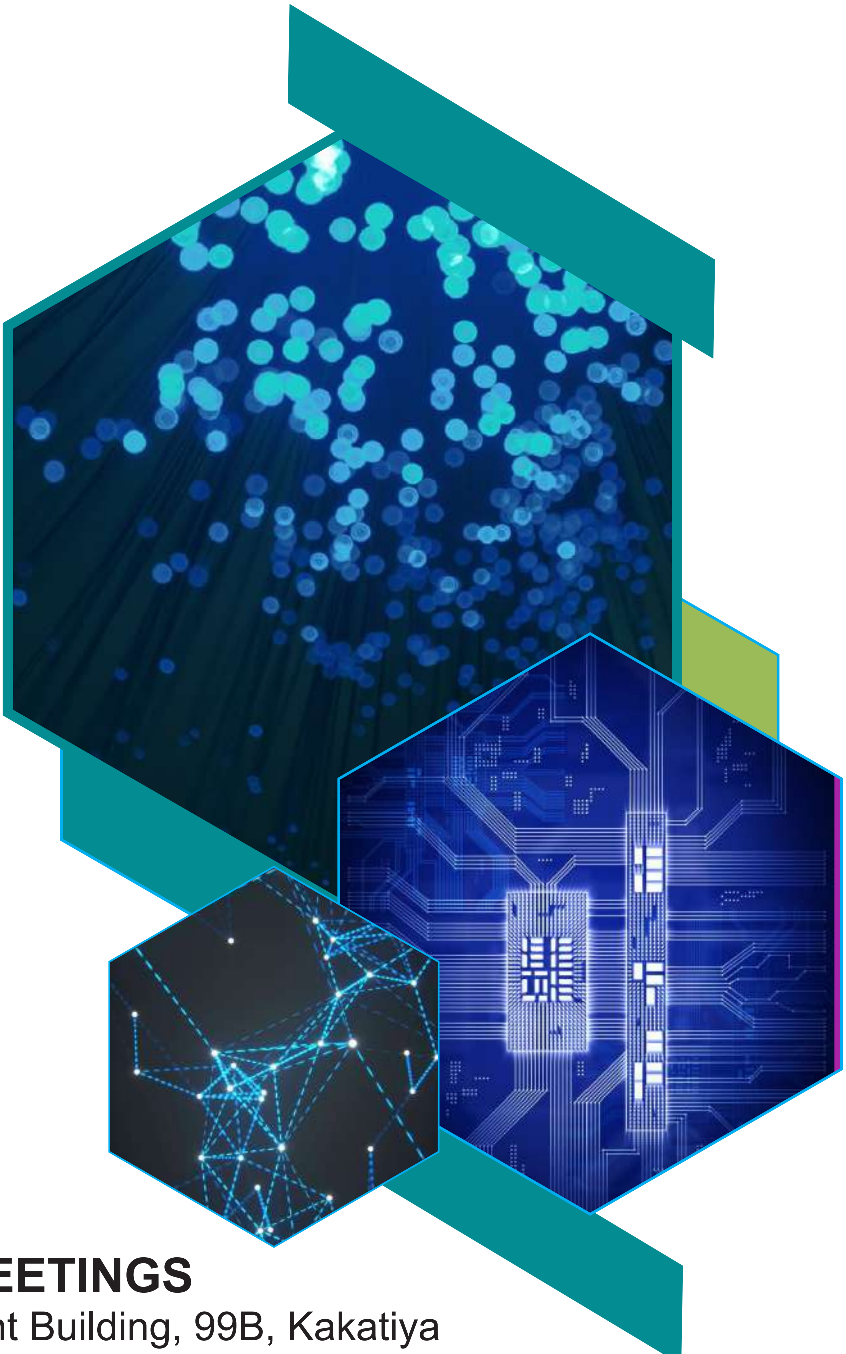
3DPRINTINGMEET2022

2nd International Meet & Expo on 3D Printing and Additive Manufacturing

Novmber 07-08, 2022 | Webinar



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Floor# 3, Advant Building, 99B, Kakatiya
Hills, Kavuri Hills, Madhapur Hyderabad,
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FOREWORD

Dear Colleagues,

It is our pleasure to invite all of the scientists, academicians, young researchers, Business delegates and students from all over the world to attend the 2nd International Conference on 3D Printing and Additive Manufacturing will be held in Chicago, USA during November 07-09, 2022.

3DPRINTINGMEET2022 shares an insight into the recent research and cutting edge technologies, which gains immense interest with the colossal and exuberant presence of young and brilliant researchers, business delegates and talented student communities.

3DPRINTINGMEET2022 goal is to bring together, a multi-disciplinary group of scientists and engineers from all over the world to present and exchange break-through ideas relating to the 3D printing and Additive manufacturing. It promotes top level research and to globalize the quality research in general, thus makes discussions, presentations more internationally competitive and focusing attention on the recent outstanding achievements in the field of 3D Printing and Additive Manufacturing.

We’re looking forward to an excellent meeting with scientists from different countries around the world and sharing new and exciting results in 3D Printing and Additive Manufacturing.

COMMITTEES

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Assessment of the Formation and Structure of 3D Printed and 3D Woven Fiber-Reinforced Composites

Abdel-Fattah M. Seyam*, S M Fijul Kabir, and Kavita Mathur

Wilson College of Textiles*

North Carolina State University, Raleigh, North Carolina, USA

* Email: aseyam@ncsu.edu

* Tel: +1 919 515 6583

Abstract

Due to their high strength to weight ratio compared to traditional materials, 3D woven (3DW)fiber-reinforced composites are the choice for numerous high performance products and markets such as aerospace, automotive, marine, building structures, defense, wind turbine blades, and leisure. 3D woven fiber-reinforced composites can be engineered to meet performance requirements by controlling fiber volume fraction from extremely low to extremely high and use of different fiber constituents (hybridization). Additionally, they can be formed to complex shapes (I, T, box, truss, cellular, etc.) and structures that are resistance to delamination and multi-hit protective capability. However, the formation of 3D woven fiber-reinforced composites requires long flow chart of processes that encompass yarn preparation, back winding, warping, drawing-in, weaving machine setting and programming, mold manufacturing, and resin infusion.

Three-dimensional printing (3DP) is a fast growing technology that has been recently advanced to form 3D fiber-reinforced composites from continuous flat yarns in the form of printable composite filament. With such advance, 3DPcomposites are qualified for high performance applications similar to 3DW composites and as such, 3DP technology is perceived as strong contender to 3DWtechnology because of its versatility in formation of even more complex shapes compared to 3DW without the need for the long flow chart of processes. However, the productivity of 3DP is currently much slower than 3DOW. Moreover, the limited materials available, lack of hybridization, and delamination, which causes premature failure, of 3DP composites are serious issues that need to be addressed. Detailed assessment of the two technologies is the topic of this presentation based on extensive research under taken at NC State University Wilson College of Textiles.

Modular Design of 3D-printed Concrete Arches for Mass Customization and Rapid Construction

Alexander Lin[1], Abhimanyu Goel1, De Hui Alwin Wong[1], Charlene Yeo1, Jacky Chung[2], Sze Dai Pang[3], Chi-Hwa Wang[4], Hayden Taylor[5,6]*, Harn Wei Kua[1]*

1. Department of the Built Environment, National University of Singapore, 4 Architecture Drive, Singapore 117566
2. Industrial Centre, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong
3. Department of Civil and Environmental Engineering, National University of Singapore, 1 Engineering Drive 2, Singapore 117576
4. Department of Chemical and Biomolecular Engineering, National University of Singapore; 4 Engineering Drive 4, Singapore 117585
5. Department of Mechanical Engineering, University of California, Berkeley, CA 94720. USA.
6. Berkeley Education Alliance for Research in Singapore, #11-01 CREATE Tower, 1 CREATE Way, Singapore 138602

* Corresponding Authors E-mail: hkt@berkeley.edu (HT) and bdgkuahw@nus.edu.sg (HWK)

Abstract

Conventional approaches for constructing arch structures by casting concrete in formworks provided limited flexibility for customizing shape/configuration of the arch and its usage of formworks and temporary shoring (i.e. falsework for supporting the partially constructed structure) significantly increased the manpower, costs and construction time. To address these limits, this study proposed a design-to-fabrication approach for an arch system fabricated by concrete 3D-printing, a formwork-free additive manufacturing process not only allowing mass customization of arch structures but also eliminating the usage of formwork and temporary supports. With incorporation of modular design, concrete segments were 3D-printed with relatively small 3D-printing equipment available in the industry and then, were interlocked together to form larger arch structures in full scale without usage of temporary shoring. Stability and strength analyses were incorporated to the proposed approach to guarantee the structural integrity of the arch at various construction stages and make sure that the fully assembled arch became a compression dominated structure providing an efficient load transfer mechanism. This study demonstrated the feasibility and scalability for deploying 3D-printed concrete arch for mass customization and rapid construction and provides a good outlook for

deploying additive manufacturing for other types of compression-dominated structures with more complicated shapes.

Keywords
Concrete 3D-printing; Arch; Modular Construction

Biography

Dr. Alexander Lin obtained his PhD/M.S. from SEMM (Structural Engineering, Mechanics and Materials) program in Department of Civil & Environmental Engineering in University of California at Berkeley (UC Berkeley), and his B.S. in Civil Engineering from National Taiwan University. After his doctoral study with a research focus in high performance cement-based composites and fiber reinforced concrete, he served as a postdoctoral research fellow for one year in a collaborative project between UC Berkeley and National University of Singapore where his research direction gradually changed to construction 3D-printing. Afterwards, he started to serve as a senior lecturer (2019 to present) in Department of the Built Environment in National University of Singapore (NUS). He is currently also a co-lead for the Thrust of AM (Additive Manufacturing) Enabled Design and Environment in Centre for Additive Manufacturing in NUS. His research team is currently focusing on integrating novel materials/technologies and building component designs for concrete 3D printing, especially in modular construction, novel interlock and reinforcement system and multi-functional cellular building components.

Additive Manufacturing of Microcellular Thermoplastic Foams

Amir Ameli*

Department of Plastics Engineering, University of Massachusetts Lowell, USA

Amir_Ameli@uml.edu

Abstract

There is a need for printed foams in a wide range of applications such as custom care and protective gear, propellant materials, impact absorbers, insulators, etc. Printed foams can combine the functionalities of cellular structures with the advantages of 3D printing process while offering light-weighting. The purpose of this study was to investigate the feasibility of in-situ foaming in fused filament fabrication (FFF) process without any need for specialized printing equipment. Thermally expandable microspheres (TEMs) were employed as foaming agent. The steps included the design of suitable material system, the fabrication of unexpanded filaments loaded with TEMs, and the establishment of in-situ foam 3D printing process. Several thermoplastics materials including polylactic acid (PLA), thermoplastic polyurethane (TPU) and polycaprolactone (PCL) were examined as the printing material. The results revealed that a proper combination of thermoplastic matrix, TEM type, and other additives such as plasticizer together with a carefully designed filament extrusion process is able to successfully deliver expandable filaments. Further, once used as feedstock for FFF process, the expandable filaments were able to foam during printing process and impart closed-cell microcellular structure to the printed parts. It was also found that the material composition and the printing process conditions have profound impacts on the density and morphology of the printed parts and can be used as control factors during in-situ foam printing process.

Biography

Amir Ameli is an Assistant Professor of Plastics Engineering at UMass Lowell. His research interests encompass material design and advanced manufacturing of functional polymeric systems. His recent focus has been on the additive manufacturing of polymer nanocomposites and foams. He received his PhD from the University of Toronto in 2011. He was the NSERC and MITACS postdoctoral fellow in Canada 2011-2014. Prior to joining UMass Lowell, he served as an Assistant Professor of Mechanical and Materials Engineering at Washington State University from 2015-2019. He has published 60+ journal articles and 110+ conference papers.

Photopolymerized Acrylate/Zeolite Composites for 3D Printing, Adsorption and Ion Exchange Applications

Yijun Zhang[1,2], Yuanyuan Gao[1,2], Jacques Lalevée[1,2],

Angélique Simon-Masseron[1,2*]

[1]University of Haute-Alsace, Mulhouse Materials Science Institute (IS2M) CNRS UMR 7361, 3b rue Alfred Werner, 68093 Mulhouse Cedex, France

[2]University of Strasbourg, France

* angelique.simon-masseron@uha.fr

Abstract

In recent years, photopolymerization has been found wide applications in industry and daily life, while many defective properties of polymers limit their development, including compressive strength, mechanical properties and functions. Photopolymerization of highly filled polymers still faces its challenge, for the poor light penetration caused by absorption and scattering.
Zeolites are microporous solids with many industrial applications as adsorbents, catalysts for example. They are a set of crystallized aluminosilicates consisting of a framework based on three-dimensional structure of SiO4 and AlO4 tetrahedra molecules linked to each other by sharing oxygen. The existence of trivalent aluminium gives the framework negative charges which need to be compensated by extra-framework cations. As fillers, zeolite can improve mechanical properties of zeolite/polymer composite and transfer their properties to composites. Furthermore, compared to other technologies, 3D printing through photopolymerization represent advantages such as high production rate, mild reaction temperature, absence of volatile organic compounds (VOCs), low energy consumption, excellent spatial and temporal control, etc.
Various types of zeolite filler were studied (FAU, LTA, *BEA, EMT) with different monomer (e.g. trimethylolpropane triacrylate (TMPTA), di(trimethylolpropane) tetraacrylate (TA), 1,6-hexanediol diacrylate (HDDA), pentaerythritol triacrylate (PETIA), poly(ethylene glycol) diacrylate (PEGDA)). The polymerization results were evaluated mainly through the depth of cure (DOC), scanning electron microscope (SEM), dynamic thermomechanical analysis (DMA), thermo gravimetric analyses (TGA), water swelling property, volume shrinkage, numerical optical microscopy and colorimetric analysis experiments. Further, laser writing technique has been applied to the light-induced polymerization on zeolite-resin composites, and some 3D patterns with excellent spatial resolutions produced, demonstrating the meaningful effect of the selected fillers on the photo polymerization. 4D behaviour of PEG-acrylate-zeolite composites has been originality shown from the ability of the 3D objects to adapt their shape in presence of water.
We fabricated highly filled composites with very high filler contents (up to 80-95 wt%) under mild photo polymerization conditions (visible LED light irradiation, room temperature, under

air). Composites with high filler-contents were treated at high temperature through a debinding procedure and their porosity has been evaluated. Thus, we showed that calcined composites (monoliths) had adsorption properties for gas (CO2, water) and ion exchange capacities (with Sr2+ and Ni2+).

Some step-like object with 3D structure was also obtained by 3D printing technique noted “layer by layer Molding/Curing”.

Hence, as a great breakthrough, this work is expected to lead to a valuable development in the field of photo polymerization in quite highly filled composites. This also will expand their potential applications for 3D printing in the fields of high-performance lightweight materials and adsorption, and opens the door to a new process of zeolite shaping.

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Keywords

photo polymerization; acrylate/zeolite composites; 3D printing; adsorption

Biography

Angélique Simon-Masseron is full Professor of Chemistry at the University of Haute-Alsace, Mulhouse (France) since 2010. Her research interests focus on microporous materials. After her PhD studies on zeolite acidity in 1998, her research focused on the synthesis of zeolitic materials (metallophosphates, zeolites) and metal–organic frameworks. She is currently working on zeolite/polymer composite development i) for 3D printing, ii) to improve mechanical properties of composite, and iii) to transfer zeolite properties to composite. She is also interested by the recovery of co-products/wastes for the synthesis of zeolitic materials. She was President of the French Zeolite Association (GFZ) from 2014 to 2016 and project manager to the French Chemical Society from 2018 to 2021.

3D & 4D Micropringting by direct laser writing

Arnaud Spangenberg[1*]

[1]Université de Haute-Alsace, CNRS, IS2M UMR 7361, F-68100 Mulhouse, France

[2]Université de Strasbourg, France

*Corresponding Author E-mail: arnaud.spangenberg@uha.fr

Abstract

3D direct laser writing based on two photon polymerization has emerged as a very popular 3D microfabrication method since it can be seen as an extension of 3D printer at the micro and nanoscale. Moreover, this technology has proven its unrivalled ability to sculpt the matters at the nanoscale, as highlighted by major breakthroughs in various fields, for instance in photonics [1] or nanomechanics [2]. On the other hand, 4D printing concept appears in 2013 with the idea to facilitate the assembling of macroscopic objects [3]. Nowadays, the fourth dimension refers not only to the ability for material objects to change form after they are produced, but also to their ability to change function after they are printed. Up to recently, the 4D printing was mainly explored at the macroscopic level, but several working groups have revealed the potential of 4D printing at the microscale. After a short introduction on 3D DLW principles, I will then discuss about the opportunities offered by micro-4D printing and how to introduce functionality into the microstructures. A special attention will be paid to the difficulties encountered to process functional/adaptive materials and to the role of the processing parameter to program or impact their final properties. In that context, I will talk about photo-controlled reversible addition-fragmentation chain transfer (RAFT) polymerization in 3D DLW and show how it can provide a convenient way to tune the surface properties of the 3D printed object. In this work, one macro-photoiniferter, synthesized by photocontrolled RAFT polymerization, is applied to 3D direct laser writing. Thanks to the exquisite spatial control of the photoreaction, 3D microstructures with feature sizes of around 500 nm are successfully obtained. Taking advantage of the presence of dormant polymeric RAFT agents, photo-induced post-modification of the printed microstructures is highlighted via the elaboration of multi-chemistry patterns including thermo-responsive ones. [4] These results open new perspectives in multi-material and 4D micro-printing.

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Keywords
3D direct laser writing, 4D micro-printing, two photon polymerization, controlled radical polymerization

Biography

Dr. Arnaud Spangenberg studied Molecular Physical Chemistry at the Paris-Sud University (Orsay, France) and received his PhD (2009) from the ENS Cachan dealing with the design and the characterization of photoswitchable nanosystems. At the University of Amsterdam, he spent two years as post-doctoral fellow in A.M. Brouwer's group (HIMS, UvA) and developed a wide variety of experimental techniques related to single molecule fluorescence spectroscopy (including FLIM, FCS, FLCS, ...). In 2011, he was the recipient of the "ANR retour PostDoctorant" career development grant of the French National Research Agency focused on new insight in two-photon photopolymerization. Since 2013, he has now a permanent position as CNRS researcher in IS2M (Material Science Institute of Mulhouse) where he is developing multi-scale additive manufacturing and associated functional materials.

Additive manufacturing in support of optical-based applications: two case studies

Valentina Bertana*, Francesco Perrucci, Felice Catania, Luciano Scaltrito, Fabrizio Pirri, Sergio Ferrero

Politecnico di Torino, Department of Applied Science and Technology, Corso Duca degli Abruzzi 24, 10129, Turin (Italy)

*Corresponding Author E-mail: valentina.bertana@polito.it

Abstract

The possibility to control and manage the electromagnetic radiation, often wrongly referred to as 'light', is always of big interests for many different applications, going from the communications field to medicine and energy harvesting. From a research point of view, lot of applications to investigate means high degree of freedom in design and the necessity to fabricate devices in small series. For these reasons, Additive Manufacturing stands out as the optimum technology to prepare models, unconventional testing setups and functional prototypes. In this view, our group at Politecnico di Torino is equipped with different rapid prototyping technologies and collaborates with several groups. Two case studies from our running projects will be presented: one regarding the fabrication of micrometric optical accelerators, one regarding the customization of a testing setup for SiC optical microrings. Two pretty different works which perfectly demonstrate the versatility of Additive Manufacturing.

Keywords
Additive Manufacturing; Integrated Systems; Two Photon Polymerization; Polyjet printing

Biography

Valentina Bertana received her BSc and MSc Degree in Biomedical Engineering at Politecnico di Torino in 2013 and 2015 respectively. In February 2020 she received her PhD degree at Politecnico di Torino in Electrical, Electronic and Communication Engineering. She is a PostDoc (Academic Discipline FIS/03 – Physics of Matter) at the Department of Applied Science and Technology (DISAT) of Politecnico di Torino. Her research activities are mainly focused on additive manufacturing, smart materials, integrated systems and microfluidics.

Multi-scale Modelling-engineered 3D-printed Catalytic Reactors

Blaž Likozar*, Sašo Gyergyek, Anja Sedminek, Andraž Kocjan, Monika Kus, Vesna Middelkoop

Blaz.Likozar@ki.si

Abstract

The use of magnetic nanoparticles as sources of heat is attracting significant attention in the field of catalysis. The possibility to localize the heat through the magnetic-nanoparticles-mediated conversion of electrical energy is an enabling technology capable of pushing many catalytic processes to their kinetic limits.[1] We have developed nanocomposite materials composed of magnetic-nanoparticles-containing alumina which were used to 3D print monoliths.[2] When decorated with well-dispersed Ru nanoparticles these catalysts, when exposed to an alternating magnetic field, efficiently and selectively catalyzed many chemical conversions such as hydrogenation of levulinic acid[3], furfural[4], ammonia decomposition and ammonia synthesis reaction.

To this end, innovative 3D printed multi-channel catalyst monoliths can be developed and tested at lab scale for a range of chemical applications. [5], [6]. Their design can be realised using emerging 3D printing technologies such as Direct Ink Write (DIW) to lay down functional materialwith high fidelity and repeatability. DIW involves the extrusion of the viscous paste through a thin nozzle in a layer-by-layer fashion using a CNC (computer numerical control) machine and an x,y,z-table. A highly defined 3D network is designed to offer an exact control of mass- and heat transfer, flow dynamics, mixing and accessibility to active particles.

What is more, multi-scale modelling simulations can in silico predict, optimize or engineer the functionalities of a reactor unit operation; that is from the atomic scale catalysis to fluid flow structuring, inherently related to packing additive manufacturing, which is tunable. Herein, many such examples will be demonstrated, starting from technology itself, spanning the latter to multi-scale modelling simulation, tackling catalysis, but also transport.[7]

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Nanoparticle printing and sorting with an opto-thermomechanical method

Chenglong Zhao*

Department of Physics, Department of Electro-Optics and Photonics, University of Dayton, 300 College Park, Dayton, Ohio 45469- 2314, USA

*Corresponding Author E-mail: czhao1@udayton.edu

Abstract

We demonstrate an opto-thermomechanical (OTM) nanoprinting method that allows us not only to additively print nanostructures with sub-100 nm accuracy but also to sort nanoparticles based on its properties under ambient conditions. Different from other existing nanoprinting methods, this method works when a nanoparticle on the surface of a soft substrate is illuminated by a continuous-wave (cw) laser beam in a gaseous environment. The laser heats the nanoparticle and induces a rapid thermal expansion of the soft substrate. This thermal expansion can either release a nanoparticle from the soft surface for nanoparticle sorting or transfer it additively to another surface for nanoprinting with sub-100 nm accuracy. Details of the printing mechanism and parameters that affect the printing accuracy are investigated. This additive OTM nanoprinting technique paves the way for rapid and affordable additive manufacturing or 3D printing at the nanoscale under ambient conditions.

Keywords
Nanoprinting; Additive manufacturing; Laser printing; optothermal expansion

Biography

Dr. Chenglong Zhao is an associate professor with a joint appointment in the Department of Physics and Department of Electro-Optics and Photonics at the University of Dayton. He received his Ph.D. from Peking University (Beijing, China) in 2011. Then, he worked at the National Institute of Standards and Technology (NIST) and the Pennsylvania State University. He leads the Nano-photonic & Nano-manipulation (NPNM) Lab, which is dedicated to developing cutting-edge nanotechnologies for additive nano-manufacturing, super-resolution nano-imaging and ultra-sensitive bio sensing. Prof. Zhao has authored and co-authored over 30 journal papers including Nature Communications, Nano Letters, ACS Nano, Light: Science & Applications, Nanoscale etc. His research findings have been widely reported by Science Daily, Physics News, National Science Foundation, Science Codex, Science News, Nano Werk, etc. His NPNM lab has been funded by National Science Foundation (NSF), National Institute of Health (NIH), and Air Force Research Laboratory (AFRL).

Improving mechanical properties and corrosion resistance of additively manufactured 316L stainless steel by ultrasonic severe surface rolling

Guosong Wu[1],* , Jiapeng Sun[1], Ying Liu[1], and Qisheng Sun[1]

[1]College of Mechanics and Materials, Hohai University, Nanjing 211100, China

* Corresponding Author E-mail: wuguosong@hhu.edu.cn

Abstract

Gradient heterogeneous structure (GHS) architecture is introduced into additively manufactured 316L stainless steel in this work by ultrasonic severe surface rolling to improve its mechanical properties and corrosion resistance. After the surface treatment, a type of interesting GHS architecture as a microstructure gradient system is successfully obtained, which is composed of a gradient structured outer layer and a hierarchically hetero-structured interlayer. Accordingly, 316L stainless steel with this gradient heterogeneous structure (GHS) has a combination of good strength and high ductility, which stems from the high microstructural heterogeneity. Moreover, the corrosion resistance in the 3.5% NaCl solution of the treated 316L stainless steel is also improved because of the formation of a nanostructured, chemically homogeneous and high quality surface, which paves a new way for preparing high-performance additively manufactured parts used in marine equipment and engineering.

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Keywords

Selective laser melting; Gradient; Heterogeneous structure; Corrosion

Biography

Dr. Guosong Wu is a full professor at Hohai University in China. In 2007, he received his PhD degree from Shanghai Jiao Tong University in China. He worked as a researcher at the Chinese Academy of Sciences, City University of Hong Kong and Kwangwoon University in South Korea for about 10 years before joining Hohai University. His research interests include surface engineering, corrosion science, additive manufacturing, and plasma related technologies. So far, he has published more than 100 academic papers that have been cited over 3700 times according to Scopus and is listed among the World's Top 2% Scientists (Career-long impact: 2020-2022) according to metrics compiled by Stanford University. Now, he is working as an editorial board member for 7 international journals, including Scanning as Chief Editor.

Direct fabrication of tube with high-quality inner surface via metal droplet depositing on soluble supports

Hao Yi[1,2,*], Lehua Qi[3]

1. State Key Laboratory of Mechanical Transmission, Chongqing University, Chongqing 400044, China
2. College of Mechanical and Vehicle Engineering, Chongqing University, Chongqing 400030, China
3. School of Mechanical Engineering, Northwestern Polytechnical University, Xi'an 710072, China

*Corresponding Author E-mail: haoyi@cqu.edu.cn (H. Yi)

Abstract

Metal droplet printing is a branch of additive manufacturing technologies. In the manufacturing process, micro metal droplets are forced out of a nozzle driven by external excitation disturbance. By elaborately regulating of droplet ejection and the 3D movement of substrate, metal droplets are successively deposited to form a 3D object according to the preset scanning traces. This technique dispenses with special raw materials or expensive equipment, and it has broad application prospects, such as printing of micro and complex structures, functional devices, heterogeneous parts, electric circuit and packaging. However, because this technique uses discrete metal droplets as the basic building cells, the directly printed parts usually possess scalloped surface morphologies. Such uneven surface morphologies can be hardly eliminated via optimizing the processing parameters due to the nature of metal droplet printing technique. The surface qualities of these printed parts should be further improved in virtue of some subtractive post-processing technologies. But the inner cavity surfaces of micro parts with complex structures are typically difficult processing regions, the surface qualities of these inner surfaces are also very difficult to be improved via subtractive post-processing technologies. Therefore, how to improve the inner surface quality has become one technical bottleneck in the fabrication of micro-complex parts with high precision.

To this end, for the first time, we combine metal droplet-based 3D printing technology with soluble core technique. The method of eliminating the uneven inner surface morphologies of the printed parts via soluble support is proposed, i.e., precise control of aluminium droplets depositing on a soluble core with preset shapes and dimensions. The soluble support is then dissolved and left behind a tubular structure with high-quality inner surfaces. The formation mechanism of inner surface defects of the printed parts is revealed using both experimental and modelling methods. The corresponding control strategies of the forming qualities are then proposed, and metal tubes with high-quality inner surfaces are directly fabricated, which further verifies the effectiveness of the proposed printing strategies. This research lays the

foundation of engineering application of metal droplet-based 3D printing in the fields of the fabrication of tubes with high-quality inner surfaces.

Keywords
metal droplet printing; gas hole; cold lap; controlled deposition; soluble support; inner surface quality

Biography

Dr. Hao Yi is currently an Assistant Professor (doctoral supervisor) in the College of Mechanical Engineering at Chongqing University, China. He received the B.S. degree in mechanical engineering from Northwest Agriculture & Forestry University, China, in 2012, and the Ph.D. degree from Northwestern Polytechnical University, China, in 2019. He is serving as Associate Editor for Journal of Mechanical Engineering Science (Proc. IMech E Part C), Experimental Techniques, Micro & Nano Letters, and Editorial Board Member for Frontiers in Materials, Advances in Materials Science and Engineering, Materials Science-Medziagotyra, etc. His main research interests focus on 3D Printing and Additive Manufacturing, Green Manufacturing, Production Research, etc.

T Progress of 3D-Printing via enhanced photopolymerization of new materials and Multiple-lights (lasers)

Jui-Teng Lin

New Photon Cor. and Medical Photon Inc, New Taipei City, Taiwan

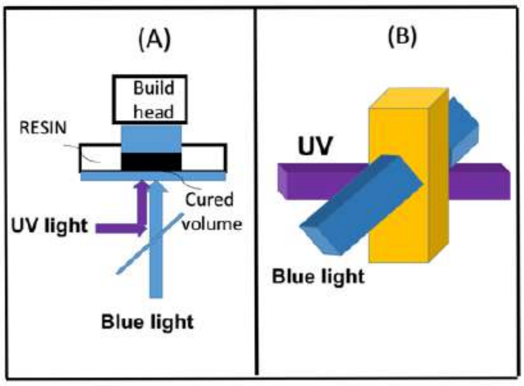
*Corresponding Author E-mail: jtlin55@gmail.com

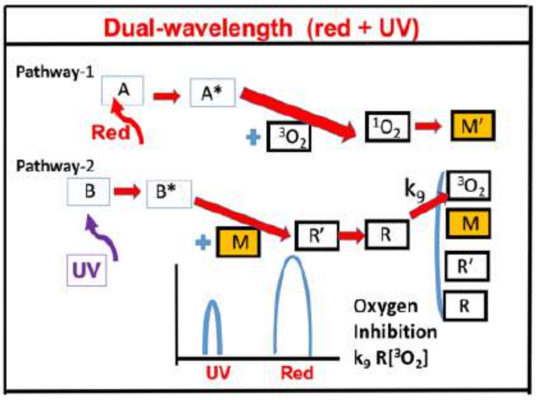
Abstract

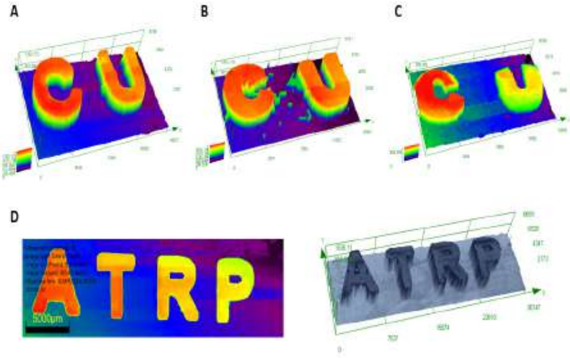
Objectives: the enhancing strategies for various photopolymerization systems are reviewed by kinetic schemes and the associated new materials and measurements for 3D printing and additive manufacturing (AM). Methods: Solving the rate equations of the system kinetic to find the conversion efficacy for various photopolymerization systems include [1-6]: (i) synergic effects by a 3-initiator C/B/A system, having an electron-transfer and oxygen-mediated energy-transfer pathways; (ii) copper-complex photoredox catalyst [5] for free radical (FRP) and cationic photopolymerization (CP); (iii) dual-wavelength (UV and blue) controlled photopolymerization confinement (PC) [3]; (iv) dual-wavelength (UV and red) selectively controlled 3D printing [4]; (v) 3-wavelength (UV, blue, red) systems; and (vi) polymer composites with Fe and graphene fillers for improved properties and enhanced depth of curing (DOC) via a dual photo-thermal polymerization process [6].

Results:

Figure 1 (left) shows the schematics of photochemical dual wavelength (blue and UV) controlled volumetric 3D printing and AM for parallel lights and orthogonal lights patterns [3]. As shown in Figure 1 (right), the strategies for controlled initiation-inhibition switch based on two mechanisms: (i) oxygen-inhibition for improved conversion, and (ii) radical-inhibition for spatial confirmation in 3D printing. Example of Figure 1(right) was reported by Childress et al [4], based on DEGEEA mixed by ZnTTP, having distinct absorption peak at UV-365 nm and red-635 nm, such that it can be independently excited by a UV and red light, respectively. As shown by Figure 2, polymerization can be induced by the photo-radical (R) and enhanced by the thermal-radical (R’). A specific measured system was reported by Ma et al. [6] for photoinitiator Irgacure 369, B is a co-initiator of the charge–transfer complex (CTC), and the M is the monomer TMPTA, filled with filler iron (Fe) or few layer graphene (FLG) [6]. Our formulas show the depth of curing (DOC) is an increasing function of the light intensity, but a decreasing function of the filler and photoinitiator concentrations. The DOC is enhanced by the additive enhancer (B).







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Keywords

3D printings; additive manufacturing; polymerization kinetics; monomer conversion; synergic effects; free radical; UV light

Biography

Prof. Jui-Teng Lin received his Ph.D in physical chemistry from the University of Rochester (NY). His current positions include: Chairman & CEO of Medical Photon, Inc. (Taiwan); New Photon Corp, and Visiting Professor of HE Medical University (China). He is the Editor in Chief of: Open Access J of Ophthalmology Research (OAJOR): Editorial Board of: Novel Approaches in Cancer Study; AS Ophthalmology. Guest Editor: Polymers (Special issue, 2022). Fellow of American Society of Laser Surgery & Medicine (ASLSM). Inventor of : Flying-spot scanning laser for PRK, Lasik (US pats, 1991-92); Laser Presbyopia Reversal (US pats, 2002, 2004). Awards: WHO's WHO in Leading American Executives (1993); Model of oversea Chinese Young Entrepreneur (1997). Prof. Lin has published 55 book chapters and approx 300 peer-review papers, including about 120 SCI-indexed journal papers. Research areas: photochemistry, phototherapy, vision corrections, corneal surgery, medical lasers design, kinetic modeling.

Additive Manufactured Biomedical Metals For Orthopedic Applications

Liqiang wang[a,b*]

[a.]State Key Laboratory of Metal Matrix Composites, School of Material Science and Engineering, Shanghai Jiao Tong University, No. 800 Dongchuan Road, Shanghai, 200240, China

[b.]National Center for Translational Medicine, Shanghai Jiao Tong University, No. 800 Dongchuan Road, Shanghai 200240, China

*Corresponding Author E-mail: wang_liqiang@sjtu.edu.cn (L. Wang)

Abstract

Currently, additive manufacturing (AM) is a promising method to manufacture titanium and its alloys with complex structures for biomedical implants. Owing to the excellent mechanical properties and biocompatibility of titanium alloys, AM-produced titanium alloys have attained significant research interests in the past a few years. As a result of their high strength, light weight, superior elastic properties, and good biocompatibility, various porous structures of titanium alloys have been developed for bone implants in the tissue engineering field. Commercial Ti6A14V alloy is used for biomedical implants owing to their good mechanical strength and complex structure. However, one of the significant drawbacks of Ti6Al4V alloy is its toxic element content, i.e., Al and V, which might lead to an allergic reaction and Alzheimer's disease in patients. Furthermore, the "stress shielding" effect resulted from the mismatch of the Young's modulii between the implants and the bones is additional shortcomings of the $\alpha + \beta$ titanium alloys. Therefore, one realistic way to solve this problem is to design titanium alloys with a low modulus. In addition, introducing a special porous structure is considered as an alternate to reduce Young's modulus to a certain extent. More importantly, the porous structures could promote bone in growth and accelerate stress transfer from the implant to the bone.

Keywords
3D printing, biomedical metals, orthopedic applications

3D Surface Inspection and Printing

Manuel F. M. Costa*

Universidade do Minho, Centro de Física da Universidade do Minho e da Universidade do Porto, Campus de Gualtar, 4710-057 Braga, Portugal

mfcosta@fisica.uminho.pt

Abstract

3D metrology with a market in 2022 in the order of 11 billion USD is becoming more and more important for 3D printing. On the other hand, 3D printing can give an invaluable contribution to 3D metrology and the evaluation and interpretation of the results of 3D inspection. Non-destructive dimensional inspection of surfaces is an issue of utmost importance in a large number of situations in R&D and at the industrial world. An increasing number of surfaces and surface types must be 3D characterized in a non-destructive non-invasive way. Statistical parameters, both 2D and 3D, are fundamental to a useful quantitative characterization of the surface' relief. However, the two and tridimensional magnified representation of the microtopographic structure of the surface, allowing a comfortable and detailed visualization of the relief structure, gives very meaningful insights and is more and more requested. Increasing computer processing power and speed and new software allows our days a very efficient visual inspection of the results of the microtopographic inspection of surfaces and parts. Recently the resolution accuracy and reliability of 3D printers is achieving rather interesting figures. It is now possible not only to visualize, in a high-resolution screen, the amplified 3D relief structured of the surface but also it is possible to 3D print it. The "tactile" visualization of the 3D printed physical model of the inspected surface is an interesting experience that may lead to a fast meaningful assessment of the relief of the inspected surface. Optical triangulation in different approaches allow the establishment of metrological systems that by its inherent relative simplicity versatility robustness and reliability can cope with most modern requirements of the non-invasive inspection of objects and surfaces both smooth or rough. In this communication we will present a brief review of the work done at the Microtopography Laboratory of the Physics Department of the University of Minho, Portugal, on the optical triangulation based microtopographic inspection of surfaces.

Keywords
3D metrology; microtopography; 3D modelling; surface inspection

Biography

Manuel F. M. Costa hold a PhD degree in Science (Physics) from the University of Minho (Portugal) where he works since 1985 at its Physics Department teaching and performing applied research in optical metrology, image processing, thin films nanostructures and applications, instrumentation, and, science education and literacy. President of the Ibero-American Optics Network, RIAO, for the term 2019-2022. President of the Hands-on Science Network, HSCI. Deputy Chair of the Scientific Advisory Board of the European Optical Society. Executive Committee member and Europe Regional Representative of the International Council of Associations for Science Education, ICASE. President of the Portuguese Society for Optics and Photonics, SPOF. Fellow of European Optical Society.

3D printing of reversible ceramic nanocomposite fuel cells

Muhammad Imran Asghar[1,2*], Peter D. Lund[1]

New Energy Technologies Group, Department of Applied Physics, Aalto University School of Science, P. O. Box 15100, FI-00076 Aalto, Espoo, Finland.

Faculty of Physics and Electronic Science, Hubei University, Wuhan, Hubei, 430062, China.

*imran.asghar@aalto.fi

Abstract

The synthesis of ceramic nanocompsite materials has improved over time, revolutionizing ceramic fuel cells with better performance at lower temperatures (400-600 oC). Using an optimized electrolyte material composition, a record-high ionic conductivity of 0.5 S/cm has been reached at 550 °C. These promising nanomaterials produced around 1.1 W/cm2 at 550 °C when used in conventional three-layer fuel cells, compared to approximately 0.8 W/cm2 when used in so-called "single-layer cell configuration". Since additive manufacturing, which includes 3D printing and inkjet printing, can create both dense and porous structures with strong mechanical and electrochemical characteristics, it has the potential to revolutionize the production of these cells. Nanocomposite inks and pastes have been synthesized with the appropriate rheological properties and thoroughly examined using the thermal gravimetric analysis, differential scanning calorimetry, dynamic light scattering, viscometer, and tensiometer. The preliminary results of our 3D printed nanocomposite electrolytes are remarable (0.31 S/cm at 550oC) and we envision a performance of >2W/cm2 at 550oC with the help of our robust nanocomposite materials and their fabrication through digital printing. Utilizing the state-of-art electrochemical, spectroscopic and microscopic characterization techniques a systematic study was conducted to understand the mechanisms in the cells.

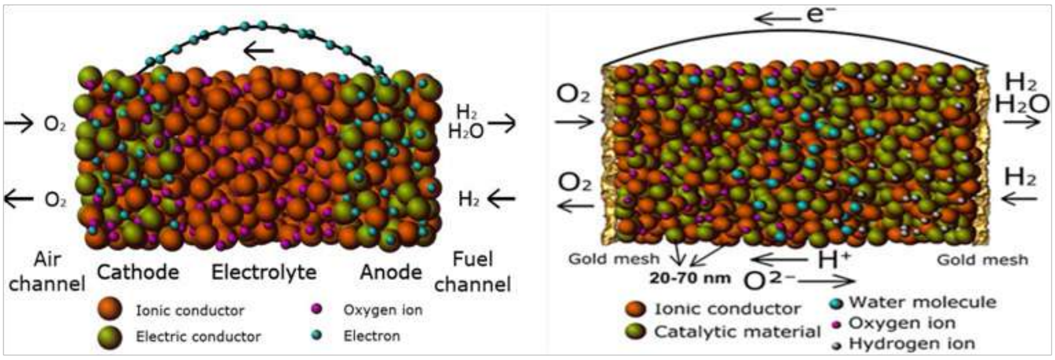

Figure 1: left) Traditional 3-layer ceramic nanocomposite fuel cell, right) Single-layer ceramic fuel cell.

Acknowledgement: This work is supported by Academy of Finland through fellowship projects granted to Dr. Asghar (Grant No. 13329016, 13 352669 and 13322738).

Biography

Muhammad Imran Asghar works in the Department of Applied Physics at Aalto University, Finland as Academy of Finland Research Fellow. He was granted the title of Docent (professor) by the School of Science, Aalto University in 2017. In addition, he is a professor in the Faculty of Physics and Electronics Science at Hubei University in China. He has been awarded with prestigious fellowship by Academy of Finland (2019-2024) and another talent 100 distinguished professor position by Hubei province China (2019-2024). He has been also working in the Finnish industry as well. He worked in Marioff Oy (UTC Climate, Control and security) for a year (2018-2019) and in a photovoltaic panel manufacturing company Solar wheeler Oy for a year (2013). He completed his Doctor of Science degree from Aalto University in June 2012, Master's degree in Micro and Nanotechnology in October 2008 from Helsinki University of Technology and Bachelor's degree in Mechatronics Engineering in May 2005 from National University of Science and Technology, Pakistan. He has expertise in ceramic nanocomposite fuel cells, dye-sensitized solar cells, perovskite solar cells, crystalline-silicon solar cells, batteries and other energy technologies. Furthermore, he is an expert on modern printing technologies i.e. 3D printing, ink-jet printing, screen-printing and tape-casting. He has given over 40 invited talks and keynote speeches in renowned international forums and acted as session chairs in many conferences. He is a member of various scientific societies such as American Ceramic Society, The Electrochemical Society, Finnish physical Society, and others. He is an associate editor of prestigious journals including WIREs Energy and Environment, Wiley interdisciplinary reviews and Nanoenergy Advances. He has published over 80 international publications in reputed journals and international conference proceedings. He has supervised numerous Bachelors, Masters and Doctoral theses. He has been given several awards including "Outstanding contribution award" at the 6th Yangzi Rover Delta International Conference on New Energy for his research work on emerging energy technologies.

External-field assisted 3D bioprinting

Prajwal Agrawal[1], Daniel Ahmed[1,*]

[1]Acoustic Robotics Systems Laboratory, Department of Mechanical and Process Engineering, ETH Zurich, Rushlikon, 8803, Switzerland

[*]Corresponding Author E-mail: dahmed@ethz.ch

Abstract

As additive manufacturing has become more prevalent, 3D (bio) printing has attracted many researchers for its potential application in tissue engineering, regenerative medicine, composite manufacturing, and among others. Although 3D (bio) printing has a number of advantages, its speed is limited due to the fact that it can be printed in 0D, 1D, and 2D. In order to overcome this situation in 2019, Kelly et al. have developed Volumetric Printing, which allows objects to be printed in 3D using CT and IMRT scan mechanisms. The use of volumetric printing is currently limited to a single material and to the use of viscous inks and materials due to its relative newness. In my presentation, I will introduce our novel methodology to overcome the disadvantage of volumetric 3D (bio) printing for their utilization in composite, tissue, food, and other industries.

Keywords
Additive Manufacturing; Volumetric Printing; Acoustics; Ultrasound

Biography

Prajwal Agrawal is currently a Research Associate at ETH Zurich, Switzerland working with Dr. Daniel Ahmed on developing cutting-edge fabrication technologies for acoustics robotics, (bio)fabrication, and precision medicine. Previously he worked as a research assistant in Dr. Shrike Zhang’s group at Harvard Medical School and Brigham's and women's hospital, USA working towards fabricating and developing novel techniques for bioprinting and tissue engineering especially for orthapedic, coloidal photonic crystals, and other applications. He has been awarded G.D. Naidu Young Scientist Award, Achievers award, and C.V. Raman Award by VIT for his outstanding academic and co-curricular performance. Moreover, he has been awarded third place for the best poster award at MaP Graduate symposium, 2022. Besides academics, he has collaborated with companies such as Bosch, Mahindra Rise, Natural's Sugar LTD, and others. Among his publications are 10+ papers in high-impact peer-reviewed journals, such as Small Structures, Applied Physics Reviews, Materials Today, Nature Communications, Advanced NanoBiomed Research, and others. He has also written two book chapters. In addition, he has written 2 editorials and 4+ conference papers. Furthermore, he serves as a reviewer for several journals published by Springer Nature and Elsevier.

Mechanical Characterization of 3D-printed Polymers: Experimental Validation of a 2D Orthotropic Constitutive Model

Roberto Torre*, Salvatore Brischetto

Department of Mechanical and Aerospace Engineering, Politecnico di Torino,
Corso Duca degli Abruzzi 24, 10144 Torino, Italy

*roberto.torre@polito.it

Abstract

Components fabricated via Fused Filament Fabrication (FFF) fit well in applications with limited load and dimensions, even in critical fields; an example is given by the structural elements of Unmanned Aerial Vehicles (UAVs). FFF has a critical impact on the mechanical properties of the finished parts. The manufacturing parameters, the post-processing software, the 3D printer itself, and the specific filament lead to an anisotropic response, often associated with an intra-part and a part-to-part variation of the properties. Assessing the compliance of a part with the design criteria is complex, as the general anisotropy is associated with the absence of standardized analysis and characterization processes.

The authors proposed a solution by analyzing components featuring a linear infill with a 100% infill percentage. When the filaments develop in parallel, all oriented in the same direction, the geometrical pattern resembles that of a composite lamina with unidirectional long fibers. The presence of geometrical planes of symmetry might reduce the anisotropy of the parts to orthotropy.

The absence of a standardized approach requires an initial test setup design to standardize the method and define the test features. The parallel with Uni-Directional Composites (UDCs) helps adapt some methodologies: rectangular constant cross-section specimens are used for tensile and in-plane shear properties determination, instead of the classical dog-bones for polymers. The method received a preliminary and quick confirmation through thin components: predictions are excellent once the in-plane behavior is determined, and the Classical Lamination Theory extends to this field. This approach can be used in Finite Element Analysis by defining a 2D orthotropic material through a 3 X 3 reduced elastic coefficients matrixand introducing an infinite shear correction factor for the out-of-plane shear. Three-point bending, simple bending, and bending-torsion tests with different laminations qualify the method, showing higher deviation in deposition directions other than 0° and 90° with respect to the longitudinal direction. The source of this decline could be the kinematic model; a possible solution consists in improving the approach through the First Order Shear Deformation Theory (FSDT). This higher theory requires determining the out-of-plane shear properties to define the factors of the 5 X 5 reduced elastic coefficients matrix. It also enables the use of 2D orthotropic constitutive models in FEA without any additional hypotheses. This work deepens the extension of the approach, discusses the shear tests design through V-notched specimens, and proposes a further validation frame.

Keywords
fused filament fabrication; PLA; experimental campaign; constitutive model

Biography

Roberto Torre received his BSc and MSc Degree in Aerospace Engineering at Politecnico di Torino in 2014 and 2016, respectively. In July 2021, he received his Ph.D. degree at Politecnico di Torino in Aerospace Engineering. During his doctoral career, Dr. Torre focused on Additive Manufacturing, with FFF/FDM as a specific target. His first concern has been to understand the structural behaviour of polymeric FFF/FDM printed elements to encourage their use in the production of functional components. His research activity won the quality prize for Ph.D. students in 2021. Currently, he holds a PostDoc position at the Department of Mechanical and Aerospace Engineering (DIMEAS) of Politecnico di Torino.His research activities are mainly focused on additive manufacturing, polymers, hygro-thermal stress analysis, numerical and analytical solutions for shells, and UAVs. He authored 15 papers published in international journals and serves as a reviewer for many international journals. In addition, he is Guest Editor for a special issue of the Journal of Composites Sciences.

Fused filament fabrication applied to structural components of small drones

Salvatore Brischetto*

Department of Mechanical and Aerospace Engineering, Politecnico di Torino, corso Duca degli Abruzzi 24, 10129 Torino, Italy

*Corresponding Author E-mail: salvatore.brischetto@polito.it

Abstract

The Fused Filament Fabrication (FFF) technology is commonly employed in rapid prototyping. 3D home desktop printers are usually used to produce non-structural objects. However, when the mechanical stresses are low, the FFF technology can also be successfully employed to produce structural objects, not only in prototyping phase but also in the production of series structural elements. The innovative idea of the present work is the application of the FFF technology, implemented in desktop 3D printers, for the production of components for aeronautical use, especially for unmanned aerial systems.

For this aim, the architecture and preliminary design of an innovative multirotor Unmanned Aerial Vehicle (UAV) is presented. This UAV is able to easily and quickly change its configuration: the principal structure is made of an universal and general plate, combined with a circular ring, in order to create a rail guide able to host the arms, in a variable number from 3 to 8, and the legs. The proposed UAV is inexpensive because of the few universal pieces needed to compose the platform for the creation of a kit. This modular kit allows to have a modular drone with different configurations. These configurations consider different numbers of arms, numbers of legs, numbers of rotors and motors, and landing capabilities.

The 3D printing technology is introduced to produce all the structural elements of the UAV. For this reason, all the components are designed to be produced via the FFF technology by means of desktop 3D printers. Therefore, an universal, dynamic and economic multi-rotor UAV has been developed and produced. Customization is combined with the concept of additive manufacturing, as all components are designed to be produced in FFF. This approach does not limit the application scenarios of the drone, but it is a further step in the direction of customization, as it allows continuous upgrades over time. After the definition of the most severe conditions for the structure, a structural validation of its performance must be conducted. The functional use of FFF-produced parts is challenging due to the anisotropic behaviour of the parts. However, some structural elements are thin-walled and they can be printed with a 100% linear infill. A simplified approach could be an analogism with unidirectional composites, whose 2D testing procedures and methodologies are well known. A finite element analysis of some elements of the frame is conducted, using shell elements to discretize the geometry. A proper definition of their mechanical response is possible because the constitutive model is not a priori isotropic but it reflects the behaviour of the finished parts. The tensile strength variability in the material reference system is high: a component-by-component comparison

proves the design to be adequate and measured to the surrounding conditions even if it remarks the absence of a defined failure criterion.

Keywords
Fused Filament Fabrication; UAV; Desktop 3D printers; material characterization

Biography

After earning his degree in Aerospace Engineering at the Politecnico di Torino in 2005, Brischetto received his PhD in Aerospace Engineering (Politecnico di Torino) and in Mechanics (Université Paris Ouest–Nanterre La Défense) in 2009. He won the excellence prize for PhD students in 2008 and the prize for young researchers in 2011 at the Politecnico di Torino. He worked as a Research Assistant at the Politecnico di Torino from 2006 to 2010, and as Assistant Professor from 2010 to 2018; currently he is Associate Professor since february 2018. His main research topics are: additive manufacturing, FFF 3D printing, smart composite structures, multifield problems, hygro-thermal stress analysis, CNTs, inflatable structures, shell 3D and 2D numerical and exact solutions and UAVs. He is the author of 158 articles, 81 of which have been published in international journals, and 1 patent. He serves as a reviewer for more than 100 international journals. He has been Guest Editor for Mechanics of Advanced Materials and Structures, for Technologies, and for Journal of Composites Science. He is a committee member for several international journals and 1 book series, and member of the "Shell Buckling People" web-site. Brischetto is Associate Editor of Curved and Layered Structures, and of Journal of Composites Science. He has been Teaching Assistant at the Politecnico di Torino for courses on computational aeroelasticity, structures for aerospace vehicles, nonlinear analysis of aerospace structures, principles of structural mechanics, aeronautic constructions, aeronautic structures, and numerical modelling and simulation techniques for aerospace structures. He was chair at the Politecnico di Torino for the courses “Aeronautic law and human factors and safety”, "Design and Additive Manufacturing for Aerospace Applications" and currently for "Aeronautic constructions", “Numerical modelling and simulation techniques for aerospace structures” and "3D shell models for composite structures". He is co-founder and co-chair of the group “ASTRA: Additive manufacturing for Systems and sTRuctures in Aerospace”, and also founder and chair of the project “PoliDrone, A multipurpose modular drone produced via 3D printing".

Substrate Stereolithography for Direct Ceramic Fabrication

Soshu Kirihara*

Joining and Welding Research Institute, Osaka University, Japan

kirihara@jwri.osaka-u.ac.jp

Abstract

In stereolithographic additive manufacturing (STL-AM), 2-D cross sections were created through photo polymerization by UV laser drawing on spread resin paste including nanoparticles, and 3-D models were sterically printed by layer lamination. The lithography system has been developed to obtain bulky ceramic components with functional geometries. An automatic collimeter was newly equipped with the laser scanner to adjust the beam diameter. Fine or coarse beams could realize high resolution or wide area drawings, respectively. As the row material of the 3-D printing, nanometer sized metal and ceramic particles were dispersed into acrylic liquid resins at about 60 % in volume fraction. These materials were mixed and deformed to obtain thixotropic slurry. The resin paste was spread on a glass substrate with 50 μm in layer thickness by a mechanically moved knife edge. An ultraviolet laser beam of 355 nm in wavelength was adjusted to 50 μm in variable diameter and scanned on the spread resin surface. Irradiation power was automatically changed for an adequate solidification depth for layer bonding. The composite precursors including nanoparticles were dewaxed and sintered in the air atmosphere. In recent investigations, ultraviolet laser lithographic additive manufacturing (UVL-AM) was newly developed as a direct forming process of fine metal or ceramic components. As an additive manufacturing technique, 2-D cross sections were created through dewaxing and sintering by UV laser drawing, and 3-D components were sterically printed by layer laminations with interlayer joining. Through computer-aided smart manufacturing, design, and evaluation (Smart MADE), practical material components were fabricated to modulate energy and material transfers in potential fields between human societies and natural environments as active contributions to Sustainable Development Goals (SDGs).

Keywords
Substrate Stereolithography, Directional Fabrication, Fine Ceramic Structure, Environmental Engineering

Biography

Soshu Kirihara is a doctor of engineering and a professor of Joining and Welding Research Institute (JWRI), Osaka University, Japan. In his main investigation "Materials Tectonics as Sustainable Geoengineering" for environmental modifications and resource circulations, multi-dimensional structures were successfully fabricated to modulate energy and materials flows effectively. Ceramic and metal components were fabricated directly by smart additive manufacturing, design and evaluation (Smart MADE) using high power ultraviolet laser lithography. Original stereolithography systems were developed, and new start-up company "SK-Fine" was established through academic-industrial collaboration.

Additive Manufacturing-enabled design and manufacturing integration towards industrial sustainability

Tao Peng*

State Key Laboratory of Fluid Power and Mechatronic Systems, Zhejiang University, 866 Yuhangtang Road, Hangzhou, China

Institute of Industrial Engineering, School of Mechanical Engineering, Zhejiang University, 866 Yuhangtang Road, Hangzhou, China

*Corresponding Author E-mail: tao_peng@zju.edu.cn

Abstract

Though additive manufacturing (AM) was invented to rapidly produce prototypes, the technology has a capability to release the design and manufacturing constraints in creating innovative products with great geometrical complexity. With nearly four decades of innovative research and development, metal AM has fundamentally and remarkably advanced in many aspects, including design methodology, material variety, processing and equipment. It has been moving into various industrial applications to revolutionize industrial product lifecycle performance, from flexible design optimization to functional improvement. It has even emerged as an important player to advance industrial sustainability in the long run. Sustainable manufacturing acknowledge the stimulating effect of metal AM on industrial applications, and aim to develop basic analytical theory and evaluation methodology for industrial case-dependent AM product lifecycle assessment. Based on the state-of-the-art review and industrial development survey, five research directions in sustainability research have been summarized, that is, 1) smart AM machinery, 2) material preparation and recycling, 3) data integration and management in AM, 4) multi-objective joint analysis, and 5) case-dependent innovative applications. However, this introduces more cross-disciplinary and case-dependent research challenges, such as function specific product design and simulation tools, high-quality cross-scale part fabrication, in-process monitoring and effective control, and reliable product lifecycle management. To improve product performance systematically, it is critical to have in-depth understanding of not only a single lifecycle stage but multiple lifecycle stages.

Keywords
Additive manufacturing; Sustainability; Design and manufacturing integration; Industrial applications

Biography

Dr. Tao Peng obtained his PhD degree from the University of Auckland, New Zealand, and Master & Bachelor degrees from Xi'an Jiaotong University, China. He is an Associate Professor and currently serves as Deputy Director at the Institute of Industrial Engineering and Associate Head of Department of Industrial and Systems Engineering at the School of Mechanical Engineering, Zhejiang University, China. Dr. Peng is also the Deputy Secretary General of Industrial Big Data and Intelligent System Branch of China Mechanical Engineering Society (CMES), and a Council Member of Industrial Big Data sub-Association of China Association for Mechatronics Technology and Application. His research focuses on innovative technologies for sustainable manufacturing systems, including system modeling and optimization, big data-driven production management, sustainable additive manufacturing towards better life cycle performance, and cognitive intelligence in manufacturing systems and supply chains. Dr. Peng is an Associate Editor of IET Collaborative Intelligent Manufacturing, Frontiers in Manufacturing Technology, and Guest Editor of a number of journals, e.g. Additive Manufacturing, Journal of Manufacturing Systems, Journal of Cleaner Production, Sensors, and etc. He is always active and maintains good international collaborations, and acts as an International Technical/Scientific/Program/Executive committee member of several conferences, such as CIRP LCE/EcoDesign/CIE/IKMAP. He has authored/co-authored over 80 publications, recognized as world's Top 2% Scientists 2020.

Advances in 3D Printing: The Past, Present, and Future

Thomas J. Webster*

School of Health Sciences and Biomedical Engineering, Hebei University of Technology, Tianjin, China

websterthomas02@gmail.com

Abstract

3D printing has already revolutionized many fields from the automobile to healthcare industries. This presentation will cover some of the more exciting advances in 3D printing in the past several years as well as future directions that are destined to continue to revolutionize 3D printing. For example, studies will be highlighted which demonstrate 3D printing of shape change materials whose shape, after implantation, can be changed remotely to delivery drugs, straighten a curved spine, deliver stem cells, and more. Further, advances in 3D printing nanomaterials to match tissue architecture and properties will be covered. As such, this presentation will set the stage for where 3D printing has been and where it is going as a premier technology in healthcare.

Keywords

Nanomaterials, nanotechnology, sensors, 4D printing

Biography

Thomas J. Webster's (H index: 111; Google Scholar) degrees are in chemical engineering from the University of Pittsburgh (B.S., 1995; USA) and in biomedical engineering from RPI (Ph.D., 2000; USA). He has served as a professor at Purdue (2000-2005), Brown (2005-2012), and Northeastern (2012-2021; serving as Chemical Engineering Department Chair from 2012 - 2019) Universities and has formed over a dozen companies who have numerous FDA approved medical products currently improving human health. Dr. Webster has numerous awards including: 2020, World Top 2% Scientist by Citations (PLOS); 2020, SCOPUS Highly Cited Research (Top 1% Materials Science and Mixed Fields); 2021, Clarivate Top 0.1% Most Influential Researchers (Pharmacology and Toxicology); and is a fellow of over 8 societies.

3D/4D Additive Manufacturing Based on Shape Memory Phenomenon

Wei Min Huang*

School of Mechanical and Aerospace Engineering

Nanyang Technological University, Singapore

Email: mwmhuang@ntu.edu.sg

Abstract

The shape memory effect (SME) refers to the phenomenon that a quasi-plastically deformed material is able to return its original shape, but only at the presence of the right stimulus. Via different working mechanisms, most polymers have the heating/chemo-responsive SME. Such a SME can be utilized in additive manufacturing of polymeric components in both 3D and 4D printing.

This talk starts with a brief review of the SME and the basic working mechanisms for the SME in polymers. 4D printing using various commercial filaments will be demonstrated in a range of different applications, from bio-medical devices to comfort fitting. A couple of new approaches for digital manufacturing to rapid additive manufacturing in solid state will be presented with demonstrations.

Biography

Dr Wei Min Huang is currently an Associate Professor (tenured) at the School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore. With over 25 years of experience on various shape memory materials (alloy, polymer, composite and hybrid), he has published over 190 papers in journals, such as Accounts of Chemical Research, Advanced Drug Delivery Reviews, and Materials Today, and has been invited to review manuscripts from over 300 international journals (including Progress in Polymer Science, Nature Communications, Advanced Materials, and Advanced Functional Materials, etc), project proposals from American Chemical Society, Hong Kong Research Grants Council, etc, and book proposals from Springer, Elsevier and CRC. He has published two books (Thin film shape memory alloys – fundamentals and device applications, Polyurethane shape memory polymers) and is currently on the editorial board of over three dozen of journals.

Relationship between Photochemical Events and 3d Printing using Vat Photopolymerization

X. Allonas*, B. Métral, A. Champion, B. Hamouda, A.S. Schuller, C. Croutxé-Barghorn, C. Ley

Laboratory of Macromolecular Photochemistry and Engineering, University of Haute Alsace, 3b rue Alfred Werner 68093 Mulhouse, France. xavier.allonas@uha.fr

Abstract

Vat photopolymerization technologies are promising 3D printing techniques in the field of additive manufacturing, which requires high performance and affordable photoinitiating systems (PIS). If the general process is well understood and currently applied in industry, there is a clear lack of knowledge concerning the relationship between the photochemical reactivity and the photonic parameters used for 3D printing.

In this paper, a model which predicts with good accuracy the change in conversion with both time and light intensity is proposed. Cure depth experiments are conducted and the critical energy (Ec) and penetration depth (Dp) are established for the resin when a photocyclic initiating system based on safranine is used. The relationship between these parameters and the corresponding RT-FTIR results was highlighted through the role of the conversion at the gel point, allowing optimization of the formulation. Confocal Raman microscopy is used to discuss the effect of the photobleaching of the photoinitiator in the absence of coinitiator on the photopolymerized films. Finally, it is shown that this formulation performs quite well for 3D printing with a resolution close to the best performance of the DLP printer.

Biography

PhD in 1995 on photoinduced electron transfer mechanism at the Department of Photochemistry in Mulhouse (France). Short post-doctoral training at the Institute of Physical Chemistry of Fribourg in Switzerland on picosecond transient grating spectroscopy. In 1996, Assistant Professor at the Chemistry Institute of Mulhouse (Ecole Nationale Supérieure de Chimie de Mulhouse). Full Professor at the University of Haute Alsace in Mulhouse in 2003. Since 2006, head of the Laboratory of Macromolecular Photochemistry and Engineering. Current research interests are the processes involved in photopolymerization studied through time resolved laser spectroscopies, real-time FTIR and molecular modelling. A particular interest is paid to the study of photoinitiating systems reactivity and photopolymerization kinetics for different applications such as laser imaging, paints and coatings, photocomposites, 3D printing... He is authors of more than 200 papers, 100 invited conferences and 10 patents.

Additive Manufacturing of Nanotechnology Enhanced Metals

Xiaochun Li*

Raytheon Chair in Manufacturing

Department of Mechanical and Aerospace Engineering and Department of Materials Science and Engineering, University of California, Los Angeles, CA, USA

Abstract

Recent breakthrough on nanoparticle self-dispersion and stabilization in molten metals paves a new, exciting way to produce bulk high performance metals containing uniformly-dispersed nanoparticles for high performance. Novel micro metal powders and wires containing uniformly-dispersed nanoparticles can be powerful feedstock materials for additive manufacturing of complex metal parts with unusual mechanical, physical and chemical properties. In this talk, our recent progress on selective laser melting (SLM) and wire arc additive manufacturing (WAAM) of high performance metal powders (aluminum alloys such as 7075) for dense metal parts is reported. The nanotechnology enhancedaluminum alloys produced by additive manufacturing offers unprecedented material properties. The experimental study revealed the effects of nanoparticles and AM processing parameters on microstructure characteristics (distribution of nanoparticles, grain size, and phase morphology of the matrix) and material properties of nanotechnology enhanced metals.Additive manufacturing of nanotechnology enhanced metals expands the traditional additive manufacturing space forwidespread applications to meet energy and sustainability challenges in today's society.

Biography

Professor Xiaochun Li is the Raytheon Endowed Chair in Manufacturing Engineering in the Departments of Mechanical and Aerospace Engineering & Materials Science and Engineering at University of California, Los Angeles (UCLA). He is also the founder of MetaLi LLC (www.metaliusa.com). and He currently serves as the Chief Technology Officer for the Western Regional Smart Manufacturing Center, USA Clean Energy Smart Manufacturing Innovation Institute. He received his Ph.D. at Stanford University in 2001. He is a holder of multiple best paper awards and patents, including more than 10 of those licensed by industry. Dr. Li received National Science Foundation CAREER award in 2002, Jiri Tlusty Outstanding Young Manufacturing Engineer Award from Society of Manufacturing Engineers in 2003, and 2008 Howard F. Taylor Award from American Foundry Society (AFS). Dr. Li was previously a professor in the Department of Mechanical Engineering and Materials Science Program at University of Wisconsin-Madison (UW-Madison) from 2001 to 2013. He served as the Director of Nano-Engineered Materials Processing Center (NEMPC) at UW-Madison between 2009 and 2013. Dr. Li has been elected Fellows in American Society of Mechanical Engineers and the International Society for Nanomanufacturing. His research interests are in manufacturing and practical applications of nanotechnology enabled metals, especially Nanoparticle dispersion, nanoparticle-metal interaction, and control of microstructures etc.

Microstructure and Mechanical Properties of Al-Co-Cr-Fe-Ni High-Entropy Alloy by Cable Wire Arc Additive Manufacturing

Xizhang Chen*, Xukai Yao

College of Mechanical and Electrical Engineering, Wenzhou University, Wenzhou, China*e-mail: chenxizhang@wzu.edu.cn

Abstract

A new type of combined cable wire (CCW) with multi-element composition has been designed and developed for arc additive manufacturing (AAM) of large volume Al-Co-Cr-Fe-Ni high-entropy, which has the advantages of high deposition efficiency, strong design ability, self-rotation of welding arc and energy saving capability. Single CCW and dual wire technology are used in the fabrication. In this paper, a combined cable wire composed of 7 wires and Co-Cr-Fe-Ni elements is designed, and filling the aluminum welding wire with the auxiliary wire feeder, a method of dual-wire arc additive manufacturing and steeples control of Al content is proposed to prepare Al-Co-Cr-Fe-Ni high-entropy alloy. The effects of aluminum content on the microstructure and mechanical properties of Al-Co-Cr-Fe-Ni high-entropy alloys were studied by changing the wire feeding speed of the aluminum welding wire. The results show that when the sample does not contain aluminum, the sample exhibits a single FCC phase. With the increase of aluminum content, the proportion of BCC in the sample gradually increased. When the wire feeding speed of aluminum welding wire is 1.2m/min, the proportion of BCC phase exceeds that of FCC phase, and the average micro hardness increases from 154.73HV to 309.33HV. The yield strength and ultimate tensile strength are also greatly improved, increasing to 662Mpa and 1071Mpa respectively, which are 159.61% and 116.80% higher than the samples without Al. It shows that the addition of Al element is conducive to the formation of BCC, the slip directions of BCC are less than that of FCC, and the strength is improved significantly. This paper opens up a new idea for the additive manufacturing of high-entropy alloys with wire. The experimental results prove that the method of dual-wire-arc additive manufacturing Al-Co-Cr-Fe-Ni high-entropy alloys is feasible, and it is convenient to prepare high-entropy alloys with superior properties.

Keywords

arc additive manufacturing; combined cable wire; high entropy alloy; microstructure and mechanical properties

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