Contents

Alexander Geht, Michael Weitzmann, Yasha Grobman and Ezri Tarazi

DesignTech lab and Material Topology Research lab, Technion-Israel Institute of Technology

Horizontal Forming in Additive Manufacturing: Design and Architecture Perspective

Extrusion based three-dimensional additive manufacturing technology forms objects by driving the material through a nozzle depositing a linear structure through vector-building blocks called roads. In common 3-axis system the roads are stacked layer upon layer for forming the final object. However, forming overhanging geometry in this way requires additional support structures increasing material usage and the effective printing time.

This research presents a novel Horizontal forming (HF) approach and method for forming overhanging geometry, HF is a new extrusion-based AM approach that allows rapid and stable forming of horizontal structures without additional support in 3-axis systems. This approach can provide new design and manufacturing possibilities for extrusion AM, with emphasis on medium and large-scale AM. HF can affect the outcome's aesthetic and mechanical properties. Moreover, it can significantly accelerate the production process and reduce material waste.

Keywords: Additive manufacturing, Support, Horizontal forming, Extrusion-based system, Fused granulate forming

Jaim Nulman, Ziv Cohen and Amit Dror

Nano Dimension

Additive Manufacturing for Electronics – Applicable Solutions

Usage of Inkjet printing technology and nano materials enables production of Additively Manufactured Electronics devices (AME).

In this lecture, [Dr. Jaim Nulman / Eng. Ziv Cohen / Mr. Amit Dror] will present the technology and unique applicable solutions such as AME multi-layer circuitry, AME Capacitors, AME Converters and more. The presentation will show unique scenarios, available only with Additively Manufactured Electronics that contribute to agile design and on-step manufacturing.

For references, you may review the following:
https://www.youtube.com/watch?v=yAxczJm1RrU

https://www.youtube.com/watch?v=sDdOqrH9v9A

www.nano-di.com

https://www.nano-di.com/nano-executive-dr-jaim-nulman

E. Almog, A. Sharma, Y. Qi and E. Rabkin

Department of Materials Science and Engineering, Technion-Israel Institute of Technology
Kavli Nanoscience Institute, California Institute of Technology, Pasadena, CA, USA

Hybrid hierarchical nanolattices with porous platinum coating

Nanolattices exhibit wide range of unique properties and attract a growing interest in many scientific fields. The architected hierarchical structure allows tailoring the nanolattice properties to obtain objects of relatively large dimensions with nano-size features. In our work we fabricated a core-shell polymer-platinum nanolattice by combining several fabrication techniques. The polymeric nanolattice was designed by CAD, and fabricated by a two photon lithography technique to achieve the required architecture. The lattices were then coated with thin film of platinum using atomic layer deposition (ALD) method. The unique interaction of the gaseous ALD precursor with the polymer surface resulted in a porous film with nano grains, providing a hierarchy ranging from the micrometer-size overall dimensions down to the microstructural features of a few nanometers. The microstructure evolution (i.e grain size, pore size and defects) caused by annealing at elevated temperature was investigated, and correlated to the mechanical behavior of the lattices during in-situ compression inside a scanning electron microscope. Deeper understanding of the microstructure and morphology of the porous Pt film was obtained employing specially developed lamellae preparation technique in FIB and characterization by scanning transmission electron microscopy (STEM).

Yoav Sterman

Faculty of Architecture and Town Planning, Technion-Israel Institute of Technology

Nike Flyprint - From Design hacking to performance products

Nike Flyprint is the first 3D printed textile in performance footwear. It was first used in the Vapour Max shoe wore by Eliud Kipchoge at the 2018 London marathon and is going to be embedded in the Nike's soccer shoes in the upcoming Olympic games. This project originated from my time at Nike with a series of experimentation and exploration that involved hacking a 3D printer and using computational design methodologies to drive the design and manufacturing of 3D printed textiles.

In the talk I go through the project and results, from the initial motivation, to the technical process of hacking a 3D printer and the computational design tools that were developed for this project. Additionally, I will highlight the many challenges in promoting the project within the Nike organization, and the path taken from a concept idea to an actual product that is being used by top athletes today.

Vladimir Popov, Andrey Koptyug, Evgeny Strokin, Alexander Fleisher, Alexander Katz-Demyanetz, Haim Rosenson and Menachem Bamberger

Israel Institute of Metals, Technion's R&D Foundation
Sports Tech Research Centre, Mid Sweden University
Materials Science and Engineering, Technion-Israel Institute of Technology

Material Design by Additive Manufacturing

Additive Manufacturing Center at Technion work on development and characterization of new and existing metal- and ceramic-based materials.

The research uses Powder Bed Fusion machines for Selective laser Melting (SLM), Electron Beam Melting (EBM), and for Binder Jetting Printing (BJP).

The advanced novel composite and composite-like materials could be produced using process parameters tailoring, beam control, powder blending, printing machine optimization, and by additional thermal post-processing [1]–[6].

Such an approach provides a new level of freedom of design – using additive manufacturing one has freedom of shape, and using tailoring of required properties by advanced composites manufacturing, the freedom of materials' properties could be achieved.

Will be presented rules of thumb for Design for Additive Manufacturing of Functional Materials.

[1] A. Koptyug, L. E. Rännar, C. Botero, M. Bäckström, and V. Popov, "Unique Material Composition Obtained By Electron Beam Melting Of Blended Powders," in *Euro PM2018*, 2018, pp. 1–6.

[2] A. Koptyug, M. Bäckström, C. A. Botero Vega, V. Popov, and E. Chudinova, "Developing New Materials for Electron Beam Melting: Experiences and Challenges," in *Materials Science Forum*, 2018, vol. 941, pp. 2190–2195.

[3] A. Fleisher *et al.*, "Reaction bonding of silicon carbides by Binder Jet 3D-Printing, phenolic resin binder impregnation and capillary liquid silicon infiltration," *Ceram. Int.*, vol. 45, no. 14, pp. 18023–18029, Oct. 2019.

[4] A. Koptyug *et al.*, "Compositionally-tailored steel-based materials manufactured by electron beam melting using blended pre-alloyed powders," *Mater. Sci. Eng. A*, vol. 771, no. October 2019, p. 138587, 2020.

[5] V. Popov, A. Katz-Demyanetz, A. Koptyug, and M. Bamberger, "Selective electron beam melting of Al0.5CrMoNbTa0.5 high entropy alloys using elemental powder blend," *Heliyon*, vol. 5, no. 2, p. e01188, Feb. 2019.

[6] I. Radulov *et al.*, "Production of net-shape Mn-Al permanent magnets by electron beam melting," *Addit. Manuf.*, vol. 30, p. 100787, Dec. 2019.

Beni Cukurel, Boris Leizeronok and Lukas Badum

Department of Aerospace Engineering, Technion-Israel Institute of Technology

Development of an Additively Manufactured Ultra Micro Gas Turbine

The work focuses on a multi-disciplinary development of an ultra-small-scale 300W gas turbine, including thermodynamic, structural, thermal and rotordynamic analyses. The main innovative feature of the presented gas turbine is its single-piece rotor, produced by additive manufacturing of ceramic (such as Zirconia and Alumina) or Inconel. This unique approach provides a path towards novel design, which resolves previously encountered challenges in other ultra-small turbomachinery studies. The research is led by a Ph.D. student, Lukas Badum.

Yacov Malinovich, Tal Rindel and Israel Vizel

Haifa3D and Shaar Giora Ltd.

Poly-Tungsten with 12g/cm3 Density – Revolutionary FDM AM Printer

Poly-Tungsten is a unique polyamide compound, mixed with Tungsten-Metal Powder. This compound is non-toxic and ROHS compliant and a Lead-Free alternative material, with high radiation shielding properties. The highest filament composition density that is available commercially for AM is 7.8g/cc and it is impossible to create a filament with 12g/cc, it is rigid and inelastic. Shaar Giora Ltd. specialize in Injection Molding of Poly-Tungsten using Granules and molds. We developed FDM AM technology and printer using Poly-Tungsten Granules as the raw material and a unique heated printer extrusion head that deposit the compound and forming it into a continuous profile.

The new AM Poly-Tungsten technology gives the ability to quickly create parts that approach the density of 12g/cc and are ideal for uses like weighting, balancing, x-ray shielding, lab equipment, reactor shielding, vibration dampening and inertial weighting. Other densities and polymers are also potentially available.

Ariel Eisenbach

PRECISE-BIO

LIFT bioprinting of implantable human tissues and organs

Laser-Induced-Forward-Transfer (LIFT) is an emerging technology in the field of micro-electronics and biological printing. The concept, first presented in 1986, is based on pulsed laser evaporation of absorptive material, generating focused pressure and pushing the printed material forward, toward the target. Although its high resolution (1µm!) and wide range of printable materials (from liquids to solid metals and polymers), it was not commercialized for many years due to its relative complexity, high materials costs, low yield and low throughput.

In the last several years Precise-Bio developed a LIFT bioprinting platform which successfully address these challenges. The LIFT bioprinter is capable of printing living cells and highly viscous biomaterials at high resolution, and was demonstrated to print functioning human corneas as well as many other tissues and models.

In the talk we will present the bioprinting platform and the LIFT process, as well as its various biological and medical applications.

<u>**Yuval Harduf**</u>

Faculty of Mechanical Rngineering, Technion – Israel Institute of Technology
RAFAEL – Advanced Defense Systems

Towards optimal dynamic response using AM based granular damping

Selective laser sintering (SLS) is an additive manufacturing (AM) technique, used mostly for metallic materials, in which powder layers are successively applied and selectively solidified by a laser beam to create a structure layer-by-layer. In the presented research, a method of encapsulating the unsolidified powder in closed chambers embedded in the solidified structure is proposed, to act as granular dampers. When the structure is vibrated, the encapsulated powder granules collide and rub with one another as well as with the chambers' walls. The inelastic collisions and frictional interfaces act as energy sinks, absorbing vibrational energy. This implementation requires no maintenance, provides high durability and long service life and of special interest in cases where the design is bound to complex geometries, confined volumes, or where standard dampers cannot be applied. Granular dampers have been a research interest for a long time now and it was already suggested to embed them within a structure. However, the use of AM to fabricate such dampers is both innovative and highly attractive as it allows a) to create the granular dampers as part of the fabrication process and b) to control the form, shape and location of the dampers to optimize the structure's vibrational response by increasing its effective damping. The behavior of granular dampers has not yet been characterized thoroughly in an analytic model and no design process that optimizes the dampers' topology has been proposed yet. In this talk the results of an experimental study on additively manufactured beams will be discussed. Beams with embedded granular dampers were shown to exhibit higher damping ratios than fully solidified beams. The response of the damped beams to excitation was found to be highly nonlinear as its damping effective damping increases with the vibration response amplitude. However, it was shown that modal theory could be applied in certain frequency ranges as it was found that the damping ratio is a modal property which depends on the mode-shape. Advanced nonlinear analysis techniques were used to investigate the properties of the beams and initial results show that the damping force exhibits bi-linear behavior, depending on the response amplitude. Initial work towards optimization and a simplified model for the investigation of various damping models will be presented as well.

Zehavit Reisin

Vice President | Head of Materials Business and Design Segment, Stratasis

What's New with Materials?

Within the Stratasys offering, designers and engineers are able today to leverage the benefits of two distinct 3D printing material technologies: FDM thermoplastics and PolyJet photopolymer resins. By expanding upon the applicative benefits of both current and newly launched materials, the Stratasys team provides key insights into how every stage of the product development and the manufacturing cycle can be improved, to effectively meet time-to-market requirements, at reduced cost and without compromising on quality and design creativity.