Making

Sydney Manufacturing Hub

Additive manufacturing and materials processing

Sydney Manufacturing Hub specialises in cutting-edge additive manufacturing (AM) and materials processing of metals, ceramics and polymers, and offers researchers and industry access to concept-to-production capabilities supported by design and technical expertise.

GE Additive

3rd Axis Additive Manufacturing

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sydney.edu.au/manufacturing-hub

Investigating copper-tin alloys for 3D-printing

Challenge

Copper and its alloys are used in applications where materials with high conductivity, corrosion resistance, strength and ductility are needed. Additive manufacturing (AM) increases opportunities for these materials to be used due to its design flexibility and structural complexity. More knowledge of the properties of copper-tin alloys is needed to harness these opportunities.

Research

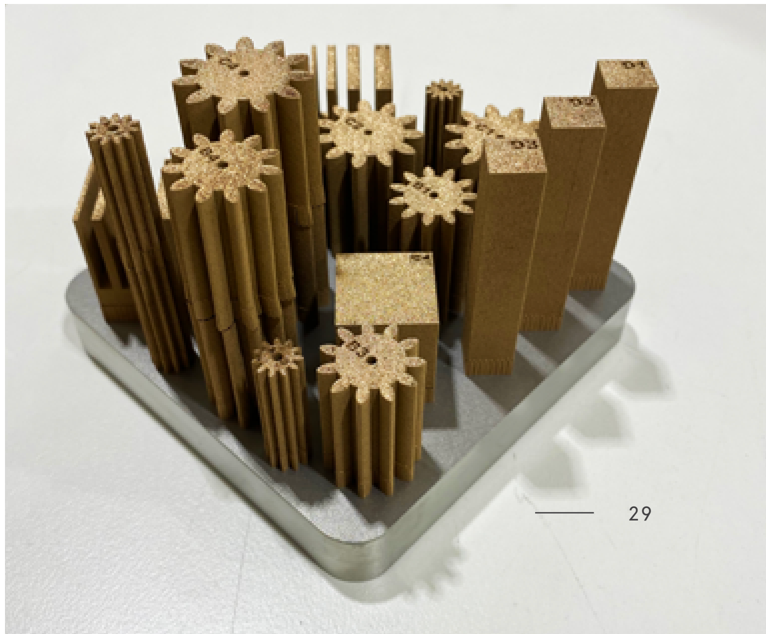
A University of Sydney team including ARC DECRA fellow Dr Keita Nomoto and PhD student Kangwei Chen (School of Aerospace, Mechanical and Mechatronic Engineering, Faculty of Engineering) are working to understand the microstructure-property relationships of AM tin-bronze (Cu-10Sn) alloys to achieve more superior mechanical and electrical properties than are possible with conventional manufacturing. A series of fully dense parts with varying specifications were successfully 3D-printed at Sydney Manufacturing Hub using the laser powder bed fusion process. Technical experts including Dr Mehdi Eizadjou from Sydney Manufacturing Hub worked with the team to develop a wide range of printing parameters with the aim of increasing strength while maintaining ductility.

Results

The team identified parameters which allowed them to successfully increase strength without compromising ductility in 3D-printed copper-tin alloy parts, exceeding the performance of conventionally cast samples using the same material. These pathfinding results are leading the team towards stronger, more conductive copper-based alloys via AM that will be a critical underpinning of the electrification revolution.

Funding sources include:

- Australian Research Council



Right: Fully dense parts 3D-printed from copper-tin alloy, using the laser powder bed fusion process. Compared with conventional casting, the additively manufactured samples achieved higher strength while maintaining ductility.

Developing musculoskeletal implants with ceramic 3D printing

Challenge
Additive manufacturing can produce intricate structures which are challenging to fabricate with conventional manufacturing techniques, and this level of precision offers enormous potential for biomedical implants. Ceramic 3D-printing is an important frontier in this area, and emerging research aims to determine optimal designs for implants.

Research
Postdoctoral researcher Dr Chi Wu from Professor Qing Li's research group (School of Aerospace, Mechanical and Mechatronic Engineering, Faculty of Engineering) harnessed novel computational modelling and machine learning techniques to develop implantable devices for the treatment of musculoskeletal disorders. The device designs incorporated complex surface geometries and intricate structures to enhance load-bearing capacity and promote tissue growth in a long-term fashion.

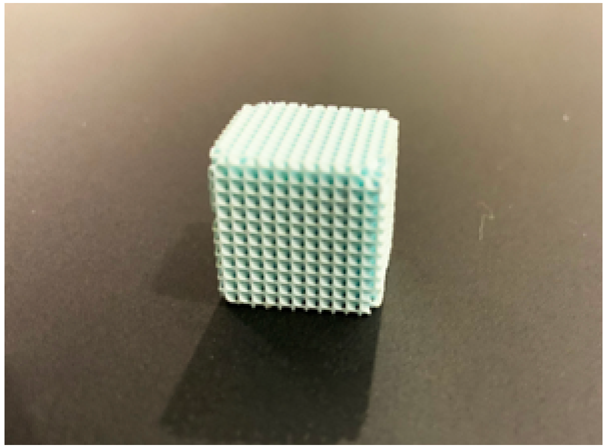
Working with Dr Katja Eder at Sydney Manufacturing Hub, Dr Wu used a ceramic 3D printer to produce the devices using a variety of biocompatible ceramics, such as hydroxyapatite, alumina, and zirconia. The ability to 3D-print in high resolution with these materials is important, as they possess the properties needed for successful implants: biocompatibility and excellent thermal and chemical stability.

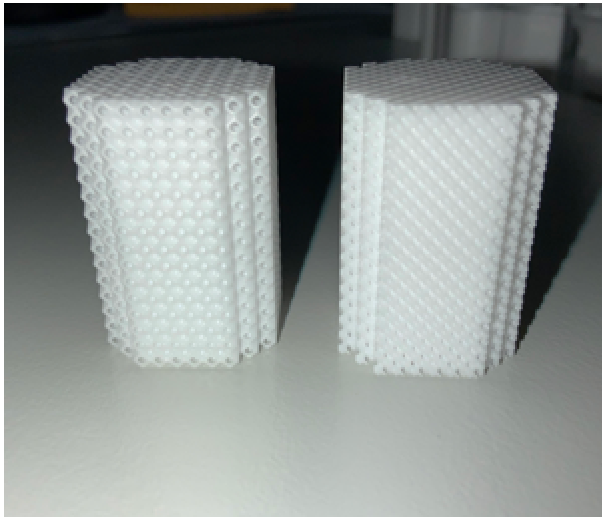
After sintering the parts at Sydney Manufacturing Hub, they were imaged using a microCT at Sydney Microscopy and Microanalysis to ensure the integrity of the structures, and then mechanically tested.

Results
Using this combination of innovative design approaches and advanced ceramic 3D-printing capabilities, Dr Wu developed load-bearing implants with rationally tailored properties capable of withstanding harsh conditions. Further, Dr Wu drew on this success to produce a comprehensive framework for creating next-generation implantable devices with enhanced long-term treatment outcomes. This work opens the way for practical new treatment options to improve quality of life for patients with musculoskeletal injury and disability. The findings were published in *Science Direct* and presented at the 12th International Conference on Structural Integrity and Failure, where it won Best Paper Award.

Funding sources include:

- Australian Research Council





Above: Dr Chi Wu's ceramic 3D-printed implantable samples, produced at Sydney Manufacturing Hub.

Additive manufacturing propels rocket science

The USYD Rocketry Team is a group of students from the School of Aerospace, Mechanical and Mechatronic Engineering (Faculty of Engineering) who design and build rockets. In 2022, they entered the Spaceport America Cup intercollegiate rocketry competition, the world's largest event of its kind. Sydney Manufacturing Hub sponsored the team by 3D printing the bulkhead of a rocket nose cone from titanium for their entry. The team won the 2022 competition, placing first in three categories!

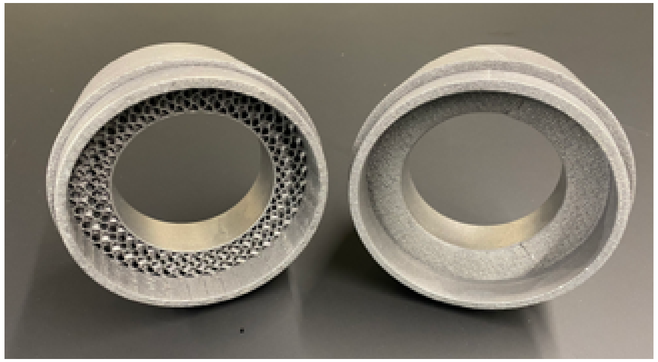
Advantages of additive manufacturing

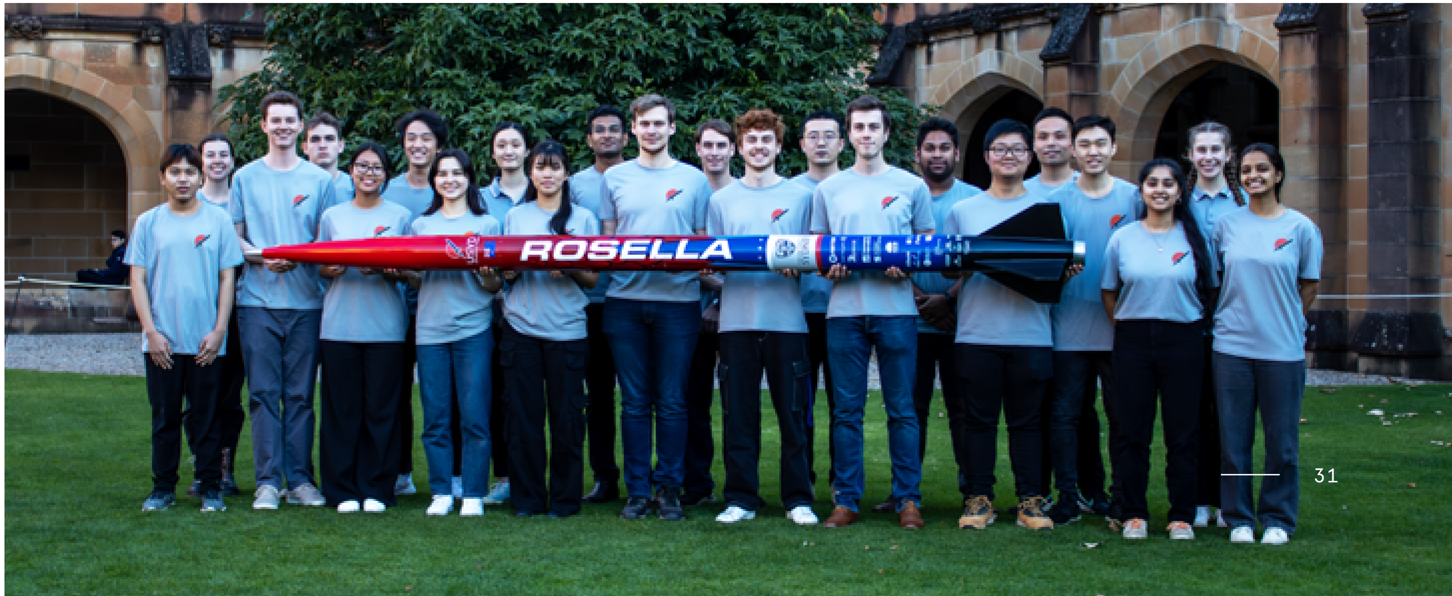
The USYD Rocketry Team are now designing their next-generation rocket. Chief Engineer Bruce McLean, Dr Wen Hao Kan and other engineers at Sydney Manufacturing Hub have been working closely with the team throughout the design process to help them better leverage the advantages of metal additive manufacturing such as rapid prototyping, fabrication of highly complex shapes, and substantial weight reductions. As a result, the latest design iterations use complex part geometries with intricate internal hollow structures to maximise aerodynamic performance and weight-savings for better fuel efficiency.

Design expertise increases efficiency

For example, Sydney Manufacturing Hub recently 3D printed the end cap for a rocket's boat tail out of F357 aluminium alloy. The end cap was originally designed for conventional manufacturing processes, so while the design could be easily produced with additive manufacturing, it did not fully leverage the advantages of the technology. Sydney Manufacturing Hub worked with the Rocketry Team on a new design for a largely hollow part supported by intricate lattice structures, achieving a weight reduction of 40%. Additionally, because unused raw material can be recycled and the volume of a part is directly correlated to the manufacturing time, the updated design was both cheaper and faster to additively manufacture compared with the initial design.

Gains like these put the USYD Rocketry Team in a prime position to excel again in their future projects.





Above: End cap samples: Sydney Manufacturing Hub worked with the USYD Rocketry team to produce an additively manufactured version with an intricate lattice structure (left), achieving a 40% weight reduction compared with the conventionally manufactured version (right). Right: The USYD Rocketry Team.