journal and peer reviewed conference papers, and 20 patents; and organized various conferences/symposiums nationally and internationally. He has received more than 36 grants from government, industry and research institutions, and advised more than 40 Ph.D. & Master students and post doctors. He is a fellow of ASME, and received many awards from various societies, organizations, and institutes. Currently he teaches and directs research in the Department of Mechanical Engineering and Mechanics at Drexel University, Philadelphia, USA.

DEVELOPMENT AND PERFORMANCE EVALUATION OF CEMENT SYSTEMS FOR AERIAL ADDITIVE MANUFACTURING

Barrie Dams[1,2], Paul Shepherd[1,3] and Richard J Ball[1,2]

[1]University of Bath, UK

[2]Centre for Integrated Materials, Processes & Structures (IMPS), UK

[3]Centre for Digital, Manufacturing & Design (dMaDe), UK

Abstract

Additive manufacturing (AM) in the construction industry is a growing area of research. A major benefit of AM is the promise to greatly reduce material waste on construction scales. In the current state of the art, the vast majority of AM investigations in construction are ground-based approaches and created buildings are informed by the dimensions and reach of the deposition device, whether a robotic arm, a gantry-based system or mobile robotic agents. The Aerial Additive Manufacturing (AAM) project proposes a novel approach to bringing aerial capabilities to AM in construction by employing multiple unmanned aerial vehicles (UAV, commonly referred to as 'drones') which are untethered, self-powered and can extrude cementitious material 'on-the-fly' in a programmed trajectory. It is proposed that multiple coordinated UAVs can create or repair a building or structure considerably larger than the dimensions of an individual aerial agent. AAM requires the miniaturisation of the deposition process, which has to be powered by a flying UAV and an additional robotic delta arm to mitigate lateral tolerances in trajectory and minimise error in the printing path. Cementitious material properties in the fresh state are required to be resistant to propellor downwash once extruded and possess suitable rheological properties that resist deformation due to self-weight and subsequently deposited layers. However, material must also possess shear thinning or 'pseudoplastic' properties, with orders of magnitude decreases in viscosity while still flowing through the deposition system required in relation to viscosity post-extrusion. This presentation provides an overview of the AAM project from principally a materials perspective, but also provides an overview of UAV trajectory design, hardware, processes and considerations. The extrusion of specially formulated pseudoplastic cementitious material by a UAV in flight is demonstrated. A series of tests was conducted to determine the key fresh and cured properties of the material, including mechanical tests such as compression and flexure, rheology tests including flow and oscillation, axial force and power requirements, extruded layer settlement and characterisation tests such as calorimetry and scanning electron microscopy. Results demonstrate the suitable rheology of developed pseudoplastic cementitious material while in the fresh state and structural viability in the cured state. Fine aggregate may be added to cementitious mixes, but buildability may also be provided with the addition of rheology modifying admixtures which promote shear-thinning behaviour and also reduce constituent segregation. Adding an aerial capability to AM in construction can complement ground-based approaches and be particularly applicable to construction in elevated or challenging conditions, reducing the inherent risks of accidents and injuries.

Day-2
Oral Presentations

EFFECT OF PULSED PLASMA/LASER SURFACE MODIFICATION ON STRUCTURE AND TRIBOLOGICAL BEHAVIOUR OF 316L STEEL: WROUGHT VS. LASER POWDER BED FUSION

Efremenko VG, Chabak Yu G, Efremenko BV and Zurnadzhy VI

Pryazovskyi State Technical University, Ukraine; Institute of Materials Research of Slovak Academy of Science, Slovakia

Abstract

Background: Steel of 316L grade is a biomedical material due to high corrosion resistance and biocompatibility however it has low hardness and wear resistance. Thus, the wear behaviour of 316L should be improved, including through surface engineering techniques.

Objective: To study the effect of pulsed-plasma/laser surface melting on tribological behavior of 316 stainless steel fabricated by rolling (wrought state) and Laser Powder Bed Fusion (LPBF).

Methods: The research was performed using optical microscopy, scanning electron microscopy, EDX, X-ray diffraction, nanoindentation measurements and tribological tests (according to the "Ball (Al2O3)-on-Disc" scheme, under 5 N normal load, in a simulated body fluid (SBF). The surface was melted up to 20-30 μm using the pulsed plasma treatment (by electrothermal axial plasma accelerator with a discharge voltage of 4.5 kV) and infrared fiber laser «TruFiber 400» with a wave of 1064 nm length.

Results: In non-modified state, LPBF 316L had a 3 times lower SBF-wear rate as compared to the wrought 316L specimen due to a more dispersed cellular structure and higher nanohardness. Pulsed plasma/Laser melting of the wrought specimens resulted in fine-grained cellular structure ensuring an increase in hardness and 2 times reduction of wear rate. As to LPBF 316L, laser melting did not change the wear rate as compared to the as-printed state, while plasma melting increased it by about 1.5 times.

Conclusion: Pulsed plasma/Laser melting is feasible to be applied for the wrought 316L steel. Regarding the LPBF 316L, these approaches of surface treatment are not efficient since they do not lead to additional structure refinement.

Biography

Vasily Efremenko has a degree of "Doctoral of Science" and long experience of a teaching (University Professor) and a research works. He specializes in Materials Science, specifically in the characterization of the structure of metals and alloys, phase transformations, heat treatment, mechanical and tribological properties, and strengthening surface treatments (laser, plasma, diffusion). Also, he deals with the 3D-printed metallic components with regards to their "structure-properties" characterization. He supervised many basic research projects funded by the Ministry of Education and Research of Ukraine and other organizations. He was a principal researcher of dozens R&D projects focused on metallurgical and machinery sectors.

3D PRINTING PARAMETERS FOR LEAKPROOF CAPSULES – ADDITIVE ENCAPSULATION OF PCM

Miguel Moreira[1,2], Tiago Silva[1,2], João Dias-de-Oliveira[1,2], Fernando Neto[1,2] and Cláudia Amaral[1,2]

[1]*University of Aveiro, Portugal*
[2]*LASI – Intelligent Systems Associate Laboratory, Portugal*

Abstract

Background: Phase Change Materials (PCM) greatly impact the energy efficiency of the thermal systems they are incorporated into, making them an alluring research subject for many researchers. The most common ways of embedding PCM in a system is through their encapsulation, whether in nano, micro or macro scale. Macroencapsulation has the most potential, as more quantities of pure PCM can be used. Nonetheless, there is a noticeable lack of reliable solutions to use these materials in academic research, and limited versatility in encapsulation methods and products for real world applications.

Objective: To assess the suitability of FDM (fused filament fabrication) 3d printing in macroencapsulating PCM, through the study of the impact of multiple printing, material and geometrical parameters on the capsule's PCM leakage.

Methods: The filled PCM capsules were weighted before and after submitting them through multiple thermal cycles, initially in a furnace, and later in a climatic chamber, for more thorough testing.

Results: Initial PETG (Polyethylene terephthalate glycol) capsules lost over 50% of their PCM content. Increases in extrusion temperature, extrusion flow and design considerations improved PETG capsules' performance successively with each itteration up to 0% PCM losses for cylindrical capsules. TPU (thermoplastic polyurethane) cylindrical capsules exceeded expectations, all having retained 100% of their PCM content.

Conclusion: Both PETG and TPU polymers are suitable to contain two types of PCM (Chrodatherm53 and SP21KE) respectively. Some of the most impactful printing parameters are the extrusion temperature, the extrusion flow, part heat management and the geometry of the capsule. Longer periods of cycle testing are required to further strengthen the conclusions on the capsule's lifespan.

Biography

Miguel Moreira has expertise in mechanical engineering, with a passion for 3d printing, manufacturing and process optimization. He is at the moment undergoing a mechanical engineering Ph.D. program at the University of Aveiro, where he aims at developing and optimizing systems and methods to reliably encapsulate phase change materials using 3d printing technologies. Has previous experience in manufacturing process optimization in metal stamping assembly lines, knowledge in the 3d printing technologies, materials and systems, and acquaintance with phase change materials and their potential, having previously participated in academic research on efficient radiant systems enhanced with PCM through the SEEFloor project.

ADVANCEMENTS IN 3D PRINTING OF CERAMIC-LIKE GEOPOLYMERS

Abrar Gasmi, Mohamed Guessasma, Ralph Davidovits, Christine Pelegris and Hamza Haddad

Laboratoire des Technologies Innovantes, France

Abstract

Background: 3D printing geopolymers contributes to environmental sustainability by utilizing green materials, and the affordability and energy efficiency of 3D printing make it a cleaner alternative, reducing the ecological footprint in material production and manufacturing processes. This synergy aligns with eco-friendly practices, fostering a more sustainable approach to production.

Objective: The development of a machine which is correlated with the rheology of the formula and predictions from 3D printing simulations, aiming to optimize printing parameters.

Methods: The material characterization involves techniques such as SEM, BET, and size distribution analysis. Rheology is assessed using a Netzsch rheometer, while a 3D printing machine with sensors is employed for precise control. Additionally, numerical simulations are conducted using Comsol Multiphysics for comprehensive analysis and optimization.

Conclusion: This study delves into the advancement of 3D printing techniques for geopolymers, specifically focusing on creating a specialized printing apparatus tailored to ceramic-like geopolymer materials. Our aim is to thoroughly investigate the intricate relationship between rheological parameters and printing conditions. By conducting systematic experiments, we aim to understand how various printing parameters impact the geopolymer beam during the printing process. This research not only enhances our fundamental knowledge, but also lays the groundwork for predicting and preventing defects. We aim to develop a real-time decision support tool that can identify and rectify defects as they occur. This proactive approach has the potential to revolutionize geopolymer 3D printing by ensuring heightened precision and quality in the fabrication of small and complex structures.

Biography

Abrar Gasmi is currently a second-year doctoral student at the Laboratory of Innovative Technologies, UPJV in Saint-Quentin, France. She earned a degree in mechanical engineering in 2022 and a master's degree in complex and intelligent systems in the same year. Her research focuses on the development of the 3D printing process for geopolymers. In her work, she is tasked with formulating a geopolymer that aligns with the company's specifications, designing a suitable 3D printing machine for the developed formula, and creating a digital decision support tool for simulating the entire printing process. Abrar is dedicated to advancing innovative technologies in materials science.

EVALUATION OF ADDITIVE MANUFACTURING FEASIBILITY IN THE ENERGY SECTOR: A CASE STUDY ON GAS-INSULATED HIGH-VOLTAGE SWITCHGEAR

Elham Haghighat Naeini and Robert Sekula

Hitachi Energy, Poland

Abstract

Background: In recent years, additive manufacturing (AM) has made considerable progress and has spread in many industries. Despite the advantages of this technology including freedom of design, lead time reduction, material waste reduction, special tools manufacturing elimination, and sustainability, there are still a lot of challenges regarding finding the beneficial application.

Objective: In this study, the feasibility of replacing traditional manufacturing methods with additive manufacturing in energy sector has been investigated, with a specific focus on Gas-insulated high-voltage switchgear (GIS). Due to the lightweight, sufficient electrical conductivity, low cost, and machinability, aluminum alloys are the main material of this product. Therefore, just aluminum parts of GIS have been considered for further evaluation.

Methods: All aluminum parts in one specific GIS product are analyzed and a decision flowchart is proposed. Due to this flowchart, printability and best AM technique has been suggested with respect to the part size, required surface roughness, requirements of electrical and mechanical properties, and additional post processes.

Results: Simple to medium complexity level of geometry, large size, high requirements for electrical and mechanical properties, threading and sealing, and lack of standard for printed parts in high voltage industry makes AM a challenging manufacturing technology for this specific product.

Conclusion: In total, implementing AM as a short series production method for GIS aluminum parts may not be sufficient due to the higher cost and more complex supply chain management, but it can be beneficial in R&D cases or prototyping scenarios where a limited number of parts are needed in a brief time limit.

Biography

Elham Haghighat Naeini is an additive manufacturing and 3D printing scientist at Hitachi Energy research with special focus on metallic alloys. Her expertise in advanced manufacturing and metallurgy helps production managers to overcome manufacturing challenges across different business units. Topology optimization, design for additive manufacturing, numerical analysis, and design of experiments for printed parts have been considered in all her projects to propose the best-case scenario from research to productization. Business case analysis and supply chain management consideration are other important factors in her conducted projects.

NUMERICAL INVESTIGATION OF INKJET BASED BIOPRINTING OF VISCOELASTIC LIQUIDS

Rahul Pundora, Vignesh TG Indranil Banerjee and Ravi KR

Indian Institute of Technology Jodhpur, India

Abstract

Background: Inkjet printing typically involves liquid drops ejected from a small nozzle, and are targeted to a surface to create a text or images in traditional printing applications. The low cost, high resolution, and high speed production of droplets by inkjet printing makes it an ideal tool for fabricating complex functional living tissues and organs. A successful printing requires the deposition of the drop at the desired place, and avoids unwanted defects. The properties of bioinks strongly influence the aforementioned outcomes. The presence of cells/particles makes these inks non-Newtonian whose effects on the printing outcomes is not well established.

Objective: In this work, we numerically investigate the dynamics of droplet formation of viscoelastic liquids from a piezo-electric based inkjet printers.

Methods: Numerical simulations are carried out using the commercial computational fluid dynamics package, Fluent, where the multiphase flow is modelled using Volume of Fluid (VOF) method.

Results: The simulations will characterize the temporal evolution of tip length of the liquid filament, drop size, and its speed as a function of the liquid properties, ejection speed. The different printing outcomes will be characterized, and a printability regime map will be proposed.

Biography

Rahul Pundora is working as a Ph.D. student in the Department of Metallurgical and Materials Engineering at IIT Jodhpur. His thesis focusses on understanding the dynamics of inkjet based bioprinting of bioinks using numerical simulations. Rahul Pundora is an advocate for interdisciplinary collaboration, believing that the future of bioprinting lies in the convergence of material science, mechanical engineering, and environmental sustainability. He is keen to connect with fellow researchers, industry professionals, and organizations about 3D printing technologies for a better future.

3D EDIBLE PRINTING: FOOD-GRADE MATERIALS WITH BINDER JETTING PRINTERS

Shahnaz Mansouri, Chung Nguyen and Yunlong Tang

Monash University, Australia

Abstract

Food binder jetting, an innovative additive manufacturing method, involves creating 3D objects by selectively depositing liquid binders in the powder bed based on a predesigned model. Despite its numerous advantages over other 3D printing technologies, such as the ability to manufacture coloured products using food colouring and the absence of heating or support structures during printing, the development of this technology is still in its infancy and largely relies on trial-and-error methods. This is primarily due to a lack of understanding of the underlying material interactions that occur throughout the printing process, particularly across different food systems. Therefore, this research, which is at the forefront of its field, aims to systematically study the connections between the chemical composition of materials and the properties of printed products.

With a meticulous approach, we carefully selected powders from various food systems and a liquid binder from existing literature to create 3D-printed products. We then embarked on a comprehensive analysis of the differences in the characteristics of these printing materials and the variations in the properties of the printed products. Our investigation included a rigorous correlation test between measured properties to identify significant connections between material properties and printed product properties.

The study's significant findings revealed that there are indeed relationships between material characteristics and printed product properties in three different powders. Notably, powder characteristics were found to largely determine the properties of 3D-printed products. As a result, we can now estimate the value of a material or product property if the measurement of its connecting factor is known, providing valuable insights for future research and development in this field.

Virtual
Keynote Presentation

CRYSTALLOGRAPHIC BASIS OF SHAPE REVERSIBILITY IN SHAPE MEMORY ALLOYS

Osman Adiguzel

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Abstract

Shape memory alloys take place in a class of advanced smart materials by exhibiting a peculiar property called shape memory effect. This phenomenon is initiated on cooling and deformation processes and performed thermally on heating and cooling, with which shape of the materials cycle between original and deformed shapes in reversible way. Therefore- this behavior can be called Thermal Memory or Thermoelasticity. This phenomenon is result of two crystallographic transformations, thermal and stress induced martensitic transformations. Thermal induced martensitic transformation occurs on cooling with cooperative movements of atoms in <110 > -type directions on the {110} - type planes of austenite matrix, along with lattice twinning and ordered parent phase structures turn into the twinned martensite structures. The twinned structures turn into the detwinned martensitic structures by means of stress induced martensitic transformation, by stressing material in the martensitic condition.

These alloys exhibit another property called superelasticity, which is performed by stressing and releasing material in elasticity limit at a constant temperature in parent phase region, and shape recovery is performed simultaneously upon releasing the applied stress by exhibiting elastic material behavior. Superelasticity is also result of stress induced martensitic transformation and ordered parent phase structures turn into detwinned martensite structure with stressing. Lattice twinning and detwinning reactions play important role in martensitic transformations, and they are driven by lattice invariant shear.

Noble metal copper- based alloys exhibit this property in metastable β-phase region. Lattice invariant shear and lattice twinning is not uniform in these alloys and gives rise to the formation of complex layered structures, depending on the stacking sequences on the close-packed planes of the ordered parent phase lattice. The layered structures can be described by different unit cells as 3R, 9R or 18R depending on the stacking sequences on the close-packed planes of the ordered lattice.

In the present contribution, x-ray diffraction and transmission electron microscopy (TEM) studies were carried out on two copper- based CuAlMn and CuZnAl alloys. X-ray diffraction profiles and electron diffraction patterns exhibit super lattice reflections. X-ray diffractograms taken in a long-time interval show that diffraction angles and intensities of diffraction peaks change with the aging duration at room temperature, and this result refers to the rearrangement of atoms in diffusive manner.

Biography

Osman Adiguzel graduated from Department of Physics, Ankara University, Turkey in 1974 and received PhD- degree from Dicle University, Diyarbakir-Turkey. He has studied at Surrey University, Guildford, UK, as a post-doctoral research scientist in 1986-1987, and studied on shape memory alloys. He worked as research assistant, 1975-80, at Dicle University and shifted to Firat University, Elazig, Turkey in 1980. He became professor in 1996, and he has been retired on November 28, 2019, due to the age limit of 67, following academic life of 45 years. He published over 80 papers in international and national journals; He joined over 120 conferences and symposia in international and national level as participant, invited speaker or keynote speaker with contributions of oral or poster. He served the program chair or conference chair/co-chair in some of these activities. In particular, he joined in last six years (2014 - 2019) over 60 conferences as Keynote Speaker and Conference Co-Chair organized by different companies. Also, he joined over 180 online conferences in the same way in pandemic period of 2020-2023. He supervised 5 PhD- theses and 3 M. Sc- theses. Dr. Adiguzel served his directorate of Graduate School of Natural and Applied Sciences, Firat University, in 1999-2004. He received a certificate awarded to him and his experimental group in recognition of significant contribution of 2 patterns to the Powder Diffraction File – Release 2000. The ICDD (International Centre for Diffraction Data) also appreciates cooperation of his group and interest in Powder Diffraction File.

Virtual
Oral Presentations

USE OF 3D PRINTED BIOSCAFFOLDS FROM DECELLULARIZED UMBILICAL CORD FOR CARTILAGE REGENERATION

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[2]*University of Veterinary and Animal Sciences, Pakistan*

Abstract

Background: Cartilage regeneration using 3D printing of scaffolds represents a cutting-edge approach in treating osteoarthritis, a degenerative joint disease. Unlike traditional treatments that primarily manage symptoms, regenerative medicine particularly through 3D printing of scaffolds aims to restore damaged cartilage.

Objectives: (1): To decellularize umbilical cord and use it as a natural bioink. (2): To characterize bioink in order to evaluate the structural, physical, thermal and mechanical properties. (3): In vitro and In vivo evaluation of fabricated scaffolds.

Methods: This study comprises different physical and chemical approaches to decellularize umbilical cord tissues followed by the solubilization to bioink formation. To enhance the mechanical stability various polymers and additives are added. Bioinks are characterized by evaluating the surface morphology, pore size swelling, degradation, antibacterial and rheological properties.

Results: Decellularization of the umbilical cord was done using detergent based method and was confirmed by analyzing through SEM, histological staining (Hematoxylin and Eosin (H&E) and 4,6-diamidino-2phenylindole (DAPI)) to visualize the DNA and was further confirmed by 1% Agarose gel electrophoresis and Nucleic Acid quantification by NanoDrop. Similarly, the preservation of extracellular matrix was confirmed by presence of collagen and glycosaminoglycans using Masson's Trichrome and Alcian Blue staining. Solubilization was done using acid/pepsin digestion to yield bioink. Infrared (IR) spectroscopy was performed using a FTIR spectrometer to confirm the amide functional group. Using acetic acid, biotin, and hyaluronic acid, we created a variety of bio-inks with unique compositions. These bio-inks underwent thorough rheological testing before being employed to 3D printed innovative scaffolds. In vitro analysis with fibroblasts confirmed their exceptional biocompatibility.

Outlooks: With the successive *in vivo* trials, bone marrow derived mesenchymal stems cells will be loaded on the printed scaffolds to evaluate the proliferation and chondrogenic differentiation potential.

Conclusion: The versatility in bio-ink composition opens avenues for tailoring scaffolds to specific tissue requirements, while the thorough characterization ensures the reliability and quality of the engineered constructs.

Biography

Tayyaba Bari has her expertise in biological scaffolds and hydrogels in improving the health and wellbeing. Her open and contextual evaluation based on 3D fabrication of bioscaffolds creates new pathways for improving healthcare. This approach is responsive to all researchers and has a different way of focusing on regenerative medicine.

INNOVATIVE REDESIGN OF DECORATIVE LIGHTING FRAMES: TRANSITIONING FROM TRADITIONAL MANUFACTURING TO ADDITIVE MANUFACTURING FOR ENHANCED SUSTAINABILITY AND CUSTOMIZATION

Liyanage Hemal

EPF Engineering School, United Kingdom

Abstract

This study investigates the redesign of decorative supporting frames for the Festilight company, transitioning from traditional aluminium manufacturing to additive manufacturing (3D printing). The primary objective is to enhance product quality while addressing the limitations of current subcontracted frames that do not meet expectations. The research emphasises the significance of selecting appropriate materials that are not only suitable for lighting applications but also recyclable and compliant with specified criteria.

A comprehensive analysis was conducted, incorporating various tools and methodologies, including a feasibility study, RDM calculations, and simulations. The study adheres to established standards such as ASTM F2792 for thermoplastic materials and ISO/ASTM 52910 for design guidelines, ensuring that the new frames meet industry benchmarks. Mechanical analyses revealed that the maximum stress experienced by the frames (38.9 MPa) remains well below the elastic limit of the selected polycarbonate material (63 MPa), indicating a robust design.

The project was organized into subgroups, allowing for collaborative efforts among ten engineering students, each contributing to different aspects of the design and validation process. The opportunity study conducted at the project's outset confirmed the feasibility and merits of the proposed transition to 3D printing, aligning with Festilight's goals of reducing costs and enhancing product customization.

Ultimately, this research highlights the transformative potential of additive manufacturing in the decorative lighting industry, showcasing its ability to provide innovative solutions that meet both aesthetic and functional requirements. By leveraging 3D printing technology, Festilight can improve its product offerings, reduce environmental impact, and foster the development of French expertise in advanced manufacturing techniques. The findings underscore the importance of integrating sustainability and efficiency in modern manufacturing practices.

3D PRINTING TECHNOLOGY AND ITS COMBINATION WITH NANOTECHNOLOGY IN BONE TISSUE ENGINEERING

R Thiruchelvi, P Saravanan and M Chamundeeswari

St. Josephs College of Engineering Chennai, India

Abstract

Background: With the graying of the world's population, the morbidity of age-related chronic degenerative bone diseases, such as osteoporosis and osteoarthritis, is increasing yearly, leading to an increased risk of bone defects, while current treatment methods face many problems, such as shortage of grafts and an incomplete repair.

Objective: To review about the application of 3D printing technology in bone tissue engineering and nanotechnology in the field of bone tissue regeneration and repair

Methods: Bone tissue engineering offers an alternative solution for regenerating and repairing bone tissues by constructing bioactive scaffolds with porous structures that provide mechanical support to damaged bone tissue while promoting angiogenesis and cell adhesion, proliferation, and activity. 3D printing technology has become the primary scaffold manufacturing method due to its ability to precisely control the internal pore structure and complex spatial shape of bone scaffolds. In contrast, the fast development of nanotechnology has provided more possibilities for the internal structure and biological function of scaffolds.

Conclusion: This review focuses on the application of 3D printing technology in bone tissue engineering and nanotechnology in the field of bone tissue regeneration and repair, and explores the prospects for the integration of the two technologies.

Biography

R. Thiruchelvi has her expertise in evaluation and passion in valorization of waste biomass and sustainable food Processing. Her open and contextual evaluation model based on zero waste-food sustainability constructivists creates new pathways for improving waste utilization in the environment. She has more than 8years of experience in experimenting, evaluation, teaching, innovative research, project proposal and Patents both in academic institutions and industry. Her passion is to nurture "Growing Food as Medicine" and valorization of waste biomass by imprinting with nanotechnology to Produce Beneficial Products, which reaches all walks of people in the society by using tool "BIOTECHNOLOGY"

EFFECT OF SELECTIVE LASER MELTING (SLM) PROCESS ON TRIBOLOGICAL BEHAVIOR OF FERROUS AND NON-FERROUS ALLOYS

Omid Ashkani, Hoorshad Mortezaei-Semnani and Sina Taheri Neyestanaki

Islamic Azad University, Iran

Abstract

Background: Selective Laser Melting (SLM) technology is always considered as one of the main methods for developing and manufacturing different parts. This method is considered due to its high speed, precise manufacturing technology and high surface quality. Among the conducted researches, attention has always been focused on the mechanical and surface properties of the manufactured parts, and special attention has not been paid to the factors affecting the tribological mechanisms of the parts manufactured with SLM.

Objective: In this research, the aim is to investigate the tribological characteristics of parts made with SLM.

Methods: In this research, first, pins with a height of 8 mm and a diameter of 4.8 ± 0.05 mm were manufactured by selective laser melting and made of austenitic stainless steel and pure titanium. Pin-on-disk method was used to check tribological characteristics. The wear force was considered to be 25 N. A scanning electron microscope (SEM) was used to investigate the characteristics of the wear surface.

Results: The weight loss of the austenitic stainless steel sample was recorded as 0.02152 grams and the weight loss of the pure titanium sample was recorded as 0.03525 grams. The results showed that the friction coefficient for stainless steel and titanium was recorded as 0.18 and 0.48, respectively. Also, the results of the examination of the wear surface indicated abrasive wear for steel and a combined mechanism of abrasive and adhesive wear for titanium.

Conclusion: The results show that the selective laser melting method can be responsive in the development of parts that need high wear resistance, both in the field of metals and in the field of non-metals. Higher hardness, greater strength and higher the uniaxial flow strength in steel were among the factors that led to increased wear resistance in ferrous alloy.

Biography

Omid Ashakni. Ph.D. candidate of advanced materials and a full doctorate in business management (DBA from Tehran University). My general activities include the development of engineering materials and simulation. I specialize in the process of selective laser melting, the development of simulation of engineering materials and Quantum materials, and I use all the necessary tools in the development of science and knowledge. I also have an extensive record of activity in scientific societies. Welding and Non-destructive Inspection Association, Advanced Technologies Association, Japan Metals Institute, as well as Iran Business Management Association are among these. Also, I am the founder of the Quantum Science Society in my area.

TITLE: IMPROVING THE FATIGUE DESIGN OF MECHANICAL SYSTEMS SUCH AS REFRIGERATOR

Seongwoo Woo

Ethiopian Technical University, Ethiopia

Abstract

Background & Objective: To enhance the lifetime of mechanical system such as automobile, new reliability methodology – parametric Accelerated Life Testing (ALT) – suggests to produce the reliability quantitative (RQ) specifications—mission cycle—for identifying the design defects and modifying them

Methods: It incorporates: (1) a parametric ALT plan formed on system BX lifetime that will be X percent of the cumulated failure, (2) a load examination for ALT, (3) a customized parametric ALTs with the design alternatives, and (4) an assessment if the system design(s) fulfil the objective BX lifetime. So we suggest a BX life concept, life-stress (LS) model with a new effort idea, accelerated factor, and sample size equation.

Results: This new parametric ALT should help an engineer to discover the missing design parameters of the mechanical system influencing reliability in the design process. As the improper designs are experimentally identified, the mechanical system can recognize the reliability as computed by the growth in lifetime, LB, and the decrease in failure rate. Consequently, companies can escape recalls due to the product failures from the marketplace. As an experiment instance, two cases were investigated: 1) problematic reciprocating compressors in the French-door refrigerators returned from the marketplace and 2) the redesign of hinge kit system (HKS) in a domestic refrigerator.

Conclusion: After a customized parametric ALT, the mechanical systems such as compressor and HKS with design alternatives were anticipated to fulfil the lifetime – B1 life 10 year.

Biography

Seongwoo Woo has a BS and MS in Mechanical Engineering, and he has obtained PhD in Mechanical Engineering from Texas A&M. He majors in energy system such as HVAC and its heat transfer, optimal design and control of refrigerator, reliability design of thermal components, and failure Analysis of thermal components in marketplace using the Non-destructive such as SEM & XRAY. In 1992.03–1997 he worked in Agency for Defense Development, Chinhae, South Korea, where he has researcher in charge of Development of Naval weapon System. He was working as a Senior Reliability Engineer in Refrigerator Division, Digital Appliance, SAMSUNG Electronics. Now he is working as associate professor in mechanical department, Ethiopian Technical University.

ULTRA THIN METAL SHELL STRUCTURE: BIG DATA, SIMULATION AND AI

Pablo Lorenzo-Eiroa

New York Institute of Technology, USA

Abstract

Background: The work of Antoni Gaudi (1852-1926) scientific innovation in architecture and understanding of nature has been largely ignored due to its criticism by the Modern Movement for its aesthetic expressionism against minimalism. Our research focuses on Gaudi's catenaries simulation-optimization signal processing to develop a metal formed shell structure.

Objective: The ultra thin metal forming shell structure is based on an origami folding technique, following stress simulation optimization with the objective of enclosing the maximum amount of space with the minimum amount of material.

Methods: The thin shell structure is based on a lower dimensional origami mesh folded and increased dimensionally into 3D thanks to a robotic incremental metal forming technique. The research implemented big data survey 3D scanning of Gaudi's work's features and structural performance, the processing of big data, and criticisms between simulations-optimizations. Several AI technologies were used: from diffusion models, to 2D to 3D estimation and prediction, to point cloud AI simulation, to AI machine vision segmentation and reconstruction, to structural simulation prediction and optimization.

Results: The ultra thin shell structure was metal formed through a robotic technique using 0.5mm aluminum alloy reaching less than 1/10th percentile of its original thickness at critical deformation points.

Conclusion: Through big data, simulation-optimization and implementing various forms of AI we believe we achieved one of the thinnest possible minimal surfaces-shell structures in architecture while exploring innovation in aesthetics and integrating technical detailing processes as part of the general aesthetic and forming of the structure. The installation Gaudi' NYC Skyscraper: Inhabiting the skyline" was set up at the Stapleton Waterfront Park in Staten Island which opened on the weekend of May 18-19th 2024 in the context of the NYC design week and as part of the Art in the Parks program.

Biography

Pablo Lorenzo-Eiroa is the Director of the AI Lab at New York Institute of Technology SoAD and Associate Professor at the MS ACT Program. He has been working with cultural heritage big data since 2004; 3D scanning since 2012; since 2015 he has been working with AI reconstruction; and since 2017 he has been working with AI point cloud data survey, mapping, and processing including both prediction data segmentation and generative AI. The result of his research has been published in the book: Lorenzo-Eiroa, P. Digital Signifiers in an Architecture of Information: From Big Data and Simulation to Artificial Intelligence, Taylor and Francis, London 2023.

Virtual
Poster Presentations

USING 3D PRINTED CARDIAC ABNORMALITY MODELS IN PRE-CLINICAL MEDICAL EDUCATION

Sthefon Tran, Stuart Ferrell, Caroline Albright, Dharshan Chandramohan and John Sohn MD

California University of Science and Medicine, USA

Abstract

Background: 3D printing has wide applications in healthcare from pre-operative planning to pre-clinical education. Prior studies have shown increased spatial understanding of anatomy with exposure to 3D printed models, however, these studies have only evaluated learning of simple anatomy without complex underlying pathologies. Academic studies on the efficacy of the use of 3D printed models of cardiac abnormalities in pre-clinical medical education are few.

Objective: To create a learning module and evaluation to assess the efficacy of 3D printed cardiac abnormalities in teaching pre-clinical medical students compared to traditional 2D modalities.

Methods: Deidentified CT images of a patient with pericardial effusion and aortic dissection were obtained from Arrowhead Regional Medical Center (ARMC) in Colton, California. CT images were then processed into 3D models with physician-approved alterations and printed via FDM.

Results: Cardiac abnormalities were successfully 3D printed using CT images from a patient that was approved and reviewed by a board-certified pathologist and radiologist. A lecture on cardiac abnormalities was created to accompany these models to teach medical students the cardiac abnormalities. The examination was created to evaluate knowledge of anatomy, pathology, and clinical relevance based on CT images obtained.

Conclusion: In conclusion, this study demonstrates the feasibility of transforming real patient pathology into tangible 3D printed models. These models accurately capture complex cardiac abnormalities typically only seen in 2D imaging and display them in a more interactive manner. The accuracy of these models compared to actual pathology has been vetted by both a board-certified radiologist and pathologist. Next steps include utilizing the 3D models alongside a teaching model to assess the development of medical students' knowledge of cardiac pathology in comparison to traditional lecture modalities. Students would be evaluated before and after exposure to the models and/or lecture to access the efficacy of 3D printed model use in medical education.

Biography

Sthefon Tran is an enthusiastic current third-year medical student at California University of Science and Medicine. He has developed his passion for 3D printing and 3D modeling through previous art projects. He is currently trying to improve healthcare by using these skills in 3D printing, especially in resource-limited areas. Another focus that he currently has been trying to help improve is the state of medical education via the use of 3D printing. His focus on changing medical education through 3D printing has stemmed from his own experiences as working as an anatomy teaching assistant and the need to see more diseases in his own hands.

THE DESIGN AND DEVELOPMENT OF 3D-PRINTED TABLETS FOR NEUROLOGICAL DISORDERS: CURRENT STATUS, CHALLENGES, AND FUTURE TRENDS

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Abstract

The technology of 3D printing is a burgeoning field that has great promise for transforming the pharmaceutical sector. In essence, 3D printing is a fabrication method where materials are deposited layer by layer to produce a variety of desired shapes. The use of computer-aided design (CAD) in 3DP technology, makes it possible to manufacture medication, formulations with the appropriate release rate and pattern. In 2015, the first 3D Printed tablet Spritam (levetiracetam) was approved by the US Food and Drug Administration (FDA). Different 3D Printing techniques have been developed to fabricate novel solid dosage forms, among which are the most well-known and discrete products today. 3D Printing can include a variety of new possibilities to optimize medicines. Patients suffering from neurological conditions or disorders can benefit from this technology. It overviews the primary 3DP methods and covers various potential and present applications, from customizable polypills to neurosurgery. All prospects point to a rapid development of this manufacturing tool over the next years intending to improve patient's quality of life.

Keywords: 3D Printing, Computer-Aided Design, Optimized Medicine, Layer by Layer, Novel technology, Spritam, Polypills, Neurological Conditions

Biography

Jeevandeep Mishra is working as an Assistant Professor in Department of Pharmaceutics at Indore Institute of Pharmacy, Indore. He is also a Ph.D. scholar at Medi-Caps University, Indore, India. He completed his M. Pharm from IPS Academy College of Pharmacy, Indore. With his M. Pharm background, he has already acquired a strong foundation in pharmaceutical knowledge and principles. His academic journey reflects a deep-rooted passion for the field of Pharmaceutics, marked by his unwavering commitment to the field. His primary research focuses in the field of 3D Printing in Pharmacy, and because of his firm commitment he is continuously upgrading himself in this field. He is continuously focusing from designing, delivering and targeting the novel ideas to overcome the future challenges. He is rigorously doing a lot of work by publishing papers in various prestigious journals, he was able to publish and present his work on 3D Printing in Pharmaceutical Sciences at International Forum (Amsterdam, Netherlands). He also presented posters based on 3D printing in Pharmaceutical Sciences at an International conference at Dubai (UAE). His dedication and knowledge continue to inspire and shape the future of Pharmaceutical Sciences by getting command over the technology and its outcomes.

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