8th | 2025

HI-AM CONFERENCE

HOLISTIC INNOVATION IN ADDITIVE MANUFACTURING

JULY 23 & 24
WATERLOO, ON, CANADA
hiam.uwaterloo.ca/2025

PARTICIPANT INFORMATION PACKAGE

UNIVERSITY OF WATERLOO

NSERC CRSNG

8th | 2025

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PARTICIPANT INFORMATION PACKAGE

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Welcome Message

This year marks the 8th edition of the HI-AM conference and the official launch of HI-AM 2.0. As we gather once again in Waterloo, ON, where the first conference began in 2018, we celebrate not only the continuation but the growth and evolution of HI-AM as Canada's premier platform for academic exchange in additive manufacturing. On behalf of the organizing committee, it is our great pleasure to welcome you to this event.

Over the years, the HI-AM Conference has travelled across Canada, bringing together researchers, industry professionals, and stakeholders from diverse disciplines and institutions. The enthusiasm and collaborative spirit of the AM research community have been remarkable, and we are thrilled to embark on this new chapter. Future events under HI-AM 2.0 promise to be larger, more diverse, and more focused, as we collectively tackle the challenges and opportunities within the AM field.

This year's conference features 80 presentations and posters, offering a unique opportunity to explore cutting-edge research and technological advancements. Participants can exchange ideas, shape future research directions, and forge new collaborations within a multidisciplinary and multi-sector network.

We are honoured to feature two keynote speakers who bring invaluable industry perspectives: Ante Lausic from General Motors and Behrang Poorganji from Nikon. Their presentations will delve into the challenges of scaling additive manufacturing and its integration into industrial processes—an area of immense relevance and potential.

In addition to keynote presentations, technical sessions, and poster exhibitions, the conference is designed to facilitate formal and informal networking opportunities. Attendees can connect with peers during various scheduled events.

We extend our deepest gratitude to all who contributed to the success of this event, with special thanks to the Natural Sciences and Engineering Research Council of Canada (NSERC) for their instrumental support. To our dedicated **scientific advisory committee**, presenters, partners, and volunteers, thank you for making this conference possible.

This welcome package has been prepared to help you make the most of your conference experience. Inside, you'll find detailed schedules of sessions, activities, and resources to ensure a seamless and enriching conference journey.

We wish you a productive and memorable experience at HI-AM 2025 and look forward to connecting with you throughout the event.

Ralph Resnick
Chairman of the Advisory Board

Ehsan Toyserkani
Conference Co-chair

Mihaela Vlasea
Conference Co-Chair

HI-AM 2025

ABOUT THE CONFERENCE

Established in 2018 as part of the NSERC Network for Holistic Innovation in Additive Manufacturing (HI-AM Network) activities, the HI-AM Conference has become a key academic event in Canada, exclusively dedicated to advancing research and development in additive manufacturing. It serves as a dynamic platform for researchers, industry leaders, and academics to explore the latest innovations and emerging trends in the field.

Following the successful completion of the HI-AM Network in 2024, the conference continues under HI-AM 2.0, the second phase of the program supported by the Natural Sciences and Engineering Research Council of Canada (NSERC).

With this new phase, the conference has broadened its scope to include additional topics such as non-metal additive manufacturing, fostering greater innovation and interdisciplinary collaboration. Peer-reviewed proceedings will also be published, enhancing the visibility and recognition of the presented work.

The 8th edition, HI-AM 2025, hosted by the University of Waterloo, will spotlight recent breakthroughs across key research themes, continuing to drive knowledge exchange and innovation in additive manufacturing.

We acknowledge the support of the Natural Sciences and Engineering Research Council of Canada (NSERC).

Nous remercions le Conseil de recherches en sciences naturelles et en génie du Canada (CRSNG) de son soutien.

Natural Sciences and Engineering Research Council of Canada

Conseil de recherches en sciences naturelles et en génie du Canada

Canada

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UNIVERSITY OF WATERLOO

MSAM

METAL AM MAGAZINE

HI-AM 2025

VENUE

HI-AM 2025 will be held in the Engineering 7 (E7) building on the University of Waterloo campus.

Photo Credit: University of Waterloo

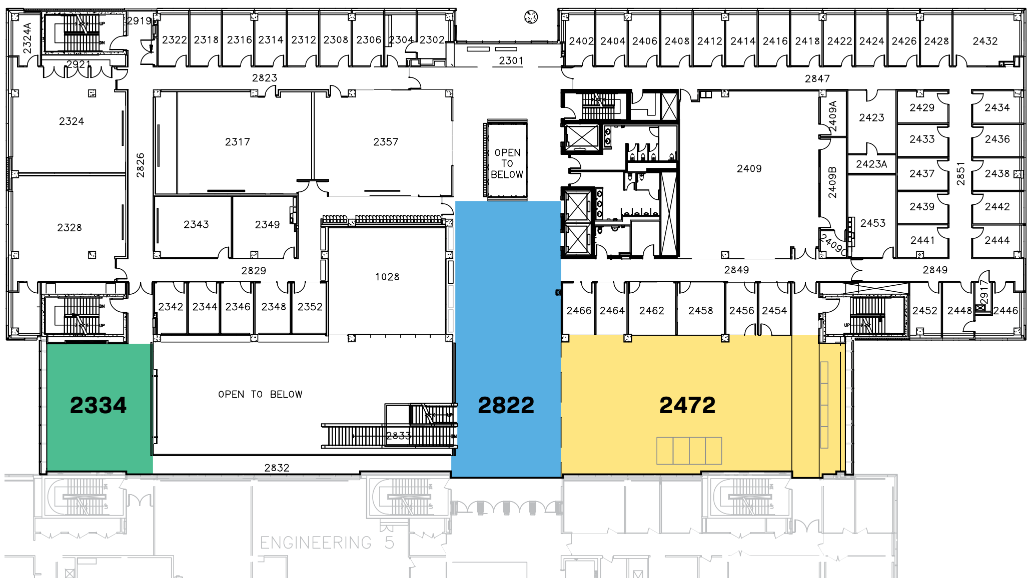
FLOOR PLAN

E7 – 2ND FLOOR

2472
Keynote Presentations and Catering (Lunch)

2822
Registration and Poster Gallery

2334
Lounge



E7 – 7TH FLOOR

ROOM 7303
Breakout Room 1

ROOM 7363
Breakout Room 2

ROOM 7411
Boardroom

7822
Catering (Coffee Break)

TRAVEL AND PARKING

For directions to the campus and information on transportation options to Waterloo, visit **uwaterloo.ca/welcome-warriors/come-campus**.

For parking information, visit **uwaterloo.ca/sustainable-transportation/about/our-parking-lots**. Participants are welcome to park in any of the designated visitor parking lots on campus. Please note that parking fee payment is processed via the AMP Mobile Pay app, which can be downloaded from **Apple's App Store** or **Google Play Store**. The closest visitor parking options to the E7 building are Lots Q and B (visitor spots at E6), with a flat daily rate of $7.25. Parking lot E is the only free parking option.

CONFERENCE DINNER

The conference dinner will take place on July 23, 2025, 7-10 pm, at Fed Hall on the University of Waterloo campus. Conference Dinner tickets must be purchased separately during registration. Badges and banquet coupons, required for entry to the event, will be distributed at the registration desk during check-in.

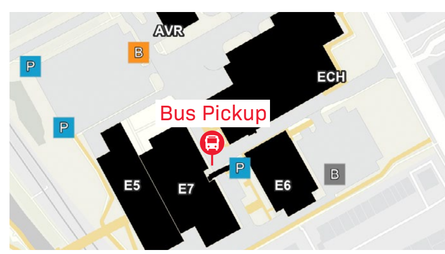


Photo Credit: University of Waterloo

MSAM LAB TOUR

Two tours of the University of Waterloo's Multi-Scale Additive Manufacturing (MSAM) Lab are scheduled—one on July 22, from 5-6 pm, and another on July 24, from 3:30-4:30 pm. If you have registered for one of these tours, please proceed to the lab at the scheduled time. Note that the MSAM Lab is located off-campus at Catalyst 137, approximately a 10-minute drive from the conference venue.

Chartered buses will be available on July 24 to transport participants registered for the second lab tour from the E7 building to Catalyst 137. Following the conference closing, please proceed to the east entrance of E7, as labeled on the image to the right, to board the bus. Departure is scheduled for 3:15 pm. Please note that this is a one-way service; attendees are responsible for arranging their own transportation after the lab tour.



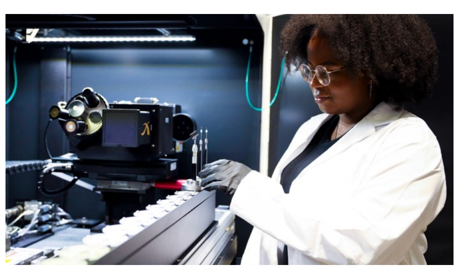
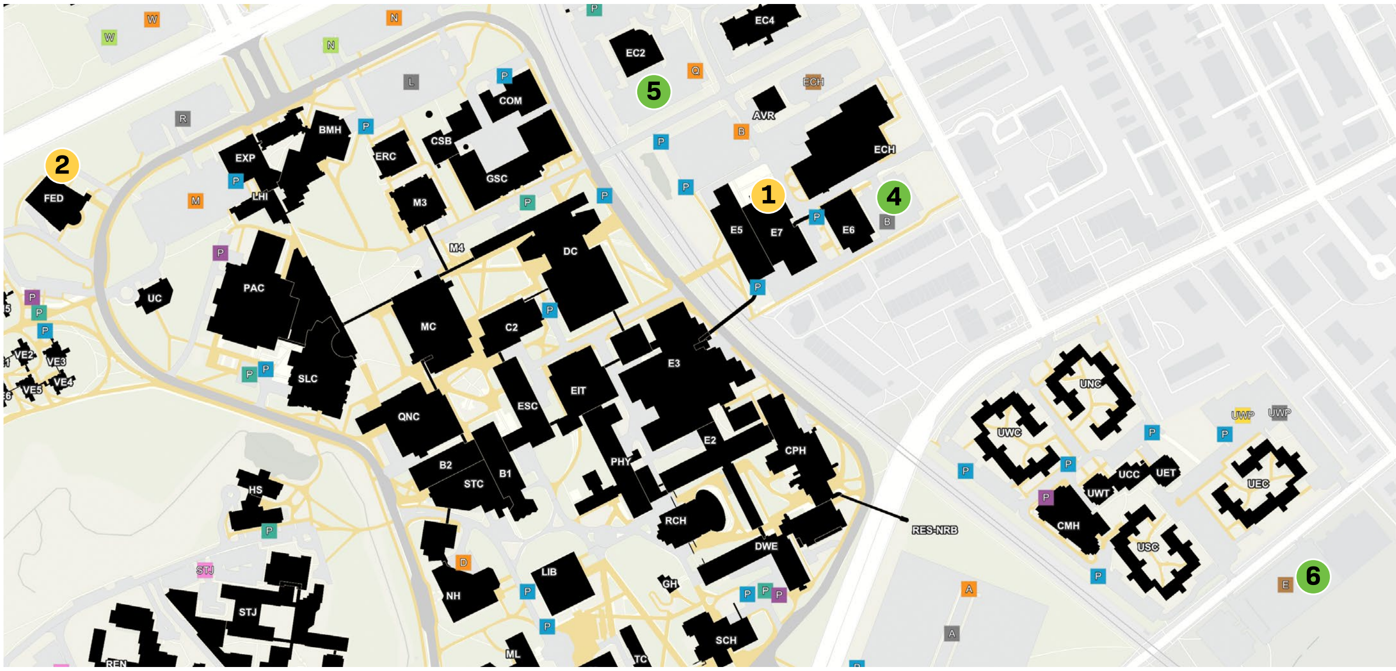
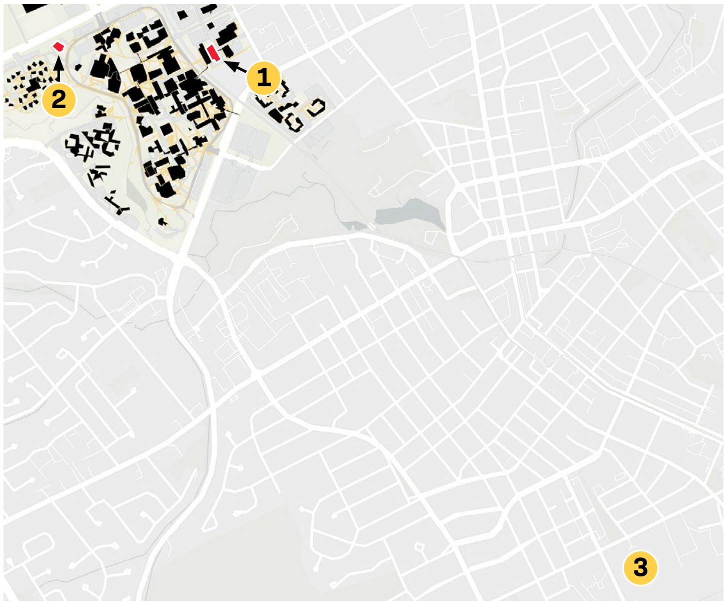




Photo Credit: University of Waterloo

KEY LOCATIONS, DATES, AND TIMES

EVENT	DATE & TIME	LOCATION	ADDRESS
HI-AM 2025	July 23, 8:00 am – 5:00 pm July 24, 8:00 am – 3:00 pm	Engineering 7 (E7)	**University of Waterloo** 200 University Ave. W. Waterloo, ON N2L 3G1
Conference Dinner	July 23, 7:00 pm – 10:00 pm	Fed Hall	
MSAM Lab Tour	July 22, 5:00 pm – 6:00 pm July 24, 3:30 pm – 4:30 pm	Catalyst 137, Unit 320	137 Glasgow St. Kitchener, ON N2G 4X8





1. Engineering 7 (E7)
2. Fed Hall
3. Catalyst 137 (MSAM Lab)
4. Parking Lot B
5. Parking Lot Q
6. Parking Lot E

Keynote Speakers

Ante Lausic

Lead Process Engineer
General Motors

Dr. Ante Lausic is the Lead Process Engineer for General Motors metal additive manufacturing work out of Warren, MI, USA where he works to industrialize PBF, DED, and MBJ for use in automotive production and manufacturing. He has spent 16 years in the AM field with the last 8 years focused on automotive and tooling applications. Dr. Lausic also supports the Canadian ISO delegation in developing standards for the AM industry.

Presentation title: *Revved up but stalled: a tale of high hopes and low volumes*

Behrang Poorganji

VP of Technology
Nikon

Dr. Behrang Poorganji is a seasoned professional with over 20 years of experience in advanced metallic materials processing and Metal Additive Manufacturing. He currently serves as a VP of Technology Nikon where he leads technological advancements in the metal additive manufacturing field. Behrang career trajectory includes diverse leadership and management roles across international borders, including Japan, Canada, and the USA. With a strong foundation in aerospace, power management, and automotive industries, he has demonstrated his adaptability and strategic acumen. Behrang has served as an influential advisor and consultant, contributing to the broader adoption of additive manufacturing solutions across global industries.

Presentation title: *Integrated multi-scale solutions for accelerating industrial-grade additive manufacturing*

DAY 1 – July 23, 2025 MORNING

Note: As of July 11.
Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

Time	Session 2 / Main	Session 3
8:00am	**REGISTRATION – Location: E7-2472**	
8:45am	**CONFERENCE OPENING – Location: E7-2472 | Chairs: Ehsan Toyserkani and Mihaela Vlasea**	
9:00am	**SESSION 1: Scaling Additive Manufacturing for Industry** **Location: E7-2472 | Chair: Ehsan Toyserkani**	
9:00am	**Keynote 1: Revved up but stalled: a tale of high hopes and low volumes** Ante T Lausic, *Lead Process Engineer, General Motors*	
9:40am	**Keynote 2: Integrated multi-scale solutions for accelerating industrial-grade additive manufacturing** Behrang Poorganji, *VP of Technology, Behrang Poorganji*	
10:20am	**COFFEE BREAK – Location: E7-7822**	
10:40am	**SESSION 2: Directed Energy Deposition** **Location: E7-7303 | Chair: Hamid Jahed**	**SESSION 3: Powder Bed Fusion I** **Location: E7-7363 | Chair: Hamed Asgari**
10:40am	**Presentation 1: Rapid prototyping of novel materials via directed energy deposition: A case study on solidification cracks at the substrate – alloy interface** Joseph Agyapong, Solomon Hanson Duntu, Caleb Osae-Morgan, Aleksander Czekanski, Solomon Boakye-Yiadom *York University, Canada*	**Presentation 5: Laser powder bed fusion of IN738: Cracking mechanism and strategies for crack mitigation** Hamid Aghajani, Ehsan Toyserkani *University of Waterloo, Canada*
11:00am	**Presentation 2: Design of new NiCoCr alloys for additive manufacturing through high-throughput experiments** Ajay Talbot, Yu Zou *University of Toronto, Canada*	**Presentation 6: Predicting nickel loss during LPBF of Ti-Ni SMA using a combination of the vaporization and melt pool modeling and in situ thermal monitoring** Donatien Campion, Matheus Soares, Alena Kreitcberg, Vladimir Brailovski *Ecole de Technologie Supérieure, Canada*
11:20am	**Presentation 3: Optimizing laser-directed energy deposition parameters for the repair of additively-manufactured die-casting tooling inserts** Benjamin F Orchard, Michael Benoit *University of Waterloo, Canada*	**Presentation 7: Preliminary assessment of a novel hybrid manufactured titanium alloy dental implant abutment** Les Kalman *Western University, Canada*
11:40am	**Presentation 4: Developing strategies for medium volume production in directed energy deposition additive manufacturing** R. Jill Urbanic *University of Windsor, Canada*	**Presentation 8: Influence of LPBF process parameters on the microstructure and magnetic properties of 3D-printed NdFeB magnets** Xavier Walls[1,2], Rene Lam[1], Mingzhang Yang[1], Mohsen K. Keshavarz[1], Mihaela Vlasea[1], Fabrice Bernier[3], Felipe Blanco[4], Sangeeth Gunalan Kr[4], Sebastian Recabal[4] *[1]University of Waterloo. [2]Carleton University. [3]Automotive and Surface Transportation Research Centre*
12:00pm	**LUNCH – Location: E7-2472**	

DAY 1 – July 23, 2025 AFTERNOON

Note: As of July 11.
Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

EDT

1:00pm	**POSTER SESSION 1** **Location: E7-2822**	**HI-AM 2.0 ADVISORY BOARD MEETING 1** **Location: E7-7411**
2:00pm	**SESSION 4: Cold Spray Additive Manufacturing** **Location: E7-7303 | Chair: Bertrand Jodoin**	**SESSION 5: Machine Learning in Additive Manufacturing I** **Location: E7-7363 | Chair: Narges Omidi**
2:00pm	**Presentation 9: Characterization of pure and blended AA6061 powder and heat treatment effects on cold spray deposition cohesive and adhesion strength** Alan Woo, Bahareh Marzbanrad, Hamid Jahed *University of Waterloo, Canada*	**Presentation 13: Data-centric machine learning for surface roughness in L-PBF additive manufacturing** Jigar Bimal Patel, Mihaela Vlasea, William Melek *University of Waterloo, Canada*
2:20pm	**Presentation 10: Additive manufacturing and cold spray of high-entropy alloys** Yu Zou *University of Toronto, Canada*	**Presentation 14: Machine learning assisted multi-material 3D printing of hierarchical composite with low stiffness and high strength** Shaojia Wang[1], Yu Zou[2], Xinyu Liu[1] *[1]Department of Mechanical and Industrial Engineering, University of Toronto, Canada.* *[2]Department of Materials Science and Engineering, University of Toronto, Canada*
2:40pm	**Presentation 11: An innovative approach to enhancing strength and ductility in cold spray 3D printing through engineered heterogeneous laminate microstructures** Niloofar Eftekhari, Hamid Jahed *University of Waterloo, Canada*	**Presentation 15: A comparative study of GAN and U-Net architectures for grain boundary detection in additive manufacturing microstructures** Chaimae Belmarouf[1], Salma Kassimi[1], Narges Omidi[1], Noureddine barka[1], Siyu Tu[2] *[1]UQAR, Canada. [2]CNRC, Canada*
3:00pm	**Presentation 12: 3D-printed ceramic parts using cold gas spray technology** Bahareh Marzbanrad, Ehsan Marzbanrad, Hamid Jahed *University of Waterloo, Canada*	**Presentation 16: A physics-informed neural network for optimizing LPBF parameters across alloy systems** Caleb Morgan *York University, Canada*
3:20pm	**COFFEE BREAK – Location: E7-7822**	

Note: As of July 11.
Online program may reflect updates.

DAY 1 – July 23, 2025 AFTERNOON

ONLINE CONFERENCE PROGRAM

3:40pm	**SESSION 6: Non-Metallic Additive Manufacturing** **Location: E7-7303 | Chair: Ramona Fayazfar**	**SESSION 7: Design for Additive Manufacturing I** **Location: E7-7363 | Chair: Maxime van Der Heijden**
3:40pm	**Presentation 17: Interfaces due to direct ink writing of bio-inspired microstructure enhance the fracture resistance of biopolymer nanocomposites.** Haresh Patil, Sanaz S. Hashemi, Dibakar Mondal, Thomas L. Willett *University of Waterloo, Canada*	**Presentation 21: Thermo-hydraulic performance of additively manufactured uniform and hybrid triply periodic minimal surfaces (TPMS) geometries** Armin Hassanirad, Osezua Ibhadode, Collins Chike Kwasi-Effah *University of Alberta, Canada*
4:00pm	**Presentation 18: Development of a porous polypropylene-polyvinyl alcohol (PP-PVOH) blend for 3D-printed prosthetic and orthotic applications** Ahmad A Basalah[1], Dilek Bartın[2] *[1]Mechanical Engineering Department College of Engineering and Architecture, Umm Al-Qura University, Saudi Arabia. [2]PolyPrintt, Turkey*	**Presentation 22: A shape error evaluation study of geometry produced using directed energy deposition** Anushree Shah, Carl Reilly, Daniel Hawker, Daan Maijer, Steve Cockcroft *University of British Columbia, Canada*
4:20pm	**Presentation 19: You are what you breathe: Measuring airborne carbon fiber particulates during FFF printing of PA6-CF filament** Dora Strelkova *University of Windsor, Canada*	**Presentation 23: Systematic decomposition of additively manufactured surface roughness and its impact on laminar flows** Nipin Lokanathan, Zachariah Mears, Jean-Pierre Hickey, Mihaela Vlasea *University of Waterloo, Canada*
4:40pm – 5:00pm	**Presentation 20: Additive manufacturing of structured catalysts for biomass conversion: An innovative route to sustainable energy production** Vahid Haseltalab, Animesh Dutta, Sheng Yang *University of Guelph, Canada*	**Presentation 24: A multiscale design and fabrication approach to create biomimetic tunable implants** Iris Quan, Ameen Subhi, Liza-Anastasia DiCecco *University of Waterloo, Canada*
7:00pm – 10:00pm	**DINNER – Location: Fed Hall**	

DAY 2 – July 24, 2025 MORNING

Note: As of July 11.
Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

Time	Session 8	Session 9
8:00am	**POSTER SESSION 2** **Location: E7-2822**	
9:00am	**SESSION 8: Multiphysics Modeling and Digital Twins** **Location: E7-7303 | Chair: Osezua Ibhadode**	**SESSION 9: Metrology, Monitoring, and Controls** **Location: E7-7363 | Chair: Ahmed Qureshi**
9:00am	**Presentation 25: A geometrically-optimized comprehensive heat source model for FE thermal simulation of laser directed energy deposition** Ali Zardoshtian[1,2], Hamid Jahed[2], Ehsan Toyserkani[1] *[1]Multi Scale Additive Manufacturing Lab, Department of Mechanical and Mechatronics Engineering, University of Waterloo, Canada. [2]Fatigue and Stress Analysis Lab, Department of Mechanical & Mechatronics Engineering, University of Waterloo, Canada*	**Presentation 29: Dual-wavelength pyrometer thermal field measurements during LPBF: Calibration and experimental validation** Matheus Soares, Donatien Campion, Vladimir Brailovski, Alena Kreitcberg *École de technologie supériere, Canada*
9:20am	**Presentation 26: Bridging machine and part-level digital twins for enhanced quality control in additive manufacturing** Mohammad Vahid Ehteshamfar, Sheng Yang *University of Guelph, Canada*	**Presentation 30: Integrating thermal camera technology into arc-wire directed energy deposition for enhanced process control and quality assurance** Maz Ansari, Dave Waldbillig *InnoTech Alberta, Canada*
9:40am	**Presentation 27: Computational flow dynamics simulation of the laser directed energy deposition process as a means to optimize process gas flow settings** Mikhail Malmyguine, Michael Benoit *University of Waterloo, Canada*	**Presentation 31: Feedforward control of the cooling rate in laser powder bed fusion using a physics-based thermal model** Nicholas Kirschbaum, Fangzhou Li, Wenda Tan, Chinedum Okwudire *University of Michigan, USA*
10:00am	**Presentation 28: Development of digital twin for optimization of print parameters of wire-based DED system** Daniel Hawker, Shaun Cooke, Daan Maijer, Steve Cockcroft *University of British Columbia, Canada*	**Presentation 32: Material classification for multi-material 3D printed objects using a portable single-exposure dual-energy X-ray detector** Neda Afkhami Ardakani[1], Steven Tilley[1], Curtis Larocca[1], Karim S. Karim[1,2] *[1]KA Imaging inc, Canada. [2]University of Waterloo, Canada*
10:20am	**COFFEE BREAK – Location: E7-7822**	

DAY 2 – July 24, 2025 MORNING

Note: As of July 11.
Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

10:40am	SESSION 10: Powder Bed Fusion II Location: E7-7303 | Chair: Michael Benoit	SESSION 11: Design for Additive Manufacturing II Location: E7-7363 | Chair: Daan Maijer
10:40am	**Presentation 33: Plasma-assisted, rapid alloying of mechanically activated multi-principal element powder (MPEP) precursors for additive manufacturing application** Ernest Mfum Acheampong[1], Ziqi Tang[1], Olga Naboka[2], Dean Ruth[2], Mark Plunkett[2], Michel Nganbe[1], Keun Su Kim[2,1] *[1]University of Ottawa, Canada.* *[2]National Research Council Canada, Canada*	**Presentation 37: An integrated computational framework for strut, plate and TPMS-type lattice design** Alex Olisa Inoma, Chinedu Ifediorah, Osezua Ibhadode *University of Alberta, Canada*
11:00am	**Presentation 34: Laser powder bed fusion of 7A76 aluminum alloy with sustainably-manufactured powder** Ali Rezaei[1], Mohsen K. Keshavarz[1], John Barnes[2], Mihaela Vlasea[1] *[1]University of Waterloo, Canada. [2]Metal Powder Works, USA*	**Presentation 38: Tailoring mechanical performance of Ti-6Al-4V structures using porous architectures** Rene Lam, Tomisin Oluwajuyigbe, Sagar Patel, Mohsen K. Keshavarz, Mihaela Vlasea *University of Waterloo, Canada*
11:20am	**Presentation 35: Uncovering shape memory effect in additively manufactured Ni-free β-titanium alloys** Soumya Kanta Panda, Sravya Tekumalla *University of Victoria, Canada*	**Presentation 39: On the design and evaluation of stochasticity in additivity manufactured architected lattice structure** Bosco Yu[1], Dmitry Karaman[1], Michael Greenwood[2], Glenn Hibbard[3] *[1]University of Victoria, Canada. [2]Natural Resources Canada, Canada. [3]University of Toronto, Canada*
11:40am	**Presentation 36: Porous transport layer optimization via additive manufacturing of inconel 718 lattice structures** Tomisin Oluwajuyigbe, Rene Lam, Sagar Patel, Mohsen K. Keshavarz, Mihaela Vlasea University of Waterloo, Canada *University of Waterloo, Canada*	**Presentation 40: Additive manufacturing of triply periodic minimal surface structures as porous electrodes for redox flow batteries** Maxime van der Heijden[1], Mojtaba Barzegari[2], Antoni Forner-Cuenca[2] *[1]University of Waterloo, Canada.* *[2]Eindhoven University of Technology, Netherlands*
12:00pm	LUNCH – Location: E7-2472	

Note: As of July 11.
Online program may reflect updates.

DAY 2 – July 24, 2025

AFTERNOON

ONLINE CONFERENCE PROGRAM

1:00pm	**SESSION 12: Powder Bed Fusion III** **Location: E7-7303 | Chair: Mihaela Vlasea**	**SESSION 13: Machine Learning in Additive Manufacturing II** **Location: E7-7363 | Chair: JiaHui Zhang**
1:00pm	**Presentation 41: Sustainability for laser powder bed fusion: Tailored microstructure, mechanical properties, and productivity for low-alloy steel** Peyman Alimehr[1], Mohsen K. Keshavarz[1], Mohammad Shojaee[1], Amin Molavi-Kakhki[2], Mihaela Vlasea[1] *[1]University of Waterloo, Canada, Canada.* *[2]Rio Tinto, Canada, Canada*	**Presentation 45: Large language model-assisted bayesian optimization for improved parameter selection in additive manufacturing** Chih Yu Chang, Milad Azvar, Raed Al Kontar, Chinedum Okwudire *University of Michigan, USA*
1:20pm	**Presentation 42: Revolutionizing metal additive manufacturing productivity through laser beam shaping** Joel J Sam *EOS, USA*	**Presentation 46: A pioneer machine learning-driven platform for in-situ vertical side surface roughness prediction in laser powder bed fusion** Sahar Toorandaz, Ehsan Toyserkani *University of Waterloo, Canada*
1:40pm	**Presentation 43: Influence of heat treatment on the high strain rate deformation of laser powder bed fused Cu–Cr–Zr alloy** Nadia Azizi[1], Hamed Asgari[2], Mahyar Hasanabadi[1], Akindele Odeshi[3], Ehsan Toyserkani[1] *[1]Multi-Scale Additive Manufacturing Lab, University of Waterloo, Waterloo, ON, Canada. [2]Marine Additive Manufacturing Centre of Excellence, University of New Brunswick, Fredericton, NB, Canada, Canada. [3]Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, SK, Canada*	**Presentation 47: Data-driven approach for predicting abnormal grain growth in sintered binder jet steels** Mingzhang Yang, Mihaela Vlasea, Mohsen K. Keshavarz *University of Waterloo, Canada*
2:00pm	**Presentation 44: Fracture performance of multi-material hybrid structures enabled by additive manufacturing** Saeed Maleksaeedi, Mohammad Shojaati, Ali Zardoshtian *University of Waterloo, Canada*	
2:20pm – 2:30pm	**CONFERENCE CLOSING – LOCATION: E7-2472 | CHAIRS: EHSAN TOYSERKANI AND MIHAELA VLASEA** **STUDENT AWARDS WILL BE PRESENTED AT THE CONFERENCE'S CLOSING SESSION.**	
3:30pm – 4:30pm	**MSAM LAB TOUR 2 – LOCATION: CATALYST 137 | CHAIR: ALLAN ROGALSKY**	

Note: As of July 11.
Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

Poster Presentation Gallery

Poster 1: Mitigation of melting mode-driven cracking in laser powder bed fusion of Ti-6242Si
Sagar Patel, Mohsen K. Keshavarz, Ali Rezaei, Sharon A Varghese, Mihaela Vlasea
University of Waterloo, Canada

Poster 2: msamDB: Towards addressing data-scarcity challenges in L-PBF additive manufacturing
Jigar Bimal Patel, Chris Vuong, Mihaela Vlasea, Tamer Ozsu
University of Waterloo, Canada

Poster 3: Investigation of the tensile properties of thin-walled structures printed from AlSi10Mg for aerospace applications
Zachariah Mears, Mihaela Vlasea
University of Waterloo, Canada

Poster 4: Design and mechanical analysis of additively manufactured primitive flexures
Jonah Leinwand, Mihaela Vlasea, Stewart McLachlin
University of Waterloo, Canada

Poster 5: Process parameter optimization for crack mitigation in CM247LC processed by electron beam melting
Sebastian J. X. Soo
Multi-Scale Additive Manufacturing (MSAM) Lab, Canada. University of Waterloo, Canada

Poster 6: Evaluating the use of electrochemical additive manufacturing (AM) in the design of efficient liquid-cooled heat sinks via a functionality-driven hybrid topology optimization & lattice design for AM methodology
Joseph N Orakwe
University of Waterloo, Canada. University of Alberta, Canada

Poster 7: Fabrication and characterization of 17-4 ph stainless steel and inconel 625 bimetallic structures using laser powder bed fusion
Shalini Singh, Ahmed Qureshi
University of Alberta, Canada

Poster 8: Effect of melt pool positioning on the microstructure evolution in laser powder bed fusion of Ti-alloy
Mahyar Hasanabadi[1], Nidia Azizi[1], Hamidreza Aghajani[1], Tatevik Minasyan[1], Hamed Asgari[2], Ehsan Toyserkani[1]
[1]Multi-Scale Additive Manufacturing Lab., Canada. [2]University of New Brunswick, Canada

Poster 9: Electropolishing of additively manufactured internal channels with various curvatures using 3D-printed polymeric electrode covers
Manyou Sun, Ali Mohammadnejad, Ehsan Toyserkani
University of Waterloo, Canada

Poster 10: Machine learning-driven optimization of laser powder bed fusion: from powder characterization to process parameters tailoring for Ti6Al4V powders
Farima Liravi[1], Ehsan Toyserkani[1], Mahdi Habibnejad-Korayem[2]
[1]University of Waterloo, Canada. [2]AP&C, a Colibrium Additive Company, Canada

Poster 11: Thermal cycling of laser powder bed fusion tooling steels used for high pressure die casting
Jorge Luis Dorantes Flores[1], Benjamin Orchard[2], Christopher Paul[3], Sevda Fatiphour[1], Robert Mackay[4], Glenn Byczynski[4], Michael Benoit[2], Abdallah Elsayed[1]
[1]University of Guelph, Canada. [2]University of Waterloo, Canada. [3]UBC Okanagan, Canada. [4]Nemak Canada, Canada

Poster 12: Phased array ultrasonic testing: A novel approach for QR code detection in AM
Farhang Honarvar[1,2], Katayoon Taherkhani[2], Sagar Patel[2], Peyman Alimehr[2], Issa Zachary Rishmawi[2], Sara Burris[3], Eric Langridge[3], Mohammad-Hossein Amini[3], Mihaela Vlasea[2]
[1]K. N. Toosi University of Technology, Iran. [2]University of Waterloo, Canada. [3]Fujifilm Visualsonics, Canada

Poster 13: Type II residual stress distribution in laser powder bed fusion: A combinatorial analysis in 316L stainless steel
Tianyi Lyu, Renfei Feng, Changjun Cheng, Yu Zou
University of Toronto, Canada

Poster 14: Remelting-based microstructure engineering in laser powder bed fusion: A case study in 316L stainless steel
Tianyi Lyu, Yu Zou
University of Toronto, Canada

Poster 15: Defects analysis in LPBF printing based on up-skin and down-skin angles using machine learning
Zohreh Azimifar[1], Ali Razani[2], Sagar Patel[3], Martine McGregor[3], Mihaela Vlasea[3]
[1]SYDE, University of Waterloo, Canada. [2]Shiraz University, Iran. [3]University of Waterloo, Canada

Poster 16: Root cause analysis of defect formation and parameter optimization for W electron beam powder bed fusion
Ali Mohammadnejad, Manyou Sun, Ehsan Toyserkani
University of Waterloo, Canada

Poster 17: Integrated HIP and heat treatment for microstructural tailoring of TiAl alloys processed by EB-PBF
Ali Rezaei[1], Mohsen K.Keshavarz[1], Andrew Cassese[2], Chad Beamer[2], Mahdi Habibnejad-Korayem[3], Paria Karimi[4], Esmaeil Sadeghi[4], Mihaela Vlasea[1]
[1]University of Waterloo, Canada. [2]Quintus Technologies, USA. [3]AP&C – a Colibrium Additive company, Canada. [4]OptiFab Technologies, Canada

Poster Presentation Gallery

Note: As of July 11.
Online program may reflect updates.

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Poster 18: Tensile and fatigue properties of Ti alloys made by additive manufacturing
Yu Zou
University of Toronto, Canada

Poster 19: Directed energy deposition of heterostructured steels for tailored mechanical properties
Xiao Shang, Yu Zou
University of Toronto, Canada

Poster 20: The influence of elevated Fe and Zn impurities on the rapid solidification behaviour of AA6061 processed using single track laser surface melt trials
Janelle Faul
University of Waterloo, Canada

Poster 21: Dissimilar resistance spot weld of Ni-coated Al to Ni-coated Mg using cold spray coating technology
Mazin Jassim Oheil, Adrian Gerlich, Hamid Jahed
University of Waterloo, Canada

Poster 22: XRD analysis to map damage in AA6061-T6 for cold spray additive remanufacturing
Sepehr Ghazimorady, Hamid Jahed
Fatigue & Stress Analysis Laboratory, Department of Mechanical & Mechatronics Engineering, University of Waterloo, Canada

Poster 23: Assessing the impact of binder saturation on print quality of binder jetted green samples of regular and irregular morphologies
Alexandra D Darroch, Edward Yang, Mihaela Vlasea
University of Waterloo, Canada

Poster 24: Design and evaluation of additively manufactured, surface-conforming spinal reconstruction implants
Richard Barina, Stewart McLachlin
University of Waterloo, Canada

Poster 25: Print fidelity of microstructures within dense nanocomposite structures printed using mandrel bed direct ink writing.
Haresh Patil, Dibakar Mondal, Thomas L. Willett
University of Waterloo, Canada

Poster 26: Sustainable additive manufacturing: Evaluating the mechanical and thermal degradation of recycled PEKK
Farshad Malekpour, Mehdi Hojjati
Concordia University, Canada

Poster 27: Adaptive aerodynamics via tunable flexure hinge mechanisms
Andrea Roman[1], Enrique Cuan-Urquizo[2,3], Armando Roman-Flores[2]
[1]University of Ottawa, Canada. [2]Tecnologico de Monterrey, Mexico. [3]Insitute of Advanced Materials for Sustainable Manufacturing, Mexico

Poster 28: Piezo-pneumatic jetting of highly viscous soldering paste
Rahele Jafari, Ehsan Marzbanrad, Ehsan Toyserkani
University of Waterloo, Canada

Poster 29: Optiworks: A multifunctional high-resolution topology optimization software
Chinedu Ifediorah, Alex Inoma, Osezua Ibhadode
University of Alberta, Canada

Poster 30: Nanoscale characterization of surface oxides on gas-atomized AA6061 powder using HRTEM
René D Pütz[1], Zhiqiang Wang[1], Bahareh Marzbanrad[2], Hamid Jahed[2], Yolanda Hedberg[1,3]
[1]Department of Chemistry, University of Western Ontario, Canada. [2]Department of Mechanical and Mechatronics Engineering, University of Waterloo, Canada. [3]Surface Science Western, University of Western Ontario, Canada

Poster 31: Airborne ultrasound sensing of packing fraction of powder bed in binder jetting
Alexander Martinez-Marchese[1], Chen Qian[1], Tomás Gómez Álvarez-Arenas[2], Chinedum Okwudire[1]
[1]University of Michigan, USA. [2]Institute of Physical and Information Technologies, CSIC, Spain

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Online program may reflect updates.

ONLINE CONFERENCE PROGRAM

Abstracts

Keynotes

SESSION 1: Scaling Additive Manufacturing for Industry
July 23 | 9:00 - 10:20am | Location E7-2472

Keynote 1 | 9:00 - 9:40am

Revved up but stalled: a tale of high hopes and low volumes

Ante T Lausic
General Motors, USA

As other industries take off with AM adoption, the automotive segment has laboured behind. The tight margins and enormous volumes have prevented mass adoption of AM and this talk seeks to highlight those roadblocks. Success stories at General Motors present key technologies and applications to build off of for future mass market adoption. While working to compete with conventional manufacturing methods, AM has also shown an ability to complement the automotive manufacturing process including casting, assembly, and in limited scenarios, serial production. Examples will include the Cadillac CT4-V and CT5-V Blackwings, the Chevrolet Tahoe, and the Cadillac Celestiq ultra-luxury sedan.

Keynote 2 | 9:40 - 10:20am

Integrated multi-scale solutions for accelerating industrial-grade additive manufacturing

Behrang Poorganji
Nikon, USA

Additive Manufacturing is rapidly transitioning from a prototyping tool to a robust industrial production technology. Yet, the qualification of new materials and processes remains one of the most significant challenges in wider adoption of metal AM since it is slow, complex, and expensive. In this talk, Nikon's vision for AM, along with our current technologies, platforms, and strategies for accelerating qualification will be shared. We'll present case studies of how an integrated, multi-scale approach is being applied to break through these barriers and enable faster AM adoption. By leveraging smart design-of-experiments, high-throughput testing, advanced material characterization, and in-process monitoring, we are streamlining the path from development to qualification. We'll also explore the role of non-destructive evaluation and Integrated Computational Materials Engineering (ICME) in reducing risk, compressing timelines, and lowering costs. This is more than process optimization—it's a reimagining of the entire AM qualification pipeline. The result: a smarter, faster, and more scalable pathway to true industrial-grade manufacturing.

SESSION 2: Directed Energy Deposition
July 23 | 10:40am - 12:00pm | Location E7-7303

Presentation 1 | 10:40 - 11:00am

Rapid prototyping of novel materials via directed energy deposition: A case study on solidification cracks at the substrate – alloy interface

Joseph Agyapong, Solomon Hanson Duntu, Caleb Osae-Morgan, Aleksander Czekanski, Solomon Boakye-Yiadom
York University, Canada

This study presents a comprehensive experimental investigation into the rapid prototyping of novel materials using directed energy deposition (DED), with a focus on understanding solidification crack formation at the substrate–alloy interface. The investigation is motivated by the persistent challenge of achieving rapid prototype builds of new materials identified through computational material science and modeling, alongside the goal of realizing defect-free builds in multi-material DED processing, particularly when interfacing dissimilar materials. A novel quinary high-entropy alloy system serves as the case study, elucidating the interplay between processing parameters, substrate material, and rapid solidification dynamics. Specimens of the newly formulated alloy system were fabricated using a state-of-the-art DED system on a range of substrates, including steel alloy, nickel alloy, aluminum alloy, and even a chemically similar HEA substrate, to mitigate interfacial cracking. Despite extensive trials with varied process parameters (such as laser power, powder feed rate and layer thickness), solidification cracks consistently emerged at the interface. Thus, post-deposition analyses were performed using optical microscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD) to reveal microstructural transformations and phase formations resulting from the rapid solidification process and influencing these solidification cracks. The systematic approach employed in this study enabled a correlation between alloying elements and the composition of substrates, specific processing parameters and the severity of interfacial defects. It was observed that the effectiveness of substrate selection is limited by the rapid solidification conditions inherent to the DED process, indicating that traditional substrate modification strategies may not be sufficient to prevent crack formation. This case study not only provides a detailed experimental framework for evaluating DED performance in rapid prototyping applications but also offers critical insights into the processing–structure–property relationships governing interfacial integrity in multi-material systems. The detailed findings will be presented and discussed at the conference.

Presentation 2 | 11:00 - 11:20am

Design of new NiCoCr alloys for additive manufacturing through high-throughput experiments

Ajay Talbot, Yu Zou
University of Toronto, Canada

The development of next-generation materials for extreme environments demands alloys with superior mechanical, thermal, and chemical properties. NiCoCr ternary alloys have emerged as promising candidates for such applications, particularly in additive manufacturing (AM). However, research to date has largely focused on equiatomic medium-entropy alloys or compositions dominated by a single principal element, leaving significant regions of the NiCoCr composition space unexplored. High-throughput techniques via directed energy deposition (DED) can accelerate the assessment of unexplored compositions by enabling the fabrication of multiple alloys on a single sample with in-situ multi-material processing. This approach streamlines characterization, mechanical testing, and materials assessment compared to traditionally inefficient one-at-a-time methods. In this work, we combine a tailored DED process optimization framework, high-throughput compositional exploration coupled with accelerated mechanical testing, and computational screening via calculation of phase diagrams (CALPHAD) to systematically map and identify Ni-Co-Cr alloys that are both printable and optimized for high hardness. This accelerated approach identifies the limitations of unprintable or hot-cracking alloys while also revealing new crack-free compositions with superior hardness compared to commercially available Ni-Co-Cr alloys. The proposed methods establish a scalable framework for discovering high-performance materials for extreme environments.

Presentation 3 | 11:20 - 11:40am

Optimizing laser-directed energy deposition parameters for the repair of additively-manufactured die-casting tooling inserts

Benjamin F Orchard, Michael Benoit
University of Waterloo, Canada

High-pressure die-casting (HPDC) tooling inserts experience severe thermal and mechanical stresses, which can lead to heat checking and premature failure. Laser-directed energy deposition (LDED) offers promising repair opportunities, but process parameter optimization for durable repairs remains a challenge. This study investigates the feasibility of LDED for repairing additively manufactured HPDC inserts, specifically peak-aged laser powder bed fusion (LPBF) inserts made from 18Ni-300 (M300), an age-hardenable martensitic tool steel. A design of experiments approach is used to evaluate the effects of laser power, scan speed, and powder mass flow rate on single-track deposits, multi-pass single-layer clads, and volumetric builds. Future work will assess repair efficacy by examining the influence of defect removal geometry on interfacial bonding strength and analyzing the microstructural effects of the repair process in heat-affected regions using peak-aged LPBF samples. By establishing optimal deposition conditions and their relationship to repair efficacy, this work aims to reinforce LDED as a viable repair strategy for industrial tooling applications, extending the lifespan of additively manufactured HPDC tooling inserts and reducing manufacturing costs.

Presentation 4 | 11:40am - 12:00pm

Developing strategies for medium volume production in directed energy deposition additive manufacturing

R. Jill Urbanic
University of Windsor, Canada

Additive Manufacturing (AM) processes enable the validation of design variants, and the manufacturing of low volume specialty components. A production on-demand solution can be established close to a customer, but the economies of scale need to be considered. Slow fabrication times are an issue for larger production volumes, but for the directed energy deposition (DED) and hybrid manufacturing (where additive and machining operations are interwoven), new process planning scenarios can be explored for both low and medium volume production levels, which aligns well with addressing on-demand service and out of production components. DED AM is a material deposition based process. Wire filament or powder is melted by a heat source such as a laser or an electron beam, and multi-axis tool paths can be employed to deposit the material. This leads to the ability to fabricate large freeform components without support material; however, production volume scalability is an issue. Prior to exploring multi-function or reconfigurable machines and dynamic layouts, the precedence diagrams, where the tasks and relationships are defined need to be determined, along with process summary data sets that reflect the specific DED AM process characteristics. With DED and hybrid AM, there are unique scenarios for the process dependencies. A framework for defining nomenclature for DED AM precedence diagrams and value stream maps, and insights for systematically decomposing components for macro and micro level process planning needs to be developed. The goal of this research is to provide a foundation for DED and hybrid manufacturing for low volume production (100 – 2000 pcs) for short planning horizons (1 week to 1 month) which would align to 'medium volume' production levels. This specific presentation will present research performed to date on addressing these challenges.

SESSION 3: Powder Bed Fusion I
July 23 | 10:40am - 12:00pm | Location E7-7363

Presentation 5 | 10:40 - 11:00am

Laser powder bed fusion of IN738: Cracking mechanism and strategies for crack mitigation

Hamid Aghajani, Ehsan Toyserkani
University of Waterloo, Canada

Precipitation-hardened nickel-based superalloys, such as IN738, are widely utilized in high-temperature applications due to their excellent mechanical properties and thermal stability. The presence of γ' precipitates enhances these properties but also introduces significant challenges in additive manufacturing (AM), particularly in laser powder bed fusion (LPBF). The susceptibility of IN738 to cracking has limited its applicability in AM, necessitating the development of effective mitigation strategies. In this study, various approaches have been employed to reduce cracking in LPBF-processed IN738. Process parameters have been optimized to control solidification behavior, leading to a significant reduction in both crack density and crack length. Additionally, the influence of microstructure tailoring on defect formation has been investigated, demonstrating that microstructural engineering can enhance the printability of this otherwise non-weldable alloy. To further understand the mechanisms driving crack formation, advanced characterization techniques, including electron microscopy and X-ray diffraction, have been utilized to examine microstructural features and cracking behavior. Furthermore, solidification modeling has been conducted to predict microstructural evolution. The findings of this study contribute to a deeper understanding of defect formation in IN738 during AM and provide a pathway for improving the processability of high-performance nickel-based superalloys. By addressing cracking through microstructural control and process optimization, the feasibility of using PBF for safety-critical applications is expanded.

Presentation 6 | 11:00 - 11:20am

Predicting nickel loss during LPBF of Ti-Ni SMA using a combination of the vaporization and melt pool modeling and in situ thermal monitoring

Donatien Campion, Matheus Soares, Alena Kreitcberg, Vladimir Brailovski
Ecole de Technologie Supérieure, Canada

Functional properties of Ti-Ni shape memory alloys are strongly linked to their composition, with even minor variations in nickel content causing significant shifts in transformation temperatures. Laser Powder Bed Fusion (LPBF) has demonstrated remarkable efficiency in producing complex Ti-Ni components, but vaporization of the alloy elements has been observed during the fabrication process, leading to composition changes. This study uses a vaporization model based on the Hertz-Knudsen equation to quantify nickel loss as a function of the melt pool thermal field. The model incorporates key LPBF parameters, including hatching distance and layer thickness, to assess a cumulative nickel and titanium vaporization throughout the manufacturing process, and predict composition variations from powder to final part. The model validation has been conducted on an EOS M280 system using Ti-50.26at.% Ni (15-45μm) powder. Thermal fields were measured using a dual-wavelength pyrometer (ThermaViz) while varying the volumetric laser energy density (30-110 J/mm3) and the material build rate (4-9 cm3/h). The printed coupons were subjected to homogenization annealing at 800°C for 1 hour, and their transformation temperatures and nickel content were measured. The composition measurements were then compared to the model predictions to assess the performance of the latter. This ongoing work will be integrated with a neural network model predicting the melt pool dimensions and temperature distributions, and validated using the thermal fields acquired with the pyrometer. This approach will produce a model framework that will be able to predict compositional variations in Ti-Ni SMA as a function of the LPBF process parameters, thereby enabling the fabrication of parts with graded functional characteristics, which is especially relevant for lattice structures.

Presentation 7 | 11:20am - 11:40am

Preliminary assessment of a novel hybrid manufactured titanium alloy dental implant abutment

Les Kalman
Western University, Canada

Dental implant components, including titanium abutments and superstructures, are currently fabricated through subtractive manufacturing. This approach has limitations on device design, is inefficient (time and material) and costly. This investigation explored a hybrid manufacturing workflow, utilizing primarily additive manufacturing (AM), for the fabrication of a novel titanium alloy dental implant abutment. The device was assessed to explore feasibility. The novel abutment was designed, digitally refined and printed in dental grade titanium Ti64 (titanium 6-aluminum 4-vanadium) using Selective Laser Melting (SLM) technology. Numerous iterations of the abutment were designed, printed and evaluated to determine the final optimized design for additive manufacturing. Post-processing involved bead blasting, fixation with a custom stabilization jig and manually creating threads using a die through subtractive manufacturing. The complex design of the novel abutment was successfully fabricated through hybrid manufacturing. All samples were deemed appropriate for testing. The coupling of the abutment with the implant body was suitable, as assessed under magnification and through radiologic assessment. Fabrication cost was reduced by over 90%. Physical testing of the abutment indicated an average pin strength of 364.4 N and an average torque into the implant body of 49.9 Ncm. Data indicated that the device could withstand the recommended torque and strength required for dental provisionalization. Hybrid manufacturing, employing primarily AM for the device fabrication using SLM, provided an alternative fabrication pathway of a novel dental implant abutment. Preliminary assessment indicated that the device would be acceptable for clinical applications. The hybrid approach (1) permitted the fabrication of complex designs, (2) provided improved efficiency (time and material) and (3) dramatically reduced the cost of fabrication. Although further studies are required, the hybrid approach appears to be a feasible approach for predictable dental device fabrication.

Presentation 8 | 11:40 - 12:00pm

Influence of LPBF process parameters on the microstructure and magnetic properties of 3D-printed NdFeB magnets

Xavier Walls[1,2], Rene Lam[1], Mingzhang Yang[1], Mohsen K. Keshavarz[1], Mihaela Vlasea[1], Fabrice Bernier[3], Felipe Blanco[4], Sangeeth Gunalan Kr[4], Sebastian Recabal[4]
[1]Multi-Scale Additive Manufacturing Laboratory, Department of Mechanical and Mechatronics Engineering, University of Waterloo, Canada. [2]Department of Mechanical and Aerospace Engineering, Carleton University, Canada. [3]Automotive and Surface Transportation Research Centre, National Research Council, Canada. [4]Greenage Materials Corp, Canada

The demand for high-performance NdFeB permanent magnets is rapidly increasing due to its critical role in electric vehicles, wind turbines, robotics, and advanced electronics. Traditional manufacturing methods, such as sintering and bonding, are limited in design complexity, material efficiency, and sustainability. These methods require extensive machining, generate substantial waste, and often involve hazardous processing steps. Additionally, global supply chain concerns surrounding rare earth elements have intensified the need for more sustainable, resource-efficient, and locally adaptable manufacturing approaches. Laser Powder Bed Fusion (LPBF) presents itself as a promising alternative to traditional methods, enabling the production of intricate geometries optimized for magnetic performance without extensive post-processing or material loss. Moreover, LPBF facilitates precise microstructure control to tailor magnetic properties to meet specific application requirements. This study examines the influence of LPBF process parameters on the microstructural evolution and magnetic properties of 3D-printed $Nd_{7.5}Pr_{0.7}Fe_{75.4}Co_{2.5}B_{8.8}Zr_{2.6}Ti_{2.5}$ magnets. A dimensionless process mapping approach was applied to optimize energy input and minimize defect formation, enabling the identification of process windows that result on highly dense magnets. This work explores how process parameters such as: laser power (52.19 – 115.63W), exposure time (87.83 – 98.69ms), point distance (25 – 50μm), and layer thickness (40 - 60μm) can be optimized to produce high density samples ranging 95 – 99% with enhanced physical integrity, reduced defects and a tailored microstructure. It was possible to achieve a saturation magnetization of 0.63T, a remanence of 0.34T and a coercivity of 522kA/m. To demonstrate the viability of this method, a complex-shaped demonstrator was printed, showcasing the ability to fabricate low-porosity, structurally sound components. The results of this study highlight LPBF as a competitive alternative to traditional methods, offering a viable pathway for the next generation of energy-efficient and sustainable magnetic materials.

SESSION 4: Cold Spray Additive Manufacturing July 23 | 2:00 - 3:20pm | Location E7-7303

Presentation 9 | 2:00 - 2:20pm

Characterization of pure and blended AA6061 powder and heat treatment effects on cold spray deposition cohesive and adhesion strength

Alan Woo, Bahareh Marzbanrad, Hamid Jahed
University of Waterloo, Canada

Cold spray is a solid-state deposition method belonging in the thermal spray group of technologies that creates coatings, mass restorations, and additively manufactured components by accelerating feedstock powders at supersonic speeds with a de Laval nozzle. Once accelerated particles collide with a substrate or existing layer build up, severe plastic deformation from impact creates mechanical and metallurgical bonding. Although named "cold" spray to increase plastic deformation feedstock powders are heated to elevated temperatures below melting point, generating depositions with various materials including metals, polymers, ceramics, and blends. Of the many materials suitable with cold spray, aluminum 6061 alloy is widely used general purpose metal also found in various industries such as automotive and aerospace as a structural material. Typically, metallic powders are manufactured with gas atomization and available as pure 6061, or as a blend with various composites to obtain desired deposition mechanical, material, and manufacturing requirements. Additionally, a solid-state powder manufacturing method using mechanical grinding has emerged providing cold spray users with 6061 powders of different metallurgy and morphology more similar to 6061 bulk material. This study characterizes the metallurgical properties of pure gas atomized and ground 6061 powders, and gas atomized powders blended with Al2O3, SiO2, and ZrO2 through microscopy. Cohesive cold spray depositions are characterized by deposition efficiency, thickness, density, and microhardness testing. Tensile specimens are extracted from depositions to observe mechanical performance with servohydraulic load frame testing, and adhesion specimens are extracted and tested in the same manner to investigate adhesion strength. Results of heat treating are explored to compare depositions to bulk like ductility. Effects of powder size distribution, morphology, and blending are correlated with deposition characteristics and mechanical performance.

Presentation 10 | 2:20 - 2:40pm

Additive manufacturing and cold spray of high-entropy alloys

Yu Zou
University of Toronto, Canada

Eutectic high entropy alloys (EHEA) with alternating FCC and BCC (B2) phases offer an excellent combination of strength and ductility. Additive manufacturing allows for the fabrication of ultrafine nanolamellar EHEA with directional growth. In this presentation, we show the effect of orientation and the lamellar size on on the deformation, strengthening, and fracture mechanisms of directional EHEA manufactured by additive manufacturing using in situ high-energy synchrotron X-ray diffraction and in situ high-energy synchrotron X-ray tomography. Our research sheds light on a better understanding of the co-deformation behavior of dual-phase alloys with orientation dependency. Moreover, our study provides insights into how to tailor the microstructure of additively manufactured directional EHEAs based on different mechanical property requirements. Also, I will talk about cold spray additive manufactring of HEAs.

Presentation 11 | 2:40 - 3:00pm

An innovative approach to enhancing strength and ductility in cold spray 3D printing through engineered heterogeneous laminate microstructures

Niloofar Eftekhari, Hamid Jahed
University of Waterloo, Canada

Achieving an ideal balance of strength and ductility in 3D-printed low-pressure cold spray materials is highly desirable yet remains a significant challenge. This paper introduces a dual heterogeneous laminated Cu/CuCrZr composite structure, characterized by varying hardness ratios between the soft and hard domains, produced through low-pressure cold spray followed by post heat-treatment. The tailored heterogeneous Cu/CuCrZr microstructure features alternating coarse and fine grains, creating effective microstructural differences. These differences result in a hetero-deformation-induced hardening, caused by the mechanical incompatibility between the coarse grain Cu and fine grain Cu-Cr-Zr layers, leading to an improvement of work hardening and increase of ductility. This performance is largely attributed to the well-bonded particles and hetero-deformation-induced (HDI) strengthening during plastic deformation. The strengthening effect is due to the accumulation of a substantial number of geometrically necessary dislocations (GNDs) at the heterogeneous interface, which enhances work-hardening and simultaneously boosts both the strength and tensile ductility of the layered alloy. This innovative heterogeneous design strategy offers a promising solution to improve strength and ductility in low-pressure cold spray materials.

Presentation 12 | 3:00 - 3:20pm

3D-printed ceramic parts using cold gas spray technology

Bahareh Marzbanrad, Ehsan Marzbanrad, Hamid Jahed
University of Waterloo, Canada

Manufacturing ceramic parts involves forming a green body and heating it to fuse the particles together, thereby densifying the part. Methods such as powder compaction in a die cavity using mechanical pressing, slip casting, and injection molding are widely employed in the industry for green body formation. However, these methods are costly, complex, and time-consuming. Recently, various 3D printing technologies have been adapted for manufacturing ceramic parts. These include slurry-based methods such as stereolithography and inkjet printing, powder-based systems like selective laser sintering/melting and binder jetting, and bulk solid-based methods such as laminated object manufacturing and fused deposition modeling. Regardless of the forming technology, the green density of the printed preform is a vital factor in achieving fully dense parts with high dimensional accuracy after firing. Among all these methods, injection molding achieves the highest green density, ranging from 75% to 85%, while 3D printing methods typically achieve green densities between 40% and 60%. Therefore, post-processing techniques such as cold isostatic pressing are often employed to enhance the density of parts up to 85%. In this research, we evaluate cold gas spray technology for 3D printing green TiO_2 parts with exceptionally high green density. By leveraging the supersonic impact of TiO_2 agglomerates, we demonstrate the ability to fabricate dense 3D structures with green densities ranging from 70% to 80%. Subsequent sintering further increases the density to well over 95%. This approach eliminates the need for powder modification, allowing as-received powders to be directly fed into the system for free-forming 3D structures, offering significant technical and cost advantages over conventional 3D printing techniques. These attributes position cold spray as a promising alternative to traditional manufacturing methods and digital printing technologies.

SESSION 5: Machine Learning in Additive Manufacturing I
July 23 | 2:00 - 3:20pm | Location E7-7363

Presentation 13 | 2:00 - 2:20pm

Data-centric machine learning for surface roughness in L-PBF additive manufacturing

Jigar Bimal Patel, Mihaela Vlasea, William Melek
University of Waterloo, Canada

Understanding and tailoring surface roughness on Laser Powder Bed Fusion (L-PBF) components is an ongoing challenge in key aerospace and medical applications. Surface roughness is known to correlate with high post processing costs, blockages (for intricate cooling channels) and reduced fatigue life. To predict surface roughness, Machine learning (ML) has seen increased adoption to accelerate and enhance experimental and simulation-based efforts. However, ML models, particularly those predicting L-PBF roughness, are often trained on scarce datasets. Such models are unlikely to generalize well, which further limits their usability when predicting surface roughness for "unseen" processing conditions (e.g. a new material). This work reports progress-to-date on generalizable and usable surface roughness prediction using ML. To achieve this, we first use a large and diverse dataset spanning ~8 builds, 3 ferrous powders (4405 Steel, Maraging Steel and 4340 Steel) and surface roughness data from over 1000 specimens across different orientations (upskin, downskin and sideskin) . ML model training is performed to predict four roughness parameters (Sa, Sz, Spc and Sdr). We perform extensive evaluation of model generalizability and robustness. To further improve the usability of these predictions, we use the predicted roughness parameters to generate synthetic roughness profiles . The preliminary results show significant potential for achieving robust prediction of surface roughness (balanced accuracy ~90% in challenging test sets). The methodology to generate surface texture, shows promise in visualizing the surface, but requires further work. In this work, we show an ML model is trained on the largest reported dataset for surface roughness. The ML models predict four roughness parameters for a more holistic estimation of the L-PBF surface. Finally, synthetic texture generation can be used during design and process planning stage to assess failure modes that correlate to roughness, such as channel blocking or fatigue failure.

Presentation 14 | 2:20 - 2:40pm

Machine learning assisted multi-material 3D printing of hierarchical composite with low stiffness and high strength

Shaojia Wang[1], Yu Zou[2], Xinyu Liu[1]
[1] Department of Mechanical and Industrial Engineering, University of Toronto, Canada. [2] Department of Materials Science and Engineering, University of Toronto, Canada

Biological systems, such as tendons and muscles, exhibit specialized mechanical properties tailored to meet specific functional demands. Replicating these properties in biomimetic components necessitates designing materials that are both soft and elastic for flexibility while maintaining high strength for load bearing. However, conventional soft materials that achieve such low stiffness often lack the necessary strength. This research aims to design hierarchical composites to reach the targeted stiffness and strength by integrating multiple materials with distinct mechanical characteristics together with unique microstructures, utilizing direct-ink-writing (DIW) 3D printing techniques. Meanwhile, to efficiently navigate the vast design space, deep learning and evolutionary algorithms are leveraged for microstructure discovery and multi-objective optimization. Combining computational insights with experimental extrusion-based printing, this project advances material design strategies to replicate biological materials with targeted mechanical properties, enabling potential applications in bio-inspired robotics and implants.

Presentation 15 | 2:40 - 3:00pm

A comparative study of GAN and U-Net architectures for grain boundary detection in additive manufacturing microstructures

Chaimae Belmarouf[1], salma Kassimi[1], Narges Omidi[1], Noureddine barka1, Siyu Tu2
[1]UQAR, Canada. [2]CNRC, Canada

In materials science, accurately characterizing the microstructure of metals is essential for predicting their mechanical properties. This paper presents an innovative approach that leverages Generative Adversarial Networks (GANs) to automate and enhance the detection of grain boundaries in microstructural images of steel and aluminum. The method begins by annotating grain boundaries within the microstructure, which are then used to train GAN models, with U-Net and Pix2Pix proving to be highly effective for boundary segmentation. U-Net excels at identifying boundaries, while Pix2Pix improves the ability to detect more complex, enclosed boundaries that are harder to capture with traditional methods. Model performance is assessed using both quantitative and qualitative metrics. An expert in microstructure analysis evaluates the segmentation accuracy. The combination of U-Net and Pix2Pix enhances boundary segmentation, providing a more reliable and detailed grain boundary delineation. The proposed method is compared with traditional image processing techniques and other machine learning models in terms of accuracy, efficiency, and reliability. Results indicate a significant improvement in grain boundary detection and segmentation, demonstrating robustness across various grades of steel and aluminum alloys.

Presentation 16 | 3:00 - 3:20pm

A physics-informed neural network for optimizing LPBF parameters across alloy systems

Caleb Morgan
York University, Canada

Metal 3D printing using Laser Powder Bed Fusion (LPBF) faces many challenges. The process relies on settings like laser power, scanning speed, layer thickness, and hatch spacing. These settings affect the quality of the parts. A setting that works for one alloy may not work for another because each alloy has its own thermal and physical traits. We build a multi-layer feed-forward artificial neural network (ANN) to address this issue. Our ANN uses data specific to each alloy and includes basic physics. This approach helps the model learn how settings relate to porosity. The model can then work with different alloys. This work improves print quality, lowers defects, and speeds up the search for the best printing settings.

SESSION 6: NON-METALLIC ADDITIVE MANUFACTURING
July 23 | 3:40 - 5:00pm | Location E7-7303

Presentation 17 | 3:40 - 4:00pm

Interfaces due to direct ink writing of bio-inspired microstructure enhance the fracture resistance of biopolymer nanocomposites.

Haresh Patil, Sanaz S. Hashemi, Dibakar Mondal, Thomas L. Willett
University of Waterloo, Canada

3D-printable bone-inspired biopolymer nanocomposites, if engineered to offer adequate strength and damage tolerance, are prospective materials for fabrication of synthetic grafts for reconstructing bone defects. The interfaces developed between cured layers during direct ink writing (DIW) exhibit different mechanical characteristics than the layers. Hyper mineralized cement lines contribute to the remarkable damage tolerance of cortical bones. Herein we hypothesized that organized interfaces in DIW printed microstructures would enhance the fracture resistance of 3D-printed nanocomposites. In this study, four photocurable nanocomposites were prepared by homogenizing heat-treated nano-hydroxyapatite into a functionalized biopolymer resin: 1) acrylated epoxidized soybean oil-(AESO) and polyethylene glycol diacrylate-(PEGDA) (named-SP30), 2) methacrylate functionalized AESO and PEGDA (named-mSP30), and third and fourth nanocomposites (named-SPT30, mSPT30) as prepared by substituting small volume of PEGDA in previous compositions. To investigate the effect of the interfaces, flexural properties and fracture resistance of cast beams and Crisscross (+/-45°) microstructures printed using a mandrel bed DIW printer were evaluated. The mechanical properties of the cured layers and interfaces were investigated using atomic force microscopy (AFM). Fractured surfaces of the microstructures were imaged using high magnification scanning electron microscopy (SEM). Microstructures of SP30 and SPT30 exhibited greater fracture resistance than cast controls. Single-point fracture toughness was calculated for mSP30 and mSPT30 cast and microstructures due to brittle failure. mSPT30 microstructures had 58% higher fracture toughness than cast controls. Printed nanocomposite microstructures had lower flexural properties than cast controls. AFM scanning measured lower stiffness at interfaces than the cured layers. SEM images of fractured SP30 and SPT30 microstructure surfaces demonstrated interface openings, and crack deflection was observed on fracture surfaces of mSPT30. This study demonstrated that the printed nanocomposite microstructures acquired higher fracture resistance than cast control confirming the hypothesis that the interfaces dissipated mechanical energy during fracture and contributed to enhance the fracture resistance.

Presentation 18 | 4:00 - 4:20pm

Development of a porous polypropylene-polyvinyl alcohol (PP-PVOH) blend for 3D-printed prosthetic and orthotic applications

Ahmad A Basalah[1], Dilek Bartın[2]
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Additive manufacturing has transformed the design and production of medical devices, especially in prostheses and orthoses. But, achieving lightweight with porous and mechanically efficient structure is challenging. In this work, a foamy, porous filament obtained by blending Polypropylene (PP) with Polyvinyl Alcohol (PVOH) was produced, optimizing it for 3D printing. PP is a thermoplastic polymer that is inexpensive and offers excellent flexibility, durability, and biocompatibility, and PVOH is a water-soluble polymer used as a sacrificial phase to create porosity in a controlled manner. It covers different PP-PVOH blending ratios, extrusion parameters and foaming methods to optimize the filament's mechanical properties and printability. The produced filament is evaluated by scanning electron microscopy (SEM) to study its sponge-like microstructure and the study of mechanical behavior including tensile strength, deformability and shape-stability. PVOH content affects porosity and weight loss to assess the possibility of load bearing in its application in medical devices. Initial findings suggest that higher PVOH leads to greater porosity, resulting in lower density with the strength necessary for prosthetic and orthotic components. The optimized PP-PVOH filament has a breathable, lightweight structure, which can be important for prosthetic sockets or orthotic supports to be more comfortable and reduce pressure points. Moreover, their controlled porous architecture can also improve ventilation, moisture control, and patient comfort, and address the limitations of conventional solid filaments. This research presents a novel approach to developing functional, patient-tailored materials for medical use. The PP-PVOH filament proposed in this research introduces an advanced solution that enables the production of high-performance and personalized prosthetic and orthotic devices by exploiting the potential of additive manufacturing compared to conventional-based materials. Future work will focus on the formulation of a more appropriate material, optimization of 3D printing parameters, and the exploration of its clinical feasibility through real-life application.

Presentation 19 | 4:20 - 4:40pm

You are what you breathe: Measuring airborne carbon fiber particulates during FFF printing of PA6-CF filament

Dora Strelkova
University of Windsor, Canada

Carbon fiber reinforced filaments are increasingly popular in additive manufacturing due to their enhanced mechanical properties compared to traditional materials like PETG, ABS, and Nylon. However, these materials present challenges, including proper drying requirements and potential fiber transfer to the skin during handling. In this study, microscopic examination of fingertips after handling PA6-CF parts revealed significant fiber transfer, raising concerns about airborne fiber dispersal during 3D printing. This research aims to quantify the dispersion of fibers from PA6-CF filament using a Bambu Lab X1C desktop material extrusion system. A custom vacuum apparatus with a water-soluble air filter was developed to capture dispersed fibers during printing experiments. The collected fiber content was then weighed and analyzed to draw conclusions. Additionally, recommendations for improving air filtration in 3D printers to minimize inhalation of these fibers are proposed. This study contributes to a safer working environment for 3D printing enthusiasts and professionals by addressing potential health risks associated with airborne fiber dispersion.

Presentation 20 | 4:40 - 5:00pm

Additive manufacturing of structured catalysts for biomass conversion: An innovative route to sustainable energy production

Vahid Haseltalab, Animesh Dutta, Sheng Yang
University of Guelph, Canada

Biomass fast pyrolysis produces highly oxygenated, viscous, and unstable bio-oil [1,2]. Catalysts such as microporous zeolites like ZSM-5 upgrade bio-oil but suffer from internal diffusion limitations and rapid deactivation from coke clogging pores [3]. Hierarchical catalysts featuring macro-, meso-, and microporous networks offer enhanced mass transport and large surface areas [4]; however, conventional fabrication methods, including impregnation, templating, hydrothermal synthesis, and powder pressing, struggle to precisely control pore size distribution and overall porosity. Additive manufacturing (AM) is emerging as the ideal approach to create hierarchical catalysts by enabling complex geometries that improve reactant accessibility and efficiency. This study aims to develop and optimize a novel 3D-printed structured catalyst to enhance biomass conversion. A Direct Ink Writing (DIW) method was employed using a modified FDM printer outfitted with a clay-capable extruder kit, enabling precise extrusion of a viscous catalyst ink and controlled deposition of layers on a leveled wooden build platform. The catalyst ink, composed of zeolite ZSM-5 powder, bentonite clay, a cellulose-based binder, and deionized water, is designed to control micro- and mesoporosity through binder and material selection, while AM primarily targets control of macro-porous structures. Systematic optimization of printing parameters—including nozzle diameter, layer height, extrusion rate, and print speed—ensured high dimensional accuracy, which directly influences surface area and the uniformity of flow channels for consistent catalytic performance. Printed parts were dried and subjected to sintering or calcination to form robust, porous structures. Experimental work has reached the process parameters optimization stage; catalyst characterization using SEM and BET analysis is underway. Initial lab-scale pyrolysis tests indicate a higher bio-oil yield from 3D-printed ZSM-5 monoliths compared to conventional catalysts, and further evaluation of product distribution and long-term stability is forthcoming. Further characterization is underway to assess catalytic performance aimed at increasing reaction rates and improving bio-oil quality and yield.

Session 7: Design for Additive Manufacturing I
July 23 | 3:40 - 5:00pm | Location E7-7363

Presentation 21 | 3:40 - 4:00pm

Thermo-hydraulic performance of additively manufactured uniform and hybrid triply periodic minimal surfaces (TPMS) geometries

Armin Hassanirad, Osezua Ibhadode,
Collins Chike Kwasi-Effah
University of Alberta, Canada

Triply Periodic Minimal Surfaces (TPMS) geometries are remarkable solutions to achieve optimal heat transfer performance in industries requiring heat exchangers (HX) with space and weight efficiency. Utilizing these additively manufactured geometries in HX applications involves a trade-off between maximizing heat transfer and minimizing pressure drop. While promising mainstream studies focus on HXs with uniform TPMS geometries (such as Gyroid, SplitP, and Schwartz-D), this research aims to investigate how hybridizing FR-D Prime and Diamond D sheet TPMS geometries can affect the thermal efficiency and flow resistance of an HX in a heat transfer application. Heat transfer setup design and Computational Fluid Dynamics (CFD) simulation, by employing k-epsilon turbulence model, conducted via Ansys SpaceClaim and Fluent based on the TPMS geometries generated by Lattgen. All geometries are created with a relative density of 20% whereas for hybridization, the sigmoid function is used for a smooth transition between FR-D Prime and Diamond D with a K value of 10. The model is validated by conducting an experiment on additively manufactured Aluminium HX. The investigation illustrates that the FR-D Prime setup has a higher Nusselt number than Diamond D while introducing a greater pressure drop to the system. Also, hybrid TPMS geometry has shown to be potentially effective in creating a thermo-hydraulic balance between the uniform FR-D Prime and Diamond D characteristics in a heat exchange system. It appears that hybrid geometry performs better in pressure preservation and heat transfer, compared to FR-D Prime and Diamond D, respectively. However, as the trade-off plays out, the hybrid structure exhibits weaker thermal performance than FR-D Prime while also experiencing an increased pressure drop compared to Diamond D. The findings of this research provide clearer insight into TPMS-based HXs in industry applications, encouraging further exploration of TPMS hybridization methods and approaches.

Presentation 22 | 4:00 - 4:20pm

A shape error evaluation study of geometry produced using directed energy deposition

Anushree Shah, Carl Reilly, Daniel Hawker, Daan Maijer, Steve Cockcroft
University of British Columbia, Canada

Personalized, additively manufactured solutions for patient specific needs are becoming the gold standard for creating medical devices and implants in the biomedical industry. A major benefit of Laser-Wire Directed Energy Deposition (L-WDED) is being able to produce custom and complex components efficiently using easily accessible CAD and 3D Slicing software. However, the dimensional accuracy of the components created using L-WDED is not well understood. Hence, this project focuses on linking printed part geometry and accuracy with L-WDED process parameters.Three parts are produced in 316L Stainless Steel (SS): a cylinder, a rectangular cuboid and a simplified pediatric implant. These components are produced by varying a L-WDED machine's bed speed, laser power and wire deposition rate. Each component is then scanned using photogrammetry and compared to the intended build geometry. Sensitivity analysis is conducted on the geometry measurement process to quantify the variability in these measurements. The geometry deviations are assessed, and the influence of process parameters is analyzed. Future work on this project includes characterization of the component microstructure to further understand the impact of process parameters and where possible, the parameters will be linked to temperatures changes occurring during the process.

Presentation 23 | 4:20 - 4:40pm

Systematic decomposition of additively manufactured surface roughness and its impact on laminar flows

Nipin Lokanathan, Zachariah Mears, Jean-Pierre Hickey, Mihaela Vlasea
University of Waterloo, Canada

The surface roughness inherent to Additive Manufacturing (AM) presents unique challenges for fluid flow applications, particularly in the laminar regime. While roughness effects in turbulent flows are well-documented, their impact on laminar flows remains less explored, despite growing evidence that AM-induced roughness can significantly increase pressure losses. This study introduces a novel decomposition of roughness induced by the Laser Powder Bed Fusion (LPBF) process into three distinct scales: (1) sinusoidal roughness, representing surface undulations caused by process parameters; (2) small-scale roughness, primarily arising from partially melted powder particles (Sa 15.8μm, ES 1.42); and (3) large-scale roughness, introduced by spatter formation (Sa: 9.6μm , ES 2.13). To systematically investigate the contributions of each roughness scale, numerical simulations are performed using OpenFOAM for sinusoidal roughness and the Lattice Boltzmann Method (LBM) for AM-generated roughness. Axisymmetric simulations of sinusoidal roughness reveal that increasing both roughness amplitude and spatial frequency leads to a significant increase in friction factor, which is well-correlated with the effective slope of the surface. Full 3D LBM simulations of AM-rough pipes, reconstructed from high-resolution surface scans, quantify the influence of each roughness scales on drag. Analysis, at a specified flowrate, indicates that AM pipes incorporating all roughness scales exhibit as high as 23% increase in friction factor compared to smooth pipes, while spatter-free surfaces show an 8% increase, and surfaces with only base undulations experience a 3–4% increase. These findings provide a structured framework for understanding the multi-scale nature of AM-induced roughness and its effect on laminar flow. The insights gained enable the development of targeted design and post-processing strategies to minimize pressure losses, thereby optimizing the performance of AM-fabricated flow components. This work helps bridge the gap between AM surface characterization and its impact on fluid flow, offering valuable guidance for engineers designing high-efficiency flow systems in AM applications.

Presentation 24 | 4:40 - 5:00pm

A multiscale design and fabrication approach to create biomimetic tunable implants

Iris Quan, Ameen Subhi, Liza-Anastasia DiCecco
University of Waterloo, Canada

Canadians across the country rely on hard-tissue implants such as hip, knee, and dental implants. Rises in aging populations are further increasing these needs, where diseases prevalent in elderly patients, such as osteoporosis (OP), contribute to these demands and can complicate osseointegration processes. To better serve these populations, current biomaterials used in bone implants must be improved, which can suffer failure from effects such as stress shielding, instability, inflammation, and aseptic loosening. In this work, a multiscale design and manufacturing approach using additive manufacturing (AM) is introduced to design tunable porous scaffolds with biomimetic hierarchical features. For tunable scaffold design, literature-driven design parameters found to be suitable for enhancing osseointegration and appropriate for AM were consulted. A Voronoi tessellation strategy was adopted to create dynamically tunable structures using a parametric modelling approach. In-model topology evaluation metrics (e.g. porosity, strut diameter, node connectivity, and intertrabecular angles) are included that provide designers insight into scaffold mimetics to different bone structures, key for considering site-specific locations and conditions, like healthy versus OP bone. Current progress related to the materials and mechanical assessment of as-printed scaffold structures will be shared. Select scaffold structures will be produced using state-of-the-art laser powder bed fusion with Ti-6Al-4V. AM will introduce micro-roughness, while chemical etching will induce engineered nanoscale texturing, which is anticipated to improve cellular adhesion and bone growth. The influence of AM and CAD parameters on material properties will be assessed in mechanical testing, while laser profilometry and scanning electron microscopy will characterize surface roughness and morphology. Overall, this work builds a foundation for the design of innovative biomimetic porous implants that can be tuned to meet patient-specific needs.

Session 8: Multiphysics Modeling and Digital Twins
July 24 | 9:00 - 10:20am | Location E7-7303

Presentation 25 | 9:00 - 9:20am

A geometrically-optimized comprehensive heat source model for FE thermal simulation of laser directed energy deposition

Ali Zardoshtian[1,2], Hamid Jahed[2], Ehsan Toyserkani[1]
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Laser Directed Energy Deposition (L-DED) is a distinctive manufacturing process known for its relatively high deposition rate, minimal waste, and ability to make complex shape and geometries. Accurate prediction of the temperature distribution and thermal history during L-DED is crucial for estimating the microstructure, porosity, and mechanical properties of the fabricated parts. However, existing analytical and numerical models often fall short in accuracy due to overlooking the geometrical characteristics and shape of the deposition. To address this issue, a multi-step statistical/numerical analysis workflow is proposed to elucidate the thermal responses in L-DED deposited tracks. First, a data-driven predictive model using statistical methods was used to estimate the deposition geometry based on the key process parameters which are laser power (P), powder feed rate (F), and scanning speed (V). Next, the prediction results were implemented in a dynamic hybrid quiet/inactive elemental control scheme to capture the deposition process. Further, activated elements are subsequently analyzed thermally through a transient 3-D finite element (FE) heat source model accounting for heat flux from conduction, convection, and radiation. The laser beam's energy follows a two-dimensional Gaussian distribution, while the heat flux over the actual deposition region, modeled as a quarter-ellipsoid with the predicted geometrical characteristics. This representation captures the actual projection of the laser beam on the deposition. The simulated melt pool depths and temperature showed excellent agreement with experimental measurements for L-DED depositions of Inconel 625 superalloy, exhibiting less than 10% deviation, thereby validating the proposed heat source model.

Presentation 26 | 9:20 - 9:40am

Bridging machine and part-level digital twins for enhanced quality control in additive manufacturing

Mohammad Vahid Ehteshamfar, Sheng Yang
University of Guelph, Canada

Additive Manufacturing (AM), also known as 3D printing, has transformed industrial production by allowing the creation of complex parts that are challenging and expensive to produce through traditional methods. However, the key challenge in AM remains the production of high-quality parts, which is often compromised by defects. A promising solution to these challenges is the Digital Twin (DT). It enables bi-directional feedback loops to monitor, predict, and control part quality dynamically during the AM process. By integrating data from simulations, real-time experiments, and historical datasets, DT offers a level of insight that was rarely achievable with previous methods. Despite the high potential of DTs, several challenges such as lack of multi-defect detection, integration between machine-level and part-level DTs, feedback control, and generalizability hinder their widespread adoption in AM. This study presents a comprehensive DT framework to fill the current gap that integrates the digital twin of the machine (DTM) and the digital twin of the part (DTP) for enhanced defect detection, prediction, and control. The DTM captures real-time data from sensors and synchronizes it with a virtual geometry model in Unity, creating a live representation of the printing process. The DTP incorporates a physics-based model, a simulation model, and a rule model to predict defects and optimize printing parameters. The integration of the DTM and DTP will ensure seamless communication. Real-time data from the DTM will feed into the DTP, enabling predictive models to detect potential issues.

Presentation 27 | 9:40 - 10:00am

Development of digital twin for optimization of print Computational flow dynamics simulation of the laser directed energy deposition process as a means to optimize process gas flow settings

Mikhail Malmyguine, Michael Benoit
University of Waterloo, Canada

This work aims to create computational flow dynamics (CFD) simulations of the deposition of powder particles using the laser directed energy deposition (LDED) process in order to optimize the gas flow settings of the LDED process, to produce desired particle velocities and melt pool shielding. Given the variety of LDED machines in industry and therefore the possible inapplicability of gas flow settings of one make of machine to another, there exists a need to optimize the gas flow settings of LDED machines in order to prevent additive manufacturing defects stemming from incorrect gas flow settings. The most common defects that this work aims to prevent are porosity, induced by excessive powder particle velocity, and oxidation, due to entrapment of air by shielding gas flows. In this work, CFD simulations are conducted at various carrier and shielding gas settings to determine the optimal gas settings for the Optomec 860 LDED machine, using LDED gas and particle stream flow literature to determine the powder velocity and inert gas concentration goals. Finally, a recomendation for the gas flow settings for the Optomec 860 machine is made.

Presentation 28 | 10:00 - 10:20am

Development of digital twin for optimization of print parameters of wire-based DED system

Daniel Hawker, Shaun Cooke, Daan Maijer, Steve Cockcroft
University of British Columbia, Canada

Wire-laser Directed Energy Deposition (DED) is a promising additive manufacturing technique to rapidly produce large, high-performance metal components. The Meltio M600 can print parts up to 600 mm tall in a relatively short timeframe. However, as printing progresses, heat accumulation alters the melt pool dynamics, potentially affecting surface finish, geometric accuracy, and thermal distortions. Despite this, printing parameters—laser power, bed speed, and wire feed rate—typically remain constant throughout the build. This work presents the development of a digital twin for the Meltio M600, utilizing a commercial finite element analysis software to simulate the thermal profile of a print. The model interprets G-code to enable realistic simulation of heat input and material deposition. Validation experiments will compare predicted and measured temperature distributions and melt pool dimensions. Future extensions aim to incorporate deformation and microstructural evolution predictions. By improving thermal process understanding, this digital twin will enable the optimization of printing parameters for consistent part quality.

Session 9: Metrology, Monitoring, and Controls July 24 | 9:00 - 10:20am | Location E7-7363

Presentation 29 | 9:00 - 9:20am

Dual-wavelength pyrometer thermal field measurements during LPBF: Calibration and experimental validation

Matheus Soares, Donatien Campion, Vladimir Brailovski, Alena Kreitcberg
École de technologie supériere, Canada

In laser powder bed fusion (LPBF) additive manufacturing, characterizing the temperature fields of a melt pool is critical, as they directly affect the microstructure, composition, and residual stresses in the printed material. However, the complexity of the LPBF process poses significant challenges in relating the thermal signature of the process to the laser scanning strategy, also in understanding its impact on the material properties. This study aims to measure the temperature distribution in the powder bed during the LPBF process to assess the influence of process parameters on the melt pool characteristics and temperatures. A dual wavelength pyrometer (ThermaViz-Stratonics) with two CMOS sensors operating at 750 and 900 nm wavelengths, was integrated into an EOS M280 LPBF system to measure the radiation intensities. Calibration was performed by measuring the radiation intensities of a tungsten filament, whose temperature is directly linked to the intensity of the electrical current applied. Printing experiments were conducted using IN625, CoCr and 316L powders. The printing strategy was designed to allow the measurements of radiation intensities in both isolated (single) and overlapping tracks for each material. The laser power ranged from 80 to 370 W and scanning speed varied from 400 to 1600 mm/s, with the radiation intensity images collected at both wavelengths. The resulting images were converted into temperature values using the Wien's approximation of Planck's Law, and the measurements were validated by comparing the thermal field images with the optical microscopy images of the melt tracks produced. Once validated, these in-situ measurements provide insights into the maximum temperatures achieved in the melt pool and temperature gradients in the heat affected zone. Ultimately, these data will be integrated into a LPBF model capable of predicting the alloying element vaporization and the as-printed material microstructure, thus enabling the production of high-density parts with controlled characteristics.

Presentation 30 | 9:20 - 9:40am

Integrating thermal camera technology into arc-wire directed energy deposition for enhanced process control and quality assurance

Maz Ansari, Dave Waldbillig
InnoTech Alberta, Canada

Arc-wire directed energy deposition (AW-DED) is a promising technology for producing high-performance components in industries such as energy, mining, and heavy machinery. However, controlling critical parameters, such as preheat, interpass, and cooling rates, remains a challenge that has hindered the widespread adoption of AW-DED for manufacturing wear-resistant components. This research focuses on integrating a thermal camera into the AW-DED system to address this gap by enabling real-time, non-contact temperature mapping of the welding process. The project involved testing the camera's calibration and validating its ability to detect melt pool variations and cooling rate changes. The system was further evaluated by producing hard-facing material prototypes to ensure optimal thermal management during deposition. The results demonstrate that integrating the thermal camera can significantly improve process control, enabling precise management of temperature parameters critical for preventing defects like cracking in wear-resistant materials, ultimately leading to enhanced component quality. This work highlights the potential of thermal camera integration to bridge the gap between academia and industry, providing scalable solutions to meet the growing demand for high-quality, durable components in harsh environments. The findings contribute to advancing the application of AW-DED in industrial manufacturing and offer new insights for future research in additive manufacturing and thermal control.

Presentation 31 | 9:40 - 10:00am

Feedforward control of the cooling rate in laser powder bed fusion using a physics-based thermal model

Nicholas Kirschbaum, Fangzhou Li, Wenda Tan, Chinedum Okwudire
University of Michigan, USA

Laser powder bed fusion (LPBF) experiences heat accumulation in complex parts, which induces spatial variations in material properties. Due to this intrinsic heat treatment, new parts must be qualified experimentally or undergo complex post-processing steps to meet specifications. One factor contributing to this variation is that heat buildup alters the melt pool, influencing the cooling rate and, consequently, the microstructure. This work presents a novel feedforward control strategy that leverages a lightweight, conduction-based thermal model to proactively regulate cooling rates by adjusting scan parameters. The model correlates in-process temperature predictions with melt pool lengths derived from high-fidelity simulations to act as a proxy for the cooling rate. This demonstrates that a lightweight conduction model can effectively decrease variations in cooling rates without relying on costly high-fidelity simulations, which are infeasible for part scales. Such control of the cooling rate has the potential to minimize variations in as-built material properties without significantly affecting print time, ultimately yielding more consistent and reliable prints.

Presentation 32 | 10:00 - 10:20am

Material classification for multi-material 3D printed objects using a portable single-exposure dual-energy X-ray detector

Neda Afkhami Ardakani[1], Steven Tilley[1], Curtis Larocca[1], Karim S. Karim[1,2]
[1]KA Imaging inc, Canada. [2]University of Waterloo, Canada

Additive manufacturing (AM) enables the creation of complex multi-material structures with customized properties, offering advantages in aerospace, biomedical and electronics applications. However, the complexity of multi-material 3D-printed objects presents challenges in quality control and performance assurance, particularly in distinguishing between different materials. We present a novel approach utilizing a portable single-exposure dual-energy X-ray detector for non-destructive material classification and inspection of multi-material 3D-printed parts. The detector contains three separate detection layers, each with a unique spectral response. This spectral data is used to generate a colorized image from a single exposure. Our colorization algorithm assigns a color to each pixel based on its approximate effective atomic number (Z_eff), distinguishing between polymers, aluminum/silicon-based materials, and metals. In this approach, organic materials (Z_eff < 10) are color-coded in orange, inorganic materials (Z_eff between 10 and 18) are displayed in green, and metals (Z_eff > 18) are shown in blue. This method enables material identification, critical for characterizing and ensuring quality control of functional and high-performance components. We scanned various materials and samples and successfully identified steel, copper wires, a cell phone battery, and small wires inside a cellphone in blue; PVC conduit in orange; and concrete and aluminum in green. This approach is compatible with conventional X-ray sources, including portable systems. This approach enhances quality control by enabling detailed inspection of material placement, such as detecting incorrect materials in each location, ensuring compliance with design specifications. Using a traditional X-ray source, the portable dual-energy X-ray detector can be integrated into assembly lines or used in field applications, offering real-time, non-destructive material analysis, reducing production errors and enhancing safety and reliability. By permitting material characterization using a conventional X-ray exposure, our method advances quality assurance and process optimization in AM, paving the way for innovative component design and manufacturing.

SESSION 10: Powder Bed Fusion II
July 24 | 10:40am - 12:00pm | Location E7-7303

Presentation 33 | 10:40 - 11:00am

Plasma-assisted, rapid alloying of mechanically activated multi-principal element powder (MPEP) precursors for additive manufacturing application

Ernest Mfum Acheampong[1], Ziqi Tang[1], Olga Naboka[2], Dean Ruth[2], Mark Plunkett[2], Michel Nganbe[1], Keun Su Kim[2,1]
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Homogeneous alloying of MPEPs can result in unusual combinations of functional properties due to lattice distortion and synergistic effects, thus has great potential for next-generation applications, specifically using additive manufacturing (AM). However, metal AM techniques require high density spherical powders for which scalable synthesis remains a significant challenge. High-energy ball milling (BM) has been proven to be one of the most reliable methods to produce MPEPs with accurate composition control. However, it requires long processing times in the range of 40 hours to achieve homogeneous solid solution. Moreover, it produces particles with irregular shape. Both shortcomings make BM unsuitable for large scale AM applications. Here, we propose a new approach to fabricate MPEPs more efficiently by combining rapid pre-alloying by mechanical alloying with continuous thermal plasma homogenization and spheroidization. First, a mechanically activated green mixture (i.e., partially alloyed powder) is produced by high-energy ball milling of an elemental powder blend. The crystal structure and composition of the pre-alloyed powders are examined using XRD and SEM-EDX analysis to optimize the process. The results indicate that pre-alloying of the powders can be achieved within 3 hours with a milling speed of 550 rpm using tungsten carbide balls. To complete the alloying and spheroidization processes, the semi-alloyed powders will be further treated by a thermal plasma jet. The thermal plasma provides temperatures well above the melting temperatures of the constituent elements of MPEPs, which facilitates spheroidization and rapid element diffusion, achieving powder homogenization within 100 msec. More characterization will follow to confirm whether composition homogeneity and spheroidization have been successfully achieved.

Presentation 34 | 11:00 - 11:20am

Laser powder bed fusion of 7A76 aluminum alloy with sustainably-manufactured powder

Ali Rezaei[1], Mohsen K. Keshavarz[1], John Barnes[2], Mihaela Vlasea[1]
[1]University of Waterloo, Canada. [2]Metal powder Works, USA

High-strength aluminum alloys exhibit a strong tendency for solidification cracking during the laser powder bed fusion (LPBF) additive manufacturing (AM) process. Introducing nanoparticles can lead to a remarkable reduction in solidification cracking during the LPBF fabrication of aluminum alloys. On the other hand, laser-material interactions would be influenced, which may negatively impact the relative density of fabricated alloy. In this study, 1 vol.% ZrH2 nanoparticles were added to a low-cost, environmentally sustainable AA7075 aluminum alloy powder with a non-equiaxed morphology. The powder morphology differs from the conventional spherical powders typically used in AM and can influence the final relative density. To systematically study melting mode behavior of AA7075+ZrH2 (7A76) alloy, a normalized processing diagram coupled with a temperature prediction model was employed. Theoretical calculations indicate that nanoparticles can increase absorptivity by up to 50%, and that the relative density of the alloy is greatly dependent on the melting mode behavior. Transition melting mode was found to be effective in minimizing elemental evaporation of Mg and Zn and achieving a defect-free 7A76 with a relative density of 99.98%. This reported relative density is the highest achieved in literature to date.

Presentation 35 | 11:20 - 11:40am

Uncovering shape memory effect in additively manufactured Ni-free β-titanium alloys

Soumya Kanta Panda, Sravya Tekumalla
University of Waterloo, Canada

Shape memory alloys such as nitinol have significant potential in biomedical applications ranging from stents to fracture fixation devices. However, nitinol exhibits two major limitations i.e., Ni hypersensitivity in the human body and significant processing challenges including machining. Therefore, in this work, we address these challenges by using additive manufacturing techniques to develop Ni-free biocompatible titanium-based shape memory alloys. We used laser powder bed fusion (LPBF) technique, an advanced additive manufacturing technique which enables the design of complex geometries, overcoming traditional processing challenges, and resulting in comparable or better mechanical properties. We subjected the as-printed alloys to solution heat treatment at 1173K followed by water quenching. Using XRD, we identified the alloys to be demonstrate fully stabilized BCC phase with a refined microstructure. We also conducted DSC tests to investigate phase transformations from Austenite to martensite. We also tested the mechanical properties of the alloys using microhardness and compression tests. Based on the initial studies, we find that LPBF technique is very promising to develop novel shape memory alloys that can be used in cardiovascular or orthopedic applications.

Presentation 36 | 11:40am - 12:00pm

Porous transport layer optimization via additive manufacturing of inconel 718 lattice structures

Tomisin Oluwajuyigbe, Rene Lam, Sagar Patel, Mohsen K. Keshavarz, Mihaela Vlasea
University of Waterloo, Canada.

Hydrogen production through alkaline water electrolysis (AWE) is a key clean energy technology, but its efficiency is hindered by poor gas and liquid transport, high ohmic losses, and material degradation. Additive manufacturing (AM), specifically laser powder bed fusion (LPBF), offers a solution by enabling the fabrication of porous transport layers (PTLs) with precise control over porosity and feature resolution, improving gas transport and overall system performance. This research optimizes PTL structures by refining printing parameters for Inconel 718 and implementing intricate lattice designs to improve bubble transport. Carefully designed lattice structures will be fabricated to enhance bubble removal, while stochastic pores generated through hatch spacing adjustments will further optimize gas-liquid interactions and increase electrochemical sites. The combination of lattice geometries and process-driven porosity is expected to improve mass transport efficiency within AWE systems. An investigation into printing fully dense Inconel 718 and randomized lattice structures using LPBF provides insights into achieving high-resolution geometric fidelity. This study will establish optimal process parameters for PTL design. Advanced characterization techniques, such as scanning electron microscopy (SEM) and X-ray computed tomography (XCT), will analyze porosity distribution, structural integrity, and overall performance metrics to validate the proposed parameters. By refining these parameters, this research will establish a repeatable method for producing high-resolution lattice structures with controlled porosity. The findings will guide improvements in manufacturing efficiency, geometric precision, and gas transport performance in additively manufactured PTLs, supporting the enhancement of clean hydrogen production technologies.

SESSION 11: Design for Additive Manufacturing II
July 24 | 10:40am - 12:00pm | Location E7-7363

Presentation 37 | 10:40 - 11:00am

An integrated computational framework for strut, plate and TPMS-type lattice design

Alex Olisa Inoma, Chinedu Ifediorah, Osezua Ibhadode
University of Alberta, Canada

Lattice structures are widely used in additive manufacturing to develop lightweight, high-performance materials. As their complexity increases, so does the demand for robust computational tools for their modeling. This work introduces a computational framework based on signed distance and trigonometric fields, providing researchers with precise control over lattice design. The framework supports various lattice types, including straight, curved, and hollow struts, plate-based structures, and Triply Periodic Minimal Surface (TPMS) geometries. It also enables custom unit cell configurations, lattice nesting and hollowing, and equation-driven grading to tailor mechanical and functional properties. After modeling the structures, the homogenized constitutive matrix of different unit cell topologies is determined using the numerical homogenization method. This approach allows researchers to analyze the isotropic behavior of the lattice and extract elastic properties such as Young's modulus and Poisson's ratio, facilitating computationally efficient simulation studies. The computational framework was validated through the fabrication of intricate lattice structures using metal and photopolymer additive manufacturing technologies. The resulting structures exhibited high geometric fidelity, making them suitable for mechanical characterization, engineering applications, and aesthetic design. Furthermore, analyses of relative density and runtime were conducted to evaluate the effects of grid resolution, periodicity, and cell topology on computational efficiency and geometric accuracy. The findings suggest an optimal level of domain discretization that balances accuracy and computational speed. With its versatility and precision, this framework serves as a valuable tool for researchers developing advanced lattice structures, fostering innovation in structural optimization, material performance, and additive manufacturing applications.

Presentation 38 | 11:00 - 11:20am

Tailoring mechanical performance of Ti-6Al-4V structures using porous architectures

Rene Lam, Tomisin Oluwajuyigbe, Sagar Patel, Mohsen K. Keshavarz, Mihaela Vlasea
University of Waterloo, Canada

Bone is a complex and hierarchical structure with the ability to provide extensive structural support to the body, while also being lightweight for ease of motion. Bone can be damaged from injury or illness, requiring the need for an orthopedic implant to provide structure and encourage growth of new bone. A challenge with current metal orthopedic implants is stress shielding, where there is a mismatch of mechanical moduli between the implant and human bone. Bone is mechanoresponsive, which means loss of load transmission due to stress shielding leads to loss of new bone growth, leading to poor implant fixation. When designing implants, it is important to tailor the mechanical response to natural bone to avoid stress shielding. This research explores a new method for implant design and manufacturing, incorporating two levels of porosity (micro-scale stochastic and meso-scale deterministic), as there are 2 types of bone, with varying porosities. Lattices are used to introduce voids (meso-scale) into the structure to reduce stiffness whilst providing structural support. The structures were manufactured using laser powder bed fusion (LPBF), an additive manufacturing (AM) technique. A second level of porosity (micro-scale) was introduced to the lattice struts or walls stochastically during printing by tailoring the process parameters such as hatch spacing and scan pattern rotation. This secondary level of pores further decreases the stiffness of the metal. The porosity of the designed lattice structures ranges from 45 - 85% to cover the range of both types of bone. The stochastic pores are expected to increase porosity of the structure by about 4 - 15%. These structures were printed in Ti-6Al-4V with a set of process parameters targeted towards dimensional accuracy of the designed struts and cavity sizes. A subset of samples was selected for compressive testing to assess the effect of hierarchical pores on mechanical performance.

Presentation 39 | 11:20 - 11:40am

On the design and evaluation of stochasticity in additivity manufactured architected lattice structure

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Architected materials, composed of precisely designed networks of struts or walls interspersed with air pockets, offer tunable mechanical properties for a wide range of applications. Advances in additive manufacturing have revolutionized their design, enabling highly optimized, application-specific structures beyond traditional manufacturing constraints. Recent research, including our own, has explored the role of stochasticity and anisotropy in enhancing mechanical performance with respect to properties such as strength, stiffness, and energy absorption. Despite the interest in this direction, a standardized method for quantifying these aspects of structure in architected materials does not exist. Typically, foam-like structures are derived through the geometric perturbation of a periodic reference lattice. However, the large number of possible such perturbations renders this approach imprecise, limiting the ability to establish universal relationships between architecture and material properties. To address this challenge, we propose a new, geometric framework for designing and evaluating the structure of architected materials. We incorporate concepts from graph theory and information theory to quantify structural stochasticity and asymmetry, drawing an analogy to the structure of crystalline and amorphous systems at the atomic scale. Details of this exploratory approach will be discussed with the goal of establishing "structure-property relationships" for architected materials in the future.

Presentation 40 | 11:40am - 12:00pm

Additive manufacturing of triply periodic minimal surface structures as porous electrodes for redox flow batteries

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Porous electrodes are crucial for the performance and cost of redox flow batteries (RFBs) as they provide the surface area for electrochemical reactions, the porous structure for electrolyte transport, and facilitate mass, charge, and heat transport. Improving the electrode performance can increase the power density and reduce the system costs of the battery. Traditional carbon-fiber-based porous electrodes, adapted from fuel cell gas diffusion electrodes, are not optimized for liquid-phase electrochemistry. Therefore, new manufacturing techniques that offer high control over electrode microstructure and properties are needed. Additive manufacturing techniques are ideal for designing controlled architectures, helping to understand geometry-performance relationships and producing high-performance electrodes with enhanced electrochemical performance and reduced hydraulic resistance. I will present our latest advancements in the additive manufacturing of advanced electrode geometries for RFBs, showcasing the versatility of this approach in fabricating electrode microstructures for electrochemical applications. This presentation will cover our work on using triply periodic minimal surface (TPMS) structures as RFB electrodes. TPMS structures, found in natural systems like butterfly wings, leaves, and sea urchin skeletons, have periodic surface structures with large surface areas, which are beneficial for RFB electrodes. Our previous research showed that electrode pillar shape affects mass transfer rates, leading us to explore various TPMS forms, including gyroid, diamond, and IWP. We fabricated TPMS electrodes using a commercial desktop digital light processing printer followed by carbonization. In organic redox flow cells, TPMS electrodes demonstrated higher internal surface area and enhanced mass transport compared to cubic periodic structures, improving reactor performance. The diamond TPMS, in particular, outperformed the regular cubic structure, showing the lowest overpotential and highest current density and mass transfer coefficient. Our work highlights the potential of additive manufacturing to create customized porous electrodes with multiscale structures, increased electrochemical performance, and low hydraulic resistance.

Session 12: Powder Bed Fusion III
July 24 | 1:00 - 2:20pm | Location E7-7303

Presentation 41 | 1:00 - 1:20pm

Sustainability for laser powder bed fusion: Tailored microstructure, mechanical properties, and productivity for low-alloy steel

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[1]University of Waterloo, Canada. [2]Rio Tinto, Canada

Laser Powder Bed Fusion (LPBF) is a leading technique in metal additive manufacturing (AM), widely used across various sectors owing to its ability to produce complex, fully dense metal parts. However, high costs and low productivity remain significant barriers to its industrialization. This study aims to enhance the cost-effectiveness of LPBF for AISI 4340 low-alloy steel, a material recognized for its affordability and applicable mechanical properties, making it an affordable alternative to expensive superalloys. The research employs water-atomized powders as a low-cost feedstock, as an alternative to traditional gas-atomized powders, and systematically explores layer thickness from 35 μm to 70 μm to boost productivity, while maintaining quality. A dimensionless number-based methodology was used to optimize process parameters across different layer thicknesses, offering a faster and more economical alternative to numerical simulations. This approach considers a broader range of process variables such as laser's beam diameter as well as power and velocity, also material properties such as absorptivity, conductivity, and temperatures of melting and build pre-heating. Although AISI 4340 has cold cracking propensity during LPBF process, understanding the effect of heat input using the dimensionless energy input values, crack-free components were successfully manufactured with relative densities of 99.2%-99.8% also resulted in tailored mechanical properties. For 35 μm layer thickness samples in the as-built condition, parts achieved ultimate tensile strengths (UTS) of 1010 MPa, 7.5% elongation at break, 36 HRC hardness, and 40 J Charpy Impact toughness. Moreover, Heat treated samples showed UTS of 929 MPa, 10.5% elongation, 33 HRC hardness, and 106 J Charpy Impact toughness on average. By combining low-cost water-atomized feedstock, optimized parameters and increased productivity, this study enhances LPBF cost efficiency while maintaining mechanical performance. These advancements make LPBF a viable and scalable technique for industries needing affordable yet robust metallic components, expanding the adoption of AM technologies.

Presentation 42 | 1:20 - 1:40pm

Revolutionizing metal additive manufacturing productivity through laser beam shaping

Joel J Sam
EOS, USA

Additive Manufacturing (AM) with metal laser powder bed fusion (LPBF) increases design freedom and opens up a wide range of new part geometries. From intricate lattice structures in medical implants that promote bone growth to massive, one-meter-high rocket engines for space exploration (some of which are entirely designed by artificial intelligence), LPBF has proven to be a successful technology across a range of industries. Until recently, the majority of LPBF machines have employed the same laser profile: a Gaussian laser beam that melts and solidifies powdered material into the desired solid geometry. If this single tool (the Gaussian laser beam profile) already offers such vast possibilities, imagine what could be achieved with a toolbox full of advanced laser beam profiles. Using a new technology called beam shaping, alternate non-Gaussian profiles (such as a ring) can be utilized to increase deposition rates by increasing the beam diameter and distributing the energy input over a larger area, without losing focus. By dynamically adjusting the beam profile across a range of "modes", The same laser can be used for high precision (using a standard Gaussian profile with a small spot size around 85 μm) of high throughput (using a ring profile with a large outside diameter around 250 μm). This increase in productivity has been validated in commonly-used alloys such as IN718 and AlSi10Mg, proving the relevance of this technology in industry. Additionally, the ring shape is beneficial to material efficiency because of its lower peak intensity and "spatter-catching" properties. This means that airborne particles can be transferred back into the melt pool, reducing material waste. Beam shaping fundamentally affects the physics of the manufacturing process, from the microscopic to the macroscopic level, and opens up a new frontier in throughput and productivity.

Presentation 43 | 1:40 - 2:00pm

Influence of heat treatment on the high strain rate deformation of laser powder bed fused Cu–Cr–Zr alloy

Nadia Azizi[1], Hamed Asgari[2], Mahyar Hasanabadi[1], Akindele Odeshi[3], Ehsan Toyserkani[1]
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This study investigates the effect of heat treatment on the high strain rate behavior of a Cu–Cr–Zr alloy fabricated via high-power laser powder bed fusion (LPBF). Experiments utilized a split Hopkinson pressure bar (SHPB) setup with firing pressures of 100 kPa and 250 kPa, corresponding to maximum strain rates of 4400 s-1 and 11300 s-1 for as-built samples, and 1700 s-1 and 4700 s-1 for heat treated samples. True stress-strain curves reveal a significant difference in strain accommodation mechanisms between as-built and heat-treated samples. Heat treatment markedly enhances the ultimate compressive strength (UCS) and work hardening rate under dynamic loading conditions, likely due to the Orowan strengthening mechanism by finely dispersed precipitates formed during heat treatment. The heat-treated samples exhibit continuous strength gains with increasing strain, reflecting pronounced strain hardening. In contrast, as-built samples show a plateau after reaching their UCS, where the activation of softening mechanisms, such as adiabatic shear band (ASB) formation, reduces the effectiveness of strain hardening. Despite the substantial changes in mechanical behavior, macro-texture analysis reveals minimal differences between as built and heat-treated samples, suggesting that the performance disparities stem primarily from microstructural changes, such as precipitate formation and distribution in heat-treated samples, rather than shifts in crystallographic orientation.

Presentation 44 | 2:00 - 2:20pm

Fracture performance of multi-material hybrid structures enabled by additive manufacturing

Saeed Maleksaeedi, Mohammad Shojaati, Ali Zardoshtian
University of Waterloo, Canada

Multi-material additive manufacturing (AM) enables the integration of dissimilar materials, facilitating the development of components with tailored mechanical and thermal properties for high-performance applications such as high-temperature tooling. This study investigates the fracture behavior of a hybrid multi-metal structure fabricated through a combination of AM and infiltration techniques. The component consists of a triply periodic minimal surface (TPMS) lattice structure, additively manufactured and subsequently infiltrated with a proprietary tungsten-silver (W-Ag) composite. The TPMS lattice design allows for precise control over mechanical performance and thermal performance, leveraging the high thermal conductivity of silver and the structural integrity and high temperature stability of tungsten to enhance both mechanical durability and heat management. Fracture behavior was systematically evaluated through a combination of quasi-static and dynamic mechanical testing. Compact tension (CT) specimens were used to assess fracture toughness, while Charpy impact testing was conducted to investigate the response of the structure under high strain rate loading conditions. Experimental results indicate that the hybridization process is able to enhance fatigue resistance and work of fracture, attributed to the synergistic interaction between the TPMS lattice and the infiltrated W-Ag composite. Notably, crack bifurcation, reinitiation, and fracture mode changes were observed during cracking, with the TPMS lattice architecture playing a crucial role in deflecting and dissipating fracture energy. The interwoven structure improved resistance to crack growth and promoted controlled failure mechanisms, while the tailored lattice design facilitated efficient thermal management under operational conditions. These findings highlight the potential of multi-material AM to engineer advanced structures with customizable mechanical and thermal properties. The study emphasizes the critical influence of lattice geometry on fracture resistance and failure mechanisms, offering valuable insights into the design and fabrication of hybrid AM structures. Future research will focus on further optimizing lattice and material composition to enhance scalability and performance for broader applications

Session 13: Machine Learning in Additive Manufacturing II
July 24 | 1:00 - 2:20pm | Location E7-7363

Presentation 45 | 1:00 - 1:20pm

Large language model-assisted bayesian optimization for improved parameter selection in additive manufacturing

Chih Yu Chang, Milad Azvar, Raed Al Kontar,
Chinedum Okwudire
University of Michigan, USA

Finding the best process parameters is both critical and challenging in additive manufacturing (AM), primarily due to the need for extensive trial and error. This paper presents a novel approach that leverages Bayesian optimization (BO) and Large Language Models (LLMs) to accelerate parameter selection by balancing exploration and exploitation. Leveraging on the contextual understanding and domain knowledge of LLMs, this method provides a head start to BO when observations are scarce, while transitioning to classical BO for a stronger statistical insight when more data becomes available. The effectiveness of the proposed method is demonstrated by tuning process parameters in material extrusion AM to minimize stringing, a common defect that occurs when material oozes from the nozzle as the extruder moves to a new location. Experimental results show that the proposed LLM-assisted BO requires fewer iterations compared to existing methods, achieving similar or improved print quality..

Presentation 46 | 1:20 - 1:40pm

A pioneer machine learning-driven platform for in-situ vertical side surface roughness prediction in laser powder bed fusion

Sahar Toorandaz, Ehsan Toyserkani
University of Waterloo, Canada

Real-time surface roughness prediction in laser powder bed fusion (LPBF) is crucial for achieving effective control and enhancing part quality. Surface roughness directly impacts fatigue life and contributes to increased post-processing costs. While in-situ monitoring has become a paradigm for real-time defect detection in LPBF, surface roughness prediction, particularly for vertical surfaces of printed components with respect to the build plate, remains entirely unexplored. Existing studies primarily address in-situ detection of the top surface roughness of printed parts, while vertical surface assessments relying on ex-situ methods that lack real-time capabilities. This limitation is attributed to the coverage of vertical walls with loose powder particles within the powder bed, obstructing the visibility/sensing of the site of interest. This study pioneers a framework for in-situ prediction of vertical surface roughness using a photodiode sensor integrated with machine learning (ML) detection algorithms. The photodiode sensor enables fast response times, capturing light intensity signals from regions adjacent to vertical surfaces during the printing process. Key time-domain and frequency-domain features are extracted from the photodiode signals and combined with essential process parameters to predict the surface roughness of each vertical side. The performance of five ML models was evaluated across multiple configurations of input features. Random Forst (RF) and eXtreme Gradient Boosting (XGB) emerged as the most robust models, achieving high accuracy and low error rates. Incorporating in-situ data significantly enhanced model performance, improving RF's R^2 from 0.35 (using process parameters alone) to 0.78, demonstrating the effectiveness of this approach. This work establishes a novel pathway for real-time vertical surface roughness prediction and provides a foundation for improved quality control and optimization in additive manufacturing processes.

Presentation 47 | 1:40 - 2:00pm

Data-driven approach for predicting abnormal grain growth in sintered binder jet steels

Mingzhang Yang, Mihaela Vlasea, Mohsen K. Keshavarz
University of Waterloo, Canada

Austenitic 316 stainless steel printed by binder jetting requires sintering to high densities to minimize porosity and have the corrosion resistance and strength required for most applications. While sintering can achieve densities above 99%, this paper reports the occurrence of abnormal grain growth (AGG) in this high-density region. A comprehensive process map is proposed, integrating key parameters to predict and inform grain sizes using regression model and machine learning approaches. Additionally, a clear relationship is identified between surface roughness, density, and grain size, offering a potential strategy for quality monitoring in serial production.

Posters

Poster 1: Mitigation of melting mode-driven cracking in laser powder bed fusion of Ti-6242Si

Sagar Patel, Mohsen K. Keshavarz, Ali Rezaei,
Sharon A Varghese, Mihaela Vlasea
University of Waterloo, Canada

This study investigates the laser powder bed fusion (LPBF) of Ti-6242Si, a near-α titanium alloy, focusing on the impact of process parameters on density, microstructure, residual stresses, and cracking. Utilizing normalized processing diagrams, we explored the influence of laser power, scan speed, and beam spot radius across conduction, transition, and keyhole melting modes. High-density parts (up to 99.98%) were achieved, primarily in the transition mode, demonstrating a broad process window for Ti-6242Si. X-ray computed tomography revealed subsurface porous defects as the primary contributor to porosity, linked to vaporization instabilities. Notably, transition and keyhole mode parameters led to macroscopic cracking, attributed to elevated residual stresses approaching the material's yield strength of ~740 MPa at 500°C. Residual stress values of 510 to 680 MPa were observed across melting modes that correlated linearly with a temperature prediction model, highlighting the role of melt pool morphology. This work uses residual stress measurements and advanced microscopy to identify the root causes of cracking as microstructure-induced residual stress during LPBF of Ti-6242Si. It demonstrates that applying process diagrams and temperature prediction models can facilitate the rapid optimization of LPBF parameters, thereby enabling the production of dense, crack-free components with low surface roughness (<10 μm) for high-temperature applications.

Poster 2: msamDB: Towards addressing data-scarcity challenges in L-PBF additive manufacturing

Jigar Bimal Patel, Chris Vuong, Mihaela Vlasea, Tamer Ozsu
University of Waterloo, Canada

Data science techniques, particularly machine learning (ML) have proven to be valuable tool in L-PBF research. While ML can rapidly model the large process parameter space of L-PBF, their efficacy is dependent on large, informative and diverse training datasets. However, scarcity in the development and availability of such datasets is an on-going challenge. This work outlines the on-going progress to address this challenge through the development of database platform, tentatively named msamDB. This platform, specifically created to manage L-PBF academic research data, is a modular, extensible and scalable database that can promote data-sharing among researchers. The initial architecture of msamDB focuses on surface roughness data generated throughout the L-PBF lifecycle. This work highlights the findings and challenges encountered in the design, implementation and pilot data population stages of msamDB. In its current stage, msamDB data spans data from ~30 builds, multiple research and industry studies, 3 different powder materials and a broad range of process parameters. Data has been collected from various stages such as powder characterization, build planning, process parameter selection, surface characterization, etc. In reference to surface roughness measurements, the database currently has more than 1000 data points across various surface orientations. This work represents first known effort to curate research L-PBF data at scale for L-PBF. The potential impact of such a database is to promote federated data for L-PBF researchers, which allows for data-driven model development to have increased usability.

Poster 3: Investigation of the tensile properties of thin-walled structures printed from AlSi10Mg for aerospace applications

Zachariah Mears, Mihaela Vlasea
University of Waterloo, Canada

In this study, the tensile properties of thin-walled structures printed from AlSi10Mg using LPBF are considered. Significant research has been completed both on the characterization of LPBF bulk material properties, as well as the design of optimized, lightweight structures which often rely on the usage of fine features. However, there has been little investigation into how material properties are affected when printing thin complex structures for load-bearing and light-weighting applications. In this work, the tensile properties of samples ranging from 1 mm to 3 mm in thickness are considered, as well as the effect of build orientation. The tensile properties of samples printed with custom parameters at angles ranging from 90 - 20 degrees with respect to the horizontal build plate are tested to investigate the effect of print angle on these thin-walled structures. The surface roughness of samples was measured and ranges between 9.3 - 56.5 μm as a function of print angle. CT scanning was used to investigate the density of samples with sample densities ranging from 99.7% to 98.8%. Lower densities were primarily observed in thin samples printed at steep angles. Finally, highlights of these results will be shown in the context of a rocket turbopump impeller printed using these parameters. Comparisons will be made between the test samples and this practical component with a focus on the applicability of these results for the design of complex structures.

Poster 4: Design and mechanical analysis of additively manufactured primitive flexures

Jonah Leinwand, Mihaela Vlasea, Stewart McLachlin
University of Waterloo, Canada

In the design of compliant mechanisms, thin flexural members, consisting of bends and curves, can be used to produce a controlled path of rotation under load. However, to date, there is little literature to characterize the design and mechanical properties of additively manufactured flexural members. To address this knowledge gap, the goal of this work was to design and additively manufacture a family of primitive flexures to explore how different design features affect the resulting mechanical response under load. Several flexure primitive design features were varied within a common 3-prong flexure component design, including flexure thickness, overhang angle, number of bends, hollowness, and latticed infills. The response of these designs was then analyzed through simulation of applied loading based on application of physiologic loading values reported for the cervical spine to mimic a targeted application of a compliant mechanism for cervical artificial disc replacement. The ability to realize complex parts with latticed or flexible features has value in improving compliance in orthopaedic applications. Designs were simulated in compression (Fz), torsion (Mz), lateral bending (My), and flexion-extension (Mx) loading. After simulation, the primitive flexure designs were printed using Ti6Al4V on the EOS M290 laser powder bed fusion system. For mechanical testing, the flexures were printed between custom-designed endplates to attach to the AMTI VIVO joint motion simulator. Designs are set to be tested under the same loading conditions as the simulation, with the primitive flexure response captured using a 3D digital image correlation system. These results will provide new understanding of the mechanical behaviour of additively manufactured primitive flexures built via LPBF. This information is needed to better inform the appropriate design and manufacturing of compliant structures like artificial disc replacements for orthopaedic surgery.

Poster 5: Process parameter optimization for crack mitigation in CM247LC processed by electron beam melting

Sebastian J. X. Soo
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The high gamma prime (Ni3(Ti, Al)) content of the nonweldable nickel superalloy, CM247LC, enhances its mechanical properties for high temperature applications, but also paradoxically contributes to its heightened crack susceptibility. The processability via laser powder bed fusion has been explored through various crack mitigation strategies. However, certain compromises were made. Electron beam melting (EBM) offers a promising alternative due to differences in the deposition process. This process optimization study explores the processability of CM247LC by EBM for crack mitigation, following a systematic ground up approach with basic build geometries. An experimental single-track study with a design of experiment format was conducted to isolate the primary EBM parameters and to study their effects on the track stability, microstructure, and cracking behavior. A process map was defined to identify parameter combinations fostering a coherent and uniform track. Melt pool analysis revealed certain track conditions were conducive for crack mitigation. Supplementary, a finite element thermal model was developed to study the thermal response of CM247LC. The temperature profiles for each experimental single track were simulated and the spatial-temporal evolution of the solidification conditions were studied. Ultimately, the relationship between process parameters, thermal conditions, and cracking behavior was defined. The model revealed low cooling rates and thermal gradients helped to reduce the crack susceptibility. Expanding on the single-track study, the single layer deposition investigated the interaction among consecutively deposited multi-tracks. The lateral track arrangement was controlled by line offset and the number of tracks. Their effects on the layer quality, microstructure, and crack behavior were explored. The different single-track recipes followed contrasting deposition character as reflected by surface topography analysis and subsequent assessment of its cross section. A clear geographical pattern of defects was observed. The established relationship hints at optimal multi-track conditions but requires further fine tuning and follow up strategies.

Poster 6: Evaluating the use of electrochemical additive manufacturing (AM) in the design of efficient liquid-cooled heat sinks via a functionality-driven hybrid topology optimization & lattice design for AM methodology

Joseph N Orakwe
University of Waterloo, Canada. University of Alberta, Canada

Researchers have explored single-liquid forced convection heat exchangers and heat sinks to maintain optimal operating temperatures in automotive power electronics modules as well as high-performing CPU and GPUs. Additionally, thermal-fluidic topology optimization (TO) is gaining traction for designing efficient heat sinks, and some works have investigated the combination of surface-based lattices (TPMS) to enhance the heat transfer process, enabled via additive manufacturing (AM). The majority of studies have been focused on designing heat sink structures for production via the widely popular Selective Laser Melting (SLM) technique. Still, another less-popular technology – Electrochemical AM has been shown to possess immense potential in producing precise intricate structures, while bypassing some of the shortcomings of the SLM process including thermal gradient management. To demonstrate the potential of the ECAM process for producing functional products, an efficient, lightweight heat sink has been created by combining advanced design methods: thermal-fluidic topology optimization and smart conformal lattice structuring while leveraging other key heat-transfer enhancements. Using a design methodology that incorporates design considerations for ECAM, allowed for the development of a performance-driven, manufacturable solution. Preliminary comparative simulations indicate immense, robust improvements in the employed mass-based, thermo-hydraulic figure of merit (FOM) by an average of 16.2% across the range of flow rates tested (0.5 – 1.0 gpm). Specifically, a 55% weight saving stacks up with consistently lower (21-34%) pressure drop predictions, and similar cooling indices, for a 350W-rated heat source, compared to a microchannel heat sink with great cooling capacity. AM build checks & prototyping of the heat sink also indicated good satisfaction of overhang, feature size & printability constraints. Finally, the heat sink produced via ECAM showed excellent capture of designed features and dimensional requirements.

Poster 7: Fabrication and characterization of 17-4 ph stainless steel and inconel 625 bimetallic structures using laser powder bed fusion

Shalini Singh, Ahmed Qureshi
University of Alberta, Canada

The development of bimetallic structures using Laser Powder Bed Fusion (LPBF) offers a transformative approach to manufacturing components with tailored mechanical and chemical properties, crucial for aerospace, nuclear, and electrochemical applications. LPBF enables precise control over microstructure and composition, facilitating the seamless integration of materials with distinct properties. In this study, a 17-4 PH stainless steel and Inconel 625 bimetallic structure was successfully fabricated using optimized LPBF parameters, minimizing defects such as thermal mismatch, element segregation, and grain growth. Microstructural analysis via Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscope (EDS) revealed a well-bonded interface with a smooth transition in Ni and Fe concentrations over a 20–30 μm interfacial zone. X ray Microscopy (XRM) inspection confirmed a low porosity level of <0.5%, ensuring high process stability. Hardness measurements showed a gradient, with Inconel 625 at ~400–450 HV, the interface at intermediate hardness, and 17-4 PH stainless steel at ~300–350 HV. The bimetallic joint combined the high corrosion resistance of Inconel 625 with the superior mechanical strength of 17-4 PH, demonstrating the potential of LPBF to create functionally graded materials with tailored properties. By precisely controlling processing conditions, an optimal balance between ductility and strength was achieved, validating the feasibility of LPBF for high-performance, multi-material additive manufacturing.

Poster 8: Effect of melt pool positioning on the microstructure evolution in laser powder bed fusion of Ti-alloy

Mahyar Hasanabadi[1], Nidia Azizi[1], Hamidreza Aghajani[1], Tatevik Minasyan[1], Hamed Asgari[2], Ehsan Toyserkani[1]
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In Laser Powder Bed Fusion (LPBF), process parameters play a critical role in microstructure evolution, which in turn influences the mechanical behavior of the fabricated parts. Understanding these relationships is essential for optimizing material properties and minimizing defects. This research investigates the effect of vertical and horizontal spacing between adjacent melt pools on the microstructural features, using numerical and experimental approaches. The modeling is employed to determine the maximum possible increment in hatch distance (up to 160 μm) and layer thickness (up to 90 μm) without causing lack of fusion defects. The findings reveal that increasing hatch distance and/or layer thickness reduces remelting and epitaxial grain growth, while promoting greater melting of fresh powder and enlarging the melt pool surface area in the vicinity of the unmelted powder. This leads to an increase in nucleation sites, resulting in finer grain structures and a texture transition.

Poster 9: Electropolishing of additively manufactured internal channels with various curvatures using 3D-printed polymeric electrode covers

Manyou Sun, Ali Mohammadnejad, Ehsan Toyserkani
University of Waterloo, Canada

Although additive manufacturing (AM) has the capability to fabricate complex parts with internal channels, issues on poor surface quality need to be addressed after printing. In this work, a novel electrode assembly combining flexible metal wire electrodes and 3D-printed electrode covers is proposed for electropolishing internal channels with different curvatures. Feasibility of the proposed method has been tested experimentally. A maximum surface roughness (Sa) reduction from 10.86±0.50 μm to 1.44±0.46 μm has been achieved using the novel electrode assembly. Design optimization of the electrode covers has been done using numerical simulation in terms of current density distribution and flow distribution. While the method shows great potential towards electropolishing internal channels, the development of high resolution polymer 3D printing techniques as well as support removal techniques might largely benefit the proposed method on reducing the channel size limit.

Poster 10: Machine learning-driven optimization of laser powder bed fusion: from powder characterization to process parameters tailoring for Ti6Al4V powders

Farima Liravi[1], Ehsan Toyserkani[1], Mahdi Habibnejad-Korayem[2]
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The quality of parts produced by Laser Powder Bed Fusion (LPBF) depends on complex interactions between process parameters, feedstock powder characteristics, melt pool conditions, and environmental factors. Among these, powder bed quality—determined by particle size, morphology, and rheology—plays a crucial role in ensuring consistent manufacturing outcomes. This work investigates machine learning (ML) approaches to predict powder flowability from fundamental powder attributes, reducing reliance on costly experimental measurements. Using standard and off-size Ti6Al4V powders, support vector regression (SVR) demonstrated high accuracy in estimating specific energy (SE), achieving a mean absolute percentage error (MAPE) of ~2.6%. Additionally, symbolic regression via genetic programming improved predictions of unconfined yield strength (UYS3, UYS9). Synthetic Minority Over-Sampling Technique (SMOTE) proved effective for modeling basic flow energy (BFE) and Hall flowability, overcoming dataset limitations. Beyond powder characterization, this research integrates ML-driven powder insights into LPBF process parameter optimization. A predictive framework was developed by leveraging photodiode-based melt pool monitoring and ML regressors—feed-forward neural networks (FFN), random forests (RF), and extreme gradient boosting (XGBoost)—to determine optimal parameters such as laser power, scan velocity, and hatch distance. Comparative analysis revealed that RF exhibited superior accuracy and generalization, achieving an average MAPE of ~2% ($R^2 \approx 94\%$) on unseen data. This study underscores the potential of ML in enhancing LPBF quality assurance through data-driven powder characterization and process optimization.

Poster 11: Thermal cycling of laser powder bed fusion tooling steels used for high pressure die casting

Jorge Luis Dorantes Flores[1], Benjamin Orchard[2], Christopher Paul[3], Sevda Fatiphour[1], Robert Mackay[4], Glenn Byczynski[4], Michael Benoit[2], Abdallah Elsayed[1]
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High-Pressure Die Casting (HPDC) is a common manufacturing process for nonferrous alloys, enabling high-volume production of complex components through the rapid injection of molten metal into reusable dies under extreme temperatures and pressures. However, cyclic thermal stresses during repeated casting cycles lead to die degradation, primarily through thermal fatigue-induced heat checking, soldering, and corrosive dissolution. The heat checking manifests as surface cracks that propagate over time, compromising product quality, productivity, and cost efficiency due to frequent die replacements. Additive manufacturing (AM) has emerged as a transformative solution to fabricate dies with embedded complex cooling channels for HPDC. This design flexibility enables enhanced thermal management during casting cycles, directly addressing a key limitation of conventional die manufacturing. However, in-service failures such as heat checking can still occur, resulting in high operating costs for manufacturers. The M300 steel is used for Die Casting tooling for its well-known wear resistance. However, after certain thermal cycles, the heat checking creates cracks that propagate through the surface. This research will simulate real world thermal cycling conditions in M300 steel to analyze the progressive mechanical properties degradation, which leads the tooling to failure and results in high cost production. The samples were repeatedly heated to 700°C and cooled to room temperature for over 5,000 cycles. The degradation will be analyzed through each thousand cycles, examining the mechanisms for heat checking. As a result, the laser powder bed fusion parameters will be optimized to increase the thermal cycling resistance.

Poster 12: Phased array ultrasonic testing: A novel approach for QR code detection in AM

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The advancement of additive manufacturing (AM) processes necessitates robust traceability and security measures. Embedding unique identification features, such as quick response (QR) codes, in AM components is vital for logistics, certification, and counterfeiting prevention. This paper introduces a novel approach to embedding QR codes within steel blocks (MPIF 4406) using laser powder bed fusion (LPBF) and examines the efficacy of high-frequency phased array ultrasonic testing (PAUT) for reading these codes. QR codes, ranging in size from 30 mm to 15 mm and composed of cubic, cylindrical, and spherical features, are embedded in steel AM blocks. While cubic and cylindrical QR codes are easily readable by PAUT, spherical codes present more challenges. Image processing techniques, including Histogram of Oriented Gradients (HOG) and ResNet-50, are employed to enhance and analyze the captured ultrasonic images, yielding similarity scores between 70% and 85%. The study also investigates the impact of printing orientation, revealing that vertically printed QR codes exhibit better readability than horizontally printed ones. Additionally, an obfuscated QR code, created by randomly distributing features across multiple planes, achieved similarity scores of 66.70% with transfer learning and 69.60% with HOG, despite being unreadable by mobile devices. The results highlight PAUT's potential as a rapid scanning solution for embedded QR codes in metal AM components, enhancing traceability and security in AM processes.

Poster 13: Type II residual stress distribution in laser powder bed fusion: A combinatorial analysis in 316L stainless steel

Tianyi Lyu, Renfei Feng, Changjun Cheng, Yu Zou
University of Toronto, Canada

Residual stress is an inevitable and often detrimental feature in additively manufactured metals in the as-built condition. To date, the macroscopic Type I and the atomistic Type III residual stress have been studied thoroughly, whereas the Type II residual stress, which acts at granular scale, receives little attention. Type II residual stress is known for its role in fatigue performance of the materials and could possibly be optimized through the parametric freedom of metal additive manufacturing. In this work, we combine several characterization techniques, most notably, Laue diffraction mapping, to probe the intra- and intergranular residual stress in 316L stainless steel made from by laser powder bed fusion. It is found that Type-II residual stress possesses dependencies on grain orientation and grain size, which are caused by the strong thermal gradients during laser fabrication. This study explores an unchartered material feature in metal additive manufacturing through the power of X-ray scattering, laying foundation for a future optimization task.

Poster 14: Remelting-based microstructure engineering in laser powder bed fusion: A case study in 316L stainless steel

Tianyi Lyu, Yu Zou
University of Toronto, Canada

In laser powder bed fusion (LPBF), the formation of bulky columnar grains often results in undesirable mechanical anisotropy. Here, we demonstrate a new strategy to control the microstructure in LPBF through tuning melt pool overlaps without changing energy densities and scan patterns. Using 316L stainless steel as an example, we generate a wide range of grain sizes and morphologies. The underlying mechanism is associated with the retainment or elimination of newly nucleated grains at a melt pool during the formation of subsequent melt pools. The propensity of retainment or elimination of grains is largely dependent on the extent of melt pool overlaps because the grains are prone to nucleate at the free-surfaces of melt pool boundaries. This facile strategy could be applicable to a wide range of metallic alloys, paving a new way for microstructure engineering in additive manufacturing.

Poster 15: Defects analysis in LPBF printing based on up-skin and down-skin angles using machine learning

Zohreh Azimifar[1], Ali Razani[2], Sagar Patel[3], Martine McGregor[3], Mihaela Vlasea[3]
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In laser powder bed fusion (LPBF) additive manufacturing, geometric features of parts have a significant impact on their printability and quality. Special attention in the literature has been given to the characteristic feature of distinction between up-skin and down-skin surface properties, where up-skin and down-skin surfaces have different orientation angles with respect to the build plate during part fabrication. By exploiting cutting-edge machine learning and deep learning algorithms, we thoroughly investigate and classify defects or voids in 3D printed components, focusing on latticed architectures, by whether they are up-skin or down-skin related. The research will utilize a dataset achieved by X-ray CT scanning of LPBF-manufactured Ti64 parts and 3D lattice structures with segmented regions of the top and bottom skins. This will allow a full investigation of defect geometries within the context of their surface normal direction. Lattice architectures with strut-based and surface-based features with a cell size of 2 mm and strut/wall thickness between 0.25-0.55 mm were utilized in this study. Machine learning and deep learning techniques such as YOLO, U-Net, and R-CNN have significantly contributed to the precision and effectiveness of defect and pore detection and classification in 3D-printed components. Outcomes are expected to enhance the defect formation mechanism knowledge and allow optimization of print and design parameters toward improved quality and reliability of key application 3D printed parts.

Poster 16: Root cause analysis of defect formation and parameter optimization for W electron beam powder bed fusion

Ali Mohammadnejad, Manyou Sun, Ehsan Toyserkani
University of Waterloo, Canada

While W and its alloys, due to their high-temperature stability and strength, have gained attention for their high melting points and strength, their brittleness and sensitivity to oxygen impose critical challenges on the production, further limiting their widespread applications. Meanwhile, additive manufacturing provided the possibility of fabricating near-net shape W parts with full control over the microstructure and chemistry of the parts. However, the printed parts have been found to be defective, with their elimination still being a challenge. In this work, various modes of defects in electron beam powder bed fusion (EBPBF) of W are explored and their root mechanism are investigated. Besides, the process window for the production of defect-free W parts is studied, with the optimum sample showing no sign of cracks and a relative density of 99.98%. Results of microstructural, using optical and electron microscopy images, and mechanical, employing Vickers hardness, analysis of the samples indicate samples with ultra coarse columnar grains and a maximum hardness of 420HV. The correlation between processing parameters and the print characteristics is further discussed.

Poster 17: Integrated HIP and heat treatment for microstructural tailoring of TiAl alloys processed by EB-PBF

Ali Rezaei[1], Mohsen K.Keshavarz[1], Andrew Cassese[2], Chad Beamer[2], Mahdi Habibnejad-Korayem[3], Paria Karimi[4], Esmaeil Sadeghi[4], Mihaela Vlasea[1]
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Titanium aluminide (TiAl)-based alloys are increasingly used in aerospace and automotive applications owing to their exceptional specific strength at elevated temperatures and weight reduction benefits, thus improving fuel efficiency in engines. Among additive manufacturing (AM) methods, electron beam powder bed fusion (EB-PBF) has proven effective for processing TiAl. However, EB-PBF parts often exhibit microstructural heterogeneity caused by varying process parameters and thermal histories, impacting high-temperature performance. Achieving application-specific microstructures, such as a duplex structure for high ductility and fatigue life or a fully lamellar structure for superior creep resistance, typically requires multi-step heat treatments

(HT) following hot isostatic pressing (HIP). In this study, we developed a novel single-step HIP/HT process for Ti-48Al-2Cr-2Nb alloy by employing controlled cooling regimes (100 K/min to furnace cooling) immediately after HIP to directly achieve fully equiaxed and duplex microstructure. This integrated approach eliminates additional HT steps, significantly reducing processing time and cost while maintaining tailored microstructural properties. The proposed method not only improves manufacturing efficiency but also enhances the industrial viability of TiAl components for high-performance applications, thereby advancing the adoption of additive manufacturing technologies.

Poster 18: Tensile and fatigue properties of Ti alloys made by additive manufacturing

Yu Zou
University of Toronto, Canada

This presentation will focus on the microstructure and multiscale mechanical behaviours of a laser directed energy deposition (LDED) produced Ti-6Al-2Zr-Mo-V alloy, with the aid of high-throughput nanoindentation mapping, in situ microscale tension, and macroscale fatigue tests. Firstly, the hardness (H) and modulus (E) of the α and β phases in both as-deposited and heat-treated titanium samples are measured, and the strong dependences of the chemical composition, crystal orientation, and nanoindentation depth on the measured H and E values are discussed. Secondly, the tensile deformation behaviours of the as-deposited and heat-treated samples are characterized, and two types of deformation behaviours, slip banding and microscale shear banding, are observed in soft and hard α grains, respectively. Microscale shear banding is, for the first time, observed and being demonstrated as a beneficial behaviour to enhance the tensile ductility of the LDED-produced titanium alloys. Lastly, the fatigue crack growth behaviours of the as-deposited and heat-treated samples are also studied.

Poster 19: Directed energy deposition of heterostructured steels for tailored mechanical properties

Xiao Shang, Yu Zou
University of Toronto, Canada

Heterostructured materials (HMs) have drawn large attention due to their potentials to show superior properties that are unattainable by their homogenous counterparts. Recent developments of additive manufacturing (AM), particularly directed energy deposition (DED) have facilitated the fabrication of HMs, thanks to DED's capability of arranging material compositions and microstructure locally. In this work, we investigate how one can leverage DED to program the mechanical properties of heterostructured bi-material steels. Samples with various materials arrangement designs are first fabricated and tested to compare their tensile properties. The parameters for the design with the best tensile performance are then varied to show how their strength and elongation-to-break can be programmed. Further, we analyse the deformation of such bi-material heterostructured steel and provide insight into the mechanism for the variation in their tensile property. This study offers new opportunities in the understanding and optimizing the mechanical properties of steels via the HM approach.

Poster 20: The influence of elevated Fe and Zn impurities on the rapid solidification behaviour of AA6061 processed using single track laser surface melt trials

Janelle Faul
University of Waterloo, Canada

Increased adoption of recycled aluminum (Al) alloys in the automotive sector can provide several economic and environmental benefits through vehicle lightweighting, decreased fuel consumption, and reduction in greenhouse gas emissions. A major challenge in the adoption of secondary Al for a broader range of products is the accumulation of impurity elements, as increased scrap use can result in the compositional drift of alloy streams, leading to degraded mechanical and electrochemical properties. The objective of the current study is to demonstrate the use of rapid solidification processing (RSP) to increase the potential adoption of recycled Al through the formation of non-equilibrium and metastable phases, refinement of microstructural features, and increased solubility of certain elements. Cast ingots of an Al alloy 6061 (AA6061) were produced with iron (Fe) and zinc (Zn) addition in amounts ranging from 0 to 1 wt% to simulate recycling impurities. Thermodynamic simulations were used to predict the crack susceptibility of each alloy composition. Laser surface melting (LSM) trials were performed on plates cut from each ingot to generate rapidly solidified microstructures. The simulation predictions and microstructure results suggest that alloy impurity composition does have an influence on the cracking behaviour observed in the resolidified melt pools, with Fe addition having a positive effect on the observed cracking behaviour, while Zn tended to increase the crack susceptibility, regardless of Fe content. The results suggest that the adoption of RSP techniques like additive manufacturing can optimize impurity control in recycled Al alloys, advancing its use for automotive applications.

Poster 21: Dissimilar resistance spot weld of Ni-coated Al to Ni-coated Mg using cold spray coating technology

Mazin Jassim Oheil, Adrian Gerlich, Hamid Jahed
University of Waterloo, Canada

Direct fusion welding of Al to Mg creates brittle intermetallics that restrict the application of these joints in structural applications. An interlayer foil can be employed to prevent intermetallic formation allowing successful resistance spot weld joint. However, the presence of a foil increases the part count, and is difficult to place during welding. Cold spray coating is a promising solid-state coating deposition technology used here to provide an enhanced interface to facilitate joining Al to Mg sheets by means of resistance spot welding. The ability of cold spray coating technology to deposit an intermediate layers on a substrate surface using powder material is shown to be beneficial in restricting the formation of the brittle intermetallic between Al and Mg. In this study, Ni powder has been successfully coated onto Al and Mg sheets. The Ni-coated coupons were then welded via resistance spot welding using optimized welding parameters. Successful welds were produced using 27 kA for 15 cycles in 2 pulses with 5 delay cycles between pulses. Metallurgical bonding between the Al, Mg, and Ni coating in the fusion zone were revealed by using scanning electron microscopy. It is shown that the bonding between the three elements inhibits the Al-Mg IMC and restricts formation of deleterious intermetallics

Poster 22: XRD analysis to map damage in AA6061-T6 for cold spray additive remanufacturing

Sepehr Ghazimorady, Hamid Jahed
Fatigue & Stress Analysis Laboratory, Department of Mechanical & Mechatronics Engineering, University of Waterloo, Canada

Cold spray is an advanced additive manufacturing technique that is capable of the restoration of damaged metallic components without exposing them to high temperatures. To expand the use of cold spray from restoring the geometry and structure of defective parts to full remanufacturing, extending their lifespan beyond the original life cycle by replacing internally damaged areas (typically only 10–15% of the part's volume), the first step is to accurately identify the location of damage. It is necessary to use a non-destructive testing (NDT) method to identify the extent of damage because the goal is to return the remanufactured component to its service life. This study explores the capabilities of X-ray diffraction (XRD) as an NDT method for assessing damage in AA6061-T6. A set of dog-bone samples made from AA6061-T6 was prepared to introduce controlled damage at different levels. XRD measurements were conducted on these damaged samples to generate test data, which then is analyzed using two different approaches. The first approach involves calculating the dislocation densities from the XRD results, which provides quantified measures of internal damages. The second approach applies machine learning techniques to establish correlations between XRD results and the extent of damage. By using these methods, this study aims to develop a reliable method for pre-remanufacturing damage assessment. In corroboration with earlier studies, we show that XRD can effectively detect internal material damage using dislocation densities through XRD-measured parameters such as FWHM (Full Width at Half Maxima, a measure of XRD peak broadening used for analyzing dislocation and strain). Integrating XRD-based damage assessment with cold spray additive manufacturing can enable precise and localized repairs. By implementing cold spray remanufacturing, this method can significantly reduce greenhouse gas emissions, lower material waste, and extend components' lifespans across various industries.

Poster 23: Assessing the impact of binder saturation on print quality of binder jetted green samples of regular and irregular morphologies

Alexandra D Darroch, Edward Yang, Mihaela Vlasea
University of Waterloo, Canada

A pivotal process parameter in binder jetting additive manufacturing (BJAM) is binder saturation, defined as the volumetric ratio of binder deposited to voids within the powder bed. Improperly tailored binder saturation may cause printing issues such as binder overspread, increased surface roughness, and layer delamination. These existing issues may be further exacerbated with the use of irregular morphological powders, which have a higher degree of interparticle friction and therefore tend to form powder beds with larger pores. This then slows down binder imbibition into the bed. This research will examine the effect of varying binder saturation on both regular and irregular powder morphologies and the resulting green part qualities using C18150 copper powder. Metrics used to assess quality include dimensional and geometric accuracy, which will be evaluated using image processing techniques to compare designed and actual feature sizes of fine through holes and horizontal slots. Mechanical strength of green parts will be tested using the three point bending test (ASTM B312) and standardized coupons, while green density will be evaluated with a precision balance and calipers on cubic samples.

Poster 24: Design and evaluation of additively manufactured, surface-conforming spinal reconstruction implants

Richard Barina, Stewart McLachlin
University of Waterloo, Canada

Spinal implant surface conformance with the underlying bone is often critical to the long-term success of spinal surgeries; however, most spinal implants have a limited ability to match the organic surface profile of the vertebral endplate. To address this challenge, this study aimed to: (1) design a novel spinal implant to match a non-uniform vertebral endplate, and (2) evaluate the surface conformance of additively manufactured lumbar intervertebral cages based on bone contact area and pressure distribution. First, an extreme lumbar interbody fusion (XLIF) device with articulating and expanding endplates was designed for additive manufacturing. Subsequently, two mock commercially available XLIF implants, two latticed implants, and two conforming implants were manufactured using SLA in resin with mechanical properties similar to polyether ether ketone (PEEK). Mechanical testing occurred on three sets of polyurethane Sawbones® machined to simulate a non-uniform vertebral endplate bone. Contact area and pressure distribution were measured using the Tekscan thin film sensor under physiologic lumbar waveforms from the Orthoload Database applied via an AMTI VIVO system. Conventional implants had a surface coverage of 30 to 50%, 4° settling motion, and peak pressure of 5-10MPa, whereas the adjustable surface conforming implants and the gyroid latticed anatomically shaped implant had 55 to 65% surface coverage, 0.5° settling motion, and 4 to 6MPa of peak pressure. These results are consistent with previous studies which found that matching the implant to the vertebral endplate surface reduces risks of implant subsidence. One limitations of this study is the use of Sawbones instead of human vertebrae. In conclusion, this study provides preliminary support for the novel additively manufactured, surface conforming implant design. Future work should look to test the design in alternate metal materials and under fatigue loading conditions.

Poster 25: Print fidelity of microstructures within dense nanocomposite structures printed using mandrel bed direct ink writing.

Haresh Patil, Dibakar Mondal, Thomas L. Willett
University of Waterloo, Canada

Print fidelity significantly contributes to print quality and overall mechanical properties of direct ink writing (DIW) printed structures. Print fidelity evaluation methods discussed in the DIW literature for porous structures are not effective for dense structures. A novel print fidelity evaluation method using interface analysis in DIW printed microstructures is presented in this study. We hypothesized that DIW of UV curable biopolymer nanocomposites would reveal distinct interfaces between the surfaces of deposited rasters and that fidelity of the printed structure could be evaluated using these interfaces. Herein, a biopolymer nanocomposite was prepared by dispersing heat-treated nano hydroxyapatite particles into a functionalized biopolymer matrix prepared by mixing acrylated epoxidized soybean oil, polyethylene glycol diacrylate, and tri-glycerol diacrylate. Dense microstructures were printed in two configurations, namely Crisscross (layers at ±45°) and Bouligand (layers with 15° increment) using a custom mandrel bed DIW printer. Scanning electron microscopy (SEM) images were collected at transverse cross-sections of microstructures and interfaces were located in the SEM images using a 'Fiji ImageJ' segmentation plug-in. Print fidelity was evaluated by measuring variations in raster area between the printed microstructure and the computer aided design (CAD) model of the intended microstructures. SEM images revealed distinctly oriented rasters within the microstructures, which confirmed the hypotheses. The morphologies differed between the printed microstructures and the microstructures in the CAD model. A reduction in print fidelity at incremental print layers was observed in Bouligand microstructure due to change in helix angle at each deposition layer. No significant print fidelity variations were measured in print layers of the Crisscross microstructure. The poor print fidelity may have resulted from inadequate shape holding of the nanocomposites during rotating mandrel bed DIW. This method can be used universally to evaluate print quality of dense structures printed using DIW and UV curable feedstock.

Poster 26: Sustainable additive manufacturing: Evaluating the mechanical and thermal degradation of recycled PEKK

Farshad Malekpour, Mehdi Hojjati
Concordia University, Canada

Space exploration is not possible without sustainable provisions, where in such harsh environments every earth-made material will count as an asset. Polyetherketoneketone (PEKK) is a high-performance thermoplastic with significant potential for additive manufacturing (AM), particularly in aerospace and space applications where material reuse is crucial for sustainability. This study investigates the mechanical degradation of PEKK through multiple recycling cycles using fused deposition modeling (FDM). Initially, the neat filament was evaluated for crystallization behavior, viscosity, and thermal stability using differential scanning calorimetry (DSC), rheometer, and thermogravimetric analysis (TGA) before undergoing subsequent FDM printing and mechanical re-evaluation. The amorphous PEKK filament was used to 3D-print tensile and bending specimens. After the first cycle of mechanical assessment, the tested parts were systematically shredded and categorized based on prior heat treatment conditions. A twin-screw extruder was employed to remanufacture recycled PEKK filament, with a preliminary step of particle size reduction (<0.5 mm) using a lab-scale pulverization machine to ensure consistent feedstock quality. This work provides insights into the recyclability of PEKK, analyzing its structural integrity and performance degradation across multiple reuse cycles. The findings contribute to advancing sustainable AM practices, particularly for in-situ resource utilization in space and aerospace applications.

Poster 27: Adaptive aerodynamics via tunable flexure hinge mechanisms

Andrea Roman[1], Enrique Cuan-Urquizo[2,3], Armando Roman-Flores[2]
[1]University of Ottawa, Canada. [2]Tecnologico de Monterrey, Mexico. [3]Insitute of Advanced Materials for Sustainable Manufacturing, Mexico

In this study, we dive into how a flexure hinge mechanism allows controlled morphing for enhanced aerodynamic performance. By focusing on a tunable range of motion, reinforcing downforce and breaking effects, all of which is imperative for applications such as vehicles and adaptive control surfaces. Different from rigid mechanical systems, this flexural hinge behaves as an adaptable mechanism, allowing for a seamless deformation without compromising structural integrity. The design features the ability to fine tune the hinge's flexibility by adjusting parameters like thickness, curvature, and material composition. This tunability is comparable to metamaterials and cellular structures, where a desirable mechanical response is obtained through geometrical configuration rather than material properties alone. Resulting in a scalable, lightweight mechanism that serves as an energy-efficient alternative to traditional triggered morphing systems. Through experimental and physical testing, we demonstrate the hinges' aerodynamic adaptability under varying load testing conditions.
Testing confirmed a controlled deformation was achieved without compromising the structural stability. Additionally, computational simulation was done to validate its ability to improve aerodynamic performance across different fields, including wind turbines, parachutes, and aircraft wings. Overall, this research highlights the importance of adaptable flexure hinge mechanisms allowing for customizable solutions across many aerodynamic applications.

Poster 28: Piezo-pneumatic jetting of highly viscous soldering paste

Rahele Jafari, Ehsan Marzbanrad, Ehsan Toyserkani
University of Waterloo, Canada

Soldering is a key process in advanced packaging for electronics and high-temperature sensors. The growing demand in these industries calls for a more automated, standardized soldering process with increased throughput and tighter tolerance levels. High-speed piezo-pneumatic jetting (PPJ) of high-viscosity soldering paste has emerged as a promising technique in additive manufacturing for precise material deposition. Previous research on PPJ of single component soldering pastes has reported a wide viscosity range from 50 to 100,000 mPa·s. In this study, a multi-component soldering paste was developed, consisting of a shear-thinning alcoholic liquid with a high thixotropic index, mixed with varied solid content ranging from 35 wt.% to 90 wt.%. The piezoelectric-driven jetting process induces shear forces that allow the controlled ejection of highly viscous materials onto a substrate, following the drop-on-demand (DOD) principle. Silver and zinc metallic particles were selected for this research due to their ability to form a sintered structure with an elevated melting point, making them suitable for high-temperature applications. To evaluate the jetting performance, micro-droplets were generated and characterized based on their size and uniformity. The results demonstrated that the optimized paste composition and jetting parameters significantly influence the droplet formation, ensuring reliable and repeatable deposition. Additionally, the study highlights the impact of shear-induced viscosity reduction on jetting stability and deposition accuracy. The findings indicate that PPJ is a viable technique for precise deposition of multi-component soldering pastes with potential applications in advanced electronic packaging and high-temperature sensor manufacturing.

Poster 29: Optiworks: A multifunctional high-resolution topology optimization software

Chinedu Ifediorah, Alex Inoma, Osezua Ibhadode
University of Alberta, Canada

The growing demand for lightweight, high-performance structures has accelerated the adoption of additive manufacturing (AM) over traditional methods. Topology optimization plays a crucial role in designing these complex structures by optimizing material distribution within a defined domain to minimize or maximize a predefined cost function while adhering to specific constraints. Despite significant advancements in topology optimization, many existing tools focus on isolated aspects, such as domain initialization, usability, or specific constraints, often resulting in fragmented resources, limited integration, and workflow inefficiencies. This work presents Optiworks, a high-resolution topology optimization (and lattice structure) software designed to streamline the entire optimization process, from domain definition to exporting the final optimized structure. Optiworks supports both imported mesh and parametrically defined cuboidal domains and offers a comprehensive suite of functionalities, including stiffness and heat transfer maximization, functionally graded porous structures with isotropic and anisotropic filters, self-supporting topologies via an AM filter, displacement and temperature constraints, and robust formulations to address manufacturing uncertainties. Additional capabilities include symmetry enforcement for computational resource control, static and thermal analysis of pre- and post-optimized structures, and smooth boundary generation even with relatively coarse meshes. By eliminating the need for additional post-process smoothing, Optiworks enables users to export optimized designs directly as mesh files for immediate 3D printing. The topology optimization functionalities described represent only one part of the broader Optiworks framework, which also integrates lattice structure optimization; however, this work focuses specifically on topology optimization. The framework's effectiveness is demonstrated through case studies, including the aircraft bracket and femur bone designs for structural compliance, showcasing porous structures, AM constraints, and displacement constraints, as well as heat sink designs for thermal compliance, highlighting temperature constraints and robust formulations.

Poster 30: Nanoscale characterization of surface oxides on gas-atomized AA6061 powder using HRTEM

René D Pütz[1], Zhiqiang Wang[1], Bahareh Marzbanrad[2], Hamid Jahed[2], Yolanda Hedberg[1,3]
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Atomization from the melt is a well-established method for producing metal powders used in conventional powder metallurgy (PM) processes and metal additive manufacturing (MAM). A critical aspect of these powders is the surface oxide layer that develops during atomization, as its properties, such as thickness, composition, inclusions, and structure, can significantly affect particle bonding and defect formation in MAM, ultimately influencing material performance, including corrosion resistance. The surface oxide properties also influence the storage abilities and reusability of the powder. This issue is particularly pronounced in aluminum alloy powders produced by gas atomization under inert gas conditions. The surface oxides in such powders can contain a notable volume fraction of minor elements with high oxygen affinity, which often segregate to the surface as oxide particles or islands. In some cases, such as cold spray additive manufacturing, pre-consolidation reduction heat treatments are required to enhance ductility, facilitating powder deformation and promoting effective oxide layer disruption for improved particle bonding or limit inclusions' formation during MAM. In this study, we examined gas-atomized AA6061 alloy powders with an average particle size of 20 µm in their as-atomized state. The surface oxides were analyzed using high-resolution transmission electron microscopy after being focused ion beam cut to determine their thickness, elemental distribution, and nanoscale structural features. The results revealed significant magnesium enrichment at the surface and nanosized inclusions with defined crystalline structures embedded within essentially amorphous oxide regions. These findings could provide valuable insights into the role of surface oxides in influencing corrosion behavior and fusion quality during MAM of AA6061.

Poster 31: Airborne ultrasound sensing of packing fraction of powder bed in binder jetting

Alexander Martinez-Marchese[1], Chen Qian[1], Tomás Gómez Álvarez-Arenas[2], Chinedum Okwudire[1]
[1]University of Michigan, USA. [2]Institute of Physical and Information Technologies, CSIC, Spain

Binder jetting is a promising technology that enables the fabrication of intricate and custom parts for a relatively low cost compared to other additive manufacturing technologies. However some challenges in the deployment of this technology remain, for example, differences in packing fraction between layers when printing, which might cause print failure. In this work we investigate the possibility of locally measuring the packing fraction using airborne ultrasound. This is possible due to the difference in amplitude of the returned signal which can be related to the acoustic impedance of the powder, which can also be related to packing fraction. For various types of transducers it was possible to relate the returned signal intensity with the measured packing density in a custom powder packing rig.

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