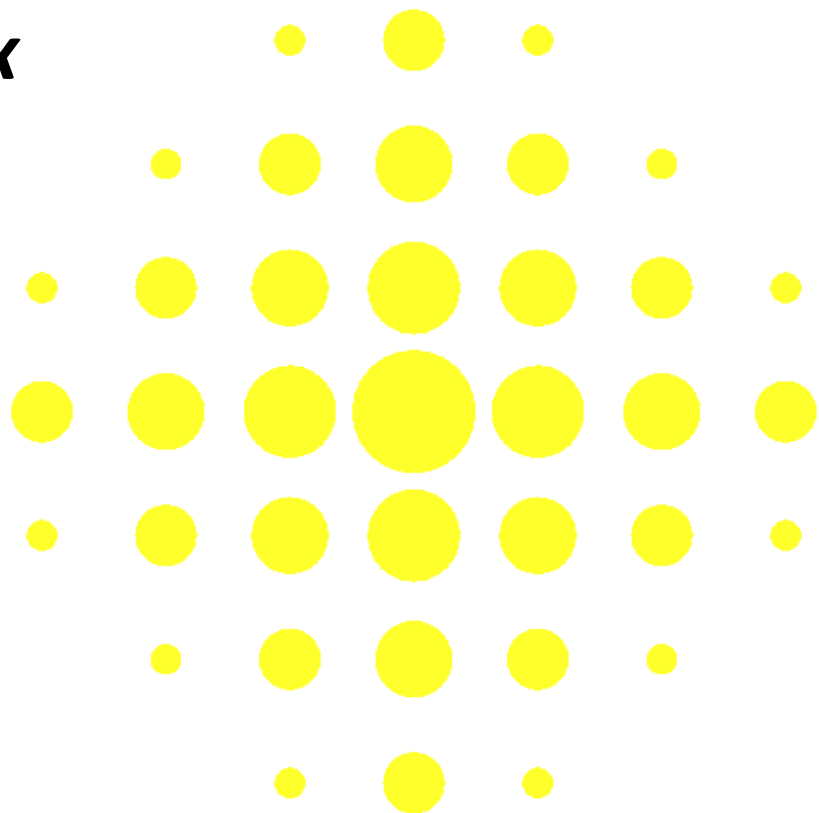


LASERFLEX *Conflux*



LASERFLEX *Conflux*

Experience

Direct

Multi Metal Printing

**An exceptional improvement of SLM
Processing**



What if...

*Your PBF system
used a slurry?*



To apply a thin layer powder...



Use a dispersion



What if...

*we apply this idea to
Powder Bed Fusion?*



Concept



Metal Powder



Metal Dispersion

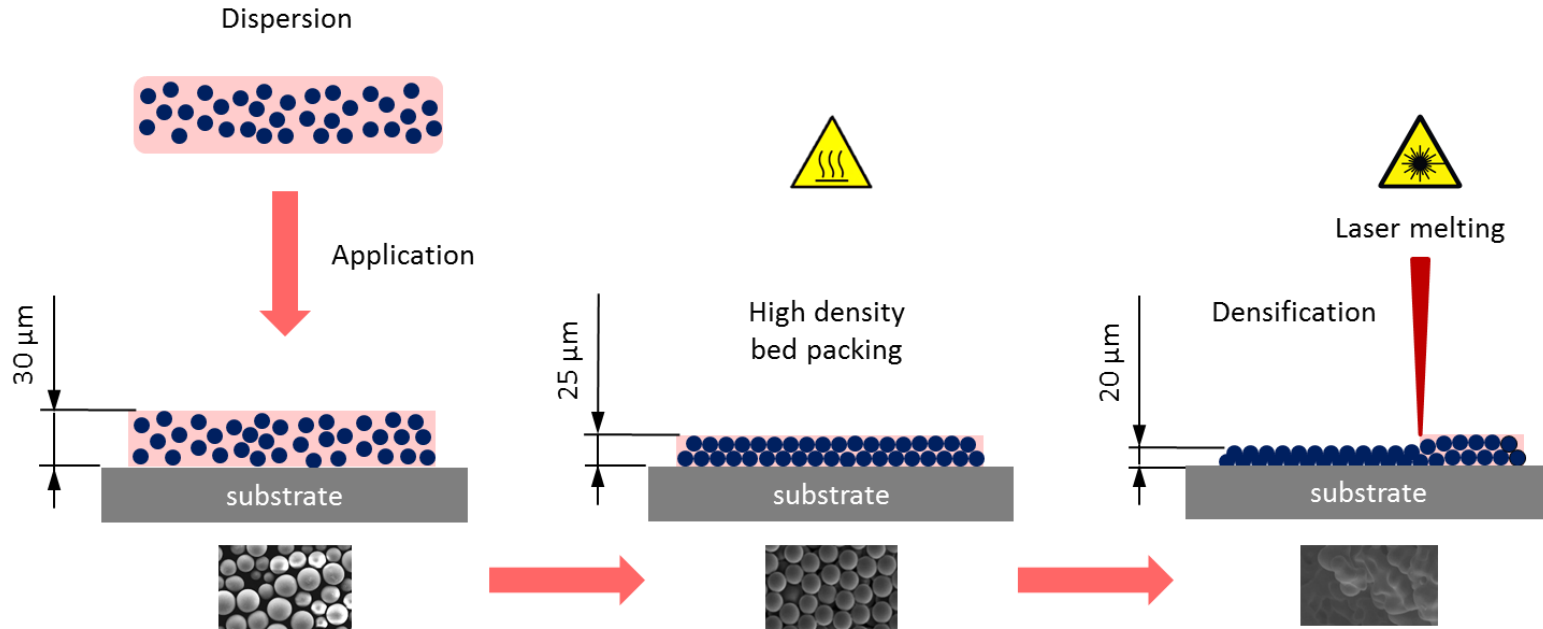


Powder Bed Fusion



3D printed Parts

Concept



You could...

**Improve powder
bed density**

**Reduce internal
stresses**

**Printing
Vertical**

Dispense or jet material

Limit porosity

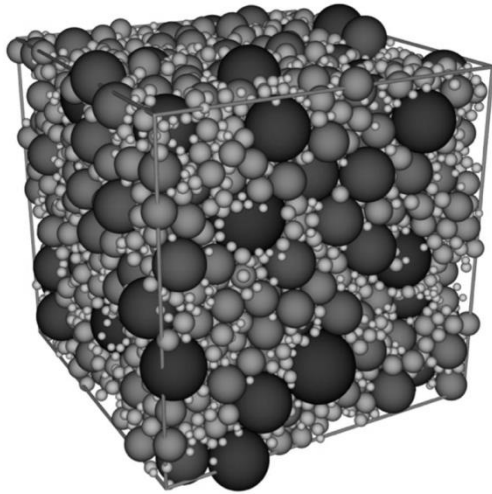
Print multi-material

**Have less health &
safety risks**

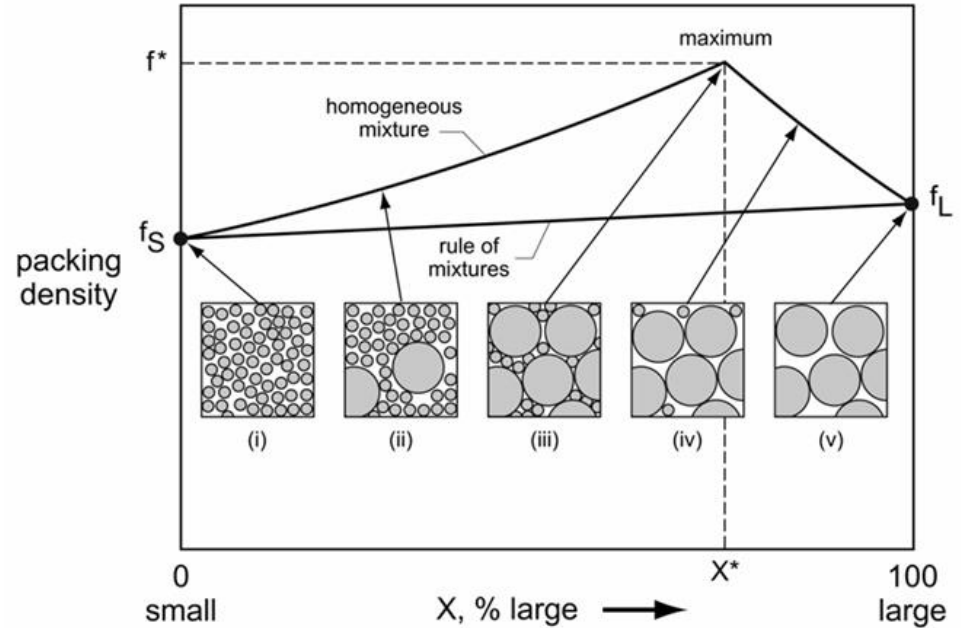
**Have Less
conditioning
problems**

**Use low cost
MIM cut powders**

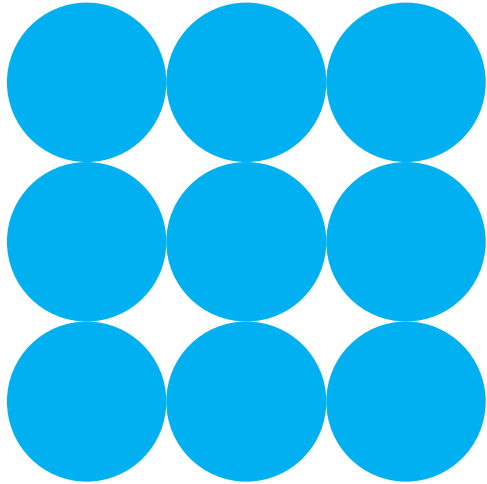
Improve packing density



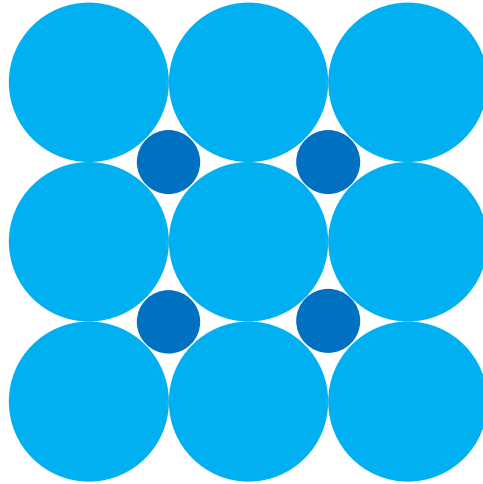
Random close packing fractions
of poly-disperse hard spheres



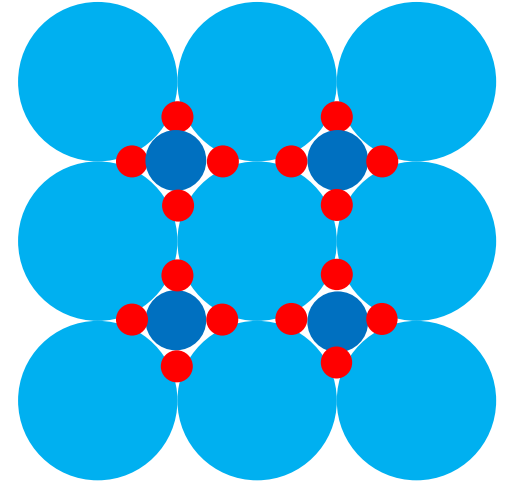
Use different type of powders



Monodisperse

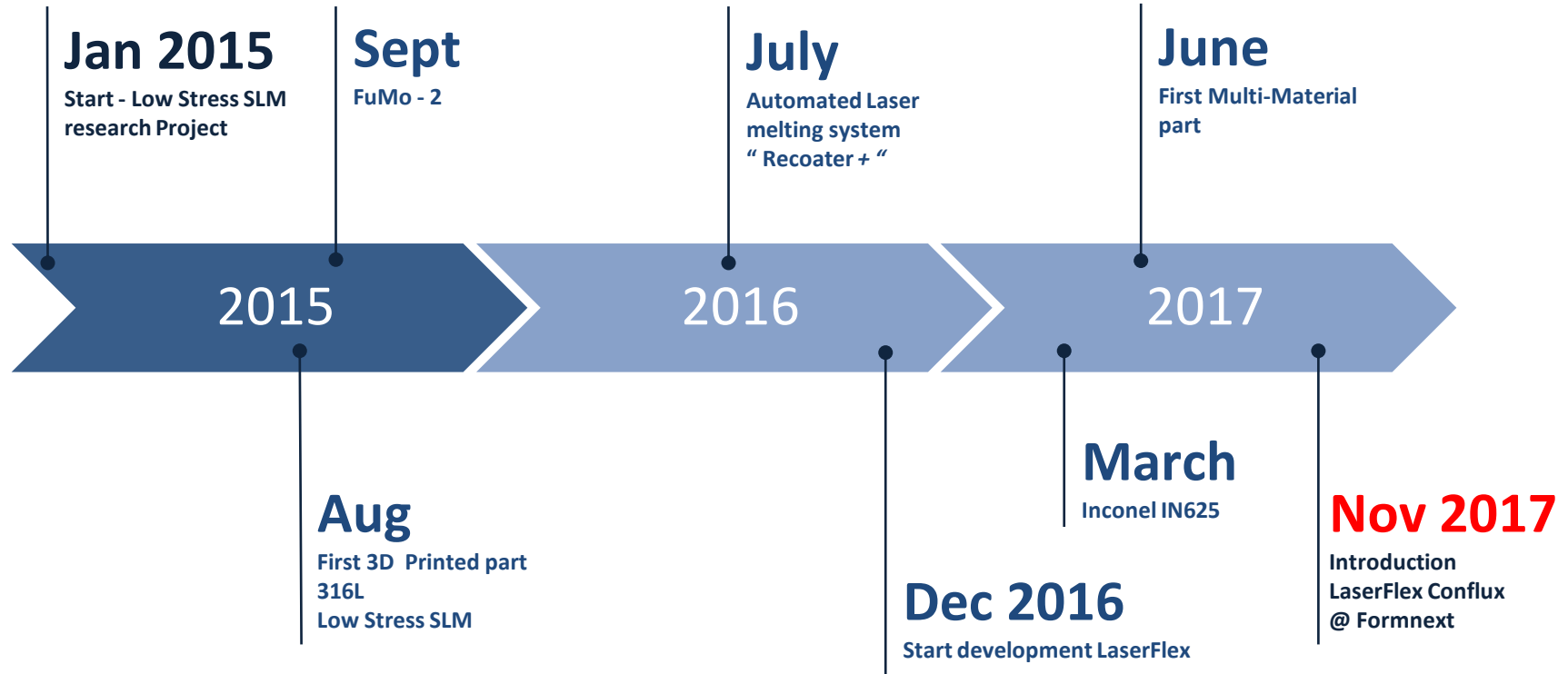


Bimodal



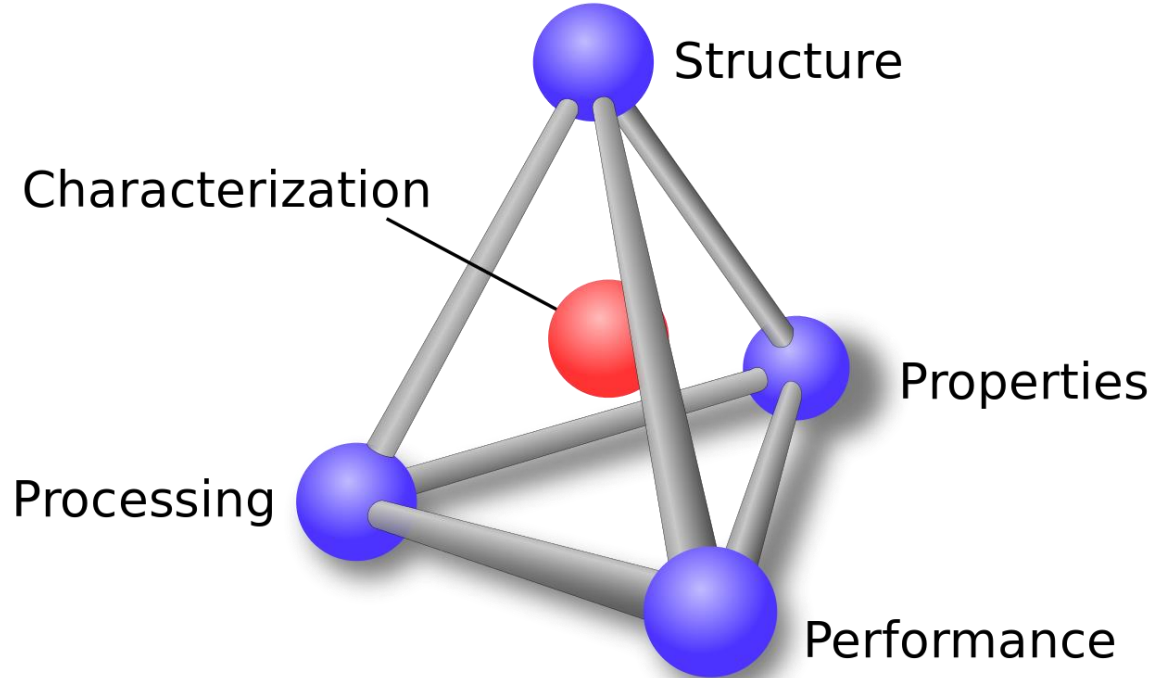
Trimodal

3D Printing Research



The materials paradigm

Materials science tetrahedron

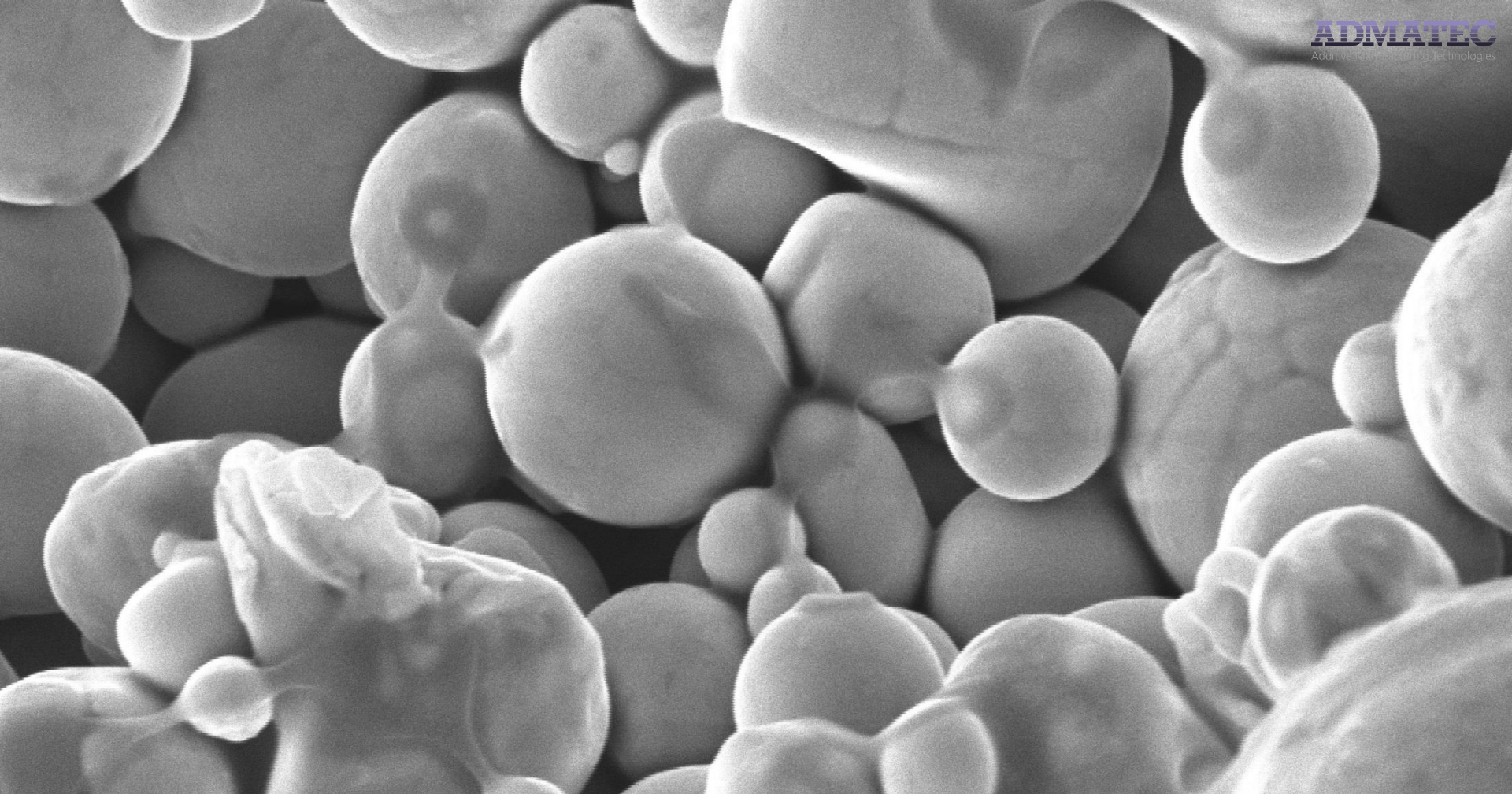


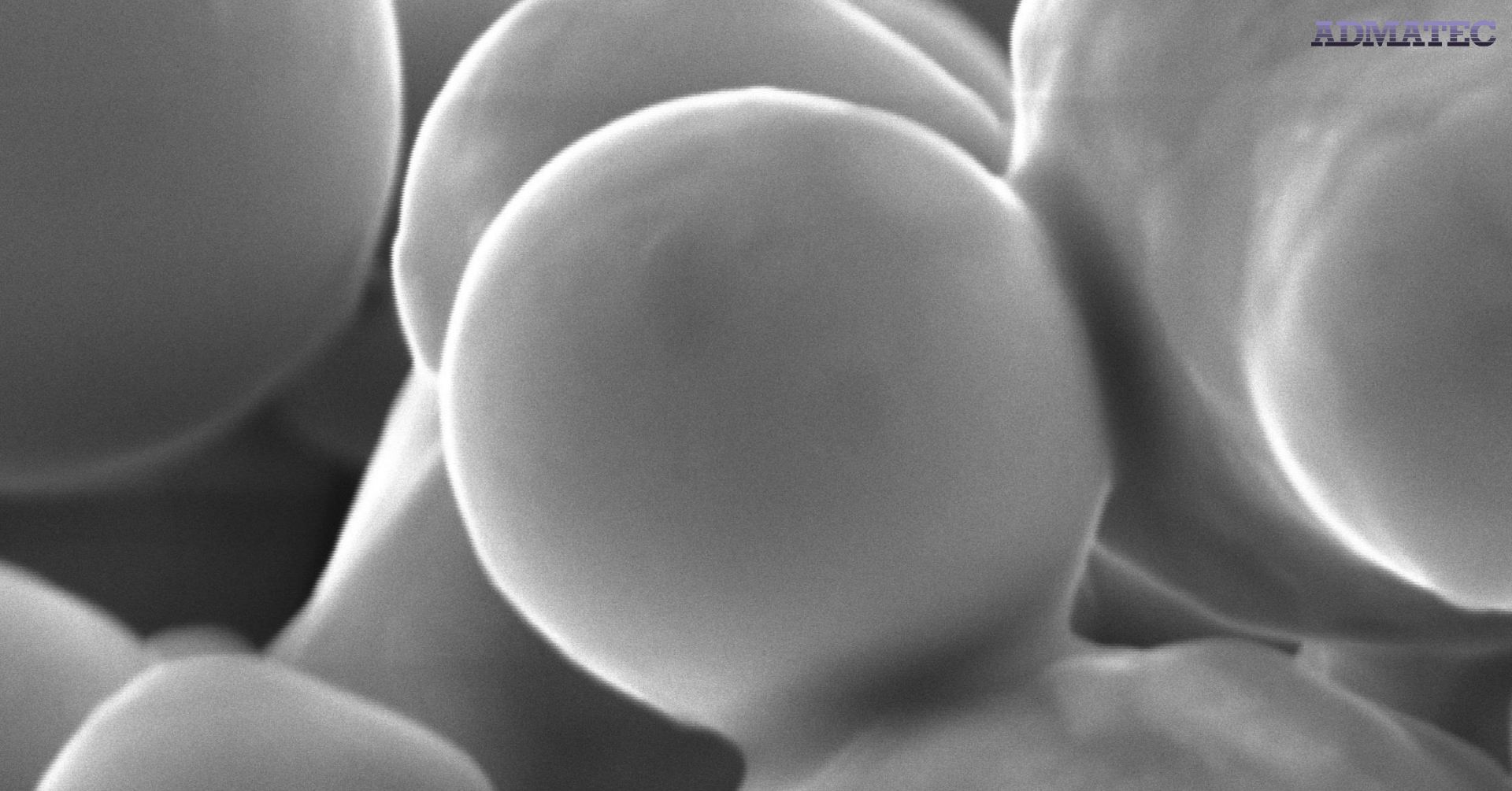
Metal Powder



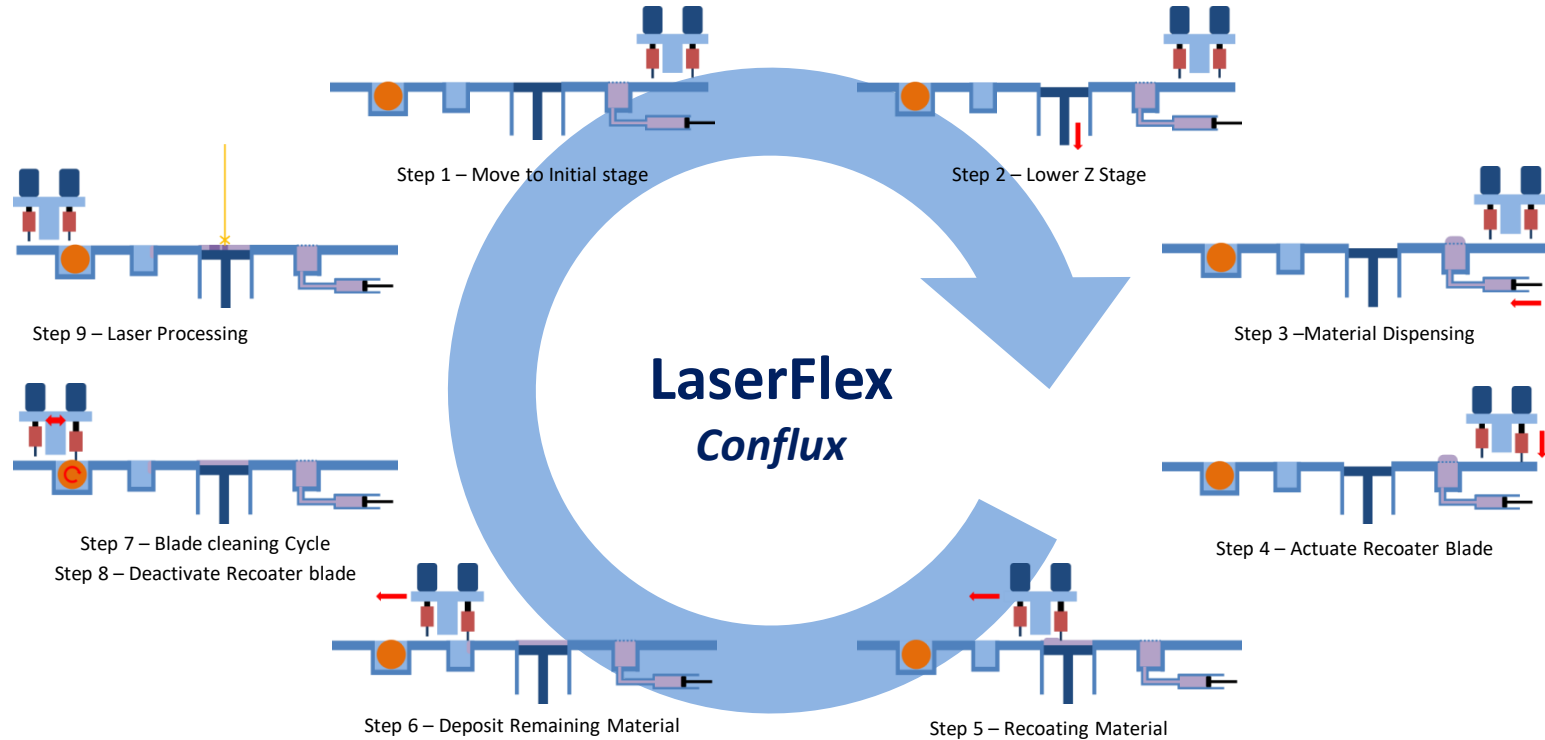
With some additives



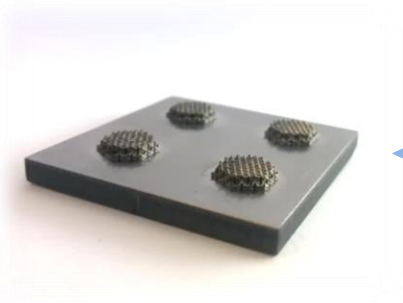
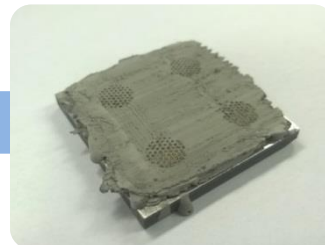
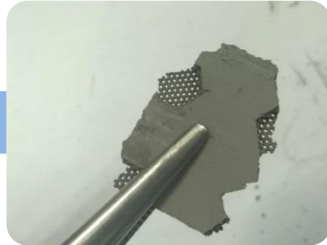
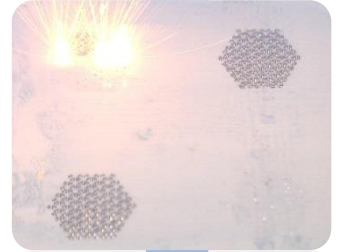
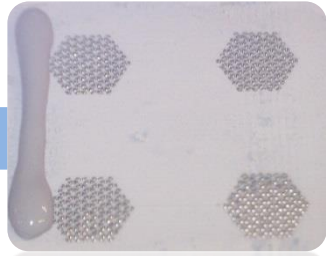




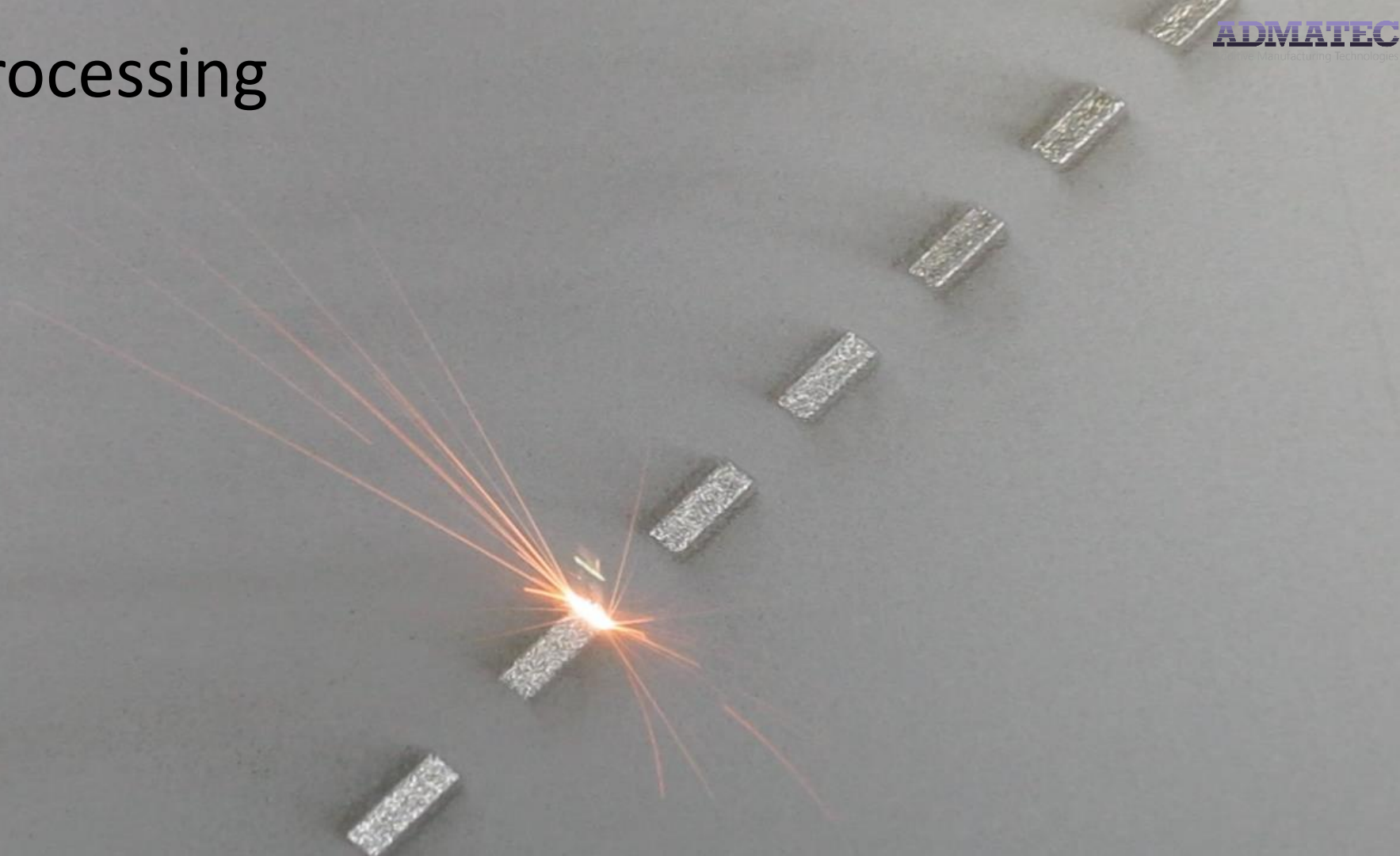
Process Steps



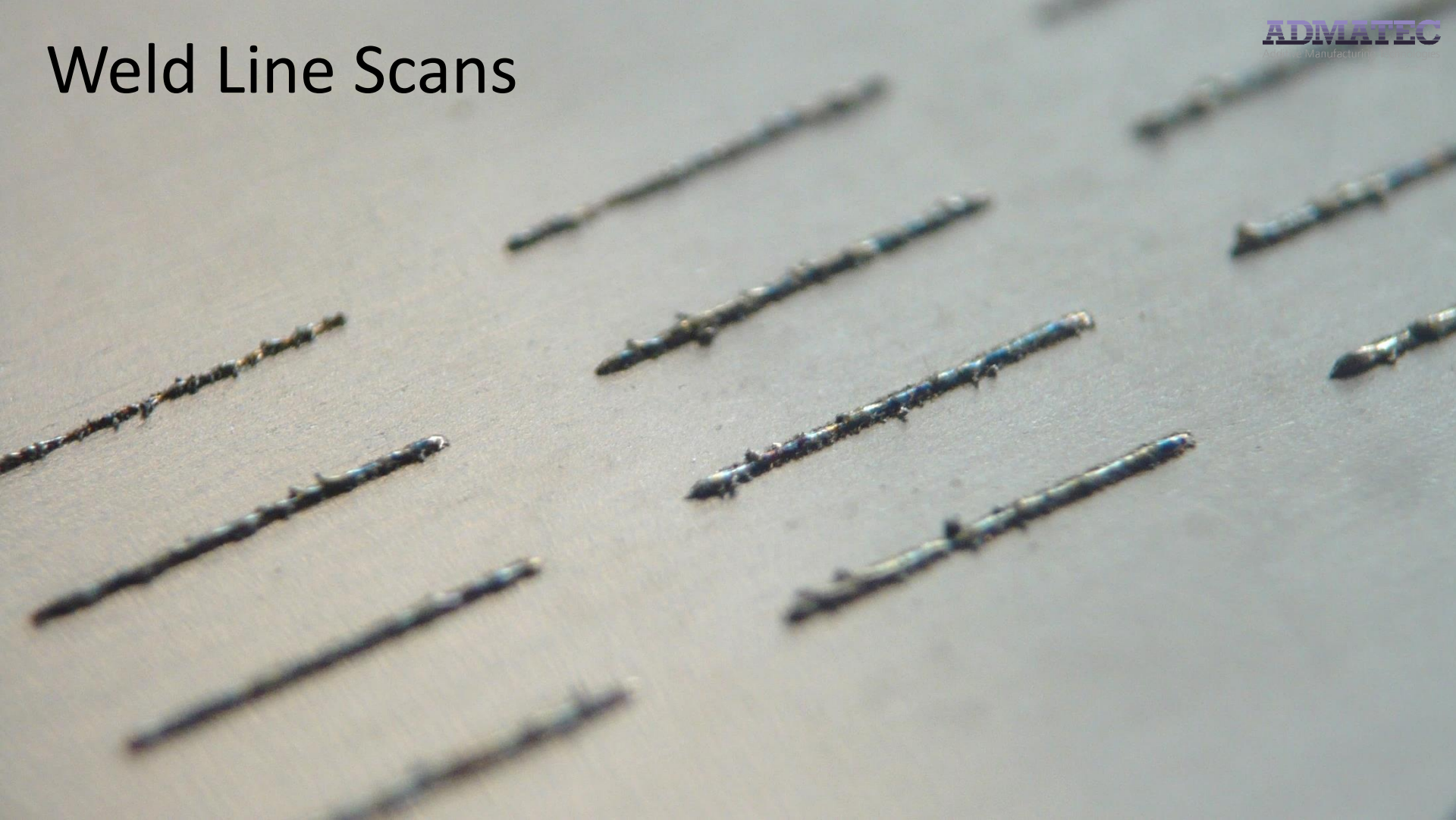
Process Steps



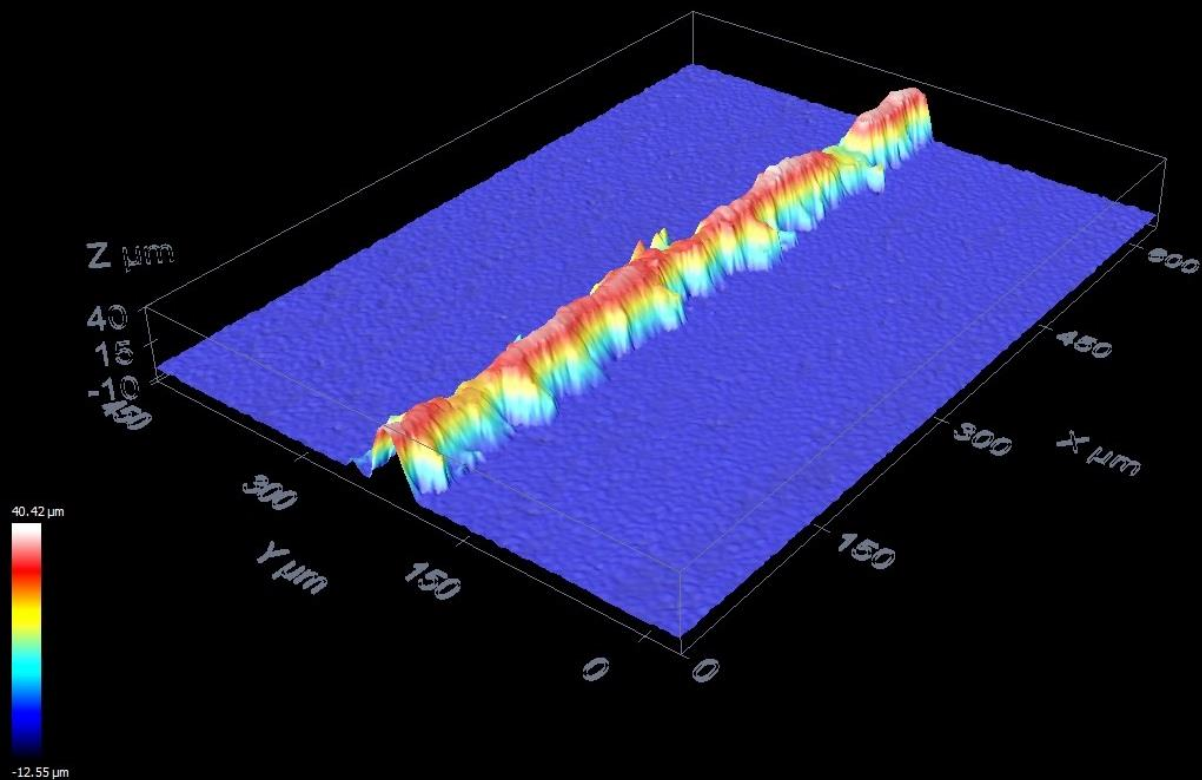
Processing



Weld Line Scans



Characterization

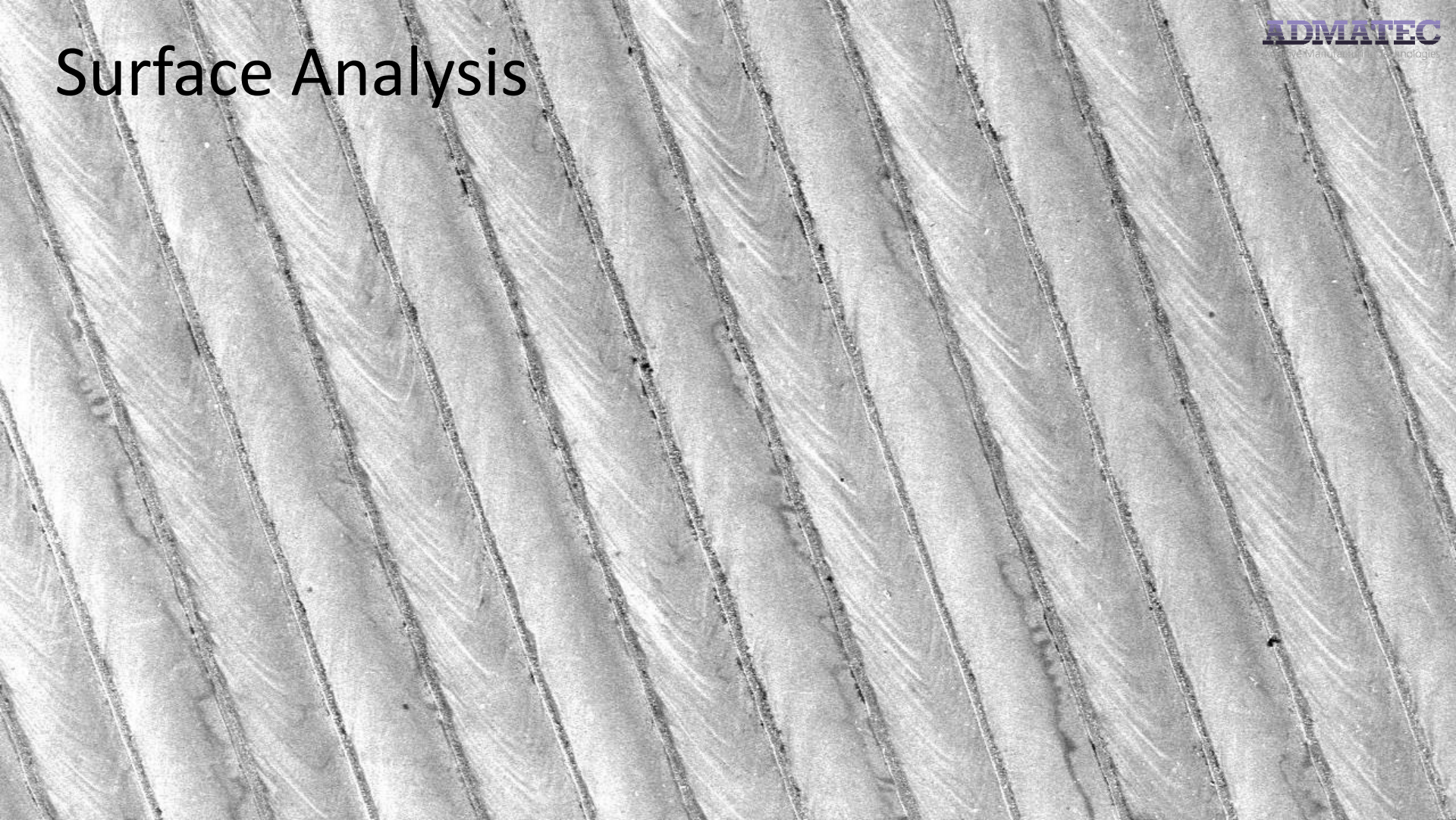


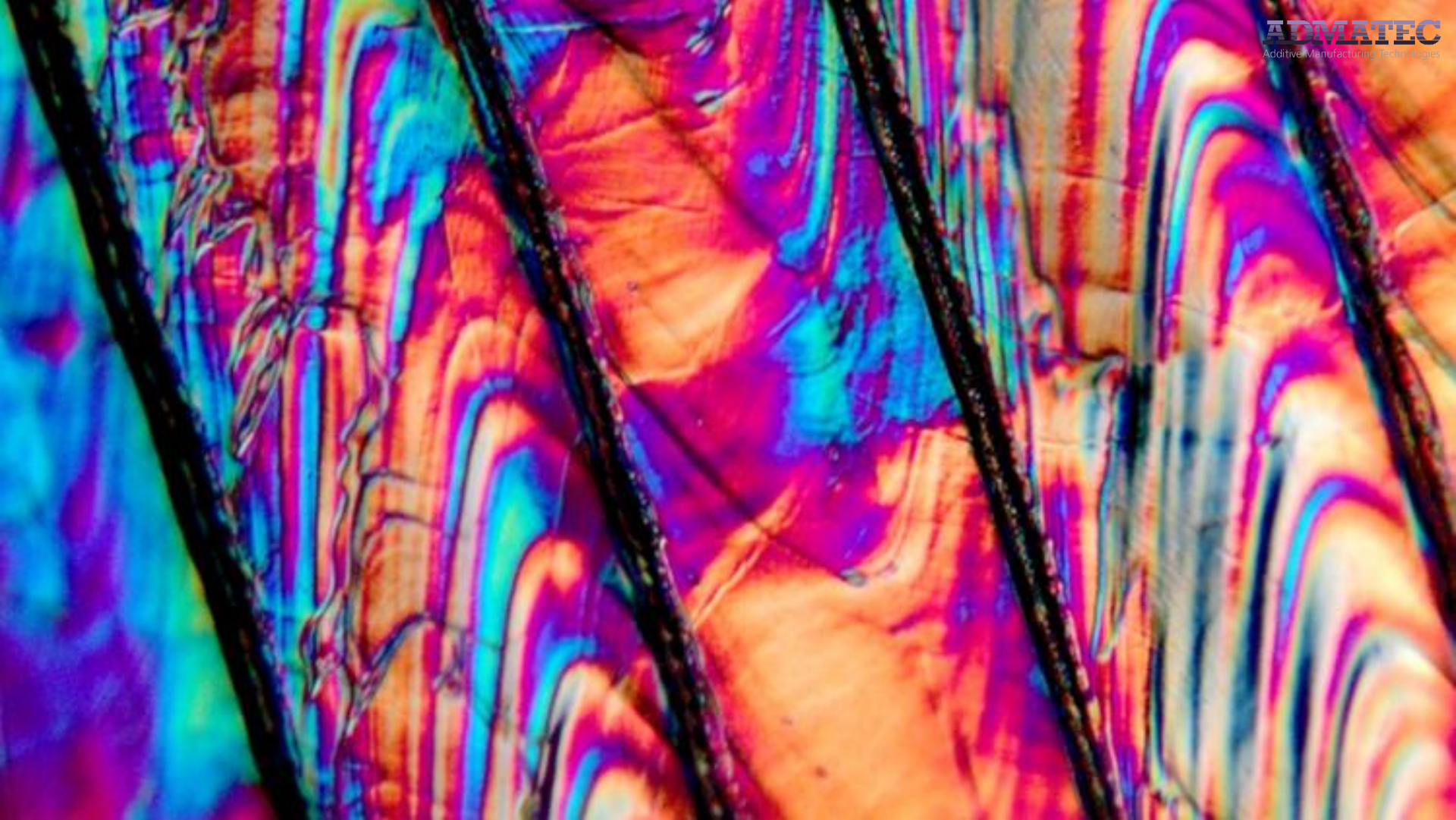


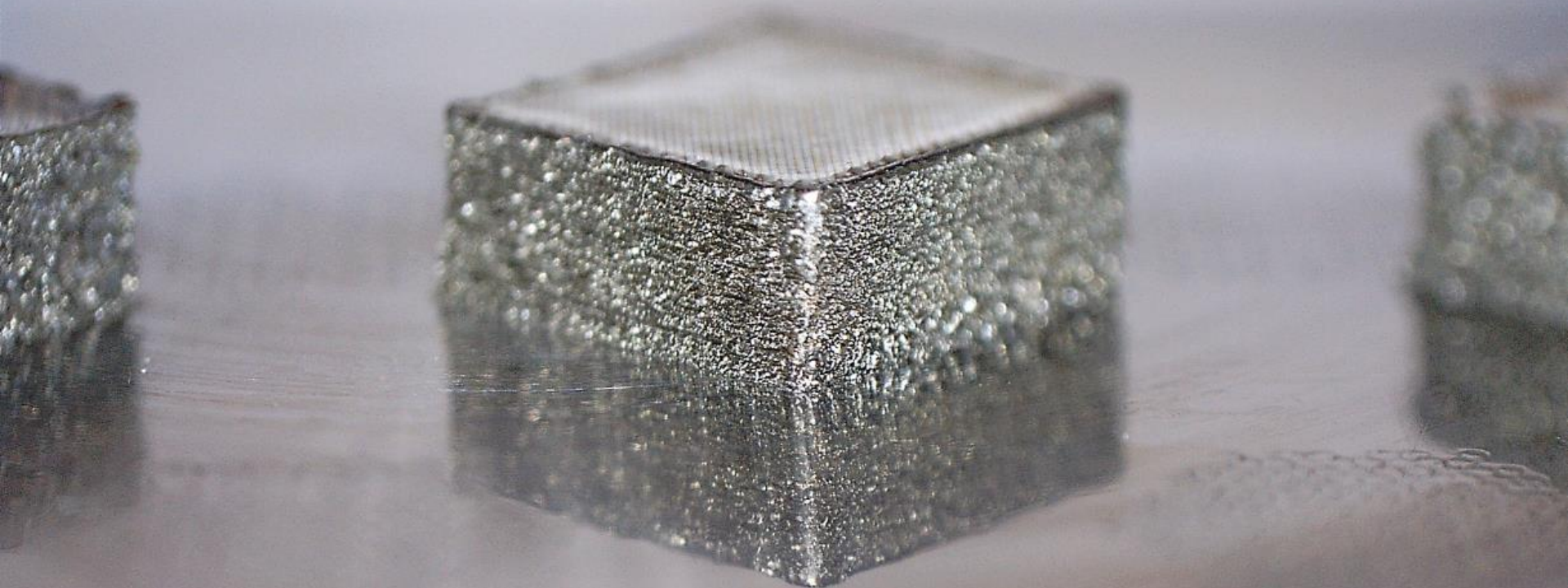
Characterization – Weld Lines



Surface Analysis









Stainless Steel 316L

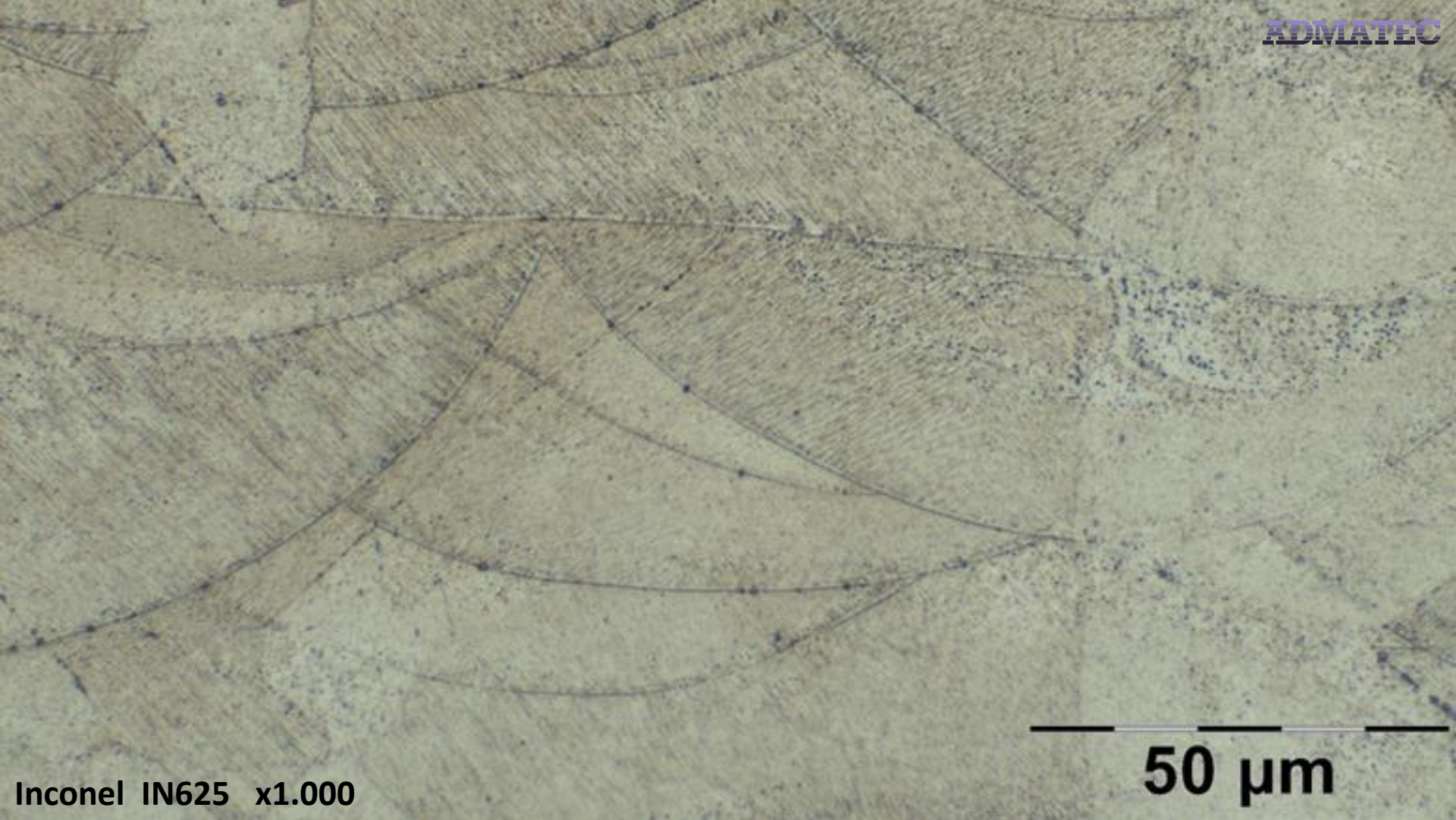


1 mm



200 μm

Stainless Steel 316L

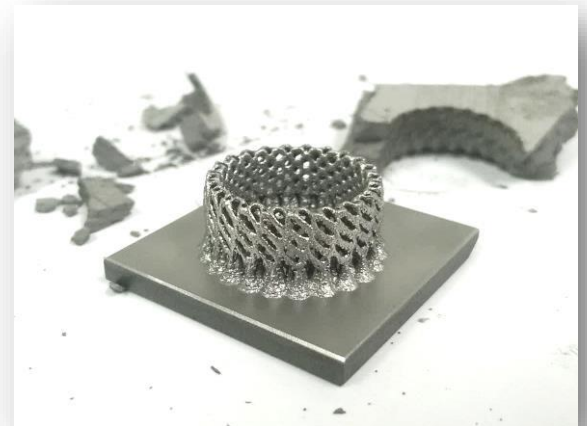
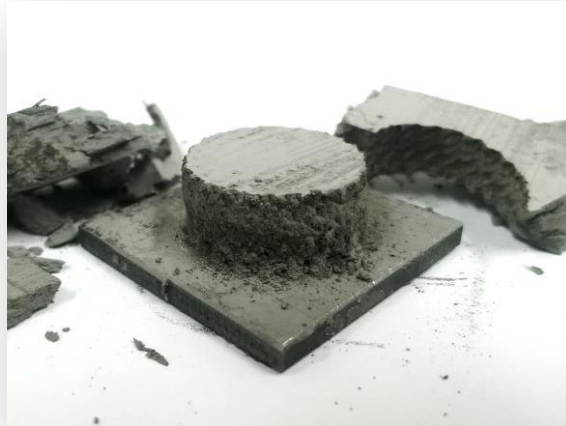


Inconel IN625 x1.000

50 μm

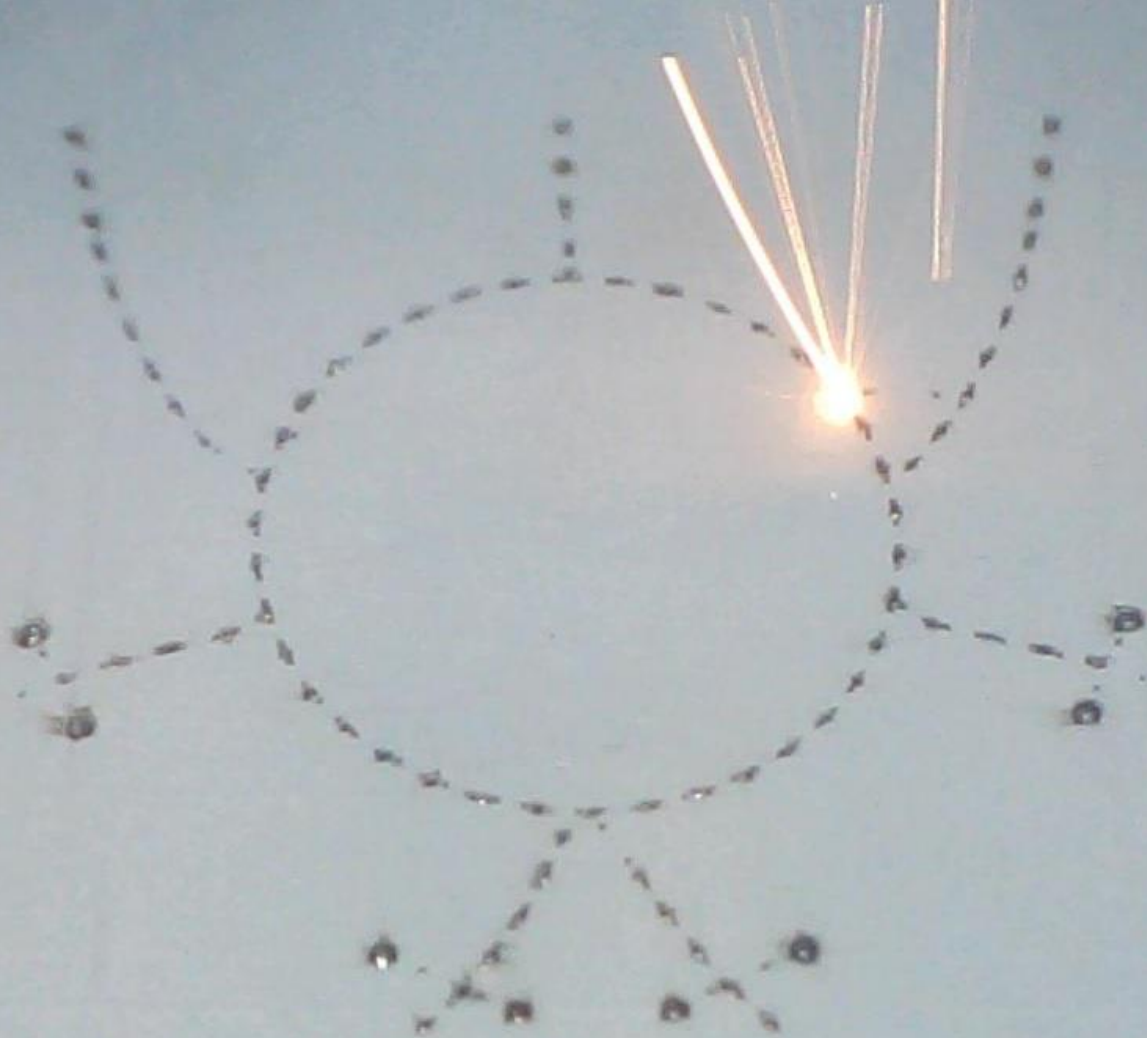


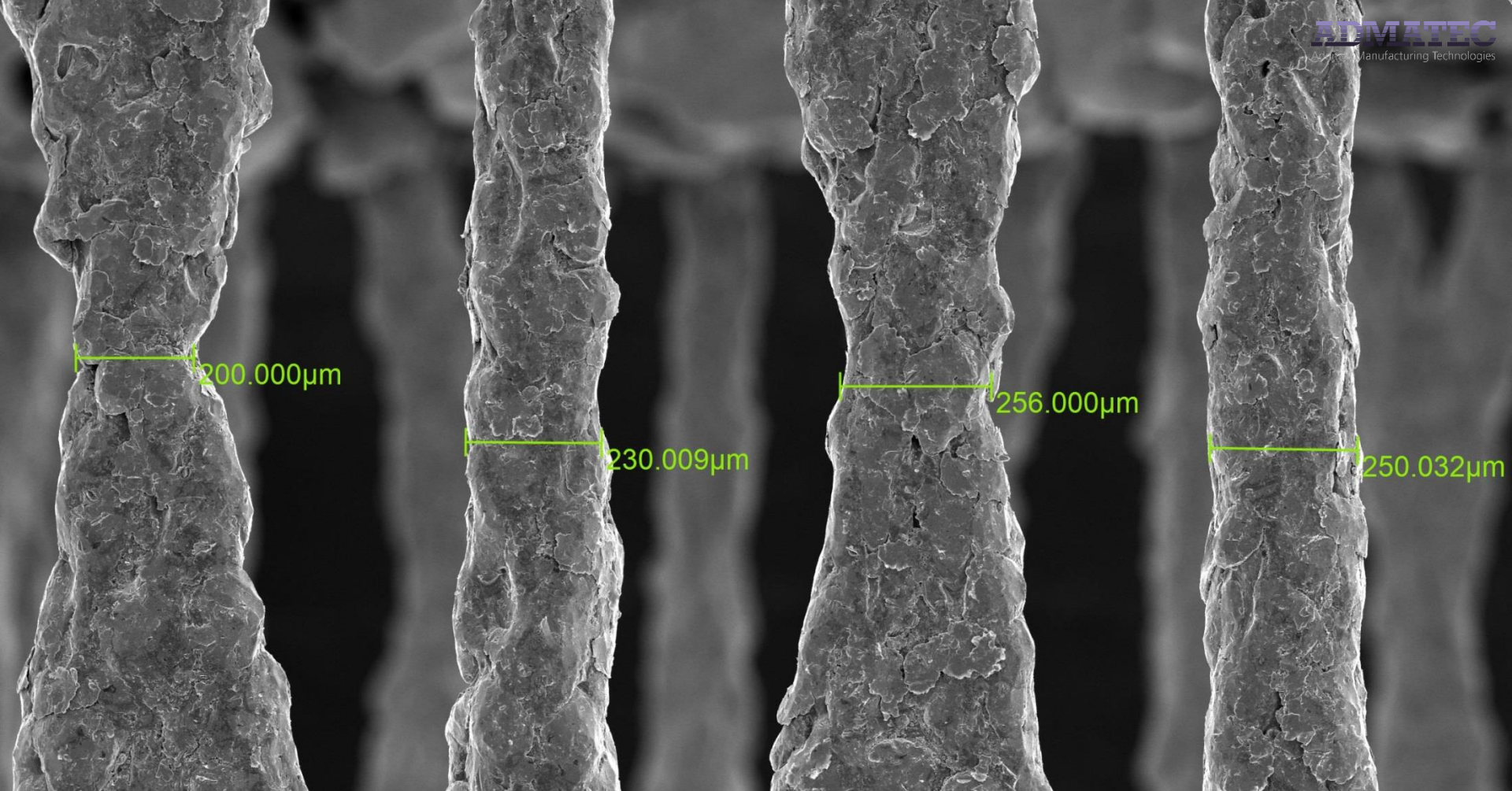
Unpacking





Features



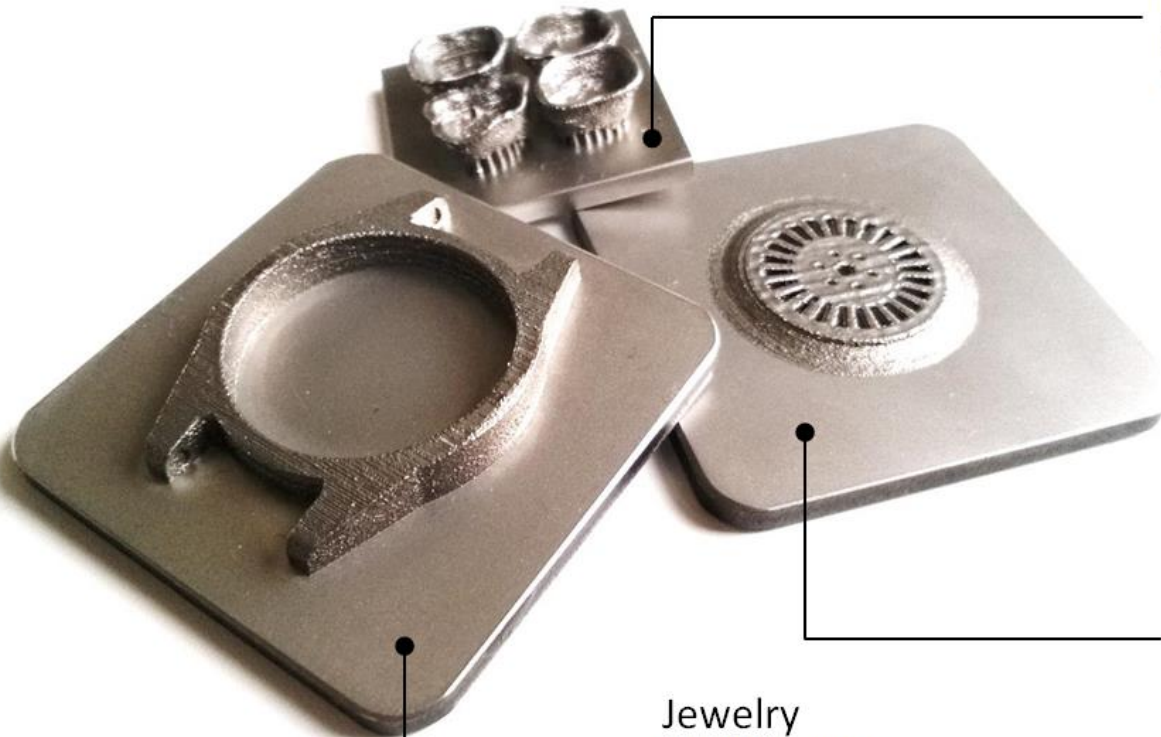


200.000μm

230.009μm

256.000μm

250.032μm



Dental
No. of layers: 330
Height: $\approx 6\text{mm}$
Volume: 0.47 cm^3

Industrial
No. of layers: 83
Diameter: 25.5 mm
Height: $\approx 1.5\text{ mm}$
Volume: 0.39 cm^3

Jewelry
No. of layers: 235
Dimensions: $36 \times 28.5 \times 4.3\text{mm}$
Printed volume: 0.92 cm^3

Material Properties

Mechanical properties

Strain – Stress measurement

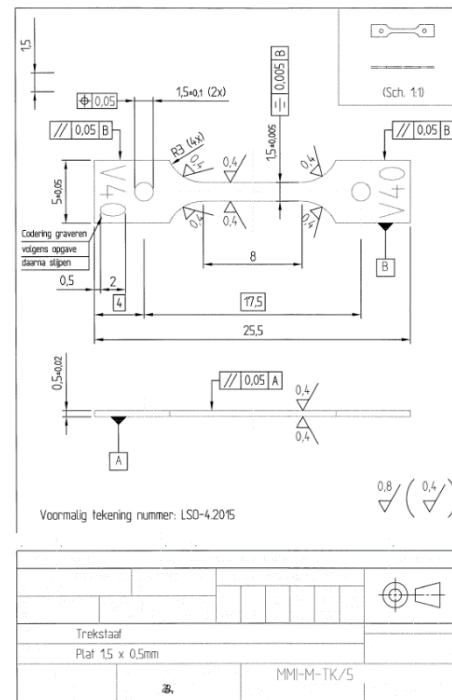
Mini Tensile Specimen

According ISO 6892 / ASTM E8M

Micro Harness

Vickers

Element detection



Mechanical Properties

EDM Wire cut from base plate
Ø 1.5 mm holes produced afterwards
Only brushed and no heat treatment
before testing



Mechanical Properties

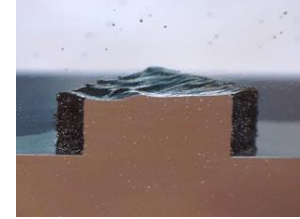
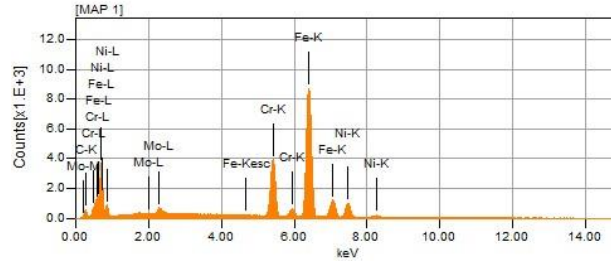
	EOS ¹ Stainless 316L		Concept Laser ¹ 1.4404 316L	SLM Solutions ¹ 1.4404 316L	ECN ² LaserFlex 316L	Reference 316L Sheet	Norm 1.4404
Orientation	Horizontal (XY)	Vertical (Z)	Average Horizontal / Vertical	-	Horizontal (XY)	-	-
Tensile Strength (MPa)	640 ± 50	540 ± 55	570	633 ± 28	675	686	500 - 700
RP0.2 Yield Point (MPa)	530 ± 60	470 ± 90	470	519 ± 25	519	315	≥ 200
Fracture Strain (%)	40 ± 15	50 ± 20	> 15	30 ± 5	19.6	80	≥ 30
Young's modulus (GPa)	185	180	200	184 ± 20			
Hardness	typ. 89 HRB		20 HRC	209 HV	≈ 200 (204 HV ≈ 12HRC ≈ 92 HRB)		Typ. 81 HRB 95 max

1: suppliers datasheets

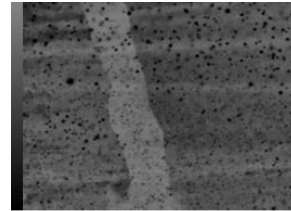
2: without annealing after printing and removal of build plate by EDM

Element Analysis

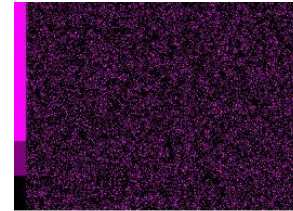
- Mapping
 - Sample 170816 – 2
 - Magnification: 10.000 x



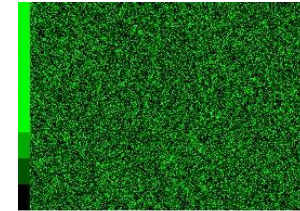
Chemical formula	Position	Reference*	
		Specification (mass %)	Result (mass %)
Fe	Core 10.000x (mass %)	Report	Balance
C	7.24	Max 0.03	0.024
Cr	17.11	16.00 ~ 18.00	17.78
Ni	10.67	12.00 ~ 15.00	12.18
Mo	1.85	2.00 ~ 3.00	2.10



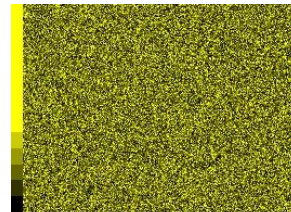
BEC



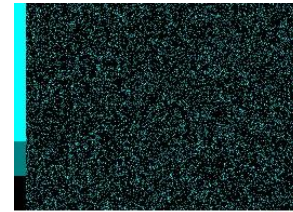
Ni K



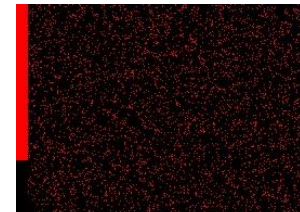
Cr K



Fe K



Mo L

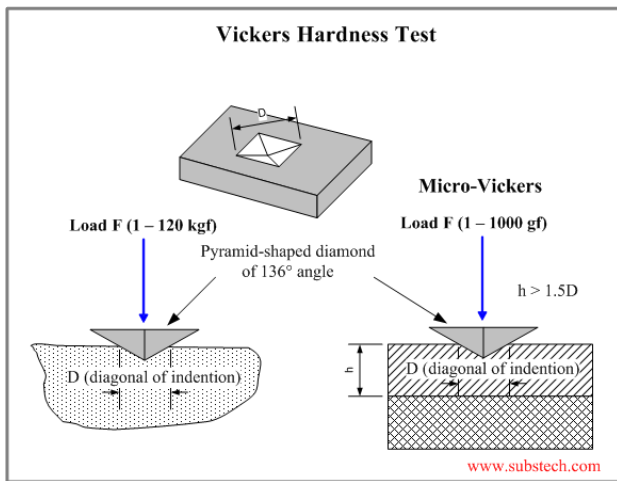


C K

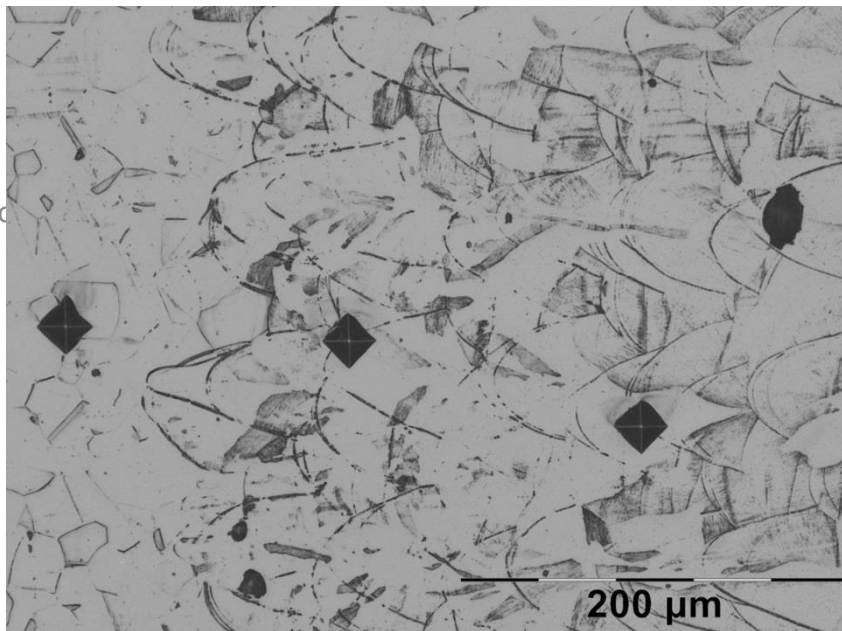
Microhardness Measurements

Micro indentations;

- To determine mechanical properties
- Micro Vickers
- Hardness -> Tensile Strength



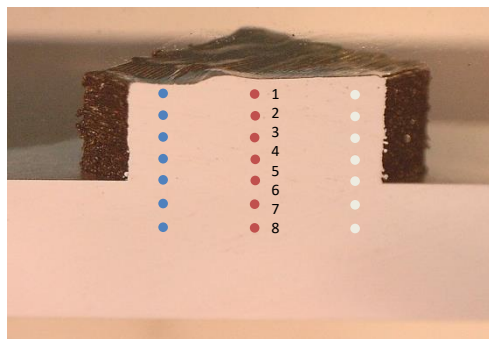
Micro



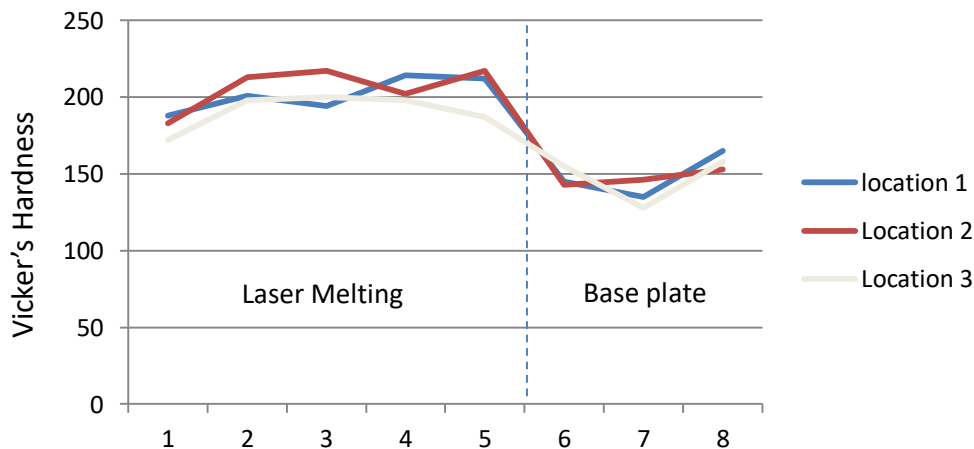
Microhardness Measurements

Material Characterization by Indentation

- Indentation hardness correlates linearly with tensile strength
- Hardness \sim Rate of Cooling
- Rate of Cooling \sim $T_{max} - T_{base}$



Micro Indentation points on cross section

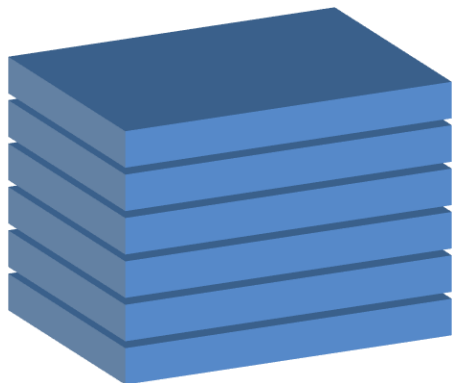


Functional Graded Materials

Multi Material Processing

1D

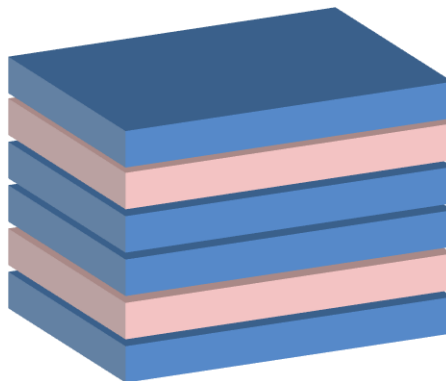
Mono Material part



No Change of Material

2D

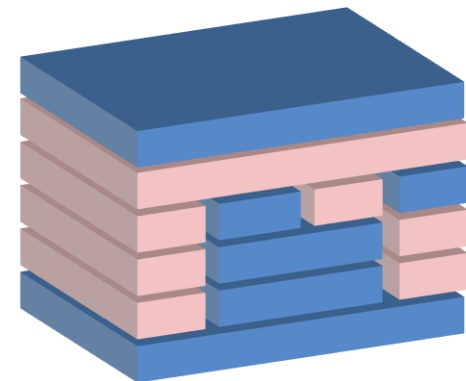
Hybrid part



One material per layer

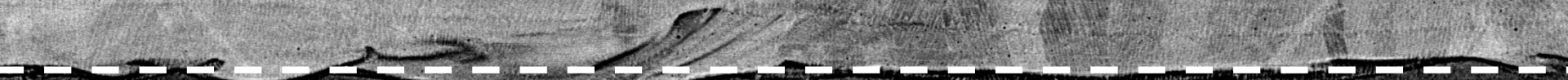
3D

Multi Material part

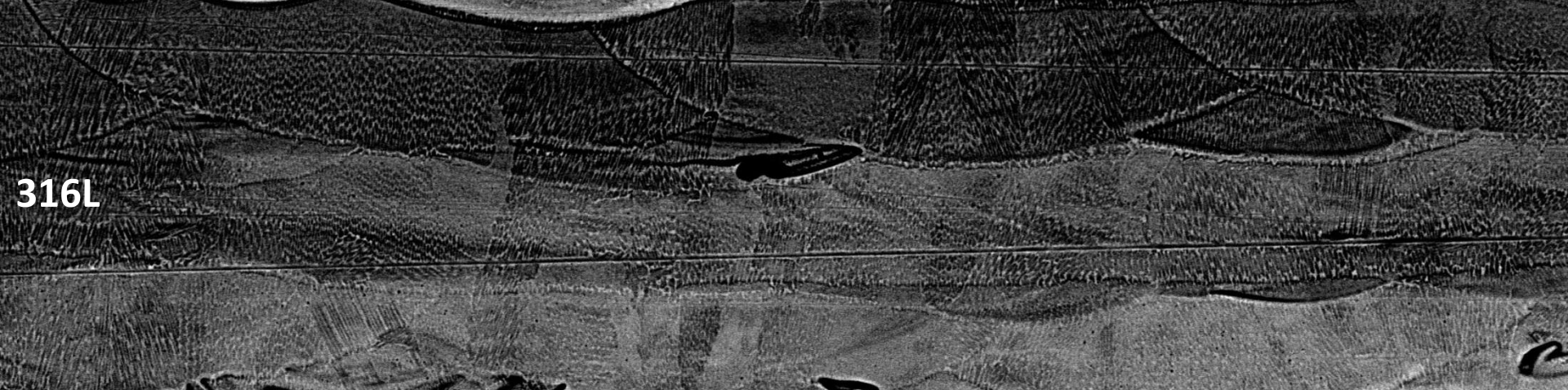


Arbitrary change of material

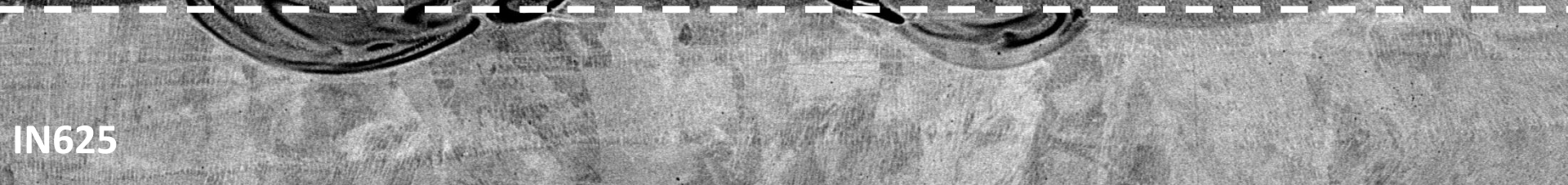
IN625



316L



IN625

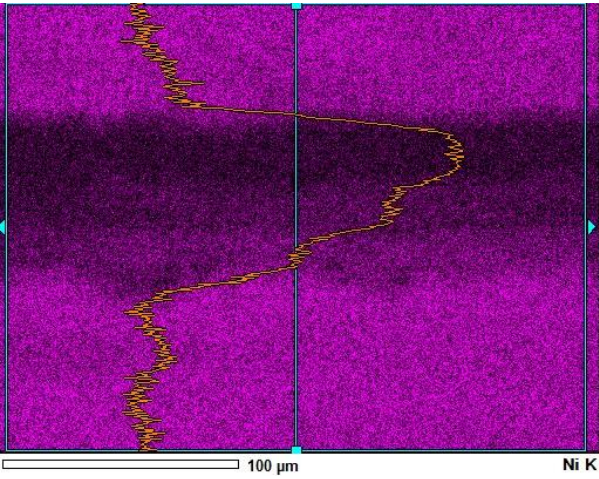


IN625

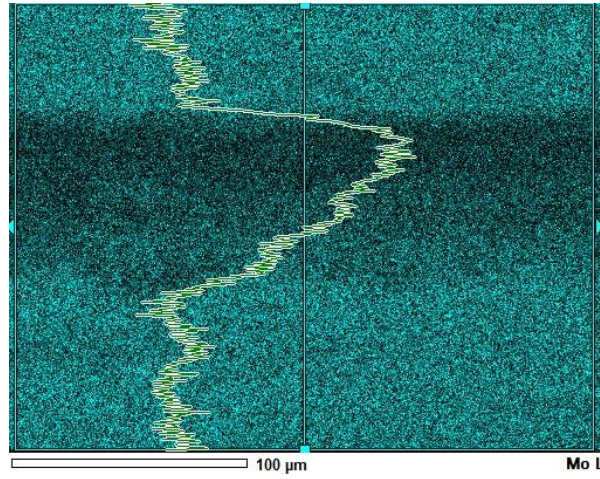
316L

IN625

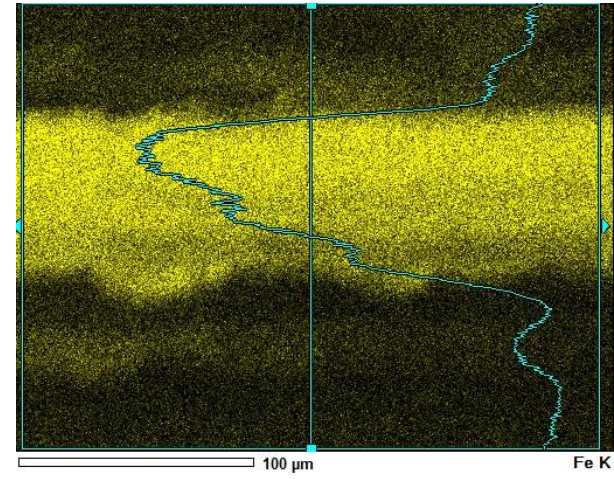
Element Mapping



Nickel

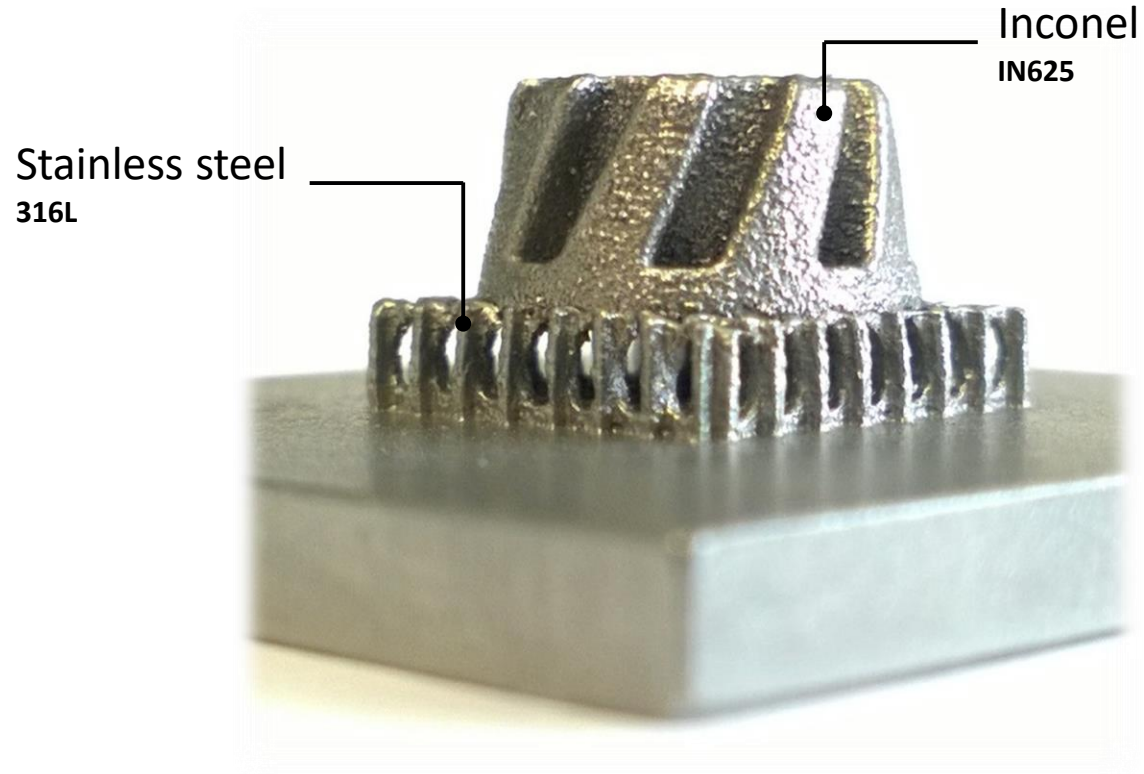


Molybdeen

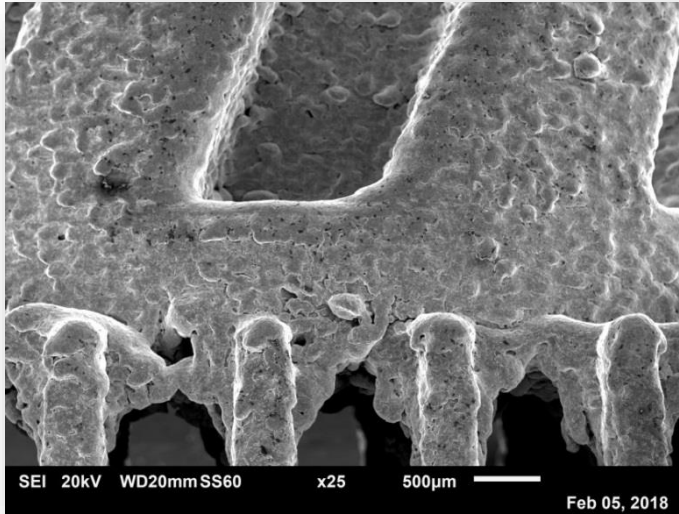


Iron

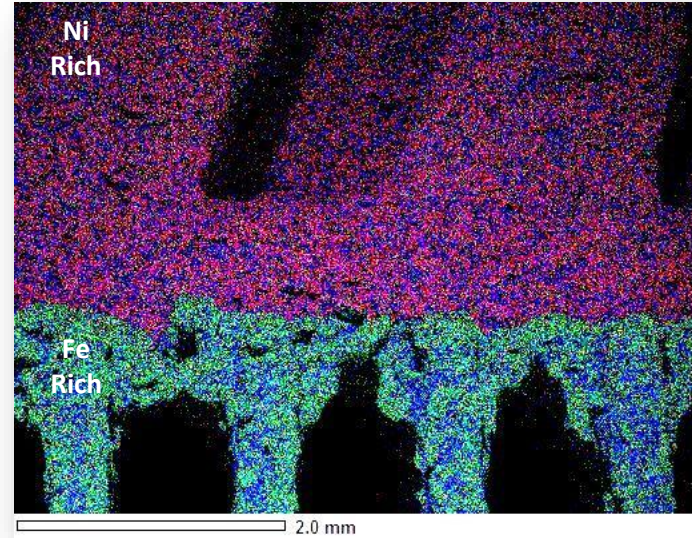
2D Multi Material Part



“Soluble” Support Structures

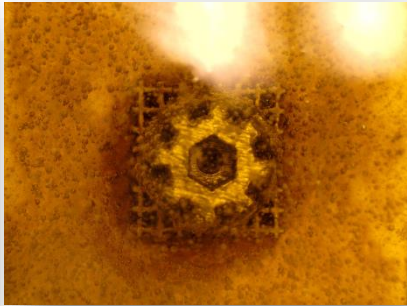
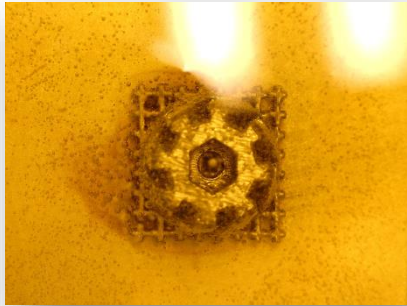
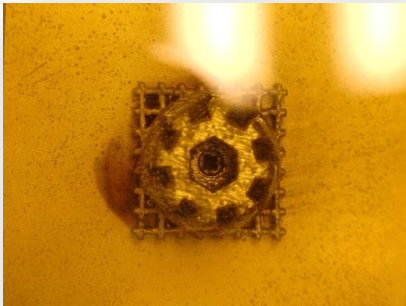
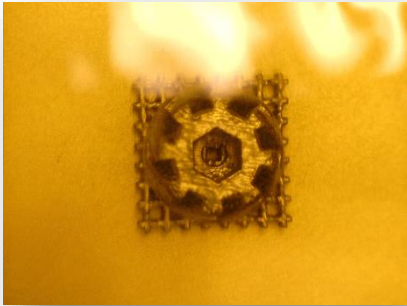


SEM Imaging



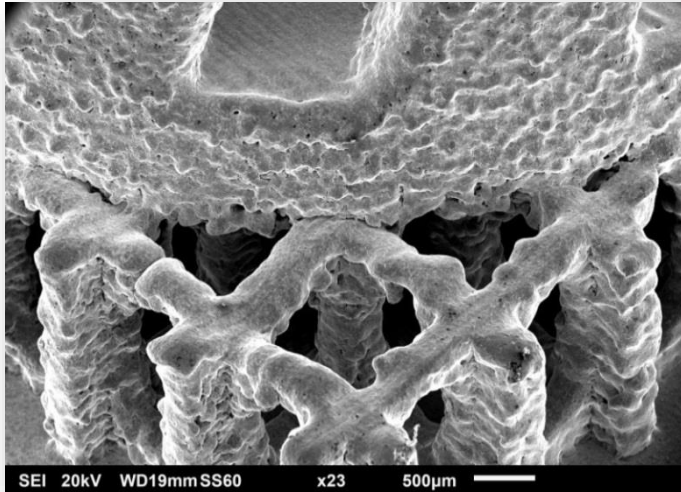
Element Mapping

Selective Etching of 316L

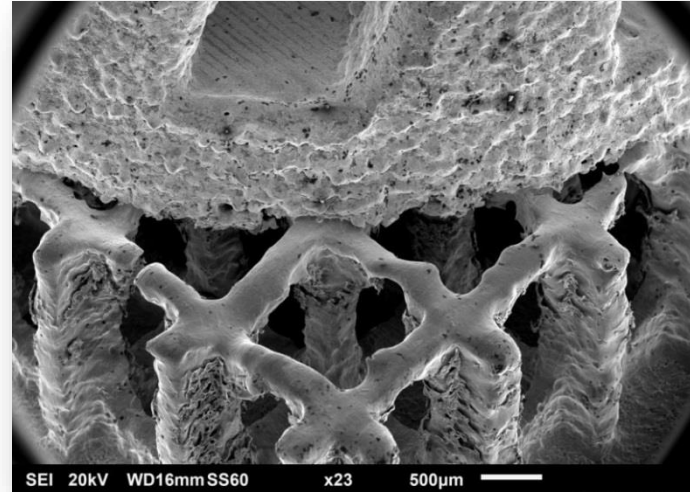


Time →

Selective Etching of 316L



Shot Peening



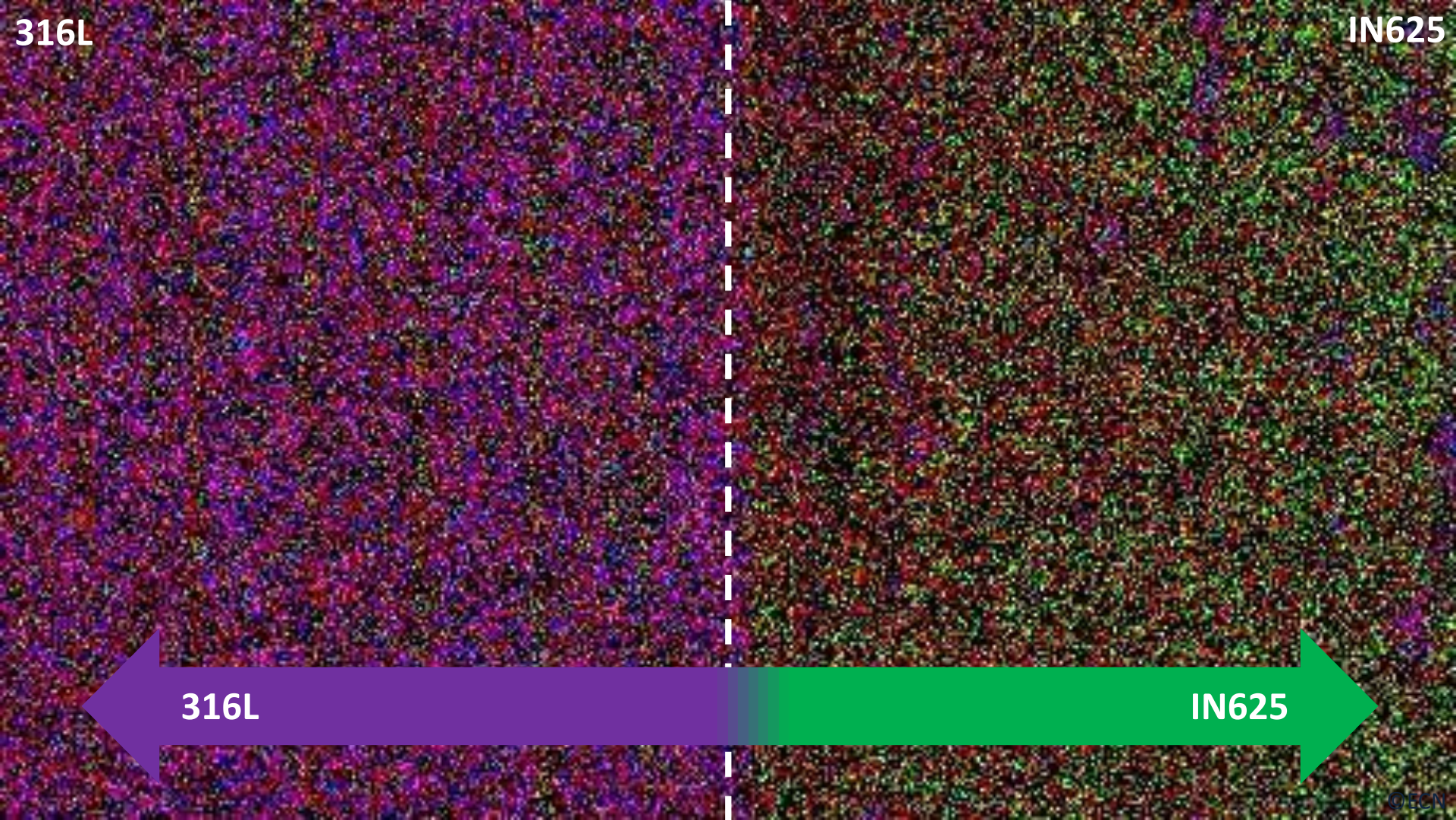
Etched



316L



IN625



316L

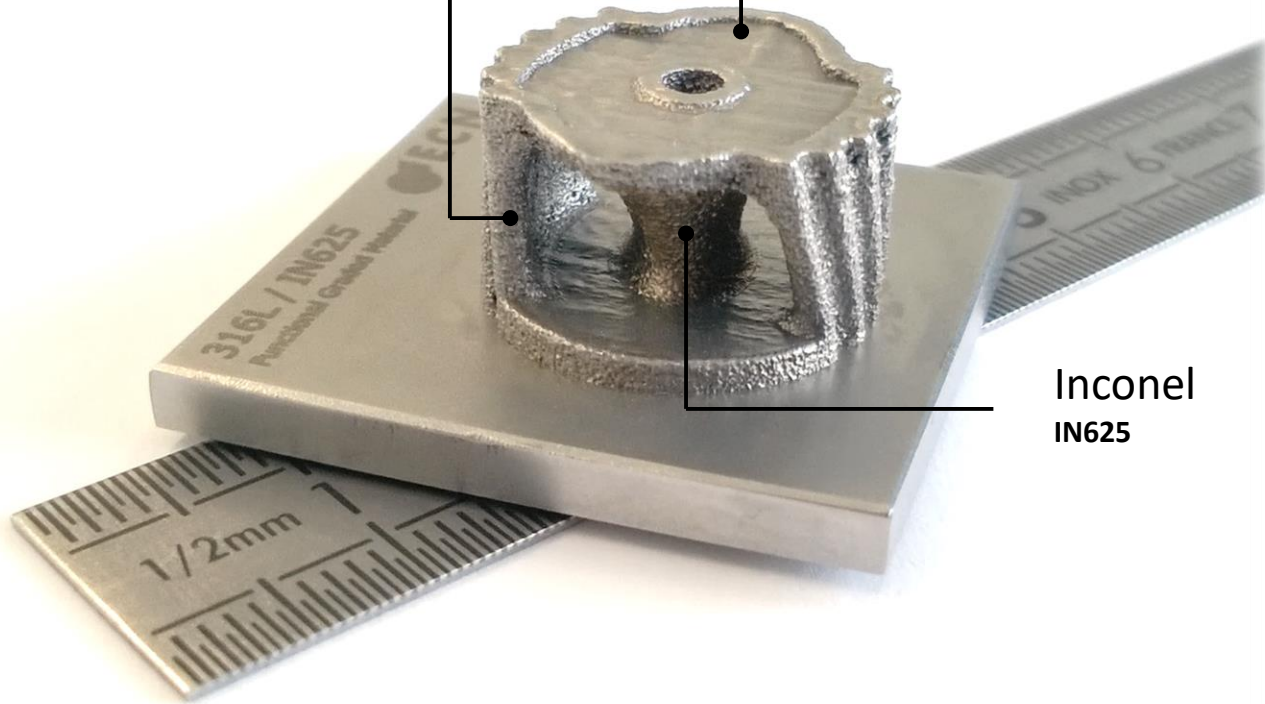
IN625

316L

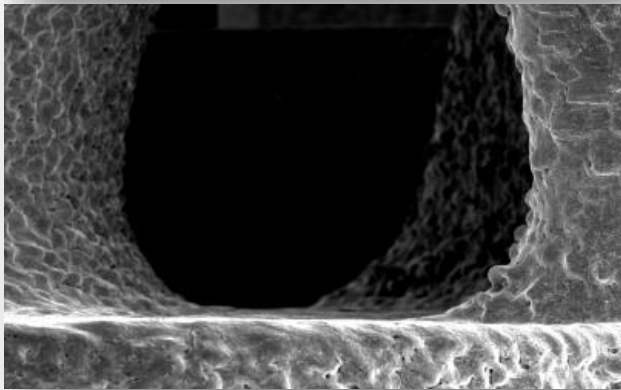
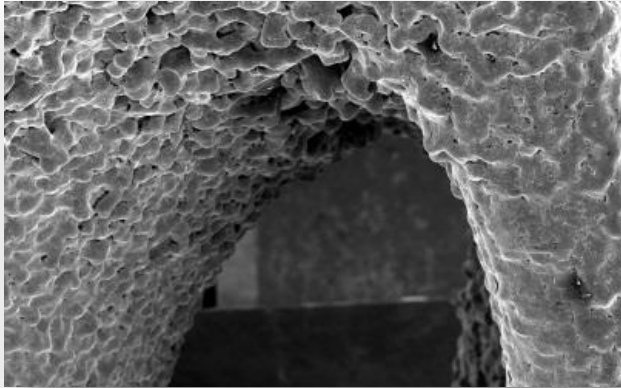
IN625

3D Multi Material Part

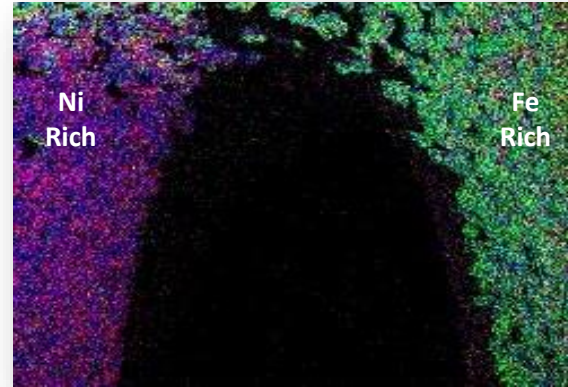
Stainless steel
316L



Inconel
IN625

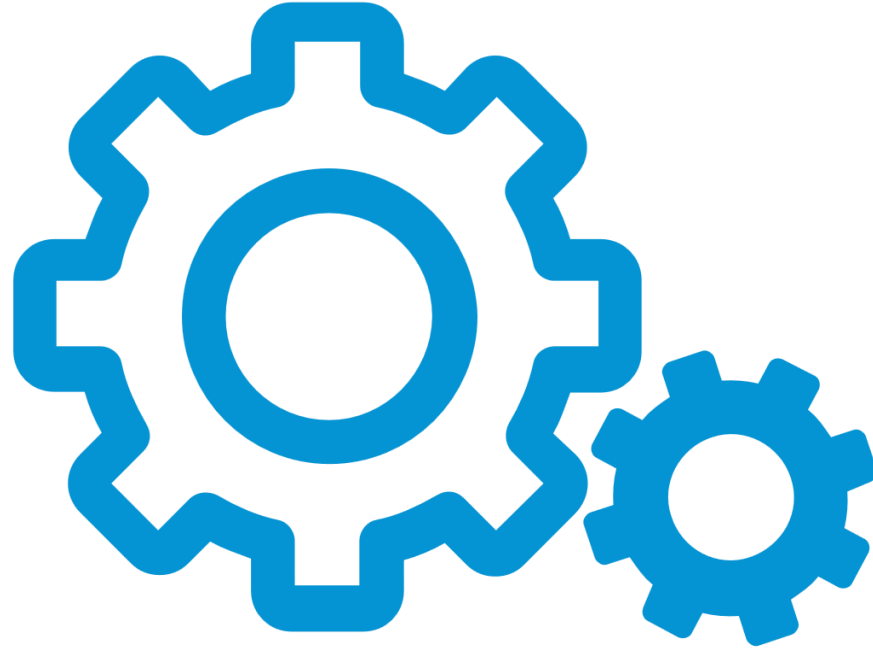


SEM Imaging



Element Mapping

Equipment Development



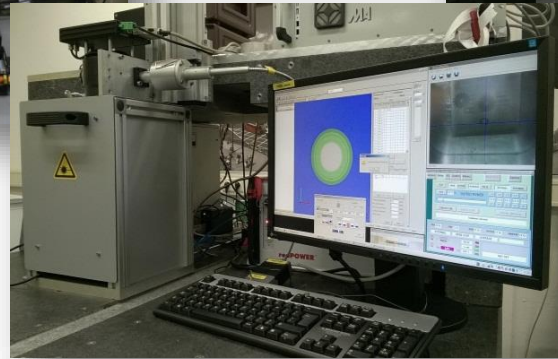
Equipment Development



FuMo 01



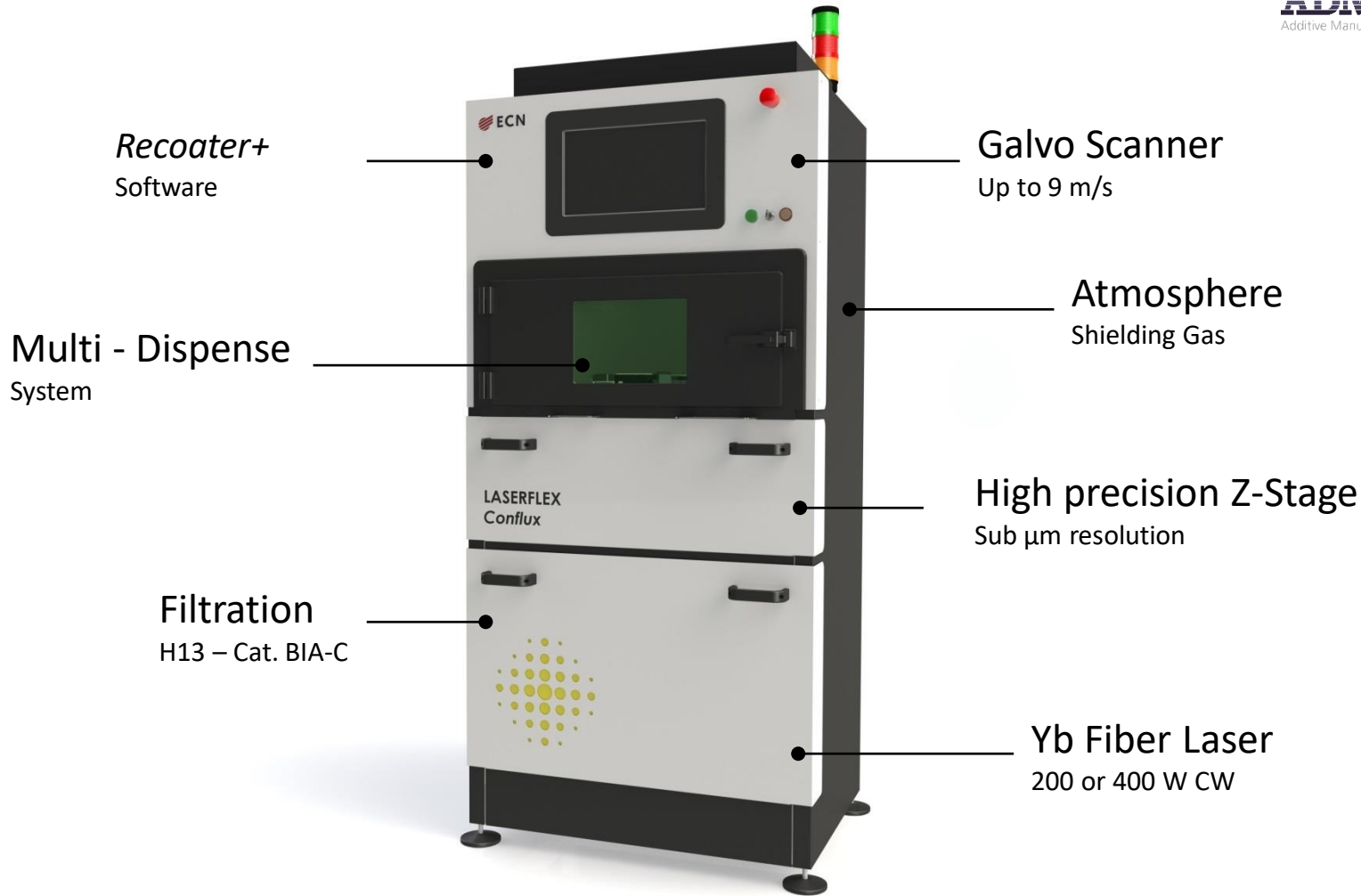
FuMo 03



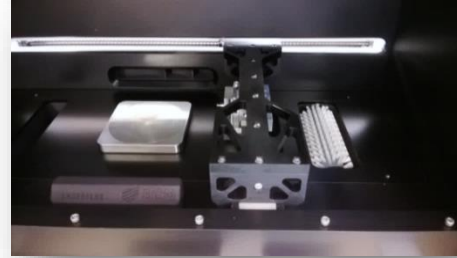
FuMo 02

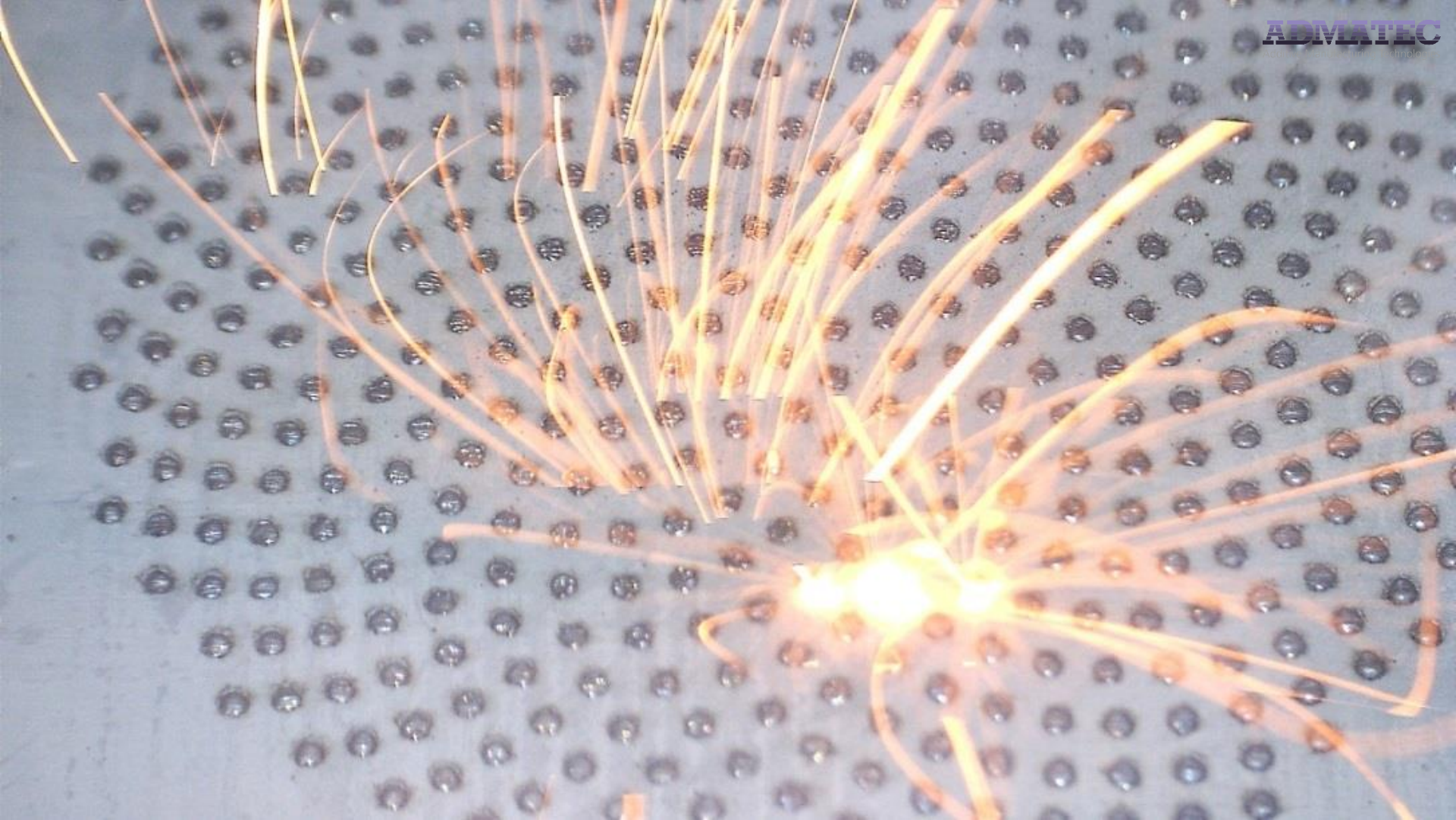


LaserFlex Conflux
Nov 2017

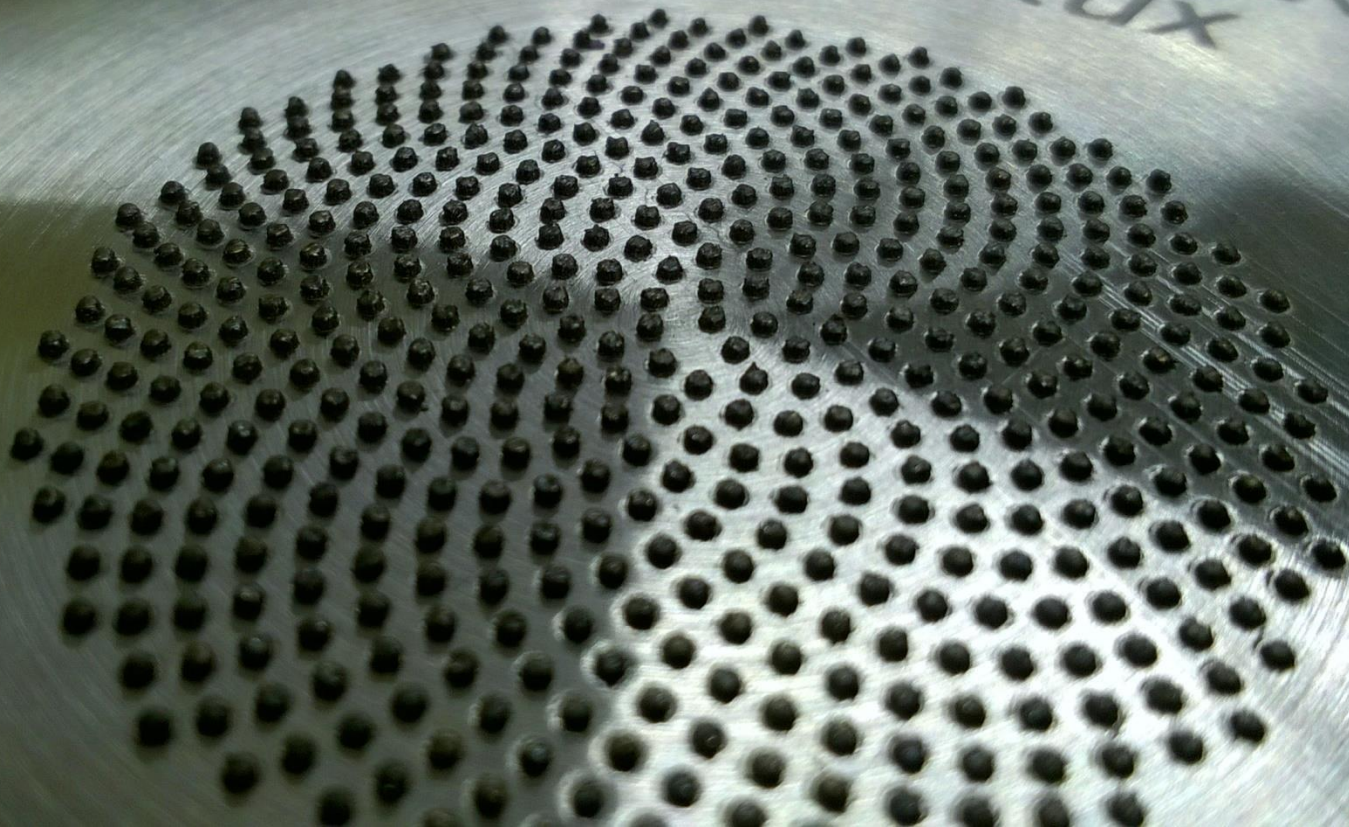


LaserFlex Conflux





LASERFLEX
Conflux



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ADMATEC

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Conflux

*Conflux / Confluence - Origin: <com-, together + fluere, to flow> The merger of rivers.
To join, combine, or come together.*



Confluence of Rhône and Arve rivers , Geneva, Switzerland