Politecnico di Torino
Dipartimento di Scienza Applicata e Tecnologia

## MECHANICAL CHARACTERIZATION OF 316L SPECIMENS

The tensile tests were carried out with an MTS Criterion Model 43 testing machine, using a 5 KN load cell, and a 25 mm resistive contact strain gauge.

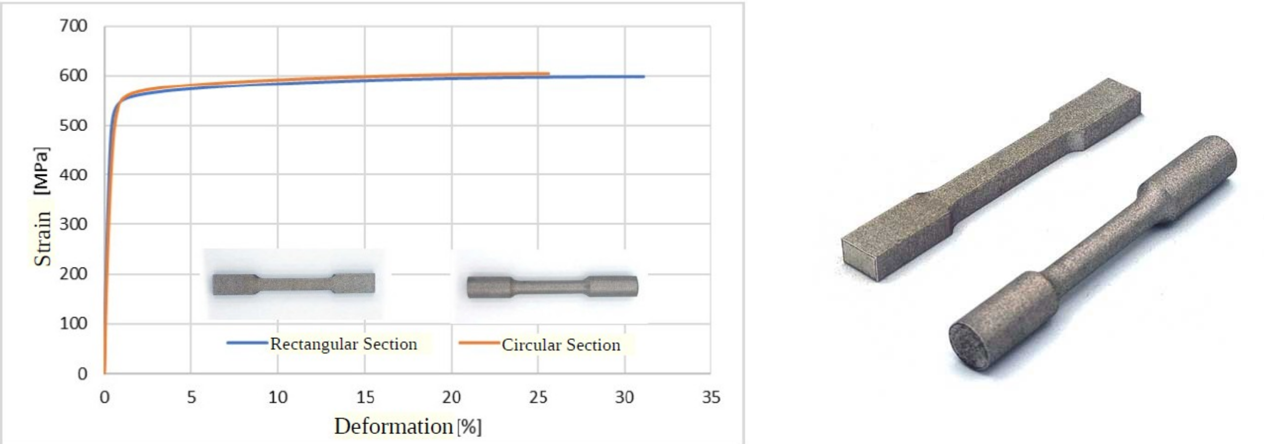



Fig 1. Stress-deformation curves of rectangular and circular section specimens

Table I shows the values of tensile strength, deformation at maximum load and the elastic modulus. Is determined by drawing a straight line passing through the points of the curve in correspondence with a deformation equal to 0.05% and 0.25%.

| | Properties | | |
|---|---|---|---|
| **Specimen** | Elastic module [GPa] | Resistance to traction [MPa] | Deformation [%] |
| Square Section | 190,8 | 598,8 | 31,4 |
| Cicular Section | 189,8 | 604,4 | 25,6 |

Table I. Mechanical properties of 316L specimens

MetalONE update 6/2021

An evaluation of 316L tensile tests

Fachhochschule Dortmund
University of Applied Sciences and Arts

**Dr.-Ing. Farzad Foadian**
FB Maschinenbau, Additive Fertigung / Werkstoffe
Contact info:
farzad.foadian@fh-dortmund.de
www.fh-dortmund.de

## Summary:

**Introduction**



## Introduction:

The samples obtained by Sharebot on 21.04.2021 from 1.4404 were examined. The execution was carried out by Robert Kremer (robert.kremer@fh-dortmund.de) at the FH Dortmund.

### 1. Overview

Five tensile specimen, three lightweight cubes and three density cubes were produced.

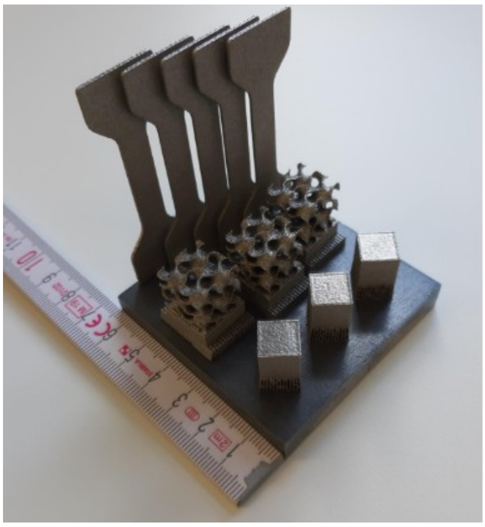


**Fig. 2** Samples received on the construction plate

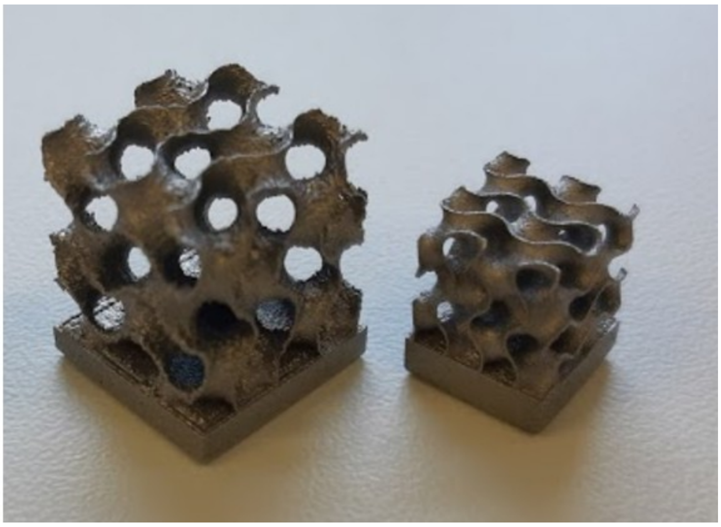


**Fig. 2** lightweight cubes in comparison; On the left, the submitted and on the right the own

It is noticeable that the lightweight cubes are larger than required. In addition, the resolution is significantly lower, indicating a larger melting track (more volume energy and/or higher layer thickness) than with the reference sample.

## 2. Density cube evaluation

Two density cubes were removed from the construction plate and sharpened on all sides. In the following density study by hydrostatic weighing, porosities of 0.7% and 0.2% respectively were determined.

| m_Luft | m_Wasser | m_Delta | Volumen | Dichte | Rel. Dichte | Porösität |
|---|---|---|---|---|---|---|
| g | g | g | cm³ | g/cm³ | % | % |
| 7,8688 | 6,8805 | 0,9883 | 0,9900752 | 7,94767909 | 99,3 | 0,7 |
| 7,9499 | 6,9559 | 0,994 | 0,99578544 | 7,98354711 | 99,8 | 0,2 |

**Fig. 3** Evaluation of the density study

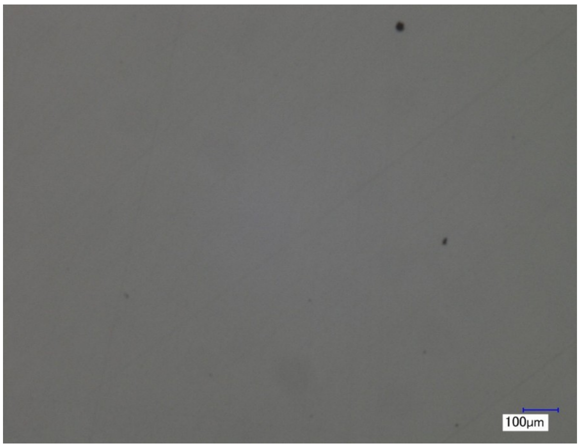



**Fig. 4** Polished cross-cut

The two samples were then embedded, sanded, polished and viewed under the microscope. A high density within the component is noticeable.

In the periphery there is an accumulation of pores.

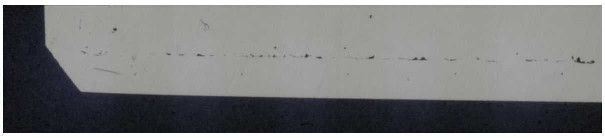


**Fig. 5** Close-up of the edge area

After the subsequent etching, it becomes apparent that the edge and surface exposure is not fully connected, which causes the pore accumulation.

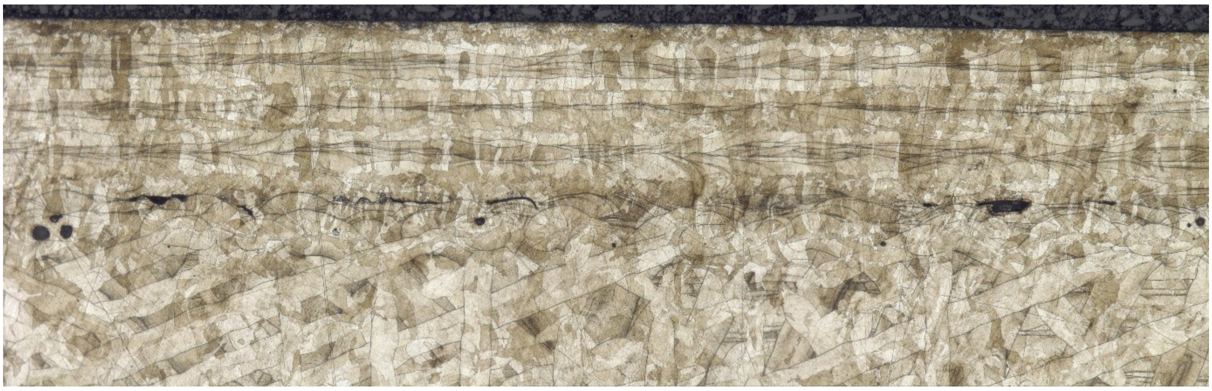


**Fig. 6** Etched recording of the edge area with visible errors in the transition area

Overall, the cut images have a typical appearance with visible melting traces.

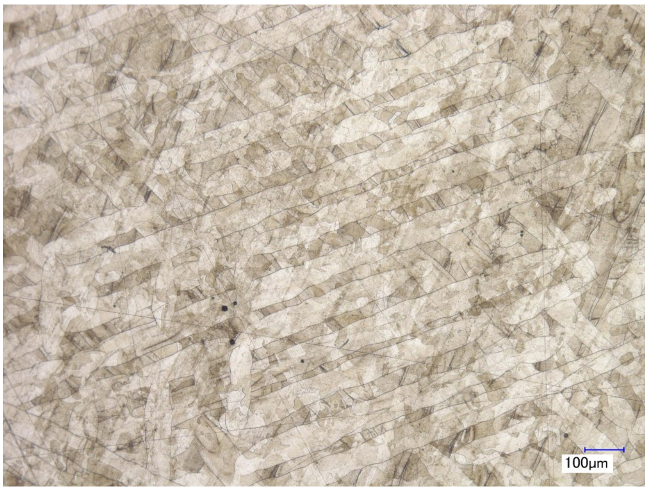




**Fig. 7** Etched plan view with visible melting traces and applied alternating exposure

**Fig. 8** Etched Side View

## 3. Tensile tests analysis

All five tensile samples have a gap in the middle, which is only interrupted by a few bridges. One possible explanation could be the interplay between surface and edge exposure.

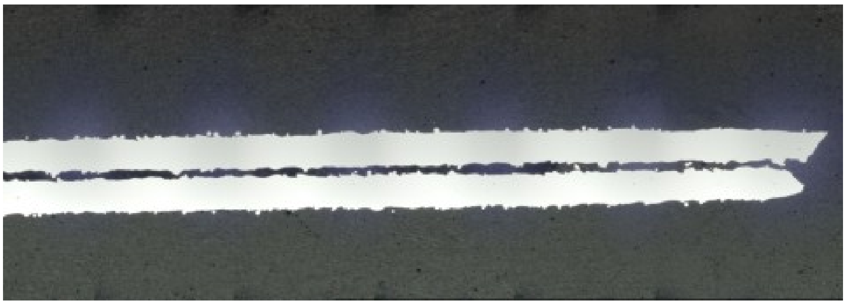
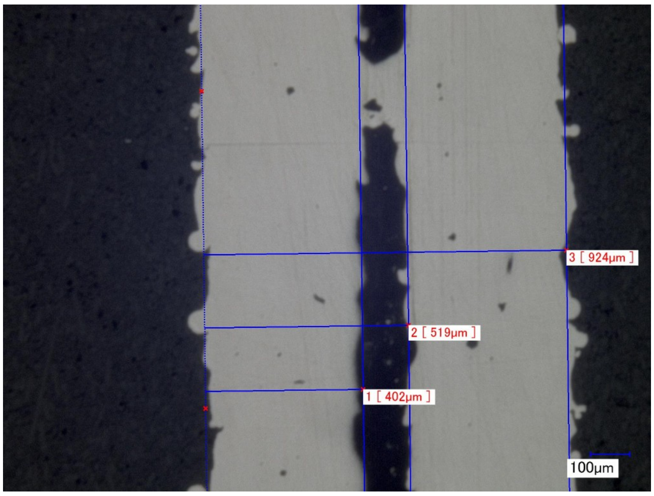


**Fig. 9** Ground cross-section of the drawn tensile sample. Clearly recognizable gap within the component



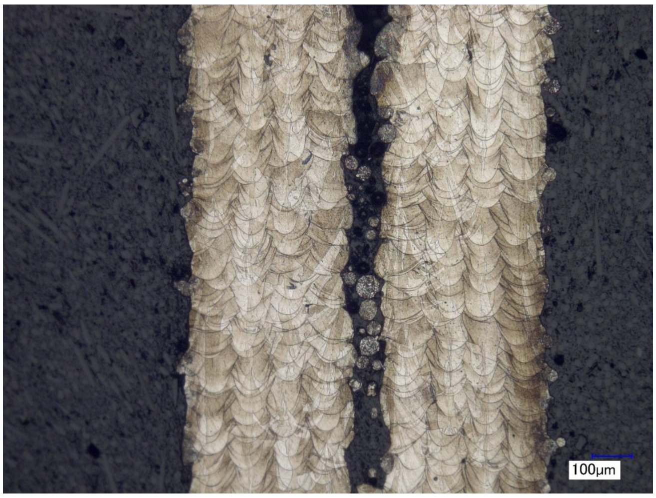




**Fig. 10** Measurement of the gap within the tensile sample

**Fig. 11** Etched view of the train sample

In the etched cut pattern, unmoltened powder particles can be seen in the middle.

In the reception of the fracture point, the gap, including adhering particles, can also be seen.

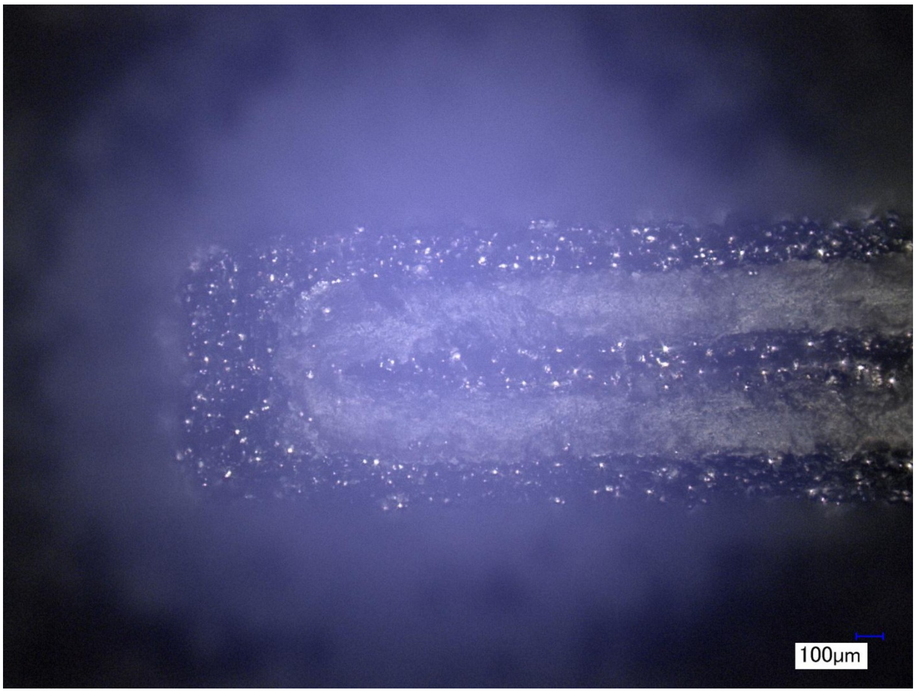
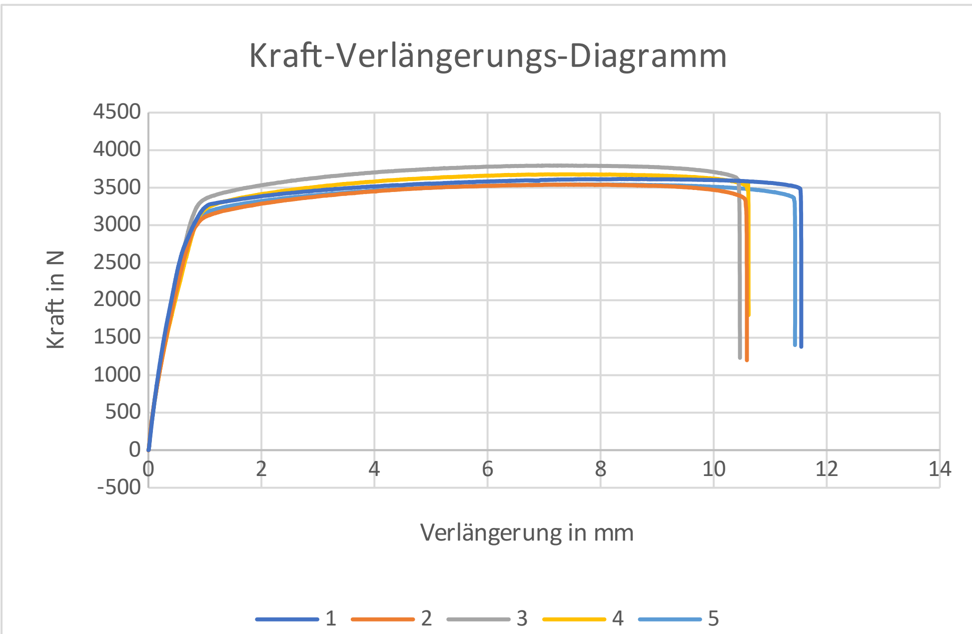



**Fig. 12** Plan view of the fracture site

Due to the incompletely constructed tensile samples and the resulting unknown or fluctuating cross-section, only a force-extension diagram is output.




The cross-section estimated on the basis of the microscopic images is 6.4 mm², which corresponds to a tensile strength of approx. 570 MPa (according to literature 500 – 700 MPa). Due to the problem described, however, the value is only partially meaningful.

SHAREBOT

This work is done under: RegioneLombardia Innovative Solutions 4.0

In collaboration with: ICMATE Institute of Condensed Matter Chemistry and Technologies for Energy LECCO

# MetalONE update 6/2021

Dear supporter,
We are thrilled to inform you that our R&D team **modified a metalONE** and we are now testing almost **pure copper.**

We began increasing the **laser source power** to 1 KW and changed all the **optical systems** accordingly.  We have now entered the testing phase to **find the right combination** of **printing parameters** (laser power, speed and focus). We know that there's a long road ahead, but we're sure that the work we're doing will bring **continuous improvements** to the metalONE system.
The following images show the results obtained from the **first print jobs** with this material.

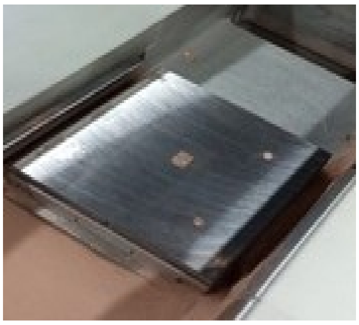


**Fig. 1** First test to understand the copper adhesion to the iron buildplate.

**Fig. 2** A failed print, the fused material did not attach to the plate and moved around.

As shown in Fig. 2 it's not an easy task to maintain the prints stuck to the print platform. **Preheating** techniques have been implemented to ensure bed adhesion and **regulate the heat dissipation** during the first layers of the prints.
Laser source **power** and printing **speeds** were also **tweaked accordingly** to find the working window that enabled us to **print the first test cubes**.

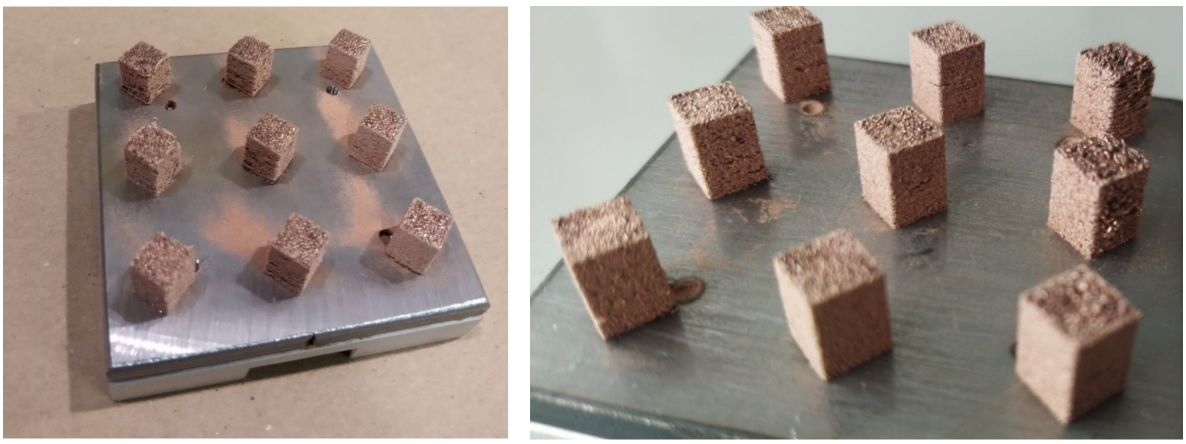


**Fig. 3 and Fig. 4** Two build plates with test cubes sintered with different laser power and speed parameters

**Sharebot srl** via Montello 18 23895 Nibionno (LC) Italia Capitale sociale 25.600 euro

Codice Fiscale, Partita IVA IT 03482570136 **Tel +39 031.692.132 Fax + 39.031.228.1412**
**www.sharebot.it - info@sharebot.it**

In collaboration with:

SHAREBOT

THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

**MetalONE update 7/2021**

Creative Design and Additive Manufacturing Lab

*"Making good progress printing pure copper with a 250W laser. Typically done with a more powerful laser, but we are getting ~95% density from our first look. More results to come! "*

Tim Gordon
**Bachelor thesis Candidate and Student**
**University of Auckland, New Zealand**

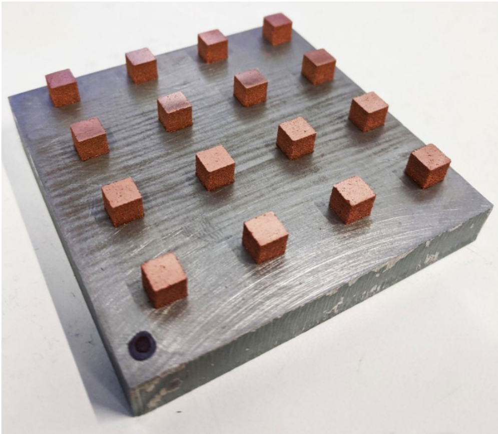


**Fig. 1** First test cubes printed to evaluate the printing parameters and density structure (~95%)

Dear supporter,
We started the month of July with a **great update** thanks to our friends from New Zealand at the **University of Auckland**.

We have no time to waste so let's get to the good stuff: **pure copper 3D printing with a 250W laser**. After the last update from **ICMATE** published just one week ago, we received some **interesting news** from the researchers of the Creative Design and Additive Manufacturing Lab in New Zealand. **Without any upgrade** to the system they accomplished **astonishing results** printing copper on our MetalONE DMLS 3D printer.

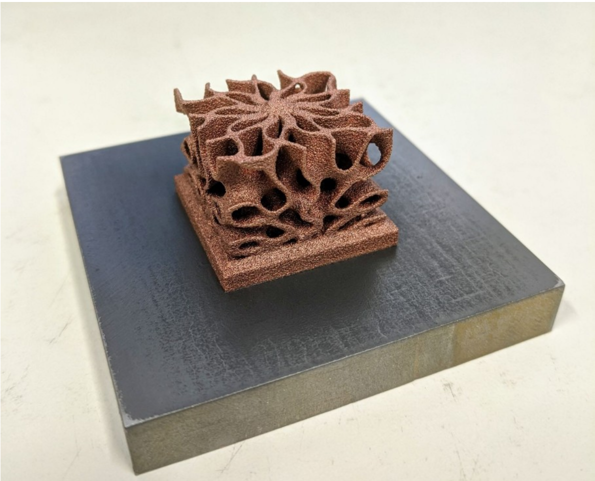


**Fig. 2** Copper's heat transfer properties make it desirable for heat sink applications and the complex geometries achievable with AM gives improved performance for a given size.

As Tim Gordon stated, this work is part of an engineering research project and the **it's only the beginning**. Take a look at Fig. 2:

*"Another pure copper print on the MetalOne printer. An optimized heat sink modeled using nTopology software, but I think it looks more like a tropical coral."*
***Tim Gordon***

Here's a testimony from **Olaf Diegel**, Professor of Additive Manufacturing at the University of Auckland.

*"Just because there's tarnish on the copper, doesn't mean there's not a shine beneath... Here are our first copper prints from our little Sharebot MetalOne **metal materials research printer**. The prints were done by our students Tim Gordon and Rachel Jingnan (from the team of Dr. Fei Yang at Waikato University)."*