2nd International Conference on

3D Printing Technology and Innovations

March 19-20, 2018 | London, UK

Scientific Tracks & Abstracts
Day 1

Sessions:

Day 1 March 19, 2018

Advances in 3D Printing & Additive Manufacturing Technology | Innovations in 3D Printing | Design for 3D Printing | 3D Printing Materials | Benefits of 3D Printing and Technology | Future Technology in 3D Printing | Challenges in 3D Printing | 3D printing in Biomaterials | Clinical applications of 3D Printing Innovations | Applications of 3D Printing in healthcare & medicine

Session Chair
Alexander V Manzhirov
Ishlinsky Institute for Problems in Mechanics - RAS, Russia

Session Co-Chair
Lin Li
The University of Manchester, UK

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Ikuo Yamamoto, Nagasaki University, Japan

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Title: **Biologically acitve and mechanically improved composite core-shell hydrogel for 3D bioprinting**
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Title: **Modern methods of additive manufacturing for biomedical products**
Patrycja Szymczyk, Wroclaw University of Science & Technology, Poland

Title: **The Application of 3D printing in micro AD biogas technology**
Guy Blanch, LEAP Micro AD Ltd, UK

Yasunori Ota, Int J Adv Technol 2018, Volume 9
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Cost reduction activity

Yasunori Ota
Value Engineering Trainer, Japan

This presentation introduces two specific approaches regarding the VE method - Benchmarking VE and Drawing VE. I have been concerned about how to come up with good ideas effectively. I have used various methods by trial and error in idea generation sessions. By doing so, I noticed two methods proved to be effective. One is Benchmarking VE. It is used at the early development stage to coordinate the relationship between function and parts. Further, by applying this method to your competitors' function and parts, you can ascertain the strengths and weaknesses of your company. and you can think good idea from comparison contents. The other is Drawing VE. It can be used before, during, and after production. Specifically, it reexamines the role of the instructions in the drawing (materials, dimensional tolerance, function of thickness, thickness of the board, post-processing). And you can think cost reduction idea from reexamines the role of the instructions in the drawing. Based on this, the method allows you to develop new solutions. I hope to share these methods with other VE practitioners around the world to contribute to the promotion of VE.

Biography

Yasunori Ota is a value Engineering Trainer and have been VE practice in 10 years, In relation to cost planning in particular, He took initiative in increasing profitability by coordinating target value in the procurement, design, and production technology departments, providing a list of items for cost reduction, and managing their progress.

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Notes:

3D printer applications for developing robotics

Ikuo Yamamoto
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3D printers are useful for seamless development of robotics. The author uses 3D printer for making parts of robotics. Specially, in the area of manufacturing surgical instruments, the ability to rapidly design, prototype, and test surgical instruments is critical. A case study of the rapid development of two biomechanism-based surgical instruments which are ergonomic and aesthetic are mentioned. It is designed, prototyped and conceptually tested in a short period of time by using 3D printer. Recently, there has been an increasing need for surgical instruments that can hold organs delicately yet stably. Such an instrument increases the efficiency of surgical operations by decreasing the physical and mental strain on both surgeons and patients. New biomechanism-based surgical instruments, based in part on the anatomical structure of a fish, provide soft-handling forceps where pressure is distributed over a larger area. The author created a seamless design method and prototyping process. This process has been used to prototype biologically-based mechanisms using 3D CAD and a 3D printer. Specifically, a fish-based mechanism which produces an elastic oscillating fin and shark skin which effectively controls hydrodynamic resistance have been found to be effective in creating superior surgical instruments. Developed user-friendly surgical instruments enable more efficient surgery, for example 50 percent reduction of surgical operating time. This process is effectively facilitated using a more seamless design through to the prototyping. Rapid manufacturing by 3D printer is important to check product in advance. In addition, several cases where 3D printer are used for the development of robotics are mentioned by the author.

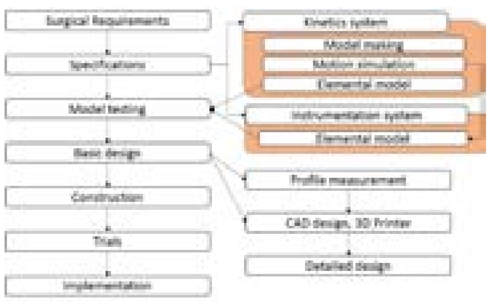

Figure 1: Development process

Figure 2: Soft handling forceps

Biography

Ikuo Yamamoto is a Professor of Nagasaki University, Nagasaki, Japan. He has worked with Mitsubishi Heavy Industries Ltd. And JAMSTEC, Japan. He is a Professor at Kyushu, Kitakyushu and Nagasaki University, Japan. He was a leader of AUV "Urashima",which established the world record for autonomous cruising; developed "Kaiko&Seabot", which was crowned champion remotely operated vehicle at 10000m depth cruising and at the World convention 2012, 2014 and 2016 and his robotic fish 'swam' in the International Space Station in 2009. He sucessfully flied multi-rotor flight robotics with real-time monitoring and environmental sensor systems in Japan, 2008. He received International Awards for developing medical robotics in 2014 and 2015. He was nominated as GlobalScot by Scotland Government, UK in 2017. His research interests are Robotics and IoT (Internet of Things).

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Functionally graded materials obtained by additive manufacturing technology

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In the current study, Direct metal laser sintering (DMLS) and Binder jetting technologies are employed for direct manufacturing of functionally graded materials. In the past, the additive manufacturing approach has been limited to non- functional parts and their repair. In this project, we are extending this technology to functional graded gears through design decomposition, process modeling and smart machines. This project aims at developing functionally graded material (FGM) manufacturing technologies that enable creation of light weight "Net Shape" parts for power transmissions used in multiple markets such as transportation and power generation. The technologies include design decomposition, additive manufacturing and material characterization. This transformational approach will enable sustainable manufacturing through reduction in material use, processing steps, energy consumption and carbon footprint and create products which have better performance characteristics. Additive manufacturing technology may provide an efficient alternative way to fabricate customized dental implants based on a CAD (Computer-aided design) file with a functionally graded structure that may minimize stress shielding and improve the long-term performance of dental implants.

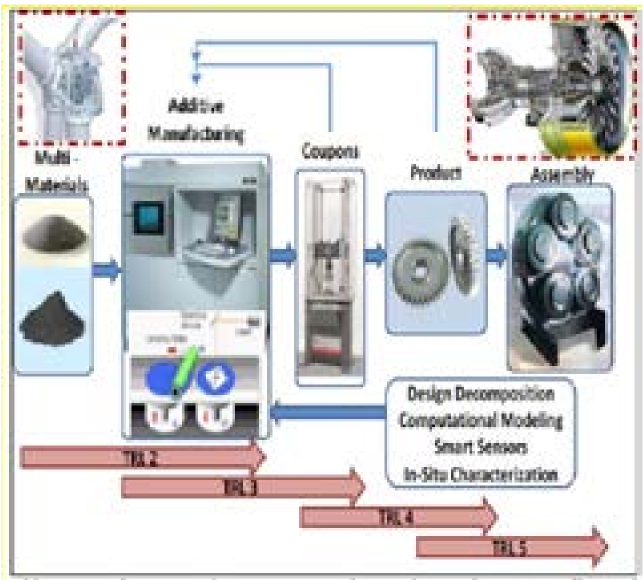

Figure 1: *Additive manufacturing of light weight functionally graded materials.*

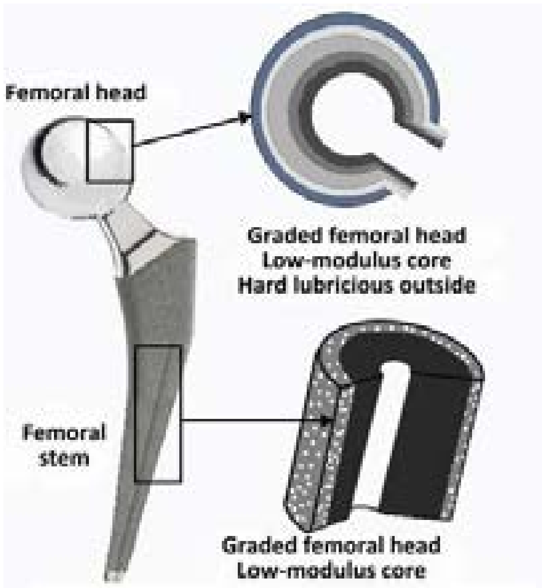

Figure 2: *Examples of functionally graded materials (FGM).*

Biography

Devi K Kalla received his PhD in Industrial Engineering from Wichita State University, Kansas, USA. He is currently an Associate Professor in the Department of Mechanical Engineering Technology at Metropolitan State University of Denver, USA. He has a strong experience in composite manufacturing, 3D printing, and modeling. His research interest includes: sustainable manufacturing and analysis in the machining of carbon fiber- reinforced polymers (CFRP) composites, additive manufacturing, green manufacturing. He has published more than 25 papers in reputed journals and conference proceedings and has been serving as an Editorial Board Member of International Journal of Material Sciences and Technology, International Journal of Industrial Engineering and Technology (IJIET) and more notably, as the Editor-in-Chief of the International Journal of Mechanical and Material Sciences Research).

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Xipeng Xu et al., Int J Adv Technol 2018, Volume 9
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The fabrication of grinding wheels with 3-dimensional controllable abrasives arrangement using stereolithography apparatus method

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In this paper, a practice to fabricate ultraviolet (UV) cured resin bond grinding wheels with abrasive grits in controllable 3-dimensional (3D) distributions was reported. The challenge in fabrication of resin-bonded grinding wheels with controllable abrasive girts distribution is to simultaneously cure heterogeneous materials with suitable slice thickness and sufficient bonding strength between cured layers. This is beyond the capability of most commercially available 3D printers. A new stereolithography apparatus equipment with automatic functions of resin applying, grits planting, resin curing and wheel lifting was developed. Successively, multi-layered abrasive wheels were fabricated by planting abrasive grits and UV curing resin layer-by-layer. In doing so, 3D grinding wheel with controllable abrasive girts distribution were fabricated. Finally, the grinding performance and wear characteristics of newly developed grinding wheels were revealed through the grinding experiments. The results indicated that the distribution of diamond abrasive grits plays a determining role in the wear behavior, and hence the grinding performance of resin grinding wheels has been greatly improved.

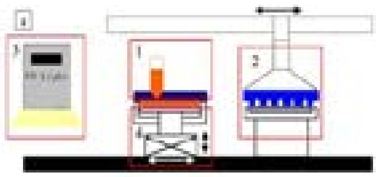

Figure 1: Manufacturing equipment for the resin bond grinding wheels with 3D controllable abrasives arrangement. a- Schematic figure; b-Machine; 1-resin applying institution; 2-abrasive arraying institution; 3-resin curing institution; 4- lifting and striking institution.

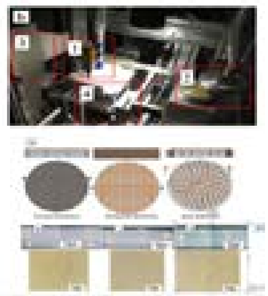

Figure 2: The grinding wheel with 3D controllable abrasive arrangement. a- Schematic of diamond abrasive arraying forms; b- The grinding wheels of circular distribution; c- The grinding wheels of Rectangular distribution; d- The grinding wheels of spiral distribution.

Biography

Xipeng Xu is the President of Huaqiao University, China. He has his expertise in machining technology and functional usage of diamond materials. He is an Executive Member of International Committee for Abrasive Technology (ICAT) and gets over 140 technical papers publication in related journals and conference

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How far we can go to print a jet engine? The beauty of a 3D printed micro jet engine

Pinlian Han
South University of Science and Technology, China

Additive manufacturing (AM) opens a new era, including aircraft engine design and manufacturing. In addition to being capable of solving problems with complex shapes that are difficult to make with traditional methods, the revolutionary power of AM is due to the feature of making objects from micro to macro scale, similar to natural processes such as how living beings grow from small to large. Now one can put different materials together where needed, either mixed or embedded. One can proactively design micro structure under the surface of a structure to arrange distribution of mass, stiffness, damping, failure mode and its location, thermal property, etc., according to the functional requirement of the part. This is what we call Additive Design (AD), not design for AM. AD will be a new area of engineering that will change people's vision of design and lead to exploring the further capabilities of existing materials by optimizing the load distribution, such as reducing stress concentration substantially. We made a micro jet engine in 3 months using AD technology developed by a small group with young people of less than 10 members. From inlet to the tail nozzle, all parts are made of metal using SLM by outsourcing to different companies. The entire engine consists of no more than 15 parts. All parts have some features that are either difficult or impossible to be made by traditional methods. These features are characterized by light weight, structural integrity, and cost savings.

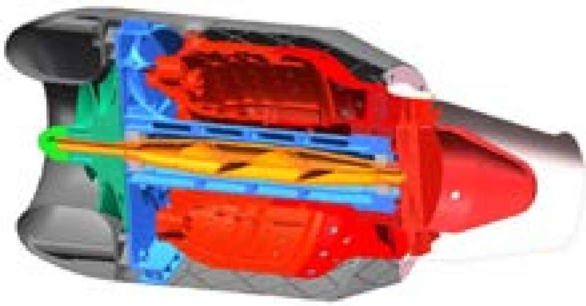

Figure 1: *Jet engine made from AD and AM*

Biography

Pinlian Han graduated with BSc and MSc from Xian Jiaotong University in China, another two MSc degrees in USA and one PhD degree in Canada. He has worked at Pratt & Whitney Aero Engine Company in USA for more than 12 years as Technical Leader In 7 different Departments. He has published over 70 papers and more than 50 patents. He is currently the Chair Professor in the Department of Mechanics and Aerospace Engineering, leading a team to break through the bolt neck of aero engine with innovative technology and methodology, focusing on additive design and developing a new type of aero engine called Amphibious Relay Gas Turbine.

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Edwin Joffrey Courtial et al., Int J Adv Technol 2018, Volume 9
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Yield stress agent for silicone 3D printing

Edwin Joffrey Courtial and **Christophe Marquette**
Claude Bernard University Lyon 1, France

3D printing deposition technology allows surgeons to produce patient-specific implants with high degree of effectiveness. However, biomimetic properties (mechanical behavior) of implants can only be obtain with silicone elastomers which are some of the most challenging materials to be 3D printed. Rheological behavior, particularly yield stress character, of viscoelastic materials is well known to be the key parameter to successfully use 3D deposition technology. Thus, if the stress reach a high enough value, the shape of printed object is holded during and after deposition, but also during post-printing polymerization process. Unfortunately, the yield stress properties of high viscosity silicone is often too low to permit efficient 3D printing. Addition of yield stress agents in silicone formulations might be a solution to this problem and silica or glass fiber are commonly used in silicone formulations to change rheological properties. However, the presence of these charges implies modifications of the final mechanical properties of the silicone related to the high rigidity of the added charges. The consequence here is then the production of 3D objects with poor biomimetic behavior. We propose the use of polyethylene glycol (PEG) as low rigidity, yield stress enhancer charge, to be used with high viscosity silicone formulations, as a breakthrough toward silicone biomimetic implants 3D printing. This charge interacts with the surface of the silica dispersed in silicone formulation through hydrogen bonds. A secondary network is then created which provides a strong enough yield stress character, leading to efficient 3D printing capability. The low energy of this network unchange the initial mechanical properties of silicone after curing. Clear experimental results will be presented together with case study of highly challenging 3D printing, demonstrating the superiority of the approach.

Figure 1: Hexagon 3D printing with silicone (left) vs silicone + PEG (right).

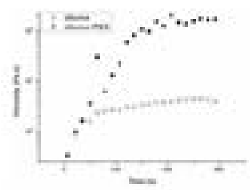

Figure 2: Yield stress character of silicone vs silicone + PEG (Stress ramp test with stress controlled rheometer).

Recent Publications

1. Mouser V H M, Melchels F P W, Visser J, Dhert W J A, Gawlitta D, Malda J (2016) Yield stress determines bioprintability of hydrogels based on gelatin-methacryloyl and gellan gum for cartilage bioprinting. Biofabrication. 8(3):035003. Doi:10.1088/1758-5090/8/3/035003.
2. Mirta I Aranguren, Elsi Mora, Christopher W Macosko and J Saam (1994) Rheological and mechanical properties of filled rubber: silica-silicone. Rubber Chem. Technol. 67(5):820-833.
3. Kotsilkova R G W (1990) A study of transient and steady-state shear and normal stresses in glass fiber suspensions. In: Oliver D.R., ed. Third European Rheology Conference and Golden Jubilee Meeting of the British Society of Rheology. Springer, Dordrecht; 280- 282. Doi:10.1007/978-94-009-0781-2¬¬_98.

Biography

Edwin Joffrey Courtial has completed his PhD from IMP (Ingénierie des Matériaux Polymères) Lab, Université Claude Bernard Lyon 1, Lyon, France. He is a Researcher specialized in materials science and rheological behaviors, and working in Institute of Molecular aand Supramolecular Chemistry and Biochemistry CBMS, Lyon, France in the innovative platform 3D FAB. These main activities are focused on correlation between (bio)materials formulations and rheological behaviors to define 3D (bio)printable conditions. His interest includes: 3D printing, rheological and mechanical behaviors and polymer formulation.

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Jia Min Wu et al., Int J Adv Technol 2018, Volume 9
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Research progress in additive manufacturing of ceramics and some related applications

Jia Min Wu, An Nan Chen, Chen Hui Li and **Yu Sheng Shi**
Huazhong University of Science and Technology, China

Compared with traditional methods, additive manufacturing (AM) technology has shown great advantages in preparing high-performance polymer and metal parts with complex shape. However, it is difficult to prepare high-performance ceramic parts with complex shape by AM technology. So far, Prof. Shi Yu Sheng's group in Huazhong University of Science and Technology has done many researches on the preparation of various ceramic materials via Selective Laser Sintering (SLS) and Stereo Lithography Apparatus (SLA). Regarding SLS, three methods, namely mechanical mixing, solvent evaporation and dissolution-precipitation, were used to prepare ceramic-polymer composite powders with good fluidity. Subsequently, porous cordierite, kaolin and Si3N4 ceramic parts with high porosity were prepared by SLS. To acquire dense ceramic parts, Cold Isostatic Pressing (CIP) process was used to densify the SLS green parts, and $Al2O_3$, ZrO_2 and SiC ceramic parts with high density and complex shape were successfully prepared by the SLS/CIP hybrid technology. In the recent research of Prof. Shi's group, dense $Al2O_3$ and ZrO_2 ceramic parts with high density and high precision were prepared by Stereo Lithography Apparatus (SLA), in which the raw materials and AM equipment were all developed independently by Prof. Shi's group. Based on above researches, the SLS and SLA technologies were used to prepare high-performance ceramic parts in the application of ceramic dental restoration, honeycomb ceramics, etc.

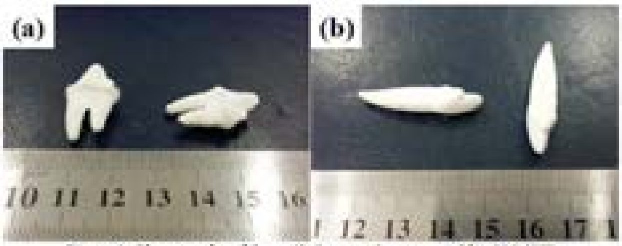

Figure1: Photographs of dense ZrO_2 ceramics prepared by SLS/CIP.

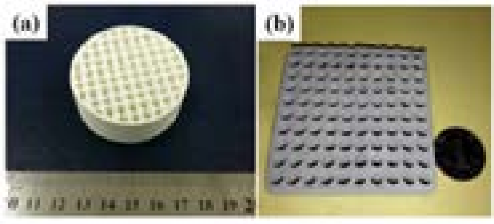

Figure2: Photographs of porous ceramics prepared by SLS: (a) kaolin and (b) Si_3N_4

Biography

Jia Min Wu has completed his PhD from Huazhong University of Science and Technology, China. He has been In Charge of more than 10 research projects in China. So far, he has published more than 30 academic papers in *Journal of the European Ceramic Society, Journal of the American Ceramic Society* and other top journals on ceramic materials. Meanwhile, he has applied for more than 20 patents in China. In addition, he has also acted as Reviewer for many ceramic related repute journals, and he has been invited to give speeches in several international conferences on additive manufactruing of ceramics. His research interest includes: additive manufacturing of ceramics and related application.

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Notes:

Sonke Steenhusen et al., Int J Adv Technol 2018, Volume 9
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Two-photon polymerization: A femtosecond laser-based technology for additive manufacturing in life sciences and microoptics

Sonke Steenhusen, Sebastian Hasselmann and **Gerhard Domann**
Fraunhofer Institute for Silicate Research ISC, Germany

3D printing has been widely adopted on the macroscopic domain not only for rapid prototyping but also in manufacturing. Several technologies ranging from the consumer market to an industrial level have been established. However, on the micron-scale the possibilities to go into the third dimension are limited as the voxel sizes are dominated either by the diameter of particles in powder-based additive manufacturing, by the thickness of the filaments, or the diameter of the droplets in inkjet printing. These constraints can be circumvented when using femtosecond laser-based photopolymerization in liquid photopolymers for creating 3D microstructures. Here, the solidification of the material is strongly confined to the focal spot of focused laser pulses where the intensities are sufficiently high to trigger two-photon absorption. Hence, two-photon polymerization (2PP) is an inherent 3D technology with voxel sizes down to 100 nm. The exposure strategy is similar as in conventional 3D printing. The volume to be written is scanned in 3D, typically in a layerwise fashion. As in UV-lithography a subsequent solvent wash (development step) is needed to get rid of the unexposed, and still liquid, resin. We will demonstrate representative application examples from different fields of research. In life sciences 2PP-written 3D structures can be used as substrates for cell cultivation, as they mimic the natural, porous environment which is required for proper cell expression. On the other hand, 2PP can be used for diffractive and refractive microoptical elements which reveal excellent surface quality and directly benefit from the freedom in design which only 3D printing can offer.

Biography

Sonke Steenhusen studied Physics in Würzburg and joined Fraunhofer Institute for Silicate Research ISC in late 2007 beginning his work in the field of additive manufacturing. At the same institute he developed machines for two-photon polymerization and investigated the 3D patterning of hybrid polymers for applications in microoptics. He is (co-)author of several papers in the field of 3D lithography. He is currently the Deputy Head of the Optics and Electronics Department at the same institute which is dedicated to the development and processing of novel materials for optical and electronic applications. His research interest includes: additive manufacturing, 3D printing, hybrid polymers, nanocomposites and two-photon polymerization.

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Teresa Russo et al., Int J Adv Technol 2018, Volume 9
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3D Printing and nanocomposite gels as a new challenge in tissue repair and regeneration

Teresa Russo, Antonio Gloria, Roberto De Santis, Luigi Ambrosio
National Research Council, Italy

Over the past years, polymer-based materials have attracted research interest in the field of tissue repair and regeneration. Porous bioactive scaffolds with controlled properties can be obtained by processing polymer-based materials, as "solids" or injectable formulations.

Design and applications of injectable systems and hydrogel-based composites able to promote the regeneration of soft tissues, trying to reduce surgical invasiveness and to enhance efficient biomolecular interactions with cells, is a crucial aspect for damaged tissue repair. Furthermore, in order to repair bone, cartilage, intervertebral disc, adipose tissue, neural, and cardiac tissue, hydrogel-based materials have been widely analyzed as cell delivery systems providing a controlled release of drugs, proteins, cells, gene and other immobilized biomolecules. The suitable combination of 3D scaffold with hydrogels can provide high performance and functional systems, also focusing the attention on the possibility to control drugs or bioactive agent release.

In this scenario, 3D polymeric and composite rapid prototyped scaffolds were properly designed and developed, by means of rapid prototyping technique.Furthermore, different formulation of collagen and collagen-low molecular weight hyaluronic acid (LMWHA) were selected and combined with 3D scaffolds. Micro-computed tomography and compression tests were performed in order to analyze the morphological features and mechanical performances of 3D structures, respectively. On the other hand, rheological and injectability tests were performed in order to obtain important information on the functional properties of the injectable systems in terms of viscoelasticity and flow behavior. Biological analyses have also highlighted interesting information on cell-material interaction.

Biography

Teresa Russo obtained a PhD in Materials and Structures Engineering (Biomaterials) at the University of Naples, Italy. She is as a researcher of the Institute of Polymers, Composites and Biomaterials (IPCB) – National Research Council of Italy and her work is mainly focused on the possibility to combine Additive Manufacturing technologies, electrofluidodynamic techniques and multifunctional injectable gels for the optimization of multifunctional devices for tissue repair and regeneration. She is currently author of national and international papers, different book chapter and communications in international and national conferences. She has also been serving as an editorial board member of repute journals.

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Additive manufacturing of metal-ceramic metamaterials for RF communications

Daniel S Engstrom[1], **Athanasios Goulas**[1], **Reza Gheisari**[1], **Darren Cadman**[1], **Shiyu Zhang**[1], **Dawei Wang**[2], **Ian Reaney**[2], **Bala Vaidhyanathan**[1], **Will Whittow**[1], **Yiannis Vardaxoglou**[1] and **Paul Conway**[1]
[1]Loughborough University, UK
[2]The University of Sheffield, UK

Metamaterials is a class of engineered materials with properties not found in nature. For Radio frequency (RF) communicatons these materials are envisaged to be used for planar antennas and RF devices where advantages are obtained by engineering the permitivity and permeability of the composite structure. Metamaterials for RF communications include those comprising of sub-wavelength highly ordered arrays of conductive materials embedded in a dielectric host material. Metals are the obvious choice for the conductive part and ceramics offer a high permitivity and low loss dielectric host medium. Additive manufacturing (AM) enables remarkable flexibility in the level of geometric complexity and lends itself well to the manufacturing of 3D metamaterials. Although AM of metals is well established, AM of combined metal-ceramic is still only at the research stage. Especially the high sintering temperatures required for ceramic manufacturing makes the process non-compatible with metals. In this project we use a dispensing system and localized laser processing to manufacture metamaterials.

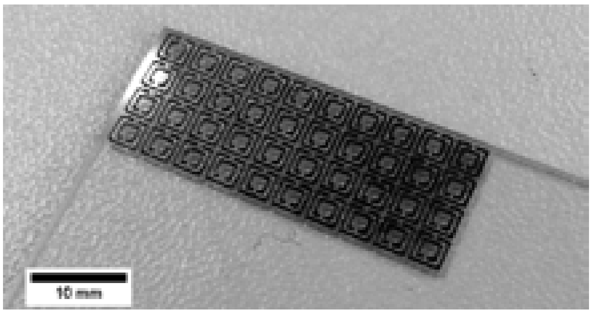

Figure 1: *a) Printed split ring resonator.*

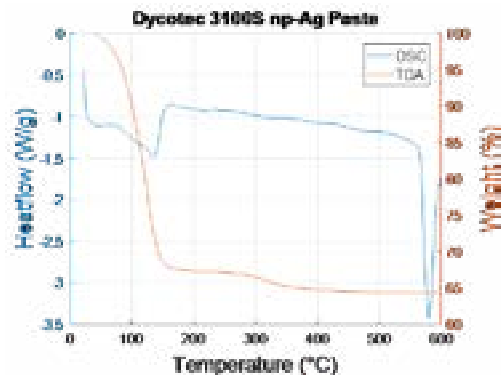

Figure 1: *b) TGA and DSC of the printed Ag nanoparticle ink.*

Biography

Daniel S Engstrom has completed his PhD from the Technical University of Denmark (DTU), Denmark and followed it by Postdoctoral positions at Imperial College London, University College London and University of Oxford, UK. He has been a Lecturer in Additive Manufacturing since 2015 at the Wolfson School of Mechanical, Electrical and Manufacturing Engineering at Loughborough University, UK as a part of the Additive Manufacturing Research Group (AMRG). His research interest includes: AM of Electronics and Metamaterials, Nanoscale AM and Embedded Electronics.

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J Yang et al., Int J Adv Technol 2018, Volume 9
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Biologically acitve and mechanically improved composite core-shell hydrogel for 3D bioprinting

J Yang, P Mistry, A Aied, A Bennett, M Alexander and **K Shakesheff**
University of Nottingham, UK

Introduction: Despite recent advances in hydrogels for 3D bioprinting, one remaining challenge is the lack of hydrogels with biological and mechanical properties that mimic human tissues. Here we have developed a novel core-shell composite hydrogel which has a mechanically robust shell and an ECM (extracellular matrix)-like core to achieve both optimal biological and mechanical properties in bioprinted tissue replacements.

Methodology: The hydrogel which makes the shell of the composite was made by mixing alginate and poly(ethylene glycol) diacrylate (PEGDA) to endow the hydrogel with improved mechanical properties. This alginate/PEGDA hydrogel was then combined with a biologically active hydrogel that supports cell functions in a core-shell configuration. The core-shell composite hydrogel strand was formed in a 3D bioprinting process which laid down the hydrogel strand layer-by-layer to form 3D cell-laden constructs. The cell viability and functions of various cell types in the bioprinted constructs were measured.

Results: Addition of PEGDA to alginate synergistically improved the mechanical properties of the hybrid hydrogel in a composition-dependent manner. We have also demonstrated the printability of the core-shell composite hydrogel into complex 3D structures. Various cell types encapsulated within the composite core-shell hydrogel demonstrated sustained high cell viability and function for two weeks.

Conclusions: We have developed a core-shell composite hydrogel that can be used in 3D bioprinting to form complex 3D structures with high cell viability and functions.

Figure 1: *Core-shell composite hydrogel for 3D bioprinting of cellular constructs.*

Biography

J Yang has completed his PhD from University of Nottingham, UK. He is currently an Assistant Professor in the School of Pharmacy at the same University. He has published 23 papers in peer-reviewed journals and was invited to present his work at internatinal and national conferences in 3D Bioprinting. His research interest includes: Bioprinting, Tissue Engineering and Regenerative Medicine and Biomaterials.

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Frank Schubert et al., Int J Adv Technol 2018, Volume 9
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Design principles for structural components and functional devices

Frank Schubert, Bernd Schob, Camilo Zopp and **Lothar Kroll**
Chemnitz University of Technology, Germany

The technology of Selective Laser Melting (SLM) is capable of generating high-performance lightweight parts featuring an outstanding geometrical complexity. Due to the time and cost intensive production method, special design strategies are required for reaching highest economic efficiency along the entire process chain. To achieve AM designs for many different parts, it is useful to apply category-related design principles. Fist strategy is mainly based on numerical topology optimizations as well as a sufficient interpretation of calculated results. This approach is suitable for structural components featuring predefined bearing positions as well as strength and stiffness requirements. By increasing geometrical complexity and design freedom of AM parts, this approach needs to be extended significantly. It is useful to divide the desired part into functional sub-components. After numerical optimization of every single element, they need to be positioned and interconnected by considering process chain limitations and operational use requirements. The presentation will show through suitable examples the application of both design principles. For AM-related interpretation of topology optimization results, a generic bracket demonstrator will serve. The design strategy for functional devices will be examined by a hydraulic valve block for aerospace applications. Furthermore, support reductions strategies as well as hybrid design approaches will be discussed.

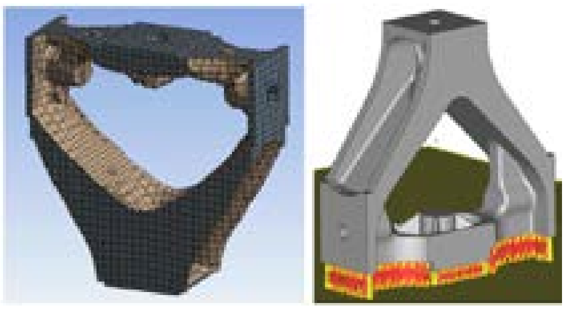

Figure 1: *Topologically optimized geometry (left) and derived AM component (right).*

Figure 2: *Positioned sub-compoments (left) and manufactured AM device (right).*

Biography

Frank Schubert studied Mechanical Engineering at Technische Universität Dresden, Germany. Since 2010, he is the Head of Additive Manufacturing at the Institute of Lightweight Structures, Technische Universität Chemnitz, Germany. His research intererest includes: additive manufacturing of high performance alloys, design guidelines and AM related process chains. The Additive Manufacturing research team is focusing on processing of new metal alloys. In cooperation with industrial partners, the achieved basic results are transferred into applications. One selected example for a successful collaboration is the 3D printed spoiler actuator manifold of Airbus A380. Since March 2017, this flight-safety relevant component is operating in A380 test aircraft.

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Notes:

Yuanqiang Tan et al., Int J Adv Technol 2018, Volume 9
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Discrete element simulation of radial heat transfer in powder bed of 3D printing

Yuanqiang Tan[1], **Yujie Chen**[2], **Shengqiang Jiang**[2] and **Y T Feng**[1,3]
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[3]ZienkiZienkiewicz Centre for Computational Engineering - Swansea University, UK

In powder bed based Additive Manufacturing (also 3D printing) processes like Selective Laser Melting (SLM) or Electron Beam Melting (EBM), the heat transfer mechanism between particles is very complicate. Due to the huge number of particles and small proportion of contact area, the calculation of radiation heat transfer between particles is very difficult, even using a continuous model by FEM (finite element method). A thermal radiation calculation method based on discrete element method (DEM) was proposed. The method include two steps, particle surface discretization and thermal integral accumulation to simulate radiation heat transfer process. The accuracy of the DEM-based thermal radiation calculation method was verified by comparing the results of the particle wall DEM model and the long plate theoretical model. The results indicate that under the same conditions, when the ratio (i) of particle wall length to particle size is greater than 100 and less than 500, the radiation heat transfer value of particle wall is larger than that of long flat plate. If the ratio (i) is greater than 500, the radiation heat transfer value of particle wall is closing to the theoretical radiation heat transfer value of long flat plate. With the increasing of ratio i, the radiation heat transfer value of particle wall is gradually equal to the theoretical radiation heat transfer results. The proposed method possesses the characteristics of high computational efficiency, can calculate the radial heat transfer with any shape surface and the calculation results are very accuracy.

Biography

Yuanqiang Tan has completed his PhD from Central South University of China. He is a Professor at the Institute of Manufacturing Engineering, Huaqiao University, a premier research organization of China. He has published more than 50 papers in reputed journals and has been serving as a Reviewer of repute journals. His research interest is simulation of 3D printing.

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Notes:

Implementation of entry-level bioprinters for biotechnological applications

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Advances in printing technologies and the increasing availability of printable materials render 3D printing a promising technology for biotechnological and pharmaceutical applications. By processing plastics or metals, 3D printing enables biotech laboratories to develop custom-made lab equipment or even completely new tools through rapid prototyping. However, the production and processing of biocompatible materials is required for the integrated printing of biologically active components, such as proteins and cells. The 3D printing of biological or biocompatible materials, designated as bioprinting, is nowadays almost exclusively applied for tissue engineering and regenerative medicine. One of the reasons why bioprinting apart from tissue engineering is still a neglected methodology, is certainly the tedious process of becoming a well-established and applicable technology. The commercially available bioprinters capable of printing the so called bioinks and hydrogels are expensive and strongly targeted for the printing of cells and the provision of cell-friendly printing environments. As a consequence, the access to these printers is strictly regulated and therefore impedes the application in non cell-based investigations. Here, two entry-level bioprinters are presented, which have been developed by simple and affordable technical modifications of conventional polymer printers. These are on the one hand a low-cost Fused-Filament-Fabrication (FFF) 3D printer and on the other one hand a Digital Light Processing (DLP) system. The applicability of these bioprinting systems is demonstrated by case studies using poly(ethylen glycol) diacrylate (PEGDA) as main hydrogel component and enzymes as biological active component. Protein containing hydrogel structures are handled in multiwell plates enabling the implementation of printed biomaterials in liquid handling station based high-throughput process development (HTPD). This approach permits the investigation of hydrogels and their surrounding liquid phase for biological applications. The presented entry-level concept combining bioprinting and HTPD is capable of accelerating the development of bio-synthetic hybrid materials and their processing into functional three-dimensional objects.

Biography

Josefine Morgenstern is a Postdoctoral Researcher at Karlsruhe Institute of Technology, Germany. She has completed her Diploma and PhD at the same institute. She is mainly interested in printing technologies and materials for biotechnological applications.

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Patrycja Szymczyk et al., Int J Adv Technol 2018, Volume 9
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Modern methods of additive manufacturing for biomedical products

Patrycja Szymczyk, Grzegorz Ziolkowski, Bogdan Dybała and **Edward Chlebus**
Wroclaw University of Science and Technology, Poland

Additive manufacturing (AM), due to its high potential for forming complex shapes in almost unrestricted manner, allows for creation of parts that cannot be produced with conventional technologies. The ability to locally control process parameters in additive manufacturing processes or the supply of two or more different materials allow for creating objects with different and unique properties. The application of those technologies opens up new possibilities for the design of modern implants, both in terms of geometric form, as well as programmed mechanical characteristics for optimal biomechanical implants, regarding interactions with the surrounding living tissues. Another aspect is the possibility of manufacturing bone scaffolds with diversified structure designed to support growth of functional bone tissue from patient's own stem cells seeded inside the implant with bioactive agents and customized implants or prostheses suited to the expected actual load, deformation and displacement resulting from an individual's anatomy and physiology basing directly on the data coming from medical CT scans. The capabilities of additive technologies to produce objects with geometries defined by computer 3D models, based on processing biocompatible metal alloys (e.g. CoCr, Ti and Mg alloys), bioceramics (e.g. hydroxyapatite) and biodegradable polymers (e.g. PLA, PLLA), however complex or intricate, have created a potential for solving many problems in medicine with its biological diversity of shapes and structures.

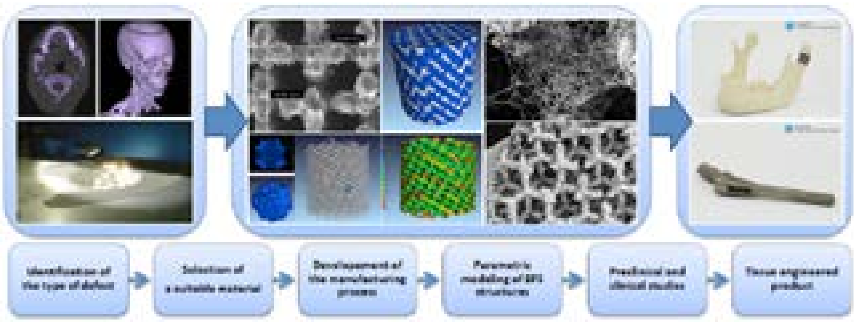

Figure 1: *Procedure for the fabrication of individualized biomedical products with additive manufacturing technologies.*

Biography

Patrycja Szymczyk received her PhD (2015) degree from the Wrocław University of Science and Technology, Poland. She is an Assistant Professor in the Faculty of Mechanical Engineering in the same university. Her current research interests are related to medical applications of AM technologies and includes the design, manufacturing and testing of advanced biomedical objects, such as biomechanical functional structures (BFS) for tissue regeneration, custom-made implants and smart drugs delivery systems for a wide spectrum of materials dedicated to the medical and pharmaceutical industry.

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Notes:

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Sessions:

Day 2 March 20, 2018

3D Printing Technology Impact on Manufacturing Industry | 3D Image Processing and Visualization 3D printing technology and innovations | Metal 3D Printing | Polymers in 3d printing | 3D Bio printing | Lasers in 3D Printing in Manufacturing Industry | 3D Printing of Supply Chain Management | Tissue and Organ Printing

Session Chair
Lin Li
The University of Manchester, UK

Session Co-Chair
Alexander V Manzhirov
Ishlinsky Institute for Problems in Mechanics - RAS, Russia

Session Introduction

Title: **Advanced Materials and Technologies in Aviation Industry**
Tomasz Kurzynowski, Wroclaw University of Science & Technology, Poland

Title: **Selective laser melting of a new medium manganese steel alloy for automotive industry**
Bernd Schob, Chemnitz University of Technology, Germany

Title: **Selective laser melting of a new tailored aluminium alloy (SilmaAl® AlSi7Mg0.6) for aerospace industry**
Camilo Zopp, Chemnitz University of Technology, Germany

Title: **How our noses could change if we lived on Mars. Transhumanist speculations**
Marta Flisykowska, Academy of Fine Arts, Poland

Title: **Multiscale additive manufacturing**
Geoffrey Mitchell, CDRSP-IPL, Portugal

Title: **Multiscale additive manufacturing for tissue engineering**
Nuno Alves, CDRSP-IPL, Portugal

Title: **Multiscale additive manufacturing for aerospace and tooling applications**
Artur Mateus, CDRSP-IPL, Portugal

Title: **Biomanufacturing at multiple scales**
Wenhui Song, UCL Centre for Nanotechnology and Regenerative Medicine, Portugal

Title: **Division of surgery and interventional science**
CDRSP-IPL, Portugal

Tomasz Kurzynowski et al., Int J Adv Technol 2018, Volume 9
DOI: 10.4172/0976-4860-C1-002

Advanced materials and technologies in aviation industry

Tomasz Kurzynowski, Wojciech Stopyra and **Andrzej Pawlak**
Wroclaw University of Science and Technology, Poland

Additive Manufacturing (3D printing) offers the possibility of producing individually designed products that perfectly fulfill their functions – even the most complex ones. AM uses layered production techniques to produce functional finished parts. This process facilitates building of a part from materials that are difficult to machine and enables the production of complex parts for demanding industries such as aerospace. This direction of AM technology development is related to the ability of producing any geometric structure and to use a wide range of processing materials, including typical "aerial" materials used to reduce mass, such as aluminum, magnesium and titanium alloys. It clearly shows the growing impact on the cost of two main factors: 1. use increasingly advanced and expensive materials and 2. technological, construction and assembly work. The use of magnesium for aviation applications is an opportunity to meet the high requirements and mass reduction of parts. The density of magnesium (1.77 g/cm^3) is almost twice as low as conventional aluminum (2.77 g/cm^3). Considering mechanical properties of magnesium (E=34 GPa, hardness 0.6-0.95 GPa), it is characterized by excellent strength-to-weight ratio (specific strength). This is the reason why in advanced areas of industry where the mass of products is crucial, magnesium alloys are the desired materials. Additive technologies (AMs) processing metals, plastics and composites that are currently in advanced development stage (or even commercially availabe) may have a huge impact on the cost of aircraft components by reducing the "buy-to-fly" ratio and eliminating some production, assembly and logistics activities. This is closely related to the capabilities of additive technologies, including: 1. the ability to create extremely complex shapes, spatial internal structures, etc., which reduce the weight of a product by up to 50% compared to conventional methods. 1. the possibility of producing one component that replaces a functional collection of several or even a dozen components made using traditional methods. 2. raw material savings – the amount of material needed (e.g. titanium or aluminum alloy) is only slightly larger than the volume of produced parts; additive technologies do not generate material waste as opposed to traditional technologies like machining, where losses can reach as much as 90% of the input material.

Biography

Tomasz Kurzynowski completed his PhD 6 years ago from the Wroclaw University of Science and Technology, Poland and a professional development program from the Stanford University, USA. He is the Manager of Metal Additive Manufacturing Technology and Materials Laboratory, a Member of the Board of the Science Infrastructure Management Society. He has published more than 20 papers in reputed journals and over 150 industrial experises. His current research interest include additive manufacturing technologies and design methods for functional optimization or weight reduction of designed or reengineered parts, especially for the aerospace industry..

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Selective laser melting of a new medium manganese steel alloy for automotive industry

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[1]Chemnitz University of Technology, Germany
[2]IWT, Germany

In the last few years Additive Manufacturing has established itself in many branches of business. Especially in the automotive industry, the technology of powder-based laser additive melting (LAM) is eminently suitable for the production of customized, high-performance lightweight parts and geometrically complex components. Currently the range of usable materials is limited to a few titanium, nickel, aluminium, cobalt-chromium alloys, as well as some stainless steels and tool steels. Therefore, development of new powder alloys for the LAM - process is required. Medium manganese steel alloys are distinguished materials due to adjustable mechanical properties, such as high strength and significant ductility, which are beneficial for automotive applications. However, the comparatively difficult processing of a medium manganese steel is bounded by the resulting densities, among other limitations. The aim of the work was to develop suitable and robust LAM process parameters for medium manganese steel combined with heat treatment to create microstructures that possess advanced mechanical properties. During the development, material densities of approximately 99.98 % could be achieved. The mechanical investigations are determined by static load in the second step. Due to the processing of the new manganese steel alloy and the resulting mechanical properties, new application potentials can be realised e.g. in automotive future body-in-whites structures.

Figure 1: *high density of medium manganese steel.*

Biography

Bernd Schob graduated in Mechanical Engineering studies at Westsächsische Hochschule - University of Applied Sciences Zwickau, Zwickau, Germany in 2007 and graduated in Economics studies at Freiberg University of Mining and Technology, Germany in 2015. Since 2016, he is a Research Assistant in the Department of Mechanical Engineering at Chemnitz University of Technology, Germany. His research focuses on additive manufacturing, specializing in processing of new materials and development of material parameters in laser additive manufacturing.

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Camilo Zopp et al., Int J Adv Technol 2018, Volume 9
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Selective laser melting of a new tailored aluminium alloy (SilmaAl® AlSi7Mg0.6) for aerospace industry

Camilo Zopp[1], **Frank Schubert**[1], **Frank Palm**[2], **Hubertus Lohner**[2], **Freerk Syassen**[2] and **Lothar Kroll**[1]
[1]Chemnitz University of Technology, Germany
[2]Airbus Central Research & Technology (CRT), Airbus, Ottobrunn, Europe, Germany

In recent years the demand for additive manufactured components has experienced a considerable boost due to increased technical, economic and geometrical requirements. Above all for the aerospace industry, the additive production technology is predestined for the production of tailor-made and geometrically complex components. In particular, laser powderbed fusion (LPB-F) is characterized as an innovative and directional production process with enormous potential. Aluminum alloys are excellent lightweight materials due to their comparatively high stiffness and strength combined with low weight. However, the current use in the additive production process is limited by the comparatively difficult processing and which can lead to undesired low material densities. The focus of the work was the development of suitable LPB-F process parameters for higher strength and low oxygen aluminum alloy AlSi7Mg0.6 (SilmagAl®). In this context, material densities of approx. 99.98 % could be achieved. In the second step, mechanical investigations were carried out under static load. A comprehensive trade-off and comparison was made between different heat treatments. In the static range, yield stresses of up to 300 MPa and tensile strengths of up to 430 MPa have been achieved. The fracture elongation at break could be adjusted accordingly with values up to 20%. Hence processing of this improved aluminum alloy and the generated mechanical properties, new application potentials in the aerospace sector will open up, e.g. for future hydraulic components.

Figure 1: *Material density of AlSi7Mg0.6.*

Biography

Camilo Zopp graduated in Mechanical Engineering studies at Dresden University of Technology, Germany in 2013. Since 2014, he is a Research Assistant in the Department of Mechanical Engineering at Chemnitz University of Technology, Germany. He is currently working in the Germany's first and only Federal Cluster of Excellence "MERGE" in the field of lightweight structures. His research focuses on additive manufacturing, selective laser melting (SLM) especially in processing of new materials and development of material parameters. Another research topic is the production of thermoplastic-based hybrid laminates. He is in interested in the processing of new metal alloys and development of design guidelines.

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Marta Flisykowska, Int J Adv Technol 2018, Volume 9
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How our noses could change if we lived on Mars transhumanist speculations

Marta Flisykowska
Academy of Fine Arts, Poland

In 2017, NASA published the results of the Human Research Program study which involved conducting a comparison of two organisms which are as similar to each other as possible — those of Scott and Mark Kelly, identical twins. The whole project was to address the question of how very long space travel, similar to that required for humans to get to Mars, will affect the human body. There is a multitude of examples showing that mankind is preparing to travel to Mars. The recent test flight of the Falcon Heavy, developed by SpaceX, bears witness to the fact that this moment is right around the corner. These events thus encourage us to view ourselves from a different perspective. The human body will have to change if we are to adapt to new physical conditions, such as lower temperature. The average temperature would be -63°C but it may drop as low as -140°C. The lowest temperature on Earth was -89.2°C, recorded in Antarctica. The atmosphere of Mars consists mainly of carbon dioxide, the gravitational acceleration on Mars equals just over a third of that on Earth. Research conducted in 2017 by the University of Pennsylvania indicates that the human body has been evolving over the centuries in order to genetically adapt to existing climatic conditions. The record of this process can be physically observed based on the example of our noses. It has been ascertained that the width of our nostrils correlates with the temperatures and humidity of the local climate in which our ancestors lived. For the 3D printing conferences, I have prepared speculative designs of noses. How the nose could change in order to adapt to the conditions present on Mars. Flexible prints made of liquid photopolymer solidified using UV light. The various shapes of noses refer to the process of adaptation to the conditions which man will have to face if the Earth's environment were to change. Perhaps speculations on this issue will become an inspiration for science and will allow us to make breathing easier here on Earth — even before we set out to conquer Mars.

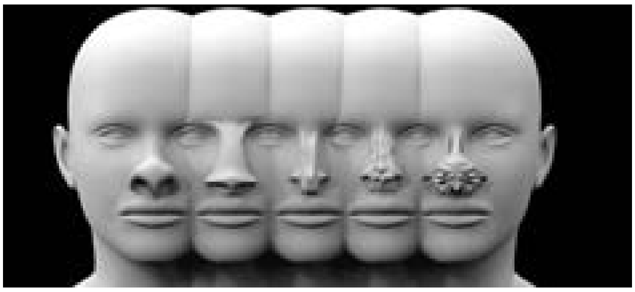

Figure 1: *How our noses could change if we lived on Mars. Transhumanist speculations visualization.*

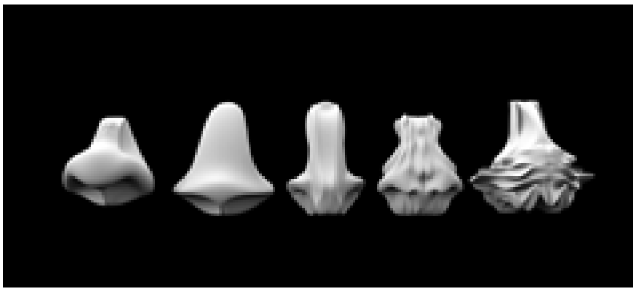

Figure 2: *How our noses could change if we lived on Mars. Transhumanist speculationsexamples of noses visualization.*

Biography

Marta Flisykowska is an independent Designer, Lecturer, Researcher. She is currently working at the Academy of Fine Arts, Faculty of Architecture and Design in the Experimental Design Unit, Gdansk, Poland. Her interests revolve around various aspects of designing, particularly in the social context. She uses her passion for the Universe, Anthropology and Futurology in her projects, exhibitions, and publications. She approaches design holistically as the meeting of local and global cultural spaces. She actively participates in various project undertakings; she's been a curator at numerous exhibitions and workshops, her works were displayed at international fairs and exhibitions such as Milan, Paris, Munich, Las Vegas, or Beijing.

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Shu Chang, Int J Adv Technol 2018, Volume 9
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Towards an understanding of digitally printed materials

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The build materials in most 3D printing processes fall into three categories: solid filaments, solid particles as powders or in suspensions, or liquids that can be solidified. From these materials, parts are constructed to meet the performance requirements defined by the product use. The part performance depends not only on the build material compositions and property, the designed geometry of the part, but also on the microstructure within the part. In 3D printing, besides microstructures in the build materials, the print process and path of material delivery also drive the formation of additional microstructures. The microstructure within the printed part can take on three forms. The first depends on the characteristics of the material which make up the smallest build unit (a voxel), such as a powder volume created by a drop of glue from the binder jetting printing. The second comes from the path that generates the progressive, layer-by-layer assembly of voxels. The last form is the intentionally designed tunable structures. The ability of placing a different material in each physical voxel will allow the construction of a part that may have a "continuum" of properties that range between the constituent materials. This presentation will discuss the different material microstructures resulted from 3D print processes and the methods we have developed to study these microstructures.

Biography

Shu Chang holds the Melbert B Cary Jr. Distinguished Professorship in the College of Imaging Arts and Sciences at the Rochester Institute of Technology (RIT), USA. Her research applies techniques from digital printing to the rapidly growing field of print for fabrication. She has focused on quantifying the material properties and the additive manufacturing process capabilities. Prior to RIT, she was in the print industry for more than two decades. She holds 27 US patents as well as 54 professional publications. She received her PhD in Materials Science and Engineering from the University of Minnesota, USA. She is interested in 3D printing materials, 3d printing resolution, 3d printing quality control and prediction.

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Notes:

David Pammer, Int J Adv Technol 2018, Volume 9
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Additive manufacturing possibilities in Hungary

David Pammer
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Additive Manufacturing (3D printing) is todays most progressive producing technology in the industrial area and in the commercial use as well. The 3D printing process satisfy the Industry 4.0 requirements besides that it needs novel engineering thinking ("think additive"). Cost and time effective functional parts can be produced individually to many industrial fields with high quality. Production, standard and qualification systems are nowadays under development worldwide. Hungary has a growing industrial market (industrial machines, medtech, automotive, areospace, power plants, research centers, etc), where "time cost money effective solutions needs to be delivered to the market. In Hungary, there is increase in number of companies which uses different 3D printing technologies (mostly polymer based technologies), but PaB Engineering has a wide production service solutions for their consumers (metals, polymers, ceramics etc.) besides their R&D projects in the additive manufacturing field. One of these project is the test of 3D printed parts. 3D printed parts should be quality checked with destructive or non-destructive test methods and needs to be qualified according to their structural integrity criteria. To making a test system, benchmark artifacts is needed depending on the production technology parameters. PaB Enginnering has developed different types of test blocks to qualify the used additive manufacturing technology which depends on the industrial fields where the final part will used.

Biography

David Pammer is the CEO of PaB Engineering Ltd., Co-founder of 3DprintBudapest, Hungary and Assistant Lecturer in the Department of Materials Science and Engineering, Budapest University of Technology and Economics, Budapest, Hungary. He is currently pursuing his PhD. His researches are focused on testing 3D printed metal parts, developing 3d printed implants, and the measurement of stability of dental implants. His further research interest include: new additive manufactured metal materials in medical and other industry areas, benchmark artifact test block, standards, quality control of Additive Manufacturing produced parts, new technologies, design, generative optimized structures.

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Notes:

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Day 2

Chao Zhu et al., Int J Adv Technol 2018, Volume 9
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Investigation on the effect of processing parameters on 3D printed structures

Chao Zhu, Chamil Akeykoon and **Anura Fernando**
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The Fused Deposition Modelling (FDM), which is one of the main additive manufacturing technologies, is widely used in many fields with multiple materials. Additive manufacturing shows a rapid development over the last decade and hence FDM printing machines have been improved remarkably. In this work, the effects of several set parameters on 3D printed samples' mechanical properties and their printing quality were explored. It seems that the fill density affects samples' mechanical properties significantly and the variation of maximum load stress and the Young's modulus changed linearly with increased density. Moreover, the fill pattern affects fiber's structure and determines the products' structural properties. The mechanical properties of samples and the printing time were also affected significantly with different layer thicknesses. Samples with different fill patterns showed highly varying properties; e.g. samples with linear fill pattern showed the best tensile properties where samples with "diamond" fill pattern can have a large deformation during tests. Furthermore, the effects of different materials (e.g. PLA (Poly Lactic Acid), ABS (Acylonitrile Butadiene Styrene), carbon fibre reinforced PLA/ABS) on the properties 3D printed structures were also observed and the results showed that the samples with both carbon reinforced PLA and ABS are better in tensile properties than pure PLA and ABS. However, they were found to be more brittle in nature. Moreover, the samples printed from carbon fibre reinforced materials showed a 45-55% increase in tensile properties and a 40-55% increase in Young's modulus compared to pure PLA and ABS.

Figure 1: *Fracture surface of samples: fill density (a).35%, (b).50%, (c).65%, (d).80%, (e).95%.*

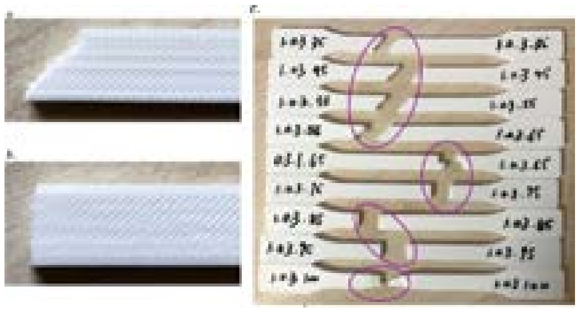

Figure 2: *Changes to the fracture plane with fill density.*

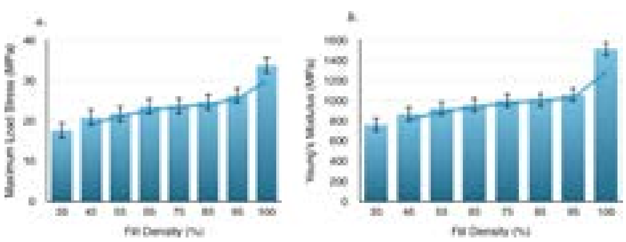

Figure 3: *The variation of maximum load stress and the Young's modulus with fill density.*

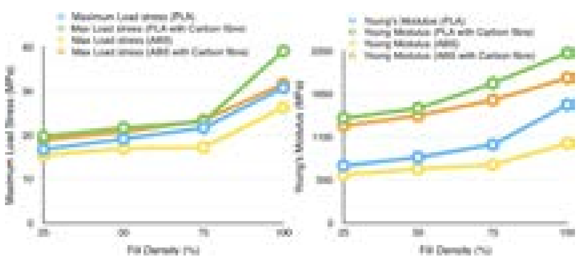

Figure 4: *Maximum load stress and Young's modulus of carbon reinforced polymer and pure PLA and ABS.*

Biography

Chao Zhu graduated with a Bachelor's Degree from Northwestern Polytechnical University, Xian, People's Republic of China. He will get a M Eng Degree from The University of Manchester next year. His interest lies in manufacturing especially in 3D Printing Future Technology.

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Sara Varetti et al., Int J Adv Technol 2018, Volume 9
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Sandwich panel with lattice core for aircraft anti-ice system made by Selective Laser Melting

Sara Varetti, Carlo Giovanni Ferro, Andrea Emanuele Maria Casini, Andrea Mazza, Paolo Maggiore and **Mariangela Lombardi**
Polytechnic University of Turin, Italy

Additive Manufacturing (AM) technology offers the possibility to build strong and light components with complex structures, as lattice, optimizing the strength/mass ratio. The goal of this work is the characterization of an innovative sandwich panel with trabecular core made by Selective Laser Melting (SLM), used as heat exchanger for many industrial applications, for example in aerospace field. In this case study, the panel is integrated into the leading edges of aircraft wings and act as hot air anti-icing system and, at the same time, as impact absorber. The system, due to its lightness and shape, leads to the optimization of the heat exchange, the improvement of the thermal efficiency, and the reduction of fuel use and gas emission. A set of experimental and numerical tests is conducted on lattice specimens through a Design of Experiment (DOE). Different design parameters were varied to understand how they affect the mechanical and thermal behavior: six different cell shapes, varying cell size and volume fraction, were tested. The same experimental program is carried out for two different metal alloys: AlSi10Mg and Ti6Al-4V. Mechanical tests involve compression test on single core and on the whole panel, flexural and impact test. Further analysis on failure mechanism is carried out by observation with optical microscope. Thermal behavior of the system is also investigated by preliminary thermal simulations, whose results are validated by experimental measurements of the temperature gradients on the external surface.

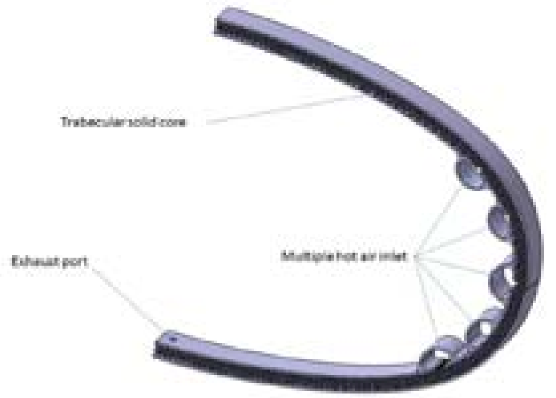

Figure 1: *Schematic drawing of the panel integrated into the leading edge of wings.*

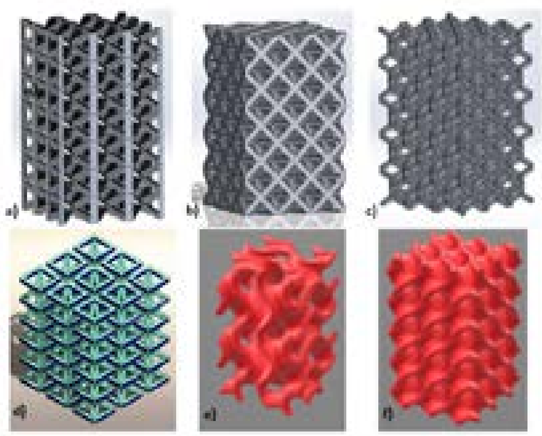

Figure 2: *3D models of specimens with different cell shapes: a) bccz, b) octet-truss, c) rombic dodecahedron, d) auxetic, e) Gyroid and f) schwarz diamond.*

Recent Publications

1. C G Ferro et al. (2017) A robust multifunctional sandwich panel design with trabecular structures by the use of additive manufacturing technology for a new de-icing system. Technologies. 5 (2):35. Doi:10.3390/technologies5020035.

Biography

Sara Varetti is a PhD student in the Department of Applied Science and Technology (DISAT) of Polytechnic University of Turin, Italy. Her reaserch activity is focused on characterization of materials used for Selective Laser Melting and in particular on aluminum alloys. Among her activities there is the design and characterization of an innovative anti-ice system for aircraft, which is patented. This study is carried out in collaboration with the Department of Mechanical Engineering and Aerospace (DIMEAS), Polytechnic University of Turin, Italy.

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Jehad Nasereddin et al., Int J Adv Technol 2018, Volume 9
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Investigation of the mechanical properties of hot-melt extruded filaments for pharmaceutical applications of FDM

Jehad Nasereddin, Peter Belton and **Sheng Qi**
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The advent of additive manufacturing techniques, namely Fused Deposition Modeling (FDM), holds many promising prospects for medical applications, from tailored polypills for personalized medicine to patient-specific implants. However, the lack of pharmaceutically-acceptable materials that possess suitable properties for FDM is the main issue standing in the way of turning FDM into a commercially viable process. And although a number of research efforts has demonstrated the feasibility of using blends of pharmaceutically relevant polymers to print pharmaceutical dosage forms, there remains little-to-no investigation into the critical parameters that govern the feasibility of an FDM process. Mechanical properties of the filament used in FDM is one such critical parameter; part of the filament feeding process involves rotating gears pushing the filament into a pinhole slit that leads on to the heating element of the printer. Trial and error attempts at feeding various in-house prepared filaments to the printer revealed that filaments need to possess specific mechanical properties; filaments which are too brittle will fracture inside the print head causing a blockage, filaments which are too deformable will coil around the conveyer gears without threading into the melting zone. This presentation outlines an in-house developed method to identify the desired mechanical properties for FDM filament: A TA.XT 2 Texture Analyzer fitted with an in-house prepared rig loosely based on the spaghetti flexure rig was used to quantify forces required to deform a number of commercial and in-house filaments. Principal Component Analysis (PCA) was used to sort the data collected from the texture analysis and categorize the various filaments into feedable and non-feedable. The method was then employed to evaluate the feedability of an ibuprofen formulation to verify its suitability as a method to test the mechanical properties of filaments.

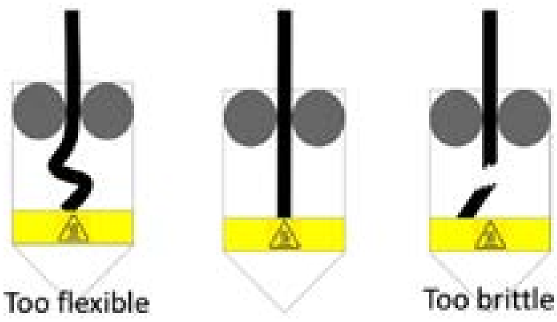

Figure 1: *Different types of mechanical properties and their effect on ability to feed a filament into the printer.*

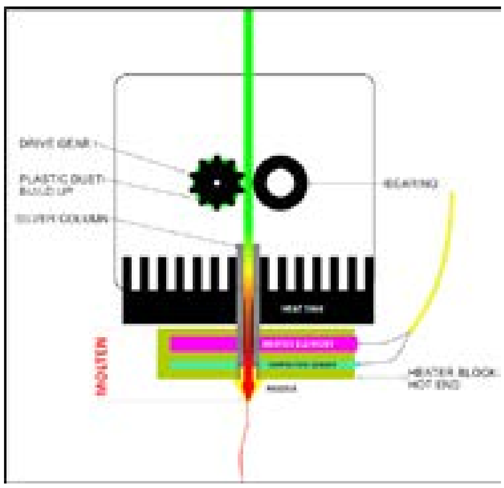

Figure 2: *Internal anatomy of an FDM 3D printer, demonstrating filament threading.*

Biography

Jehad Nasereddin completed his BSc in Pharmacy from the University of Petra, Amman, Jordan in 2015. He pursued Master of Science in Pharmaceutical Technology Program at the University of Bradford, UK in 2016. In April 2017, he started his PhD at the University of East Anglia, under the supervision of Dr. Sheng Qi. His project focuses on investigating the process parameters involved in Fused Deposition Modeling. His research interest includes: hot melt extrusion, amorphous pharmaceutical solids, fused deposition modeling,pharmaceutical dosage forms and thermoplastic polymers.

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Sarah Gretzinger et al., Int J Adv Technol 2018, Volume 9
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Cell characterization methods for use in 3D bioprinting process development

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The development of biocompatible 3D printing methods has pushed the limits in tissue engineering and regenerative medicine in the past years and is considered to be a key technology in these application fields. Since the processing of living materials represents a major increase in process complexity, a directed and systematic process development approach is highly recommended for 3D bioprinting of cells. Such an approach is, however, profoundly dependent on the availability of suitable and accurate cell characterization methods. In this study, we evaluated different state-of-the-art cell characterization methods concerning applicability in 3D bioprinting process development. One metabolic assay, namely, PrestoBlue® and one flow cytometry approach. The theoretical evaluation was based on method versatility and high-throughput screening (HTS) compatibility, as well as method robustness. Further, we have evaluated the performance of two methods that differ in their corresponding mechanism. In this case study, INS-1E was used as model cell line. The evaluation was done with one non-invasive and one invasive cell characterisation method. As a non-invasive strategy, the metabolic assay PrestoBlue® was chosen, since the colometric assay can be performed by analysing the supernatant. A flow cytometry strategy was chosen as an invasive method. Here, a subsequent de-solubilization of the 3D printed object is necessary, in order to gain a single cell suspension. Our study demonstrates the importance of analytical method evaluation, for a specific application, and will facilitate a guidance for method selection.

Biography

Sarah Gretzinger is a PhD student at the Karlsruhe Institute of Technology, Karlsruhe, Germany. She has completed her Master's studies form the University of Ulm in cooperation with the Biberach University of Applied Science, Biberach an der Riss, Germany. Her research interest is: process development for cell-based products.

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Notes:

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Micro-structures fabricated by SLA 3D printing to enhance the electrochemical effects of supercapacitors

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[1]Chung Yuan Christian University, Taiwan
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In this study, SLA (Stereolithography) method was used to fabricate three-dimensional micro-structures. A soft polymer such as PDMS (Polydimethylsiloxane) was used as a mold to duplicate the pattern of the micro-structures. Polyaniline (PANI) films with micro-structures on the surface using PDMS molds were prepared as electrodes of supercapacitor. A specific capacitance 391 F/g at a of 1 A/g was measured for the PANI micro-structures, while the specific capacitance of PANI plane is 304 F/g. To achieve higher energy storage, laser interference lithography was employed to fabricate nano-structures on the micro-structures. The specific capacitance 487 F/g was obtained for the micro/nano hierarchical structures due to increase in the surface of PANI electrodes.

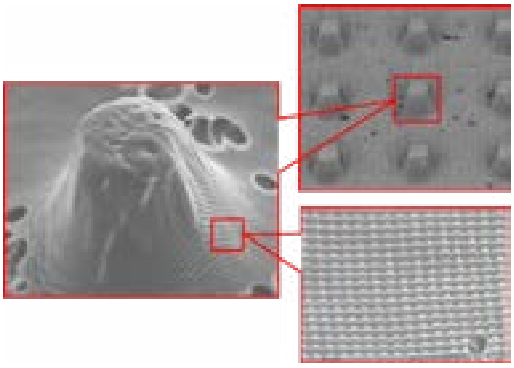

Figure 1: *Hierarchical structures fabricated by SLA 3D printing and laser interference lithography.*

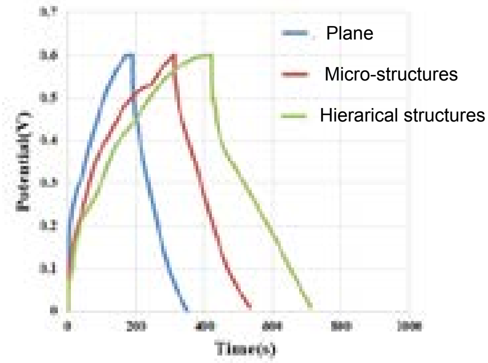

Figure 2: *Charge–discharge cycling curves of the different PANI electrodes at a current density of 1 A/*

Biography

Jiun Hong Liu is studying at the Institute of Mechanical Engineering in Chung Yuan Christian University, Taiwan. His major research is in Optomechatronics.

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M Aburaia et al., Int J Adv Technol 2018, Volume 9
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Freeform-FDM process development using natural fibre reinforced biopolymers

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[3]Shanghai University, P R China
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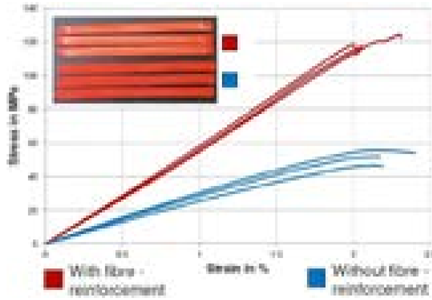
The authors demonstrate a freeform printing process using a robot and fibre reinforced biopolymers (PLA, PHB) because the regular FDM (fused deposition modelling, FFF = fused filament fabrication) relies on layer-by-layer additive manufacturing. As fibres, both conventional (glass fibre, aramid fiber, carbon fibre) and natural fibres (flax, hemp) are used. Also, nano-scaled cellulosic nano crystals (CNC) and/or carbonized biobased nanofillers are used as reinforcement. A new 5 axis/6 axis 3D printing method for load path oriented fibre placement on freeform surfaces (FFF- based and robot arm-based) was developed. A four-fold increase in tensile strength, compared to the non-reinforced polymer, was found for aramid in PLA. Current challenges are melt strand cooling and melt strand chopping. Further increase in mechanical strengthening is expected from optimization of the sizing agent. Freeform printing was demonstrated for up to 45°C of extruded strand angle, without the need for a support structure, using air cooling and regular extrusion speed. Tensile testing according to ISO 527 reveals that the print direction has a market influence of mechanical properties in tensile testing.



Biography

Mohamed Aburaia is a PhD student at the University of Innsbruck, Austria. His PhD topic deals with the usage of industrial robot manipulators for freeform printing. He is the Deputy Program Director of the Master program Mechatronics/Robotics at the University of Applied Sciences Technikum Wien, Austria. He is also the Project Manager of a research facility that uses industrial robots to simulate processes and value chains that are analyzed and optimized concerning Industry 4.0 and related challenges. His research interest includes: Freeform Printing and Biopolymers.

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Notes:

Jennie Von Seckendorff et al., Int J Adv Technol 2018, Volume 9
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Shape matters: Benefits of 3D printing for the design of packed-bed reactors

Jennie Von Seckendorff[1,2], **Normen Szesni**[3], **Richard Fischer**[1,2,3] and **Olaf Hinrichsen**[1,2]
[1]Technical University of Munich, Garching, Germany
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The packed-bed reactor is one of the principal employed reactor types within the chemical industry. In essence, they consist of a long tube either randomly filled with small packing elements or well arranged with structured packing parts. The geometry of the packed parts strongly influences fluid dynamics as well as heat and mass transfer and thus the efficiency of the reactor. However, the currently used production techniques for the packing parts are very limited in terms of achievable shape variability. Therefore, the applicability of 3D printing as a supplementary production method is investigated, as 3D printed parts can be of hardly any imaginable geometry. Shape optimization is performed following a sequence of simulation methods coupling discrete element method with computational fluid dynamics. Inert prototypes can be printed and tested in known testing units to predict efficiency increase. However, printing of catalytically active parts having both significant porosity and sufficient stability is the challenge to be solved in future.

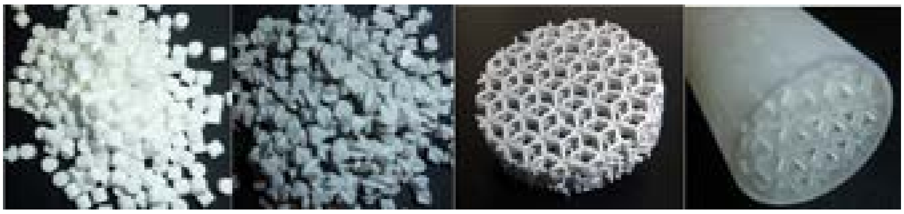

Figure 1: *Examples of reactor packings: a) industrially used random packed bed elements; b) printed alternative with more complex shape; c) printed structured packing element; d) printed reactor tube with integrated structured packing.*

Biography

Jennie Von Seckendorff obtained her BSc and M.Sc Degree in Chemical Engineering at the Technical University of Munich, Germany. She completed a research project at the University of Auckland, New Zealand. She is in the final year of her PhD at the Chair of Technical Chemistry I under Prof. Dr. Ing Olaf Hinrichsen, Technical University of Munich, Germany. Her research interest includes: CFD simulations, design optimization, prototyping, 3D printing of ceramics.

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Katarzyna Czwakiel et al., Int J Adv Technol 2018, Volume 9
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Using digital image corelation in assessment of anisotropy of strength properties of 3D printed specimens

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With 3D printing technology research accelerating year by year and with increasing number of applications of adaptive manufacturing in final products, engineers face the problem of having access to realiable design codes for elements manufactured with those new technologies. By the very nature of the 3D printing technology, manufactured elements are characterized by high degree of anisotropy of strength properties. The aim of the presented research is to establish reliable testing protocol for assesment of anisotropy of mechanical behaviour and to create data bases of experimental results for validation and calibration of numerical models. Besides traditional experimental techniques, new techniques based on Digtal Image Correlation (DIC) and in house developed software are incorporated into the experimental pipeline. In the presented research relatively, simple test cases of specimens under uniaxial tension and compression were analyzed. That allowed for simpler correlation of results from strength testing machine, DIC analysis and simple mechanical model, as well as clearly showed anisotropy effects. The rough surface of printed specimens turned out to be ideal for DIC measurements. The results obtained can be used to calibrate numerical models before testing more complex cases.

Image

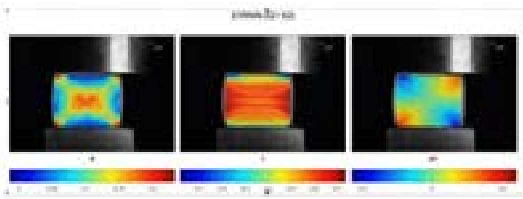

Figure 1: Specimen in commpression test with superimposed strain maps obtained by DIC.

Biography

Katarzyna Czwakiel has obtained her MSc in Civil Engineering at Cracow Univeristy of Technology, Poland. In 2017 she has joined Chair of Building Materials Engineering, where she carries research towards her PhD under the supervision of Prof. Izabela Hager. Her research interest includes: 3D printing, building materials, strength of materials.

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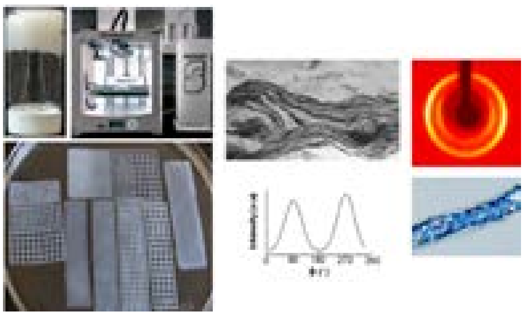
3D printed cellulose nanocrystals based hydrogel scaffolds for biomedical applications

Sahar Sultan and **Aji P Mathew**
Stockholm University, Sweden

Cellulose nanoparticles extracted from natural resources are used extensively in biomedical field because of its favorable biological properties, such as, biocompatibility, biodegradability and low toxicity. However, the 3D printing of these nanoparticles have opened a new area of customization, personalization with better control over structural properties. Much work is devoted to cellulose nanofibers (CNFs) and its biomedical products are already commercialized. Recently the 3D printing of cellulose nanocrystals (CNCs) and the directionality induced in the 3D constructs due to shear-induced orientation of CNCs have open challenges for CNCs to get as much attention as CNFs in biomedical field. Therefore, CNCs based double crosslinked interpenetrating polymer network (IPN) hydrogel has been made and 3D printed into scaffolds with and without gradient porosity. The pore sizes are in the range of 80-2080 µm and 195-2382 µm in the wet and freeze-dried states respectively. The directionality studies showed that degree of orientation varies between 61-76 % depending on the point of measurement within the 3D construct. The nanoscaled roughness (visible for scanning electron images) and mechanical properties (in aqueous medium) are favorable for cell interaction. We believe that we have opened the route for CNCs to enter into the biomedical field. The interesting part of this study is that with a little optimization of pore size and ink composition, our 3D printed scaffolds will have potential applications in bone and/or cartilage regeneration.



Recent Publications

1. Sultan S, Siqueira G, Zimmermann T, Mathew A P (2017) 3D printing of nano-cellulosic biomaterials for medical applications. Current Opinion in Biomedical Engineering. 2:29-34.
2. Markstedt K, Mantas A, Tournier I, Martínez Ávila H, Hägg D, Gatenholm P (2015) 3D bioprinting human chondrocytes with nanocellulose–alginate bioink for cartilage tissue engineering applications. Biomacromolecules. 16(5):1489-1496.
3. Siqueira G, Kokkinis D, Libanori R et al. (2017) Cellulose nanocrystal inks for 3D printing of textured cellular architectures. Advanced Functional Materials. 27(12): 1604619.

Biography

Sahar Sultan is a second year PhD student in Stockholm University, Sweden. She is actively working with 3D printing of cellulose nanoparticles. She has also served the industry for 5 years by working as a researcher and Safety Officre in a solar cell company called Exeger, Sweden AB, Stockholm, Sweden. She is interested in researching 3D printing and cellulose nanoparticles.

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2nd International Conference on

3D Printing Technology and Innovations

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An investigation into the quasi-static response of 316L gyroid structures manufactured using selective laser melting

Qian Tang[1], **Shuai Ma**[1], **Qixiang Feng**[1] and **Xiaoxiao Han**[2]
[1]Chongqing University, China
[2]Loughborough University, UK

Porous structures manufactured using selective laser melting (SLM) have been widely used in fields such as tissue engineering, aerospace, and automobile. SLM-built gyroid structures made in stainless steel 316L has superior properties such as good corrosion-resistance, good biocompatibility, good self-supporting performance, and excellent mechanical properties. In this study, gyroid structures with different sizes were modelled and manufactured using SLM. Then the mechanical properties of the structures under quasi-static compression loads were investigated. The elastic moduli and yield stresses of the structures were calculated from stress-strain diagrams which was obtained by conducting quasi-static compression tests. Moreover, to estimate the discrepancies between the designed and the as-produced gyroid structures, an optical microscope was used to observe their micromorphology. Results shows that sizes of the as-produced structures were larger than their CAD (Computer-aided design) sizes, and the elastic moduli and yield stresses of the structures were improved as their thickness values increased. The process of compression failure shows that 316L gyroid structures manufactured using SLM has good toughness.

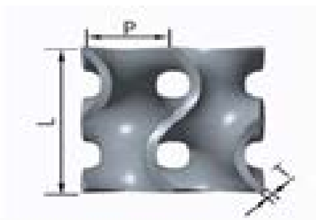

Figure 1: Unit of gyroid structure.

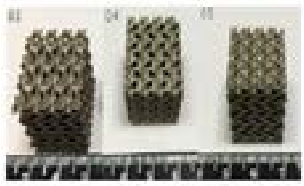

Figure 2: 316L gyroid structure samples manufactured using SLM.

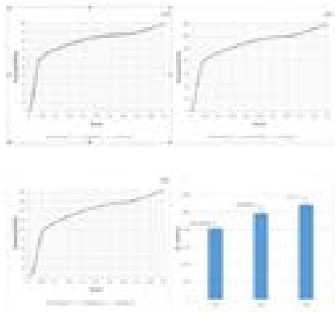

Figure 3: Nominal stress-strain curves and elastic modulus of gyroid structures.

Biography

Qian Tang has completed her PhD from Chongqing University, China. She is a Professor and Assistant Dean of College of Mechanical Engineering at the same university. Her research area focuses on the mechanical properties and the design methods of metallic components fabricated using Selective Laser Melting. Her other research interests are porous structure, tissue engineering and Finite Element Analysis.

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