SCHOOL OF ENGINEERING

TRINITY COLLEGE DUBLIN

INAUGURAL RESEARCH DAY

APR 25TH, 2024

MUSEUM BUILDING

ORGANISERS

Prof Michael Monaghan- Director of Research SoE

Jay Cui

Teresa Ruibin Capuz Lladró

Sarah O'Brien

Prof Bidisha Ghosh

Dr Mary Kerrigan

Dr Neelam Yadav

Phil Lynch

Patricia Huges

INTRODUCTION

Welcome to the inaugural PhD Researcher Day of the School of Engineering, a celebration of innovation, exploration, and the pursuit of knowledge in the field of engineering. We are delighted to present this schedule, a compendium of the remarkable research undertaken by our talented PG researchers in the School.

During this day, you will see a snapshot of the diverse and cutting-edge research that defines our School of Engineering. We also introduce the mechanisms in which researchers can leverage their skills for future funding or progressing into new career pathways. Our researchers have dedicated countless hours to complex problems, developing novel solutions, and pushing the boundaries of what is possible in the world of engineering.

We are one of the largest Schools in Trinity College Dublin, a research intensive university and Ireland's premier University. Research staff are a critical asset to our efforts and this day is dedicated the efforts of the 80+ individuals who make up research staff. Their work not only contributes to the academic excellence of our School but also holds the promise of transforming industries, improving lives, and making a positive impact on society for a sustainable future.

We thank the researchers who have agreed to share their work, to their mentors, advisors and supervisors who have guided them on their intellectual journey, and to the faculty and professional staff who support and facilitate research.

We encourage all to engage with the research, to foster dialogue, and to seek opportunities for collaboration and innovation. Together, we can address the challenges of today and shape a more sustainable tomorrow.

We hope that the research showcased here inspires you as much as it has inspired us.

Prof Michael Monaghan

Director of Research

School of Engineering

SCHOOL OF ENGINEERING

The School of Engineering owes its establishment to the leadership of Humphrey Lloyd, with valuable support from mathematicians James McCullagh and Thomas Luby. This pivotal moment in the history of Trinity College occurred on June 15, 1841, when the Board publicly announced their intention to create a School of Civil Engineering and sought to appoint two Professors. As part of the application process, students interested in the two-year civil engineering course had to have successfully completed the Junior Freshman year of the Arts program at the university.

Engineering lectures commenced on November 16, 1841, with Humphrey Lloyd delivering a *praelection* the day before to mark the official opening of the School. In his address, Lloyd articulated the significance of teaching engineering within a university context. He emphasized the opportunities provided by the University for students' education and professional development. He underscored the transformation of engineering from a field primarily concerned with engines to one that had risen to the forefront of the liberal professions. With extensive public projects underway, the responsibilities of engineers were numerous and substantial, demanding a wide-ranging and comprehensive knowledge.

Lloyd encouraged students to take full advantage of the educational opportunities presented to them, to be diligent in their studies, take comprehensive notes during lectures, and combine the knowledge they acquired with their personal reading. He emphasized that students had ample motivation to excel in their studies, as the path towards becoming a professional engineer was fascinating and appealing. The subsequent career in engineering offered an opportunity to serve their country with distinction, earn a respectable livelihood, and attain an honourable reputation. He concluded by extolling the virtues of the engineering profession, encouraging students to pursue its study, and offered insights that remain relevant today.

Throughout its history, the strategic mission of the School of Engineering has consistently centred on the pursuit of excellence in both teaching and research in engineering. The primary goal has been to produce graduate engineers with the capability for independent and creative problem solving, analytical thinking, and innovative design. This unwavering commitment to nurturing skilled and forward-thinking engineers remains the school's enduring mission.

Cox Ron, '1841-2016: A Brief History of Engineering at Trinity', 2016, School of Engineering. TCD.

Cox Ron, 'Engineering at Trinity', 1993, School of Engineering. TCD.

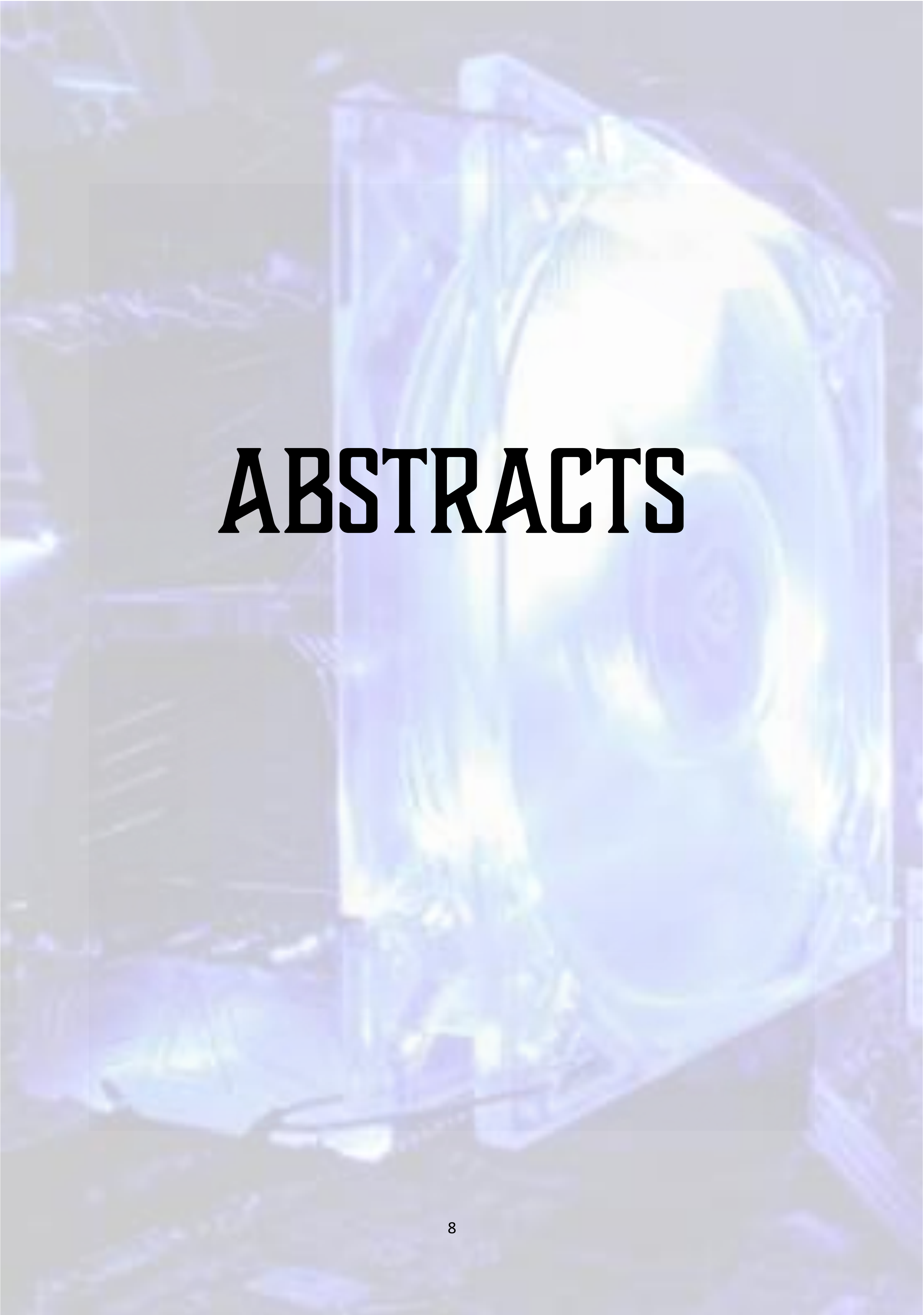
AGENDA

9:15	Arrivals	
9:30	*Opening Address*	Professor Alan O'Connor PhD, FTCD, CEng FIEI. Head of School of Engineering
9:40	*Research in SoE*	Prof Michael Monaghan, Director of Research
10:00	*Researcher Presentations*	12 + 3 minutes for Q&A
10:00	***Exploring the Mechanism of Flame Flashback for Laminar Jet Premixed Hydrogen-air Flames*** Syed Ali / Mechanical, Manufacturing, & Biomedical Engineering	
10:15	***Challenges and Prospects for Better Integration Between Policy and Practice for Disaster Risk Reduction in India, Case of Mizoram*** Rahul, Aditya / Civil, Structural, & Environmental Engineering	
10:30	***RIS-Assisted OTFS Communications: Phase Configuration via Received Energy Maximization*** Mohamad Hejazi Dinan / Electronic & Electrical Engineering	
10:45	***Feature Size Dependent Manufacturability Influences the Functional Properties of Additively Manufactured Ti-6Al-4V Micro-strut Lattices*** Conor O'Keeffe / Mechanical, Manufacturing, & Biomedical Engineering	
11:00	Coffee Break in the Drawing Office	
11:30	Researcher Presentations	12 + 3 minutes for Q&A
11:30	***EMERALD: Energy efficiency in AI Tools for Post Production Workflows*** Hareesh Veekanchery / Electronic & Electrical Engineering	
10:30	***Growth Factor Patterning into Fusing Microtissues: 3D Bioprinting of Spatiotemporal Cues for Cell Spheroid and Organoid Based Tissue Engineering***	

	Josephine Wu / Mechanical, Manufacturing, & Biomedical Engineering		
12:15	***School Postdoctoral Academy Launch*** Dr. Neelam Yadav		
12:30	Lunch and Poster Presentations in the Drawing Office		
14:00	***Research Grant Opportunities***	Dr Mary Kerrigan, Research Project Officer Schools of Engineering and Natural Sciences	
14:30	Industry Opportunities and Engagement		
14:30-15:10	Dr. Chris Keely & Dr. Jurgen Osing	Business Development Manager Trinity Innovation	***How researchers can connect with industry***
15:10-15:25	Dr. Joanne Conroy	Consultancy Development Manager Consult Trinity	***How researchers can connect with organizations via consultancy projects***
15:25-15:50	Prof. Anil Kokaram	Head of Dept. of Electronic & Electrical Engineering	***The success story behind Spin out company "Green Parrot Pictures"***
15:50-16:00	Sarah O'Brien	Industry Liaison Officer School office, School of Engineering	***Further information on research and industry collaborations***
16:00	***Equality, Diversity and Inclusion in Research and Innovation*** Professor Bidisha Ghosh		
16:15	***Career Panel Discussion*** Moderator- Michael Monaghan Panelists: Prof Sarah McCormack – Civil Engineering Friedrich Wetterling- Electronic Engineering Laurence Gill- Civil Engineering		
17:15	Closing Address followed by reception in foyer		

LIST OF POSTERS:

Name	Discipline	Title
Thomas Grey	CSEE	*Testing an approach to identify common housing hazards affecting older people in Ireland and to support the integrated care for older persons programme*
Sara Corbezzolo	MMBE	*Melt electrowriting of synclastically curved patches compensating the mechanical anisotropy of the infarcted myocardium*
Ruhhee Tabbussum	CSEE	*Neural Network Driven Early Warning System for Groundwater Flooding: A Comprehensive Approach in Lowland Karst Areas*
Robert Johnston	MMBE	*Design, computational and experimental evaluation, and 3d printing of patient specific tents for the treatment of paediatric aortic coarctation*
Neelam Yadav	EEE	*Giant Permittivity and Superparaelectricity in phenyl pyrimidine based liquid crystal*
Majid Akbarzadeh Khorshidi	MMBE	*Using finite element analysis to better understand penile tissue biomechanics*
Jennifer O'Donoghue	CSEE	*Residential long-term care, Covid-19 and architecture and design of the built environment*
Irina Munina	MMBE	*Enhanced antenna design using additive manufacturing*
Ekaterina Koroteeva	MMBE	*Multi-Wavelength Pulsed LED System for High Dynamic Range Flow Velocimetry*
Annalisa Rovinelli	MMBE	*Fluorescence lifetime imaging microscopy unveiling the metabolic demands of hiPSCs-derived chamber specific cardiac organoids*



ABSTRACTS

RESIDENTIAL LONG-TERM CARE, COVID-19 AND ARCHITECTURE AND DESIGN OF THE BUILT ENVIRONMENT

DESMOND O'NEILL[1], DIMITRA XIDOUS[1], JENNIFER O'DONOGHUE[1], MEHAK PUNTAMBEKAR[1], TOM GREY[1]

[1] Trinity College Dublin

Introduction: The huge death rate in nursing homes during the COVID-19 pandemic raised serious questions as to whether the built environment of nursing homes was a factor in this very high mortality, as well as a factor in quality of life.

Method: We embarked on a wide-ranging study involving a review of Irish policy, stakeholder engagement, Irish case studies, literature review, and international case studies to understand the key issues that influence the planning, design, and operation of nursing home settings, and to identify how these shape care models and the physical environment.

Results: The project generated the following key themes: a) including the voices of residents, family and staff in co-creation of design and research; b) integrating nursing homes with the overall housing spectrum; c) linking nursing homes with ageing in place policy; d) further research on optimal design; e) understanding resident diversity; f) greater inclusion of Universal Design principles; g) designing for resilience; and h) convergence between infection control and quality of life.

Discussion: Our research findings have been developed to identify major current issues related to the built environment and its role in creating a balance between quality of life and COVID-19 infection control in Irish and international nursing home settings. These findings are relevant for a wide range of stakeholders and will be disseminated across a number of channels to continue this conversation and help to continue the evolution of nursing home design.

TESTING AN APPROACH TO IDENTIFY COMMON HOUSING HAZARDS AFFECTING OLDER PEOPLE IN IRELAND AND TO SUPPORT THE INTEGRATED CARE FOR OLDER PERSONS PROGRAMME

TOM GREY[1], JENNIFER O'DONOGHUE[1], DIMITRA XIDOUS[1], SIMON NICOL[2], SEAN KENNELLY[1,3], EMER COVENEY[4] AND DESMOND O'NEILL[1,3]

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2 Building Research Establishment, UK

3 Tallaght University Hospital

4 Age Friendly Ireland

Background

The health and well-being of older people is greatly affected by housing, representing an essential aspect of preventative healthcare in the community. Living in housing which is off good quality is an important factor in a person's ability to maintain good mental and physical health, as well as sustain good quality of life. This is particularly true for older people who may spend more time at home than other demographics. This study explores the linkages between housing conditions and the health and wellbeing of older people with the aim to inform housing designers, providers, and policy makers about the key aspects of healthy homes and common housing hazards, affecting older people.

Method

The research involves an in-depth stakeholder engagement strategy, with activities including focus groups, diaries, and interviews to place the perspectives of older people at the centre of the work. The research also include a series of case study visits to the homes of patients of an Integrated Care Programme for older people, where the research team conducted a series of qualitative semi-structured interviews with the patient, as well as a technical and quantitative survey of the home.

Results

Some of the key themes identified throughout the research programme include overarching themes such as healthy ageing and housing and ageing in place; themes related to the hospital and integrated care, and the local authority; housing conditions and hazards; and built environment issues across the key spatial scales.

Conclusions

There is a need for better, more accessible data on the housing issues, conditions, and hazards throughout Ireland. Additionally, it is essential to consider the needs of patients with additional care requirements, such as those living with dementia, as the built environment greatly impacts them.

ENHANCED ANTENNA DESIGN USING ADDITIVE MANUFACTURING

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INTRODUCTION

Nowadays, increasing data throughput and the rising number of users have led to new requirements for the hardware design for wireless communication networks, particularly antennas. Energy efficiency and low cost are not the only targets for antenna design. They should also provide broadband operation and agile control of the radiation pattern alongside low losses and low side lobes level. Simultaneously satisfying most of these requirements is the driving force for progress in antenna design and fabrication processes.

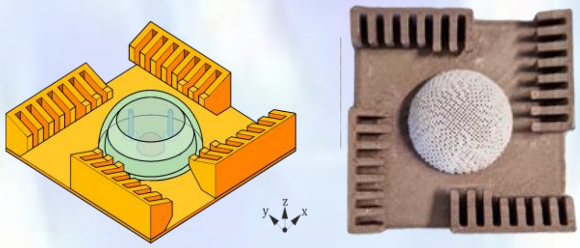
Additive manufacturing, commonly known as 3D printing, is an emerging area in antenna design [1]. With advancements in 3D printing technology, the feasibility of producing antennas using various 3D printing techniques has significantly increased compared to conventional methods. 3D printing offers numerous advantages over traditional manufacturing techniques, such as the ability to create complex and customized geometries with greater precision and at a lower cost. This technology has ushered in new possibilities in antenna design, enabling the fabrication of antennas with unique geometries that were previously challenging to achieve.

MATERIALS AND METHODS

The characterization of electromagnetic parameters of materials for 3D printing is a crucial aspect of antenna design because many materials are not specifically intended for such applications, and their dielectric and conductive properties are often unknown. Various resonant and non-resonant methods can be employed for material characterization. In our work, we utilize a non-resonant method based on microstrip line sections to characterize the dielectric constant and loss tangent of materials. We have developed a specialized methodology for extracting material parameters from measured S-parameters. This technique offers advantages in terms of simplicity and the ability to characterize materials across a wide operational frequency band.

RESULTS

Presented in this work is a novel, fully 3D-printed hemispherical dielectric resonator antenna with metallic walls, specifically designed for wide circular polarization performance within the C-band, targeting applications in future 5G/6G satellite Internet of Things (IoT) mobile terminals [2]. The design integrates multiple techniques to broaden both impedance and axial-ratio bandwidths (Fig. 1). This includes a pioneering use of multi-layer design with varying infill percentages to precisely adjust the dielectric constant of each layer, thereby enhancing impedance bandwidth performance. Furthermore, for the first time, the vertical metallic walls are fully 3D printed and integrated with the ground plane to expand the axial ratio bandwidth. The entire antenna is fabricated via 3D printing, facilitating straightforward adjustments of relative permittivity in different layers using the same material throughout, thus eliminating the possibility of air gaps.



(a) (b)

Figure 1 Inhomogeneous hemispherical DRA with metallic walls: model (a) and 3D printed sample(b).

DISCUSSION

The presented 3D-printed hemispherical Dielectric Resonator Antenna demonstrates the efficacy of additive manufacturing in achieving wide circular polarization performance within the C-band, showcasing the potential for tailored antenna designs in future 5G/6G IoT applications. This innovative approach not only broadens impedance and axial-ratio bandwidths but also underscores the versatility of additive manufacturing in optimizing antenna performance for specific frequency bands and application requirements.

REFERENCES

[1] Munina, Irina, et al. "A review of 3D printed gradient refractive index lens antennas." *IEEE Access* 11 (2023): 8790-8809.
[2] Przepiorowski, Jakub, et al. "Fully 3D-Printed Hemispherical Dielectric Resonator Antenna for C-band Applications." *2023 17th European Conference on Antennas and Propagation (EuCAP)*. IEEE, 2023.

MULTI-WAVELENGTH PULSED LED SYSTEM FOR HIGH DYNAMIC RANGE FLOW VELOCIMETRY

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INTRODUCTION

Particle Image Velocimetry (PIV) technique has become the most common optical method for whole flow field visualization and measurement in a wide range of scientific and engineering applications. There are still specific issues, however, associated with PIV measurements, two of which are addressed in the present work. The first issue is the need to use lasers as a light source, which are bulky, expensive, and require safety measures. The other issue is the limitations of PIV systems in flows with a wide range of velocity scales.

Here, we present a novel approach to PIV measurements aimed at increasing the dynamic velocity range and decreasing the overall cost and energy consumption. The approach includes using the multiple pulse separation (MPS) technique [1] and replacing laser illumination with several high-powered Light Emitting Diode (LED) sources [2] with different wavelengths. Based on that, a multi-wavelength pulsed LED system is constructed and validated on a submerged impinging water jet flow.

MATERIALS AND METHODS

The main components of the LED-based PIV system are red (625 nm), green (530 nm), and blue (460 nm) Luminus CBT-120 LEDs (overdriven mode), 12 V power supply, electronic driving circuits for each LED, cooling fans, collimating optics, and a fiber optic line-light assembly [3]. A Point Grey Grasshopper 3 camera captures a series of double frame images with different pulse separations at a frame rate up to 160 fps. A Microchip ATmega328P microcontroller is used to send TTL (transistor-transistor logic) input signals to the circuits and the camera. To achieve microsecond accuracy in pulse timings, the controller is programmed using direct port manipulation and timer interrupts.

The feasibility of the developed system is tested on a single slot jet impinging perpendicularly onto a flat surface. The flow is seeded with 10 µm silver-coated hollow glass spheres. The obtained velocity profiles are compared against Laser Doppler Velocimetry (LDV) measurements. The 2D LDV system (Dantec) uses a 500 mW Ar-Ion laser generating 488 nm (blue) and 514.5 nm (green) beams and operates in a backscattering mode providing precise non-contact point measurements of two velocity components simultaneously.

RESULTS AND DISCUSSION

The multi-wavelength pulsed LED system is designed (fig. 1), fabricated, and tested. The system is supposed to be a low-cost, compact, safe, yet accurate alternative to the conventional PIV techniques with laser-based illumination. Based on the MPS technique to increase its dynamic velocity range, it can be effectively applied to study flows exhibiting high velocity gradients and a variety of velocity scales (such as impinging jet flows).

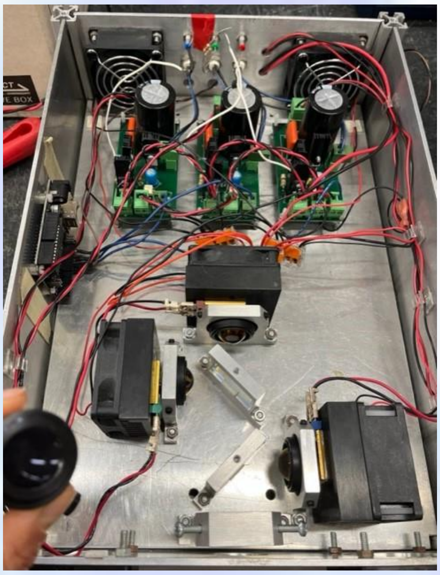

Figure 1 Final design of the illumination system with 3 LED sources.

REFERENCES

[1] Willert C *et al.*, Meas. Sci. Technol., 21: 075402, 2010.
[2] Persoons T, AIAA Journal, 53 (8): 2164-2173, 2014.
[3] Frank F, High Dynamic Range Particle Image Velocimetry using a Pulsed LED System, MAI, Trinity College Dublin, 2018.

CHALLENGES AND PROSPECTS FOR BETTER INTEGRATION BETWEEN POLICY AND PRACTISE IN DISASTER RISK REDUCTION SECTOR IN INDIA: CASE OF MIZORAM

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INTRODUCTION

India is highly vulnerable to natural disasters. According to the global ThinkHazard database, India ranks "High" in almost every natural hazard indicator, including floods (coastal, urban, and river), landslides, cyclones, water scarcity, extreme heat, and wildfire (Thinkhazard, 2022). Climate change is expected to exacerbate these risks and have severe adverse impacts on human development, economic growth, and ecological resources. India was the seventh most climate-affected country in 2019 (Eckstein, 2021).

Indian Himalayan region in particular are much more susceptible to climate change related risks. Ecological resources such as forests are already under stress from rising temperatures and changes in precipitation patterns, which will further increase as average temperatures in India. Indian Himalayas are facing a continuous cycle of extreme heat, landslides, cloudbursts, and flash floods.

This study analyses the challenges and prospects for better integration between policy and practise in disaster risk reduction sector of North East region in India through case of Mizoram state.

Subsequently, disaster finance sector of Mizoram is analysed to identify its shortcomings and contribute in resilient development.

RESULTS

Following gaps and challenges were identified in policy and practise for disaster risk reduction in Mizoram:

Gaps in policy

- Building regulatory framework
  - Inadequate building regulations such as large building footprint, no provision for cutting of slopes and high permissible building heights
  - Absence of floodplain zonation
- Inadequate hazard specific data and vulnerability assessment
  - Inadequate hazard zonation maps
  - Absence of a robust and common system to document historical incidents, patterns, causes, and impacts of disasters.
  - Low granularity of Vulnerability assessment
- Absence of risk-based planning approach
  - Planning is not focussed on resilience building
  - No provision for Disaster risk assessment of Critical infrastructure

Gaps in practise

- Lack of manpower
- Inadequate technical expertise
- Inadequate financial resources

Disaster Finance

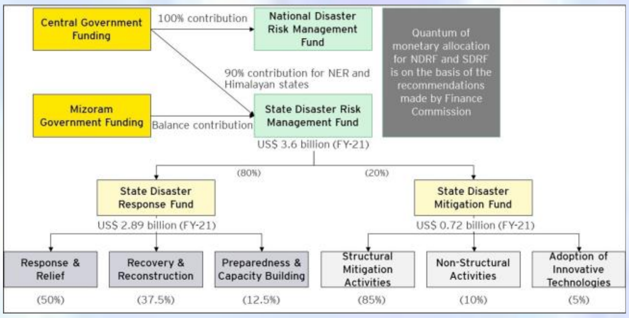

Figure 1: Overview of disaster finance in Mizoram

Gaps in disaster finance sector:

- No formal framework or roadmap to develop a shelf of disaster mitigation projects
- State officers lack capabilities to prepare DPRs to avail international disaster risk financing
- State is not covered under disaster insurance instruments

REFERENCES

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Eckstein, D. (2021). *GLOBAL CLIMATE RISK INDEX.* Germanwatch.

NEURAL NETWORK DRIVEN EARLY WARNING SYSTEM FOR GROUNDWATER FLOODING: A COMPREHENSIVE APPROACH IN LOWLAND KARST AREAS

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ABSTRACT

Enhancing flood prediction is critical given the significant socio-economic consequences of flooding, exacerbated by the projected increase in frequency due to climate change. In this context, artificial intelligence (AI) models have emerged as invaluable assets, offering heightened accuracy and cost-effective solutions to simulate flood processes. This study focuses on developing an early warning system for groundwater flooding in the lowland karst area of south Galway, Ireland, utilizing neural network models with Bayesian regularization and scaled conjugate gradient training algorithms. The lowland karst area is characterized by numerous groundwater-fed intermittent lakes, known as turloughs, which fill up during periods of heavy rainfall when the underlying karst system becomes saturated. Training datasets incorporate several years of field data from the study area and outputs from a meticulously calibrated semi-distributed hydraulic/hydrological model of the karst network. Inputs for model training include flood volume data from the past 5 days, rainfall data, and tidal amplitude data over the preceding 4 days. Both daily and hourly models were developed to enable real-time flood predictions. Results demonstrate strong performance by both Bayesian and Scaled Conjugate Gradient models in real-time flood forecasting. The Bayesian model exhibits forecasting capabilities extending up to 45 days into the future, achieving a Nash-Sutcliffe Efficiency (NSE) of 1.00 up to 7 days ahead and 0.95 for predictions up to 45 days ahead. Meanwhile, the Scaled Conjugate Gradient model outperforms up to 60 days into the future, with an NSE of 0.98 up to 20 days ahead and 0.95 for predictions up to 60 days ahead, along with significantly reduced training time compared to the Bayesian model. Additionally, both models exhibit a Coefficient of Correlation (r) value of 0.98 up to 60 days ahead. Evaluation measures such as Kling Gupta Efficiency reveal high performance, with values of 0.96 up to 15 days ahead for both Bayesian and Scaled Conjugate Gradient models, and 0.90 up to 45 days ahead. Integrating diverse data sources and considering both daily and hourly models enhance the resilience and reliability of such an early warning system. Notably, the Scaled Conjugate Gradient model emerges as a versatile tool, balancing predictive accuracy with reduced computational demands, thus offering practical insights for real-time flood prediction, and supporting proactive flood management and response efforts.

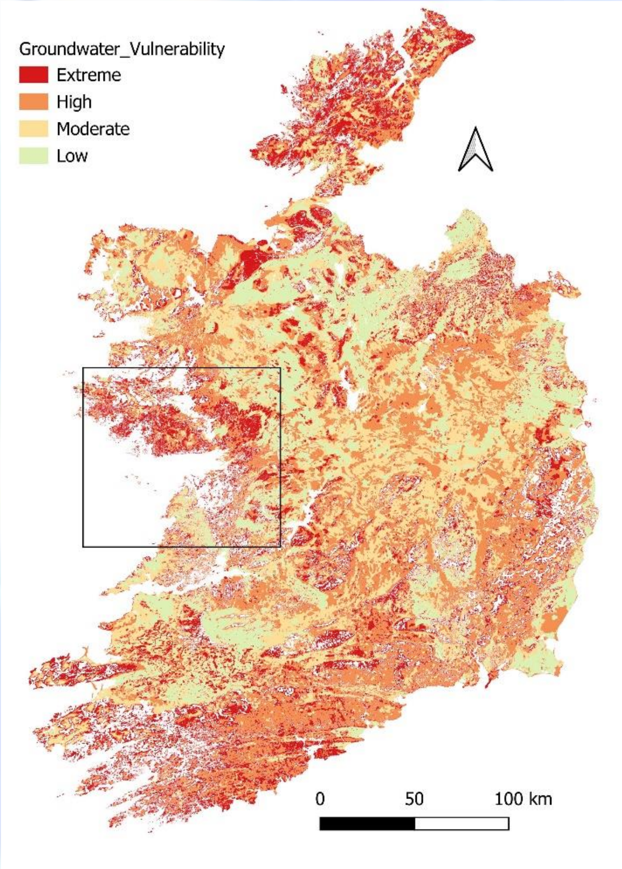

Figure 1 Groundwater vulnerability map of Republic of Ireland (study area shown in the black box.

Exploring the Mechanism of Flame Flashback for Laminar Jet Premixed Hydrogen-air Flames

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INTRODUCTION

Hydrogen (if produced from renewable sources) is considered as the cleanest and greenest alternative fuel, with zero carbon emissions. However, due to its high reactivity and high diffusivity, its use in the combustion devices pose a big challenge. Under same conditions, hydrogen, in comparison to natural gas, is five to six times more reactive. This leads to flashback of hydrogen flames resulting in damaged combustion systems. For instance, if the flame flashes back from a boiler plate, it can reach to the mixing chamber, leading to explosion. **Figure 1** shows one such example of flame flashback from a quartz tube, where adding hydrogen to natural gas leads to a flashback [1]. The objective of the current study is to study this flashback mechanism for lean premixed hydrogen-air flames.

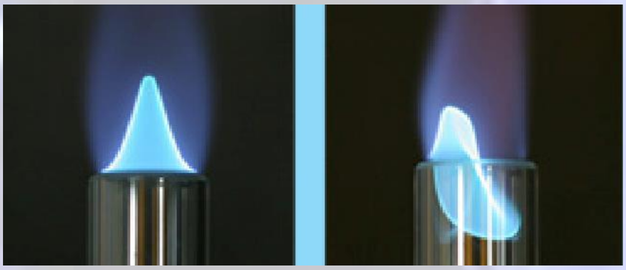

Figure 1 Flame Flashback for premixed natural gas/hydrogen/air mixtures.

MATERIALS AND METHODS

Details of the domain for 2D-axisymmetric steady-state computations are available in **Figure 2**.

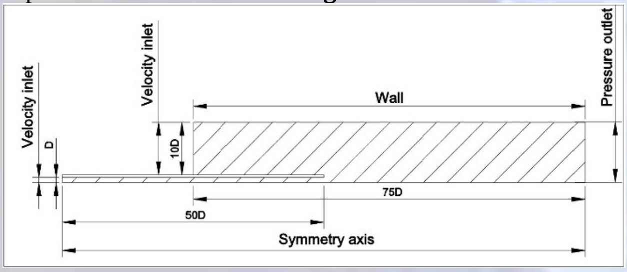

Figure 2 Schematic of computation domain with imposed BCs.

H_2-air reactant mixture at fixed equivalence ratio ($\phi = 0.42$) was used. Thermo-physical properties were calculated using KTG with thermal diffusion, and conjugate heat transfer included. Once, stable flame was obtained, reactant velocity was decreased in velocity steps sizes of 5-10 cm/s [2,3]. Close to flashback condition, the step-size was further reduced to 2 cm/s. **Figure 3** shows this obtained flame flashback for two different diameters. Interestingly, the flame shapes (flat and V- shape) obtained at flashback are different for the two diameters, reasons for this phenomenon are explored in results section.

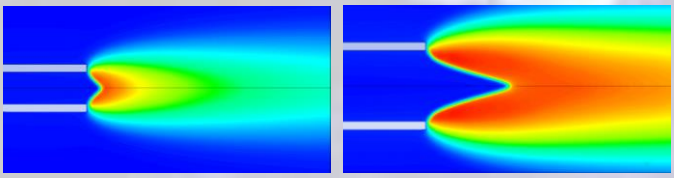

Figure 1. Temperature contours comparison for two diameters (*D* =2.16 & 4.52 *mm*) with reducing velocities.

RESULTS & DISCUSSION

The comparison of equivalence ratio and hydrogen concentration post flashback showed accumulation of hydrogen near the burner wall [4]. **Figure 4** shows that this accumulation becomes more severe at larger diameters due to faster and larger increase in burner tube temperature leading to hydrogen accumulation by Soret (thermal) diffusion effect.

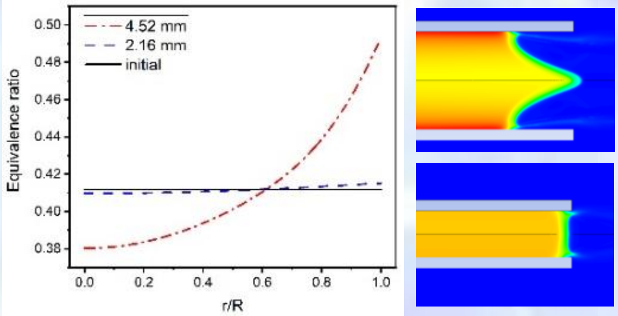

Figure 4. Equivalence ratio and hydrogen concentration comparison for two diameters (*D* =2.16 & 4.52 *mm*) at flame flashback.

Figure 5 shows the comparison of burner temperature for the larger burner (*D* =**4.52** *mm*) under pre and post flame flashback conditions.

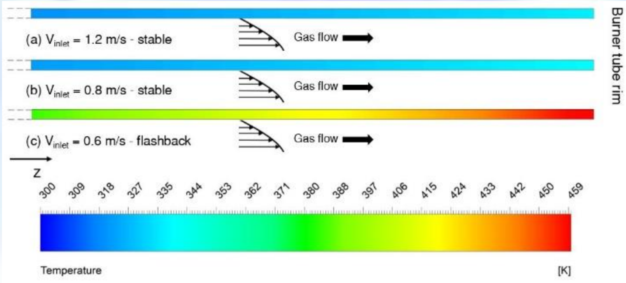

Figure 5. Comparison of the pre and post Flame flashback burner temperature (*D* =4.52 *mm*).

Around 125-130 K increase in burner temperature was observed in pre and post flame flashback conditions. This temperature difference leads to hydrogen accumulation near the burner rim leading to different flame structures (flat and V-shape as shown in **Figure 3**) during flashback [5].

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GROWTH FACTOR PATTERNING INTO FUSING MICROTISSUES: 3D BIOPRINTING OF SPATIOTEMPORAL CUES FOR CELL SPHEROID AND ORGANOID BASED TISSUE ENGINEERING

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INTRODUCTION

Cell spheroids or microtissues are powerful biological building blocks for tissue engineering of several organ systems. They are inherently cell-dense, leverage the simplicity of cellular self-assembly, and recapitulate key features of physiological development. Throughout development, tissues respond to spatiotemporal gradients of growth factors, motivating the need for biofabrication methods which can incorporate these changes in stimuli.

Existing approaches typically rely on pre-specification/differentiation of cell phenotypes within individual spheroids prior to their assembly into larger tissues. However, secreted boundary proteins around the periphery of such spheroids typically inhibit fusion with neighboring bodies after several days, limiting the ability of mature microtissues to fuse into larger, cohesive tissues. Sacrificial writing into functional tissue (SWIFT) is an approach to vascularize highly cellular tissues by bioprinting sacrificial channels for endothelialization into a support bath comprised predominantly of cardiac organoids. Here we hypothesized that a similar bioprinting concept could be used to pattern spatiotemporal cues into a living matrix of immature spheroids to promote native-like tissue development and organization.

MATERIALS AND METHODS

Using cartilage for proof-of-principle, we derived chondrogenic spheroids from bone marrow mesenchymal stromal cells in a medium-high throughput fashion and assembled them into bioprinting support baths after 2 days (3000 cells/spheroid, 1800 spheroids/print). Transforming growth factor beta 3 (TGF-β3) drives chondrogenesis and its spatiotemporal gradients are critical to stratified native-like cartilage development. Therefore, we incorporated TGF-β3 into an alginate bioink with laponite nanoparticles, tuning the release profile for 3-week sustained delivery.

RESULTS AND DISCUSSION

Engineered tissues which only had TGF-β3 released from bioprinted alginate filaments had higher sulfated glycosaminoglycan content and better histological properties compared to counterparts receiving standard culture medium supplementation of TGF-β3 (10ng/mL every 3-4 days) **(Figure 1).** Higher print speeds resulted in lower filament diameters and splitting the same total quantity of TGF-β3 between two smaller filaments instead of a single large filament resulted in equivalent or superior tissue quality.

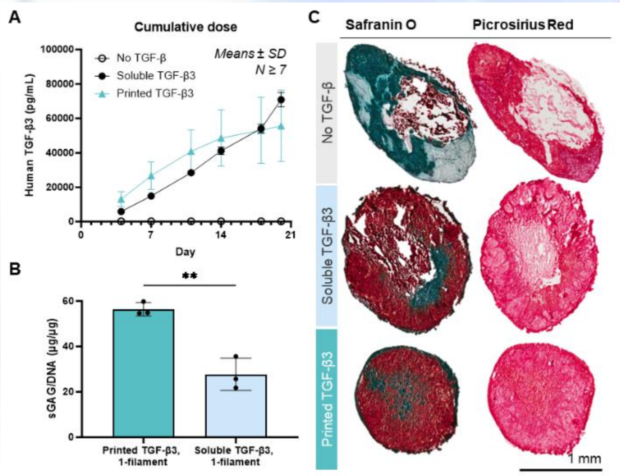

Figure 1. (A) Cumulative dose of TGF-β3 released into culture media over 21 days of culture from printed constructs containing no TGF-β, soluble TGF-β3, or printed TGF-β3. **(B)** Sulfated glycosaminoglycan (sGAG) content normalized by DNA content in whole samples after 21 days of culture as measured by 1,9-dimethylmethylene blue (DMMB) and Hoechst 33258 assays, **P < 0.01. **(C)** Safranin O stain for proteoglycans (red) and Picrosirius Red stain for collagens (pink).

In the case of cartilage, its interactions with the subchondral bone play a role in development, homeostasis, and disease. To induce a more endochondral/hypertrophic phenotype in a subset of microtissues, we incorporated bone morphogenetic protein 2 (BMP-2) into our alginate bioinks. From a support bath of phenotypically homogenous spheroids maintained in a shared basal medium, we anticipate that spatiotemporally distributed growth factors via bioprinted alginate filaments can drive the formation of an osteochondral gradient.

In summary, we established a platform for patterned release of growth factors alongside cell spheroid building blocks for cartilage tissue engineering and anticipate its application for delivery of various bioactive agents across diverse tissue types.

EMERALD: ENERGY EFFICIENCY IN AI TOOLS FOR POST PRODUCTION WORKFLOWS

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INTRODUCTION

Video dimensionality has increased recently, offering greater temporal and spatial resolutions together with a wider color gamut for high dynamic range (HDR) visuals [1]. High-end production and post-production tasks generate and process massive data volumes, of the order of many petabytes per day, requiring extremely high compute capability achieved through clusters of processing hardware including CPUs, GPUs and specialised digital processing (ASICs/FPGAs). Additionally, digital media accounts for over 80% of the internet traffic covering a spectrum of both entertainment and work-related applications [2]. Various signal processing accelerators and AI algorithms are actively being developed and utilised to assist artists in post-production tasks and to improve streaming efficiency, among other applications. However, the massive amount of data and acceleration requirements lead to significant energy utilisation, an issue that the media industry is becoming increasingly sensitive to.

METHODS

The project involves collaborations with partners across Europe, including the BBC, DISGUISE, FILMLIGHT, BRAINSTORM and MOG, and the University of Pompeu Fabra (UPF, Spain), with the aim to develop energy-efficient techniques and tools for tasks within the media processing and media delivery pipeline.

In the Horizon EU project, EMERALD, we aim to develop tools and techniques to provide insights into where and how the energy is consumed within the media pipeline through granular energy profiling, in conjunction with TCD contributions on optimising AI algorithms and efficient compression techniques to show the energy benefits that can be achieved in this domain. Power analysis is done using the using the tools such as NVIDIA System Management Interface (nvidia-smi) and INTEL running average power limit (RAPL) interfaces. The Intel RAPL interfaces facilitate the reporting of Intel CPU energy usage overall over several power domains [3]. The nvidia-smi is a command-line utility built on top of the NVIDIA Management Library (NVML) that helps manage and monitor NVIDIA GPU devices [4].

RESULTS

Software packages are used to analyse the power consumption data for the CPU and GPU while executing various tasks in Nuke 15.0v4 VFX and Film editing software. The results indicate that tools related to video processing consumes a significant amount of energy.

DISCUSSION

Numerous research publications have demonstrated that on-chip power sensors suffer from a large error rate and poor sampling intervals (usually in the range of tens of milliseconds) [5]. Consequently, relying on data from these sensors for optimizing algorithms is unreliable. Optimizing energy in tools for post-production workflows requires precise energy profiling and in-depth energy analysis.

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DESIGN, COMPUTATIONAL AND EXPERIMENTAL EVALUATION, AND 3D PRINTING OF PATIENT SPECIFIC TENTS FOR THE TREATMENT OF PAEDIATRIC AORTIC COARCTATION

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INTRODUCTION

Aortic coarctation is a congenital heart disease that has an incidence rate of 0.3 to 0.6 in 1000 live births [1]. Currently, neonatal coarctation is treated surgically via a thoracotomy procedure, which involves excision of the narrowed section of the aorta followed by an end-to-end anastomosis to restore blood flow. For older children and adolescents, stenting is the procedure of choice. While stenting is associated with low instances of acute complications, there is a risk of hypertension in the long term and possible aneurysm development [2]. Due to the small patient cohort and little financial incentive for medical device companies, there is no approved stent for the treatment of aortic coarctation. In recent years, an increasing number of stents are being touted as possible solutions for the treatment of aortic coarctation. These current designs lack patient specificity and do not consider the geometrical variability and the material characteristics of the aortic coarctation site. Therefore, the objective of this work is to develop the framework to optimize the design and manufacture through 3D printing, a patient specific stent for the treatment of aortic coarctation.

MATERIALS AND METHODS

Computational setup - For the materials, 316L stainless steel was described by an elastic-plastic material model with elastic modulus of 196 GPa, Poisson's ratio of 0.3 and a yield strength of 375 MPa [7] and printed titanium Ti6Al4V by an elastic modulus of 65.09 GPa, Poisson's ratio of 0.3 and a yield strength of 663.519 MPa.
Crush tests were simulated by modelling two parallel rigid plates, meshed using SFM3D4 quadrilateral elements. Zero friction and hard contact was assigned between the stent and plates. The bottom plate was fixed, whilst the top plate was assigned a displacement boundary condition corresponding to half the stent diameter (5 mm).
Crimp tests were simulated by assigning a cylindrical coordinate system at the centre of the stent geometry. A radial displacement boundary condition was then applied to simulate the crimping response to a pre-set diameter.
3-point bend tests were simulated according to ASTM standard F2606-08. Three pins were modelled as rigid, with two pins fixed and separated by a span length of 30.30 mm and indented by 6.06 mm by a third centrally placed pin.

3D printing and postprocessing of stents - A Realizer SLM 50 was used to 3D print stent designs (10 mm diameter, 400 μm strut thickness) using Ti6Al4V powder using previously established parameters [5]. A scan and hatching strategy were employed to ensure continuous build-up of the structure. After printing, the stents were post-processed by sandblasting and chemical etching to achieve a strut size of 100 μm.

Crush tests, crimping & 3-point bend tests of printed stents -
Crush tests was conducted by compressing the 3D printed stents by two parallel plates as shown by Fig. 3A. Stents were compressed to 50% of their nominal diameter at a compression rate of 3mm/min in accordance with ISO 25539-2 standard.
Crimping and balloon expansion was conducted by firstly crimping the 3D printed stents down to known diameters of 3D printed cylinders using a Machine Solutions Inc. HV 500 crimping tool. After being fully crimped, the balloon from the Express LD stent delivery system was used to expand the crimped stent to its maximum dilation.
3-point bent tests were conducted by the test method outlined in ASTM F26060-8. Like the computational setup, span length and maximum deflection was calculated and used for the test. Stents were pre-loaded to 0.1 N and deflected at a rate of 10 mm/min.

RESULTS

Experimental tests qualitatively validated all our computational simulations. Our models can accurately predict the experimental response when crushed to 50% of their diameter. Radial crimping of the 3D printed stent shows the ability to crimp down to a smaller diameter. Furthermore, balloon expansion shows unfolding of the stent geometry without fractures. Lastly, 3-point bend experiments agreed with our computational results showing an elastic response in our 3D printed stents.

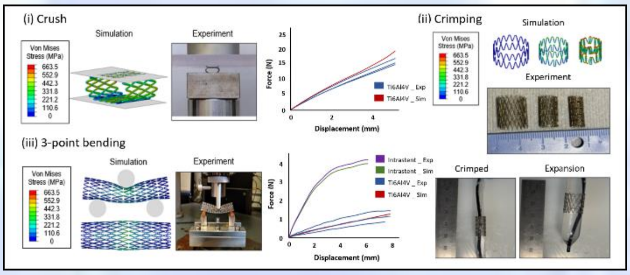

Figure 1 (i) Crush simulation and experimental comparison (ii) Crimping and balloon expansion (iii) 3-point bending simulation and experimental comparison

DISCUSSION

This study shows a feasible framework for creating patient specific stents for treatment of aortic coarctation. Using these virtual simulations and further validation of these using experimental methods, it is possible to estimate the geometry and material-dependent variations in radial strength, crimpability and three-point bend flexibility of the stents. enabling optimization, design, and manufacture of patient specific stents.

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FEATURE SIZE DEPENDENT MANUFACTURABILITY INFLUENCES THE FUNCTIONAL PROPERTIES OF ADDITIVELY MANUFACTURED TI-6AL-4V MICRO-STRUT LATTICES

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INTRODUCTION: Porous titanium biomaterials fabricated by additive manufacturing (AM) techniques such as Selective Laser Melting (SLM) have been widely adopted for orthopaedic implants and bone tissue engineering applications [1]. Despite the many advantages of this approach, process inherited defects such as internal porosity and surface non-homogeneities remain an issue; having been shown to negatively affect both mechanical properties and cell-substrate interactions [1]–[3]. Although minimisation of these defects through parameter optimisation is well established for traditional, bulk AM, it remains poorly characterised for lattice structures. Several studies have reported a discrepancy in the frequency of such defects, particularly with changes in feature size, indicating a size effect. Furthermore, the optimal SLM parameters for bulk materials are not necessarily translatable to the individual micro-struts which build the lattice [2]. The application of post-process surface cleaning techniques is also limited. This is largely a consequence of geometrical tortuosity, ill-suited to traditional techniques such as grinding and polishing [3]. In this study, in-process and post-process manufacturability are assessed as a function of feature size, with the objective of optimising micro-strut material properties, and cell-substrate interactions.

METHODS: **In-Process:** Parameter optimization was studied as a function of feature size; between micro-strut (ø300-700µm ASTM-E8 adaptations) and bulk samples ($10mm^3$). Here, relative density was assessed across a range of energy density inputs, along with estimation of thermal histories using computational modelling. Micro-strut mechanical properties were assessed in tension, fatigue and compression (full lattice). Having optimized micro-strut relative density, process inherited surface defects were assessed as a function of feature size. Roughness and morphology were measured, along with characterization of mechanical properties.

Post-Process: An incremental $HF/HN0_3$ chemical etching process was used for refinement of the as-built surface. Modifications in roughness and morphology were measured, along with characterisation of mechanical properties. Cell-substrate interactions and mineralisation were assessed *in vitro* using MSCs seeded across the range of developed topologies.

RESULTS & DISCUSSION: The window of suitable processing parameters for bulk materials did not translate to micro-struts. An increase in the frequency of 'lack of fusion' defects was observed at low energy densities, indicative of incomplete melting (Fig.1a). Computational modelling demonstrated that this was a consequence of higher rates of heat loss due to an increased surface-to-volume ratio as feature size is reduced. Consequently, a higher energy density input was required for micro-strut processing. Minimisation of these defects coincided with improved tensile and compressive properties. During fatigue loading, cracks generally initiated at the surface, even in the presence of large internal pores, highlighting an increased surface free energy in small diameter struts.

Surface defects remained an issue after optimising micro-strut relative density. Both fatigue and tensile properties were compromised by these defects, acting as critical sites for crack initiation, and reducing the effective % volume of load bearing material. Post-process chemical etching was implemented to refine the as-built surface (Fig.1b). After continued etching, surface defects were entirely removed, resulting in improved mechanical properties as a consequence of more efficient load bearing capacity. *In vitro* cellular assessment also revealed that chemical etching influenced osteogenesis. With increased etching, greater cell spreading was observed, suggestive of osteogenic differentiation, and accompanied by enhanced mineralisation (Fig.1c).

To conclude, characterisation of SLM manufacturability as a function of feature size has enabled us to adapt both in-process and post-process SLM parameters, resulting in enhanced material properties and cell-substrate interactions in lattice structures targeting orthopaedic applications.

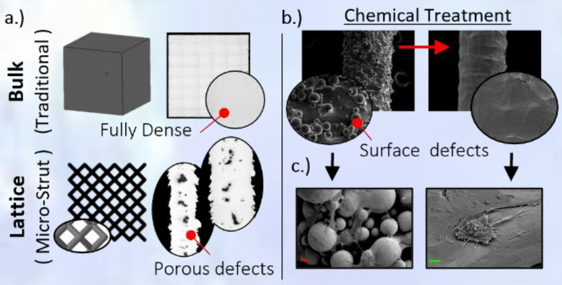

Figure 1 a.) Process inherited porous defects between bulk and micro-strut samples. b.) Removal of unavoidable surface defects by chemical etching. c.) The resultant cell-substrate interaction.

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RIS-ASSISTED OTFS COMMUNICATIONS: PHASE CONFIGURATION VIA RECEIVED ENERGY MAXIMIZATION

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INTRODUCTION

Reconfigurable intelligent surfaces (RISs) have gained attention due to increased connectivity demands and the surge in mobile data traffic. This state-of-the-art technology is set to play a crucial role in 6th-generation wireless networks (6G). RIS is a surface composed of electromagnetic metamaterial with numerous small, cost-effective, and energy-efficient reflecting elements [1]. These elements can manipulate the scattering and propagation in the wireless channel by applying a predetermined phase shift to the incoming wave. Effectively, RIS technology presents a transformative paradigm shift, that can convert the unpredictable and disruptive propagation environment into a smart radio setting. This results in an improvement of received signal quality and provides a revolutionary advancement in wireless communications [2].

On the other hand, orthogonal time frequency space (OTFS) modulation has emerged as a novel solution to address the diverse requirements of the 5th-generation wireless networks (5G), particularly in scenarios with high mobility, such as vehicle-to-vehicle communication and high-speed trains [3]. Traditional modulation schemes like orthogonal frequency division multiplexing (OFDM) face challenges in maintaining effective channel estimation at high speeds. In contrast, OTFS introduces a revolutionary approach by transforming the time- varying multipath channel into a two-dimensional domain, specifically the delay-Doppler (DD) domain [3], [4]. Such transformation, combined with equalization in the DD domain, ensures that each transmitted symbol experiences a nearly constant channel gain. This process involves spreading all in- formation symbols across both time and frequency dimensions, which leads to the exploitation of maximum effective diversity [5]. Hence, OTFS proves to be a flexible modulation technique that combines features from both code division multiple access (CDMA) and OFDM [3].

The inherent benefits of both RIS and OTFS have in-spired researchers to integrate these cutting-edge technologies to create a robust and energy-efficient approach, effectively tackling challenges at high-speed wireless communications. In this paper, we investigate the RIS-assisted OTFS system and establish a connection with conventional OTFS without RIS. This paper considers the complete bandwidth of an OTFS block and assumes fixed phase shifts of RIS elements throughout an OTFS time frame. Hence, we introduce a phase shift design algorithm wherein the RIS is configured to address all paths and considers the dynamic nature of the channel.

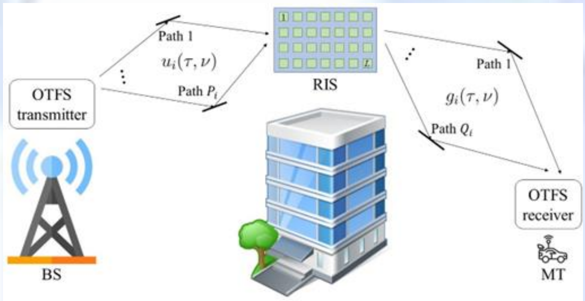

Figure 1 An RIS-assisted OTFS setup.

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