MONASH University

Additive Manufacturing

Nick Birbilis

MONASH University

Additive Manufacturing of mainly metals, but also other related stuff…..

Nick Birbilis + the Monash team

Materials

- Essentially all structural materials are ***anthropogenic*** (i.e. man-made)
  - Only real exception is timber, with maybe an honourable mention to bamboo
- As such, we have only ourselves to thank (or blame) for their properties.
  - This has a significant relevance in the context of advanced manufacturing (and what it means for future manufacturing and future industry)

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Images: Google Images

In terms of materials design, this is what we have to begin with….

Image: Google Images

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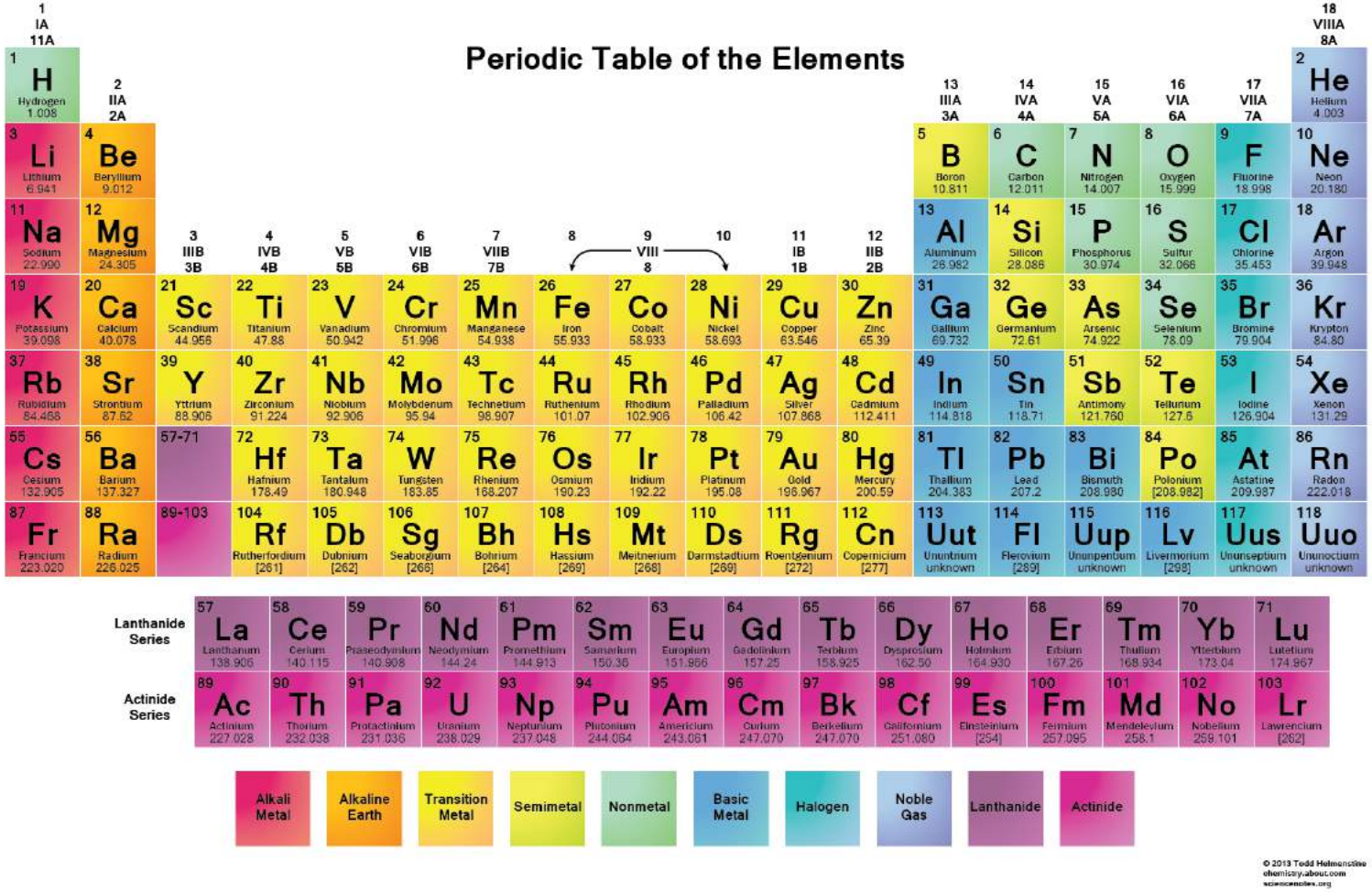
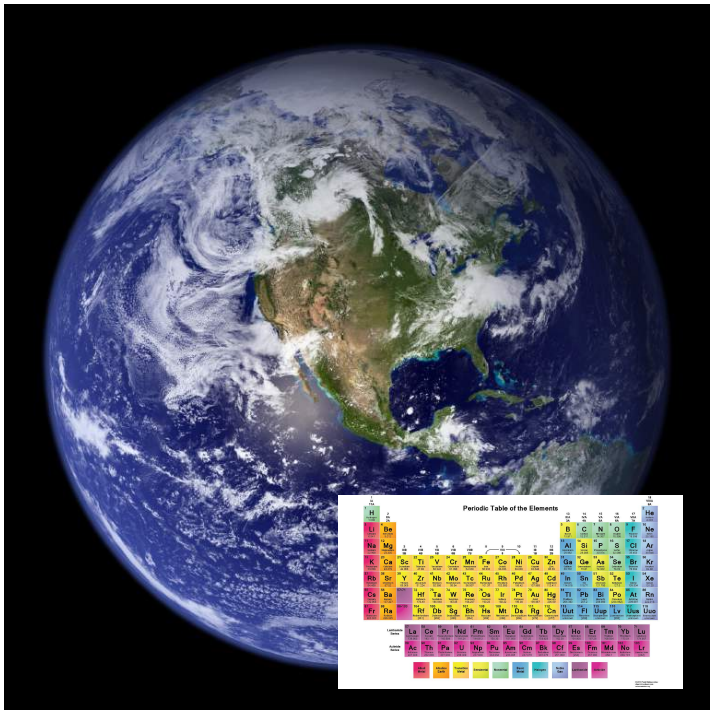
Images: Google Images

Our toolkit is:





The traditional manufacturing route is however very much non-ideal, for a number of reasons

(rivets, corrosion, logistics, design limitations, sustainability, waste, optimisation, etc. etc.

Image: Google Images

- **What are the drivers for Metal AM ??**
  - Cost reduction, minimising waste, rapid building of complex c
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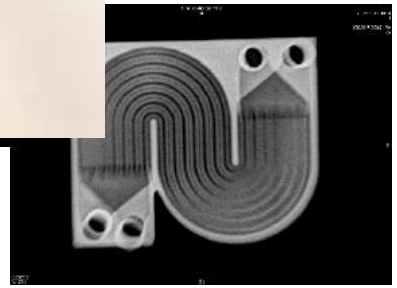

AUSTRALIAN MADE

PRODUCT OF AUSTRALIA

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woodside

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3D printing: Australian researchers create jet engine, breakthrough captures attention of Airbus and Boeing

By environment and science reporter Jake Sturmer

Updated 26 Feb 2015, 1:52pm

3D printing can help reduce new engine development time from the current 20 years down to <2 years

Time to produce an engine down from the current 2 years down to <2 weeks

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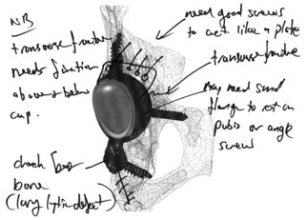
Custom Triflange Shell
HA Coating with Silver Ions

Signature ORTHOPAEDICS

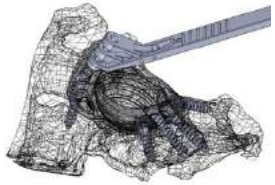
10th July 2015

Acusure Ag® Technology Clinical Case

PLANNING



SURGEON FEEDBACK



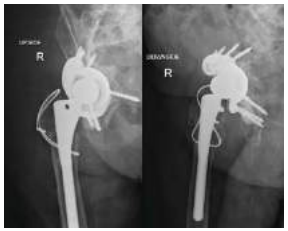
CUSTOM DRILL GUIDE FOR ACCURATE DRILLING

CEMENTED XLPE LINER

CUSTOMISED SCREW TRAJECTORY FOR OPTIMAL BONE PURCHASE

STERILE TRIAL
USED FOR SIZING & FIT

STERILE PACKED IMPLANT
Ti6Al4V WITH HA COATING
+ SILVER IONS FOR ANTI-INFECTION



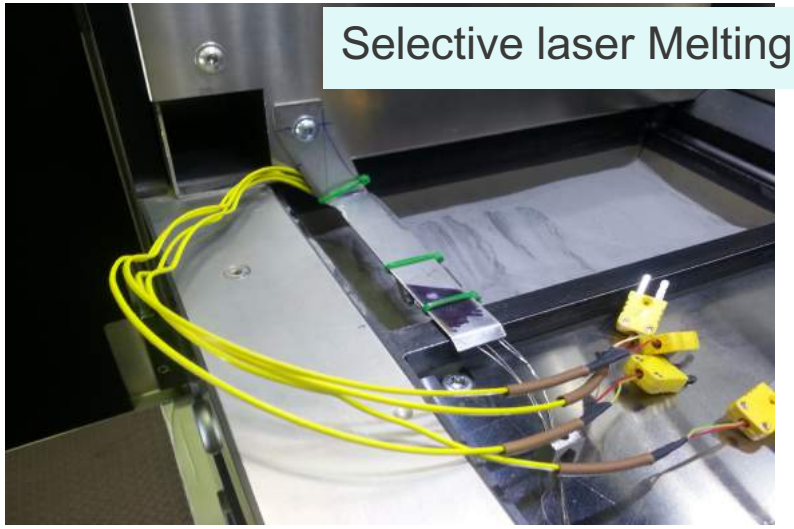
POST OP

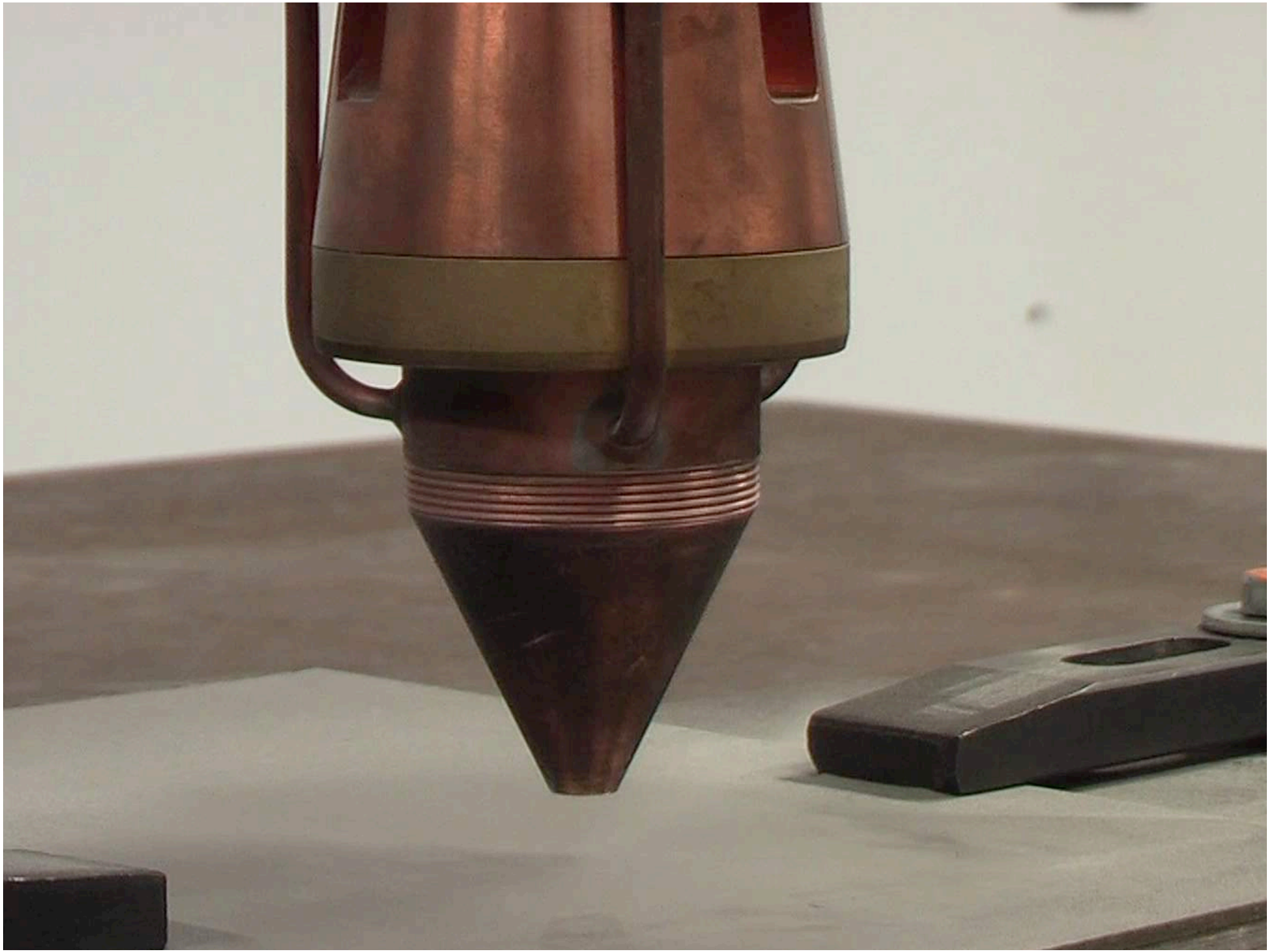
4 Weeks

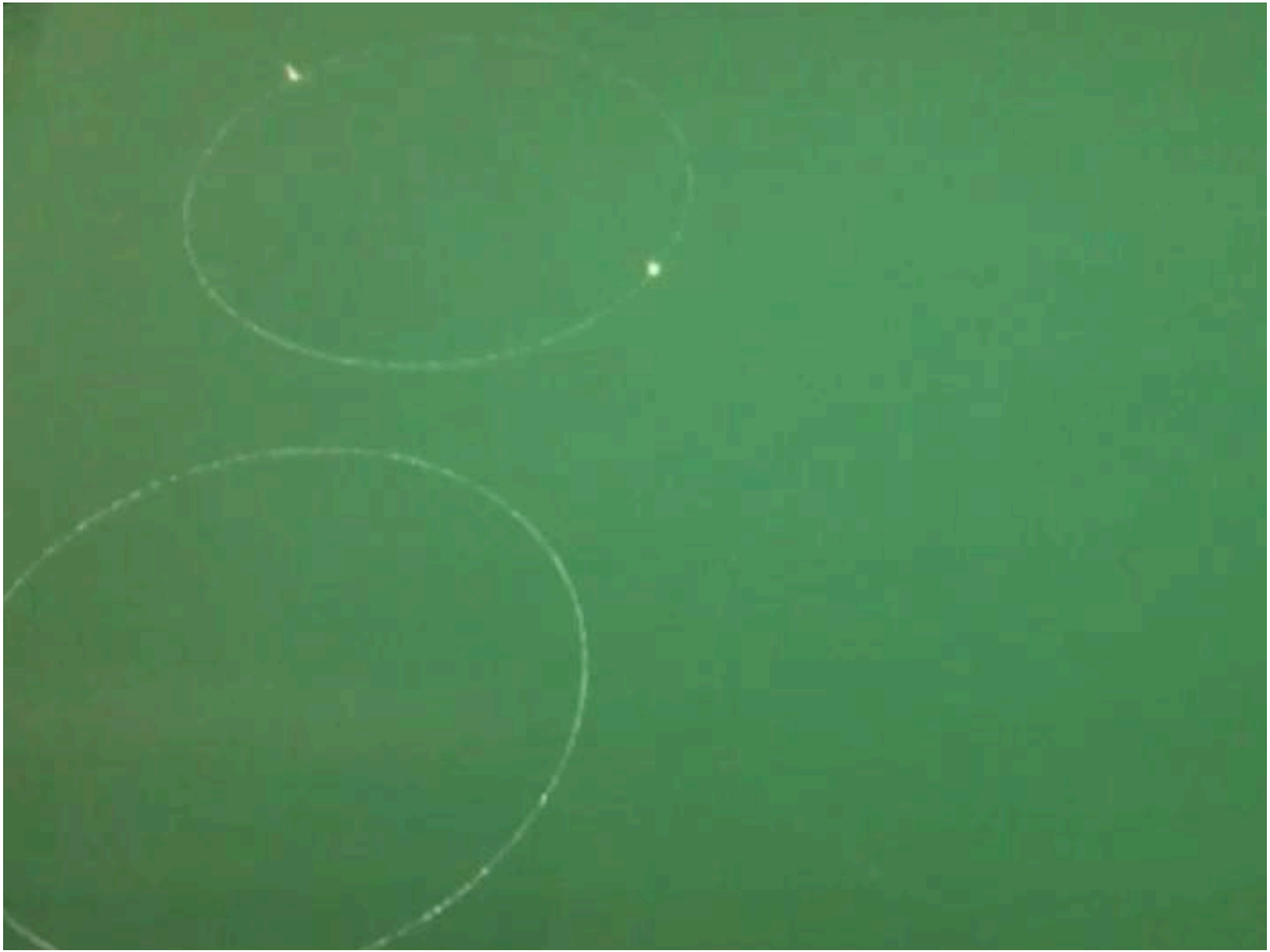
141-02-0061 Rev

Direct Laser Deposition (DLD)

Selective laser Melting (SLM)







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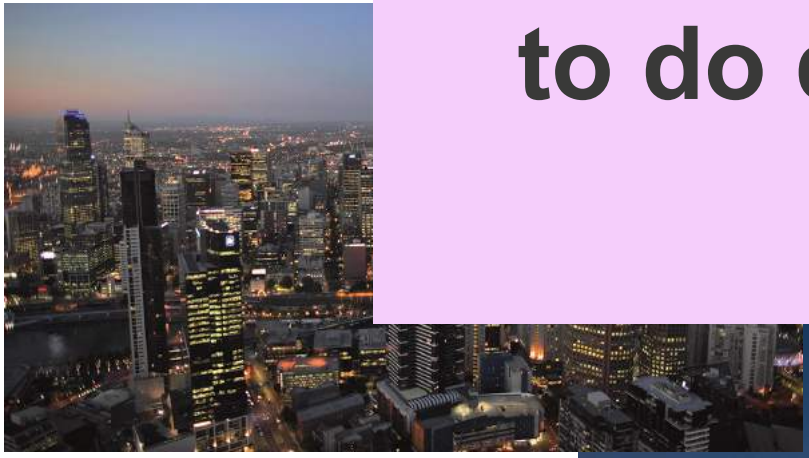
What can Additive Manufacturing allow us to do differently???



Images: Google Images

For a start……..

- **Complexity comes for free**
  - Negative space (or free space) is now a design variable
- **Rapid (very) rapid manufacturing and very local manufacturing**
- **Democratization of technology**
  - A good form of ‘localisation’, as opposed to de-globilisation
  - Important for sovereignty issues
  - Even more important for being enterprising
- **Ability to produce >999,999,999,999,999,999,999,999,999,999,999,999,999,999,.. alloys never previously ‘producible’**
  - This includes so-called High Entropy Alloys
- **Unheard of properties**
  - Turning materials selection on its head (i.e. stainless steels or Al-alloys…..)
- **Ability to produce multi-metal blends**
- **Ability to produce multi-materials……**

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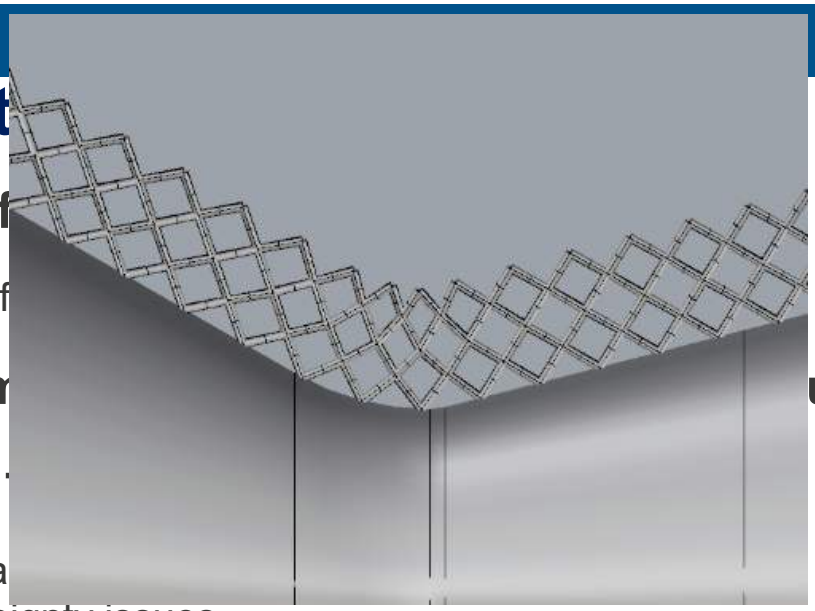

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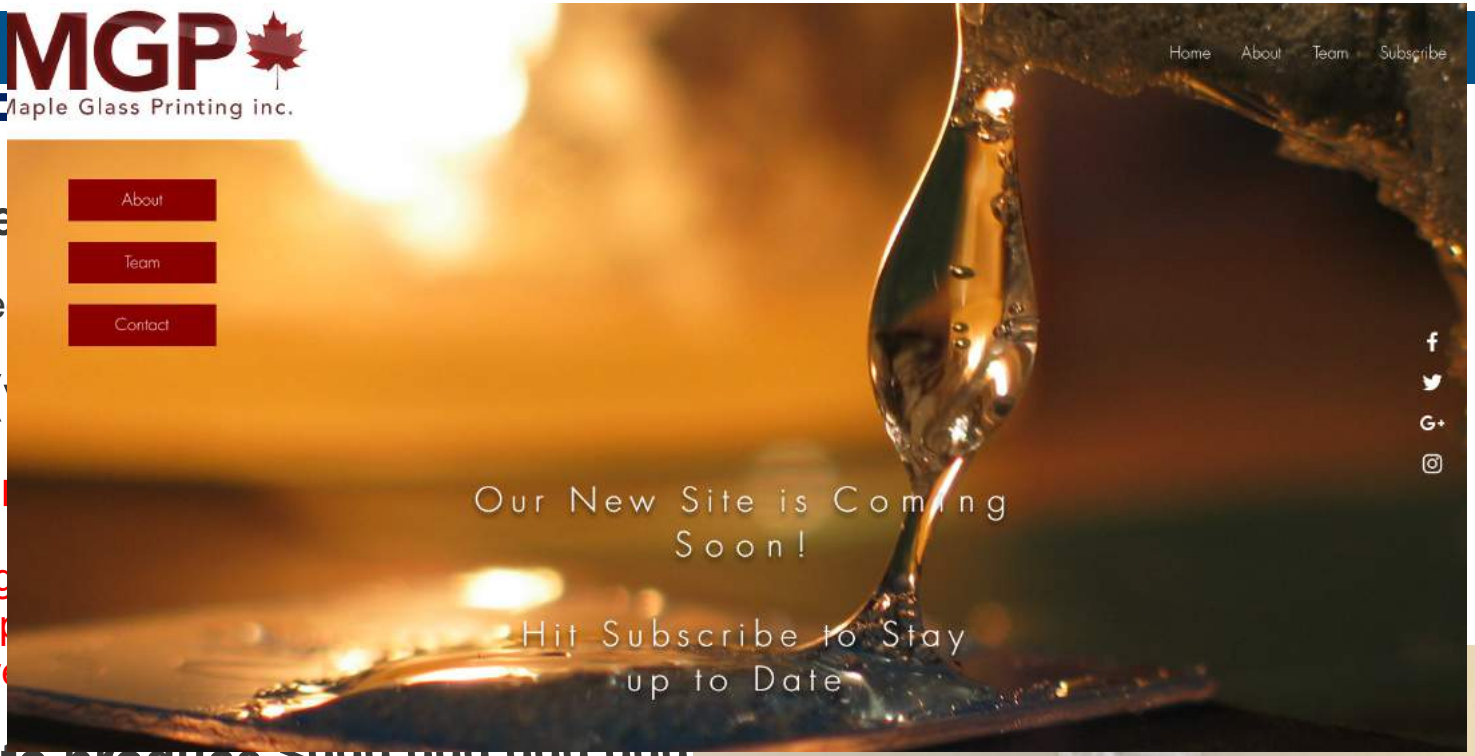
For a start…….

Ability to produce multi-materials……

MGP Maple Glass Printing inc.



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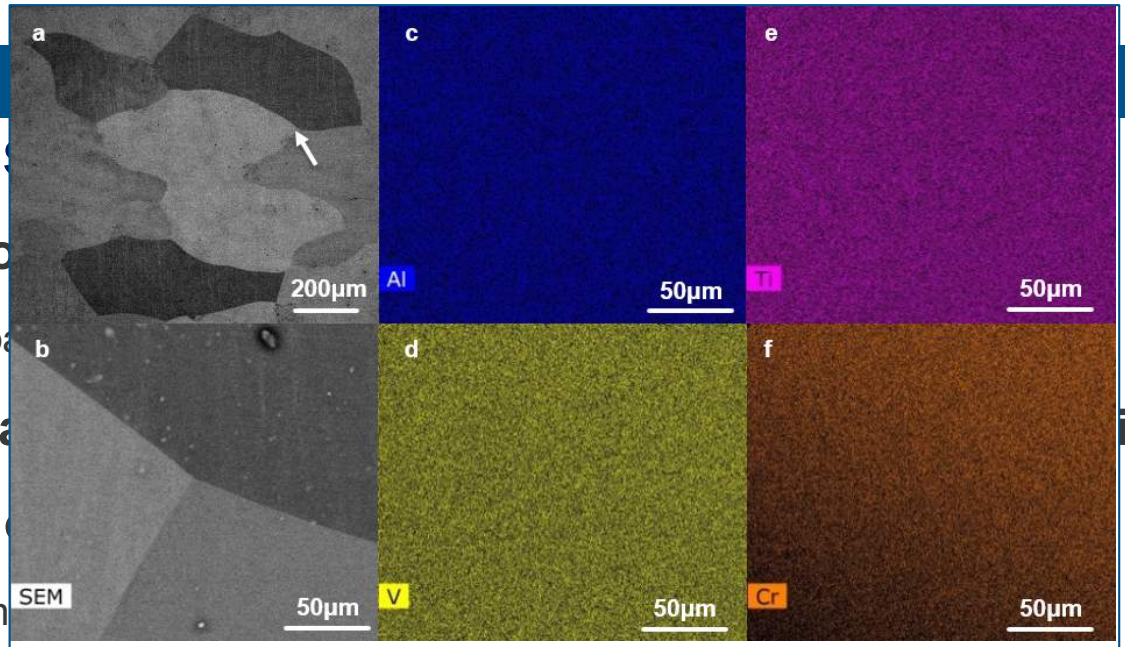
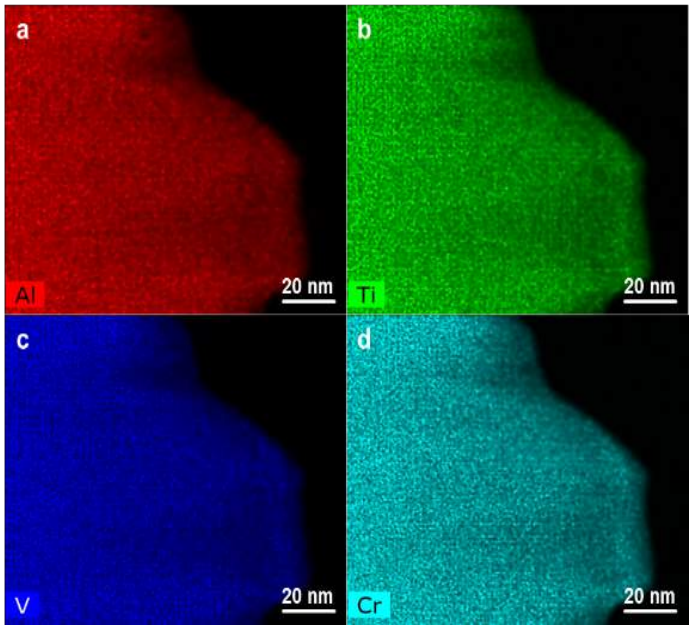


BSE SEM and EDXS of AlTiCrV



STEM mapping AlTiVCr revealing that Al, Ti, V and Cr are uniformly distributed.

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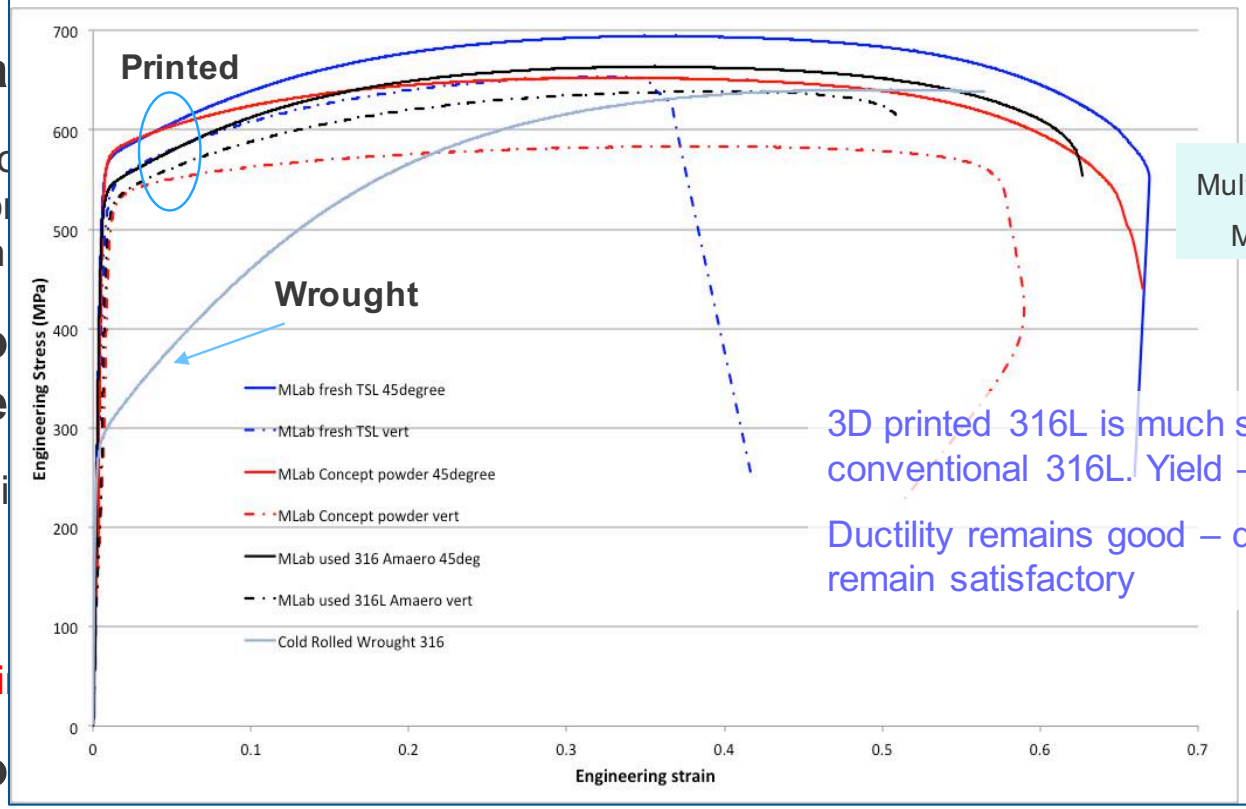
AM produced 316L austenitic stainless steel



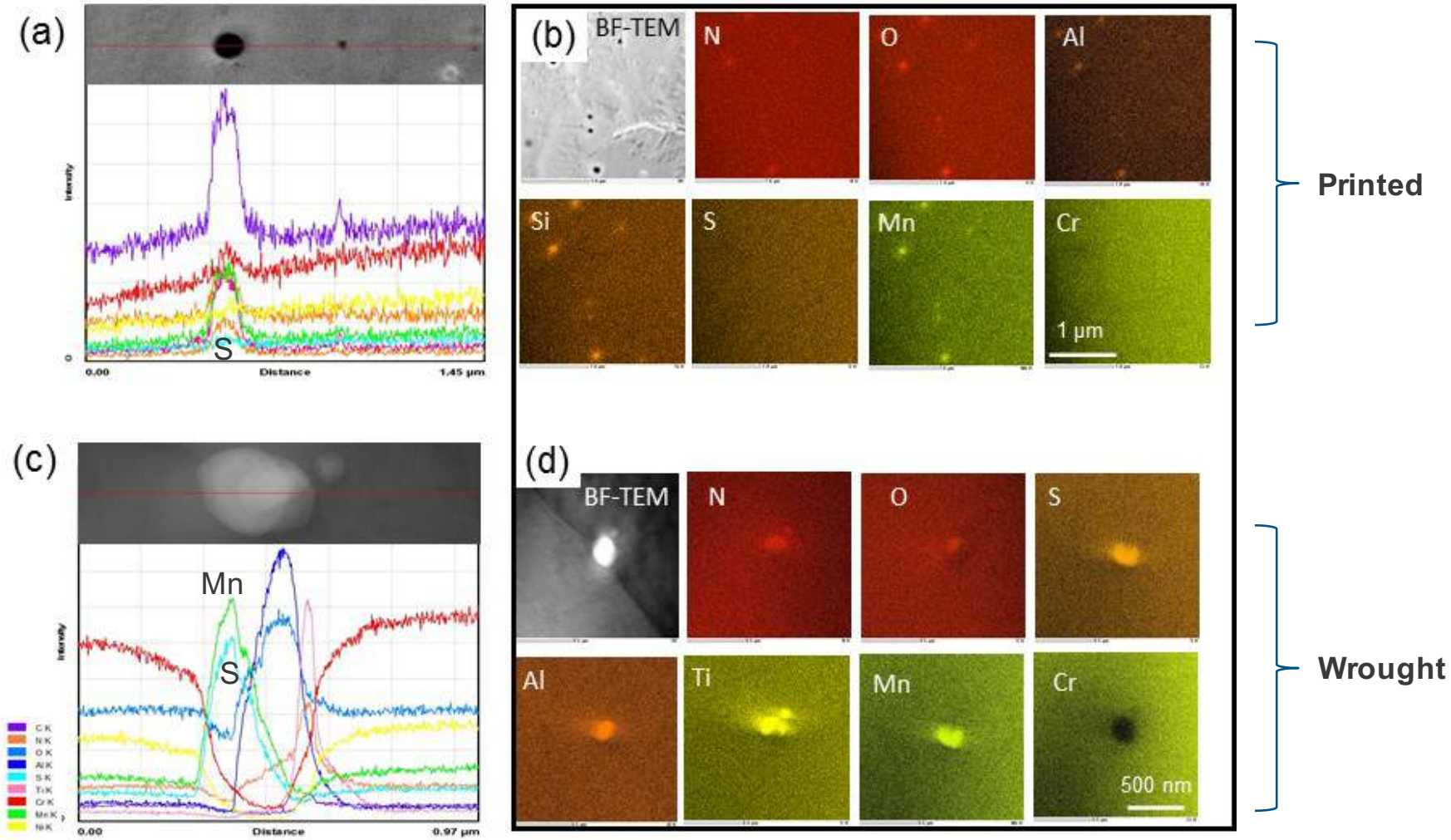
Multiple powder suppliers
Multiple orientations

3D printed 316L is much stronger than conventional 316L. Yield – 540MPa vs 280MPa.

Ductility remains good – damage properties remain satisfactory

MnS inclusions can be annihilated during SLM, increasing the pit initiation resistance.

Inclusion analysis in AM prepared 316L



TEM-EDS line profiles and mapping

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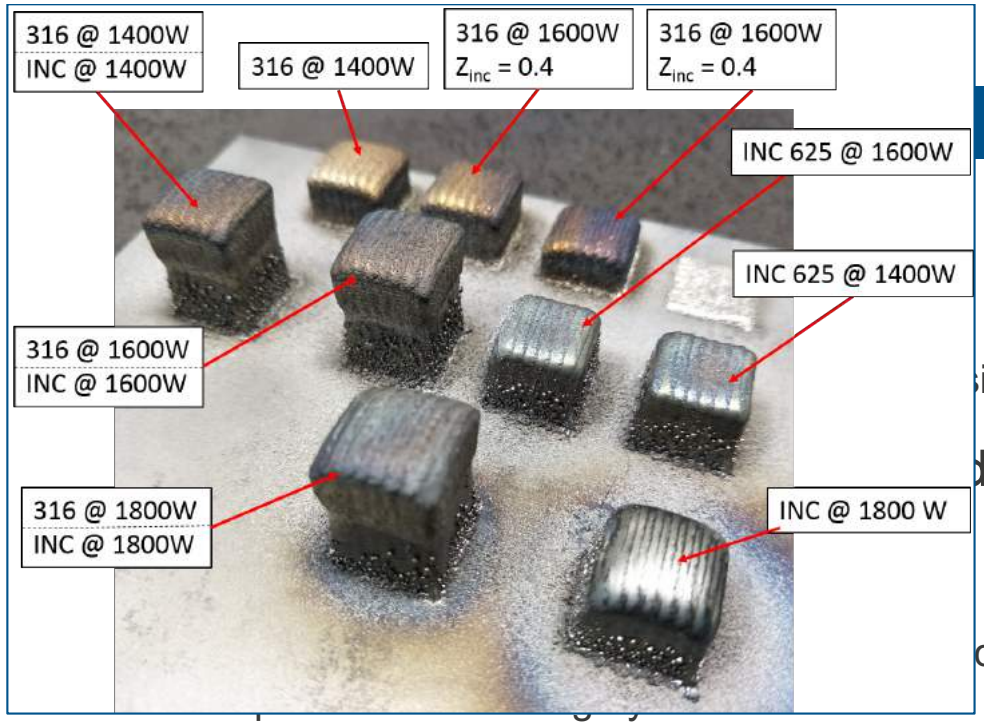

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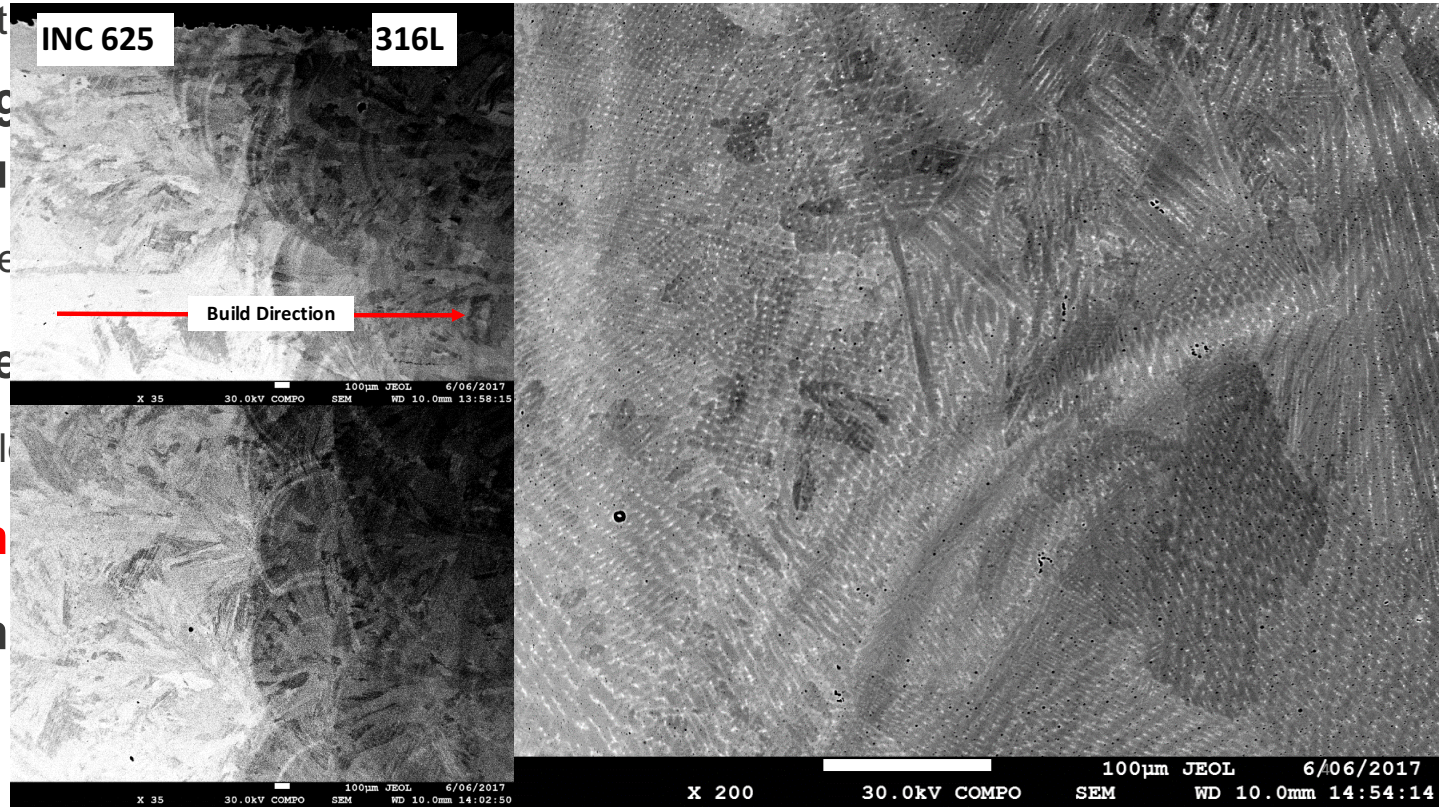

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Conclusions……..

- **AM technology scene is complex but is it bleeding edge ?**
  - Something to ponder over discussions……
- **AM is both in deployment and development at the same time.**
  - AM technology is an enabler…. It is not the technology that is a bottleneck, the immediate issues / challenges are now obvious
- **Today (and tomorrow) issues include:**
  - Design process for 3d printing. “We want to reproduce existing parts without having to make a full design package - but our obligations for design integrity are unchanged” (Neil Kavanagh)
  - Qualification of parts
  - Qualification of parts (again!!)
  - A new generation of metal scientists (different to the last)
  - A new interdisciplinary engineer (this touches on the training aspect)
  - Working out what to do with near-infinite design freedom, and how to deploy (that will define the ‘winner’)…… what is the end-point?
- **An important need to work together. All Victorian universities have something valuable (and unique) to add.**

Thank You

nick.birbilis@monash.edu

Acknowledgments:

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SAFRAN Microturbo

Office of Naval Research ONR Science & Technology

DNV·GL

Signature ORTHOPAEDICS

CleanTeQ environmental innovation

ARL

Mercedes-Benz

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