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3D printed Spacer Fabrics

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Abstract

Spacer fabrics are three-dimensional textiles composed of two fabric layers and a filler yarn that connects the outer layers, while maintaining some distance between them. Spacer fabrics are favorable thanks to their soft, breathable, and elastic properties. Indeed, they are prevalent in a variety of products such as bags, footwear, and protective equipment. Spacer fabrics are usually knitted on large and expensive double-needle bar warp knitting machines. These machines can produce spacer fabrics in a variety of thicknesses, patterns, and densities. However, they are limited in their potential to modulate these parameters within a single knitted fabric. In this talk, we present a non-uniform 3D printed metamaterial analogous to knitted spacer fabrics, which we refer to as 3D Printed Spacer Fabrics (3DSF). We produce these fabrics using desktop 3D printers and off-the-shelf Thermoplastic Polyurethane (TPU) filament. 3DSF exhibits nonlinear compression behavior due to the construction of the filler strands between the faces. We provide a design tool that enables controlling different geometry and printing parameters of the 3DSF, for tuning the dimensions, appearance, and compression of the material. To evaluate how the different parameters affect the compression behavior, we conduct a series of compression tests. The results show that the compression behavior can be tuned to fit specific applications. Finally, we suggest two use cases: biker shorts and a knee pad that uses the 3DSF for padding.

Additive Production of Architectural Building Blocks with Cyanobacteria

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Abstract

Cement and concrete production are responsible for nearly 8% of the world's annual emissions of Global

Greenhouse Gas such as carbon dioxide (CO2). Biodesign aims to address such challenges within architecture by integrating living materials capabilities in fabrication processes. Harnessing living materials in such processes can potentially enhance the ecological footprint and environmental performance of construction materials by inheriting new properties such as carbon dioxide fixation, degradability, and recyclability.

As part of an interdisciplinary approach between microbiology and architecture, the current research proposes to develop a systematic design approach that leverages additive manufacturing (AM) processes based on the biological data of cyanobacteria for the production of architectural components. Unlike other bacteria, the significant ecological advantage of utilizing cyanobacteria in a fabrication process is their inherent ability to perform photosynthesis through light capturing followed by fixation and conversion of CO2 to calcium carbonate (CaCO3) crystals. As calcium carbonate is the main ingredient in limestone and cement, the biological activity of cyanobacteria within sand mixtures can potentially promote the production of bio-based cement that utilizes microbial-induced calcium carbonate precipitation (MCP) for the solidification of the printed components. AM presents a significant advantage for the viability of cyanobacteria due to the bacteria's photosynthetic nature. Different from casting techniques, it enables the manufacturing of porous structures that are optimized for increased surface area and light penetration. Our preliminary experiments have successfully inoculated colonies of cyanobacteria into mixtures of sand and agar. By applying microbiological protocols (i.e., optical density and fluorescence measurements), we examined the behavior of cyanobacterial growth and were able to determine the seeding time and cell concentration within the mixture for optimizing MCP. Moreover, through printing experiments, we are developing a co-fabrication workflow to enable cyanobacteria MCP within the robotic extrusion of sand-based mixtures taking into consideration both printability requirements and cyanobacterial viability needs. By providing designers with an understanding and access to such knowledge, we aim to improve the mutualism between building materials and their surroundings and, enable designers to become active participants in fostering sustainable environments.

Keywords: Biodesign, Additive Manufacturing, Biofabrication, Cyanobacteria, Sustainability,

Carbon Dioxide fixation.

Toward Structural Polymerization of Liquids for Advanced Space Habitats (SPLASH): concept and preliminary experiments

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Abstract

Current additive manufacturing technologies suffer from significant constraints both on the size of 3D printed elements and the duration of the fabrication process. In an era where NASA has identified In-Space-Manufacturing (ISM) as a significant pillar for future space exploration, the limiting factors of traditional 3D printers are restricting the scale and scope of possible 3D printed space structures.
Fluidic Shaping is a new additive manufacturing approach that was developed at Technion, in which interfacial phenomena under microgravity conditions is leveraged to shape liquid volumes into optical components. When using liquid polymers, these components can then be cured to yield solid objects.
SPLASH — Structural Polymerization of Liquids for Advanced Space Habitats — is a joint initiative between research labs in architecture and mechanical engineering at Technion, which aims to expand the principle of the approach for the creation of useful structural components. Relying both on Fluidic Shaping and on principles borrowed from glass blowing, and utilizing a neutral buoyancy environment to simulate microgravity conditions in the lab, we will present several approaches for shaping liquids and demonstrate their utility in creating various structural elements. The approach is scale invariant and thus has the potential to overcome the size and print-time limitations of existing technologies.

Additive Manufacturing Process Chains: Product-Process Co-Design Challenges and Opportunities

Dr. David W. Rosen, Mechanical Engineering Georgia Institute of Technology

Abstract

Consideration of the entire process chain, from the additive manufacturing (AM) process to all the post-processing operations, during design is critical to achieve design requirements. For example, metal AM parts typically require heat treatment, support structure removal, and finish machining. During product design, the designer needs to design parts to be fabricated using AM and their process chains so that all product requirements can be met. This type of product-process co-design can be challenging since it requires extensive manufacturing knowledge. On the other hand, co-design offers opportunities to optimize across the process chain to achieve the best product performance and process efficiencies possible. In this talk, I introduce AM process chains and the Process Chain Map that relates design requirements to each step in the process chain. Design examples of metal and polymer AM parts are presented. Looking to the future, emerging and hybrid AM processes introduce additional challenges and opportunities. Design of complex 3D fiber-reinforced polymer composite parts and their process chains is explored. 4D printing – inducing shape changes in 3D printed parts – is an emerging technology with huge potentials in medical, aerospace, and other industries. Recent results related to 4D printed parts and their AM process chains are presented. Finally, multifunctional devices, such as structural parts with printed electronics and embedded communication capabilities, require hybrid and highly integrated processes. Recent developments are highlighted and initial product-process co-design methods are presented.

Biodata

David Rosen is a Principal Research Scientist at the Institute for High Performance Computing and the Singapore Institute for Manufacturing Technology, both A*STAR institutes in Singapore. He was a Professor in the School of Mechanical Engineering at the Georgia Institute of Technology for many years. Additionally, he held faculty and research positions at the Singapore University of Technology & Design. He received his Ph.D. at the University of Massachusetts in mechanical engineering. His research interests include computer-aided design, additive manufacturing (AM), and design methodology, with a specific interest in design for additive manufacturing. He is a Fellow of ASME. Also, he is the recipient of the 2013 Solid Freeform Fabrication Symposium, International Freeform and Additive Manufacturing Excellence (FAME) Award and is a co-author of a leading textbook on AM. In the standards community, he chairs the ASTM F42 subcommittee on design for additive manufacturing and was awarded the ASTM Award of Merit and promoted to Fellow of ASTM in early 2022.

Solid-State Additive Manufacturing of Metallic Alloys: motivation, challenges, and future research

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Abstract

Additive manufacturing technologies for metallic alloys can be divided to two main groups: liquid-state and solid-state methods. The former, which include laser and electron beam methods, involve local melting of the metal. Alternatively, in solid-state methods, the metal remains at the solid phase during the entire printing and complementary post-printing densification processes.

The general differences between the two groups will be presented, with a focus on their applicability to a unique group of metallic materials: Shape Memory Alloys (SMA). The majority of existing AM technologies used for SMA belong to the liquid-state methods. However, in these methods, the repeated melting impairs the resulting microstructure, and consequently limits the shape-memory (SM) and super-elastic (SE) performance of SMA. This motivates the exploration of alternative AM methods that rely on solid-state processes (e.g., binder jet), where a mixture of metal powder and an organic binder is printed to form a “green” compact, followed by densification heat treatments.

In this talk, I will review the main challenges in solid state AM manufacturing, focusing on SMA, and discuss research directions to overcome these challenges. For example, an important issue in solid-state AM is controlling the residual carbon content that originates from the organic binder. During high temperature sintering, residual carbon readily interacts with metals with high affinity to carbon (e.g., Titanium in Ni-Ti) and forms stable carbides. These carbides change the chemical composition and directly affect the mechanical properties. Our initial results on AM of Ni-Ti using solid-state lithography-based process show this effect, and at the same time indicate that carbides can have both negative and positive effects on the SM and SE properties of SMA NiTi. Seeking alternative solid-state AM processes for SMA NiTi, in which the fraction of organic additives in the starting mixture is minimal will be discussed. Another challenge related to solid-state AM of SMA is developing methods for modifying and controlling the final microstructure. Approaches for refining the grain size, e.g., by mechanically modifying the grain size in the starting powder, will be discussed.

Sinter based Additive Manufacturing of Shape Memory Alloys

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Speaker: Yeshurun C. , Mechanical engineer, Rafael LTD. And the Technion – Israeli institute of technology

Abstract

Shape Memory Alloys (SMA) are a group of metallic alloys with an ability for strain recovery through heating, or large strain recoverable deformation. Due to their unique properties, these alloys are used in many applications in various fields: Bio-Medical industry, Aerospace, Transportation and more.

Conventional production methods limits the currently available SMA materials to several basic shapes: wires, plates, rod, tubes, and other similar geometries. A demand exists in the market for a more versatile production method in terms of geometry, especially due to difficulties in machining of some common SMA, such as Nickel-Titanium Alloy (Ni-Ti).

The emerging technology of Additive-Manufacturing (AM) allows a greater geometrical design and manufacturing freedom. However, SMA possess some unique properties which are complicated to achieve in current metal AM technologies. A key factor influencing SMA properties is the microstructure: The grain boundaries, the dislocation arrangement and density, and other microstructural features. The challenge melting based metal AM is that the process is based melting of a powder, which eliminates any previous microstructure in the SMA.

In this work, we propose a new approach for obtaining better microstructure and shape memory properties from an SMA produced by AM: A sinter-based process. In these AM methods the powder is combined with a binder to create parts which undergo complementary de-binding and sintering processes to gain the final geometry and microstructure, which differs from conventionally AM SMA. Some challenges which are likely to appear in this process are linked to the reaction of the binder with the SMA during the process and the creation of high impurity contents.

In this work, a Ni-Ti (Nickel-Titanium) SMA was manufactured using the sinter-based AM process and examined with various tests, including mechanical tests. An analysis of several key process parameters and their influence on SMA characteristics will be presented.

Biodata

Yeshurun C. is a mechanical engineer in Rafael LTD which specializes in the field of Shape memory alloys and in the field of additive manufacturing, especially of ceramics.

Yeshurun C. is currently a student for M.Sc. degree in the Technion – Israeli institute of technology, with a research subject of Sinter based Additive Manufacturing of Shape Memory Alloys

Cloud-based design and 3D printing: Pathways of dissemination in schools and teacher education

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Laura Levin-Bacari, Technion Faculty of Education in Science and Technology, Center for Robotics and Digital Technology Education

Abstract

The value of learning additive manufacturing technologies, starting from the school years, has been widely recognized, but its implementation faces organizational and methodological challenges. The proposed project aims to develop, implement, and evaluate AM dissemination through the pathways of educating prospective and in-service teachers, high school and junior college students, and mechanical engineering students. Our team includes Technion researchers in digital technology education who are experienced teachers planning to conduct AM dissemination activities in their schools and colleges in the frame of the project. The common approach behind these dissemination activities will be based on the following principles:(1) using a cloud-based design platform Onshape allowing both in-class and remote education;(2) evaluation of student progress in 3D design and printing using the learning analytics software Education Enterprise; (3) fostering generic skills needed in the age of the Fourth Industrial Revolution. We hope that the learning activities that we develop and conduct with the support of the Technion Additive Manufacturing Center will serve as pathways for further AM dissemination in school and higher education.

Additive manufacturing of ECM-based oxygen-sensing skin graft for the personalized treatment of chronic wounds

Prof. Marcelle Machluf , The Faculty of Biotechnology & Food Engineering

Prof. Aharon Blank, The Schulich Faculty of Chemistry

Chronic wounds, mostly caused by complications of diabetes, have wide variability between patients in terms of shape, size, and vascular properties, thus calling for a personalized treatment. One emerging promising approach to treat chronic wounds is the use of skin grafts, which aim at mimicking skin extracellular matrix (ECM). To this end, the use of bioactive materials such as decellularized porcine skin ECM can lead to successful graft integration and promote regenerative processes. Moreover, through advanced wound imaging and additive manufacturing, these grafts can be personalized to perfectly fit each wound. As the skin regeneration is greatly affected by the oxygenation of the tissue, treatments for increasing oxygen concentration in and around the wound were suggested in combination with skin graft application. However, the lack of simple tools for measuring the actual oxygen concentration in and around the healing wound leads to poor monitoring of these treatments. The main goal of the proposed research is, therefore, to develop a personalized solution to actively treat chronic skin wounds and monitor the treatment progress through accurate sensing of wound oxygen levels. A personalized wound-specific artificial skin graft will be developed, and combined with personalized oxygen therapy, relying on wound-specific oxygen data. The geometry of real wounds will be determined by analysis of advanced 3D images and the grafts will be correspondingly tailored from porcine dermal ECM using additive manufacturing, thus harnessing the natural bioactivity of ECM in a controllable, tailor-made personalized graft. To monitor oxygen levels within the healing wound, the 3D skin graft will be incorporated during its manufacturing procedure with unique oxygen sensing paramagnetic micro-crystallites that will allow for real-time oxygen measurements, thus utilizing the skin graft not only as a temperate for tissue regeneration but also as a unique oxygen sensing platform. Altogether, this newly-developed unique theranostic approach will offer a complete personalized solution for chronic wound patients.