QUALITY TESTING

LABORMETDUE

EQUIPMENT

Industrial Computed Tomography

Tool for Scientific Research and Technological Development

AITA ASSOCIAZIONE ITALIANA TECNOLOGIE ADDITIVE

AIM ASSOCIAZIONE ITALIANA DI METALLURGIA

TORINO PIEMONTE Aerospace We know how

FROM CONCEPT TO CAR

AIPnD

1. Labormet Due Srl – What we do

We are specialized in the field of scientific instruments for **laboratory** and **quality control**:

- ❑ Instruments and related consumables for the control of **metals**, **polymers**, **ceramics** and **composites**
- ❑ Characterization and measurement techniques: **metallography**, **optical** and **electronic microscopy**, **image analysis**, **physical** and **mechanical tests**, **environmental simulation**, **chemical analysis**, **metrology** in **research**, **production** and **quality control**

We provide services by means of our Laboratory of **Metrology** and **Industrial X-Ray Computed Tomography**

- ➢ Failure Analysis
- ➢ 3D metrology
- ➢ Reverse Engineering
- ➢ Defect Analysis
- ➢ Electronics inspection
- ➢ Assembly Verification
- ➢ Weld Quality Analysis
- ➢ Product contamination
- ➢ Food Product Inspection
- ➢ Packaging Inspection
- ➢ Cultural Heritage
- ➢ e molto altro

2. Labormet Due Srl - Certifications

BUREAU VERITAS Certification

LABORMET DUE SRL

Corso Orbassano, 402/18 - 10137 TORINO (TO) - ITALY

Certified site:

Corso Orbassano, 402/18 – 10137 TORINO (TO) - ITALY

Bureau Veritas Italia S.p.A. certifies that the Management System of the above organization has been audited and found to be in accordance with the requirements of the management system standards detailed below

ISO 9001:2015

Scope of certification

Trade and service of instrumentation for quality assurance. Metrological and failure analysis services.

IAF sector(s): **29, 34**

Original cycle start date:	**10 October 2016**
Expiry date of previous cycle:	**09 October 2019**
Certification / Recertification Audit date:	**05 September 2019**
Certification / Recertification cycle start date:	**09 October 2019**

Subject to the continued satisfactory operation of the organization's Management System, this certificate expires on: **09 October 2022**

Certificate No. - Version: IT270431- 1 Revision date: **09 October 2019**

ANDREA FILIPPI- Local Technical Manager

Certification body address:
Bureau Veritas Italia S.p.A., Viale Monza, 347 - 20126 Milano, Italia

ACCREDIA

Further clarifications regarding the scope of this certificate and the applicability of the management system requirements may be obtained by consulting the organization. To check this certificate validity please refer to the website www.bureauveritas.it

SGQ N° 009A

Bureau Veritas Certification

Certificate of Approval

This is to certify that the Quality Management System of:

LABORMET DUE SRL

CORSO ORBASSANO 402/18-10137 TORINO (TO) - Italy

has been audited in accordance with the requirements of EN 9104-001:2013 by Bureau Veritas Certification and conforms to the following Quality Management Systems Standards detailed below

Standards

BS EN ISO 9001:2015
EN 9100 : 2018
(Technically equivalent to AS9100D)

Scope of certification

Metrological and defectological analysis services for ASD Sector

Certification Structure: **Single Site**

This certificate forms part of the approval identified by certificate number: **IT302717**

Original ASCS Approval:	**21-December-2020**
Certificate Issue Date:	**21-December-2020**
Certificate Expiry Date:	**20-December-2023**

ADS aerospace sector certification scheme

UKAS MANAGEMENT SYSTEMS 0008

Trevor William Douce
Authorised Signatory

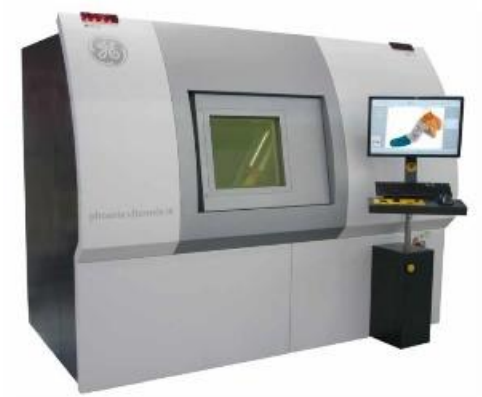
Further clarifications regarding the scope of this certificate and the applicability of the management system requirements may be obtained by consulting the organisation.

Certification Body: Bureau Veritas Certification Holding SAS-UK Branch 5th Floor, 66 Prescot Street, London, E1 8HG, United Kingdom

1/1

3. Our industrial CT Systems: Phoenix v|tome|x series

Waygate tech. Phoenix v|tome|x m

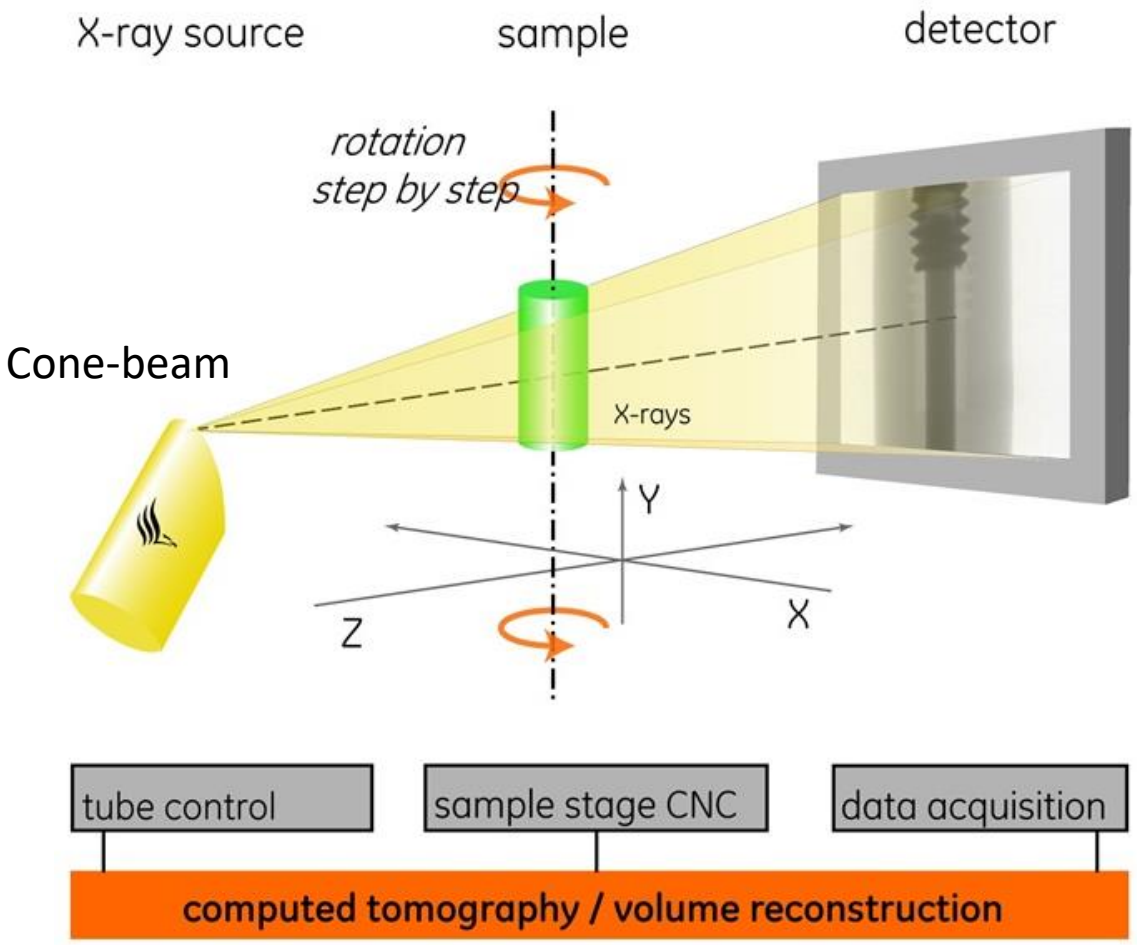


Microfocus X-Ray Tube	Open & Directional
Max tube voltage	**300 kV**
Max power	500 W
Focal Spot	**4 µm**
Detector type & dimensions	DXR 250 GE 300 x 300 mm
Diode dimension - pixel	**200 µm**
Filament & Target	Tungsten
Frame Rate	30 fps
Grayscale	16 Bit
Window	Berillium
Max Sample Sizes & Weight	**300 x 600 mm 50 Kg**

Waygate tech. Phoenix v|tome|x c Scatter|correct / HS

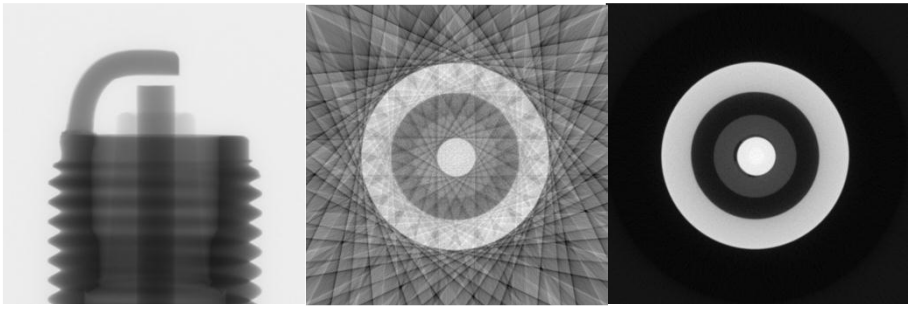
Minifocus X-Ray Tube	Closed
Max tube voltage	**450 kV**
Max power	700 W / 1500 W
Focal Spot	**0,4 mm (700 W) / 1,0 mm (1500 W)**
Detector type & dimensions	GE dynamic 41|200, 410x410 mm, 2036x2036 pixels
Diode dimension - pixel	**200 µm**
Filament & Target	Tungsten
Frame Rate	30 fps
Grayscale	16 Bit
Window	Berillium
Max Sample Sizes & Weight	**500 x 1000 mm 50 Kg**

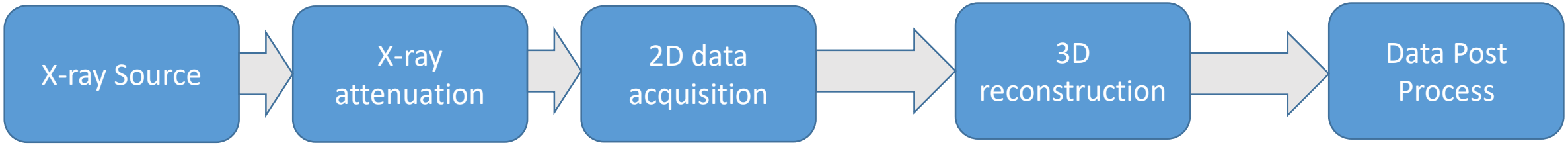
3. Principles and System description



SOFTWARE:

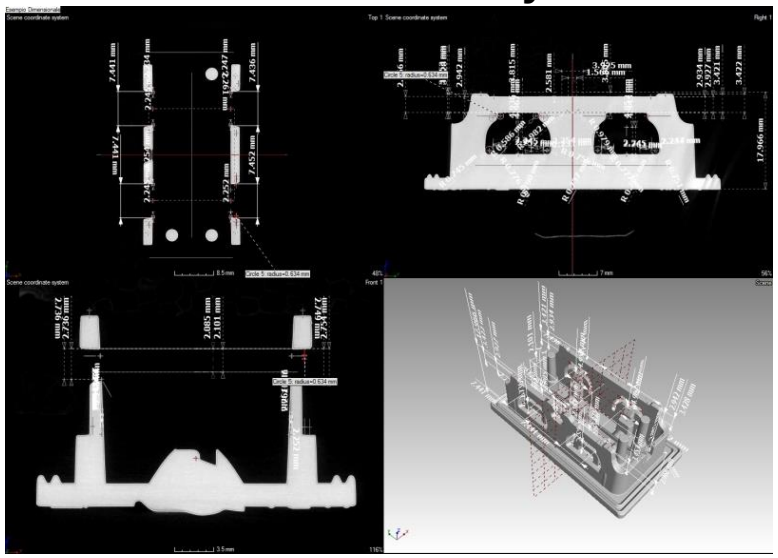
- ❑ Datos|X (3d reconstruction)
- ❑ VGStudio MAX (Post-process & analysis)



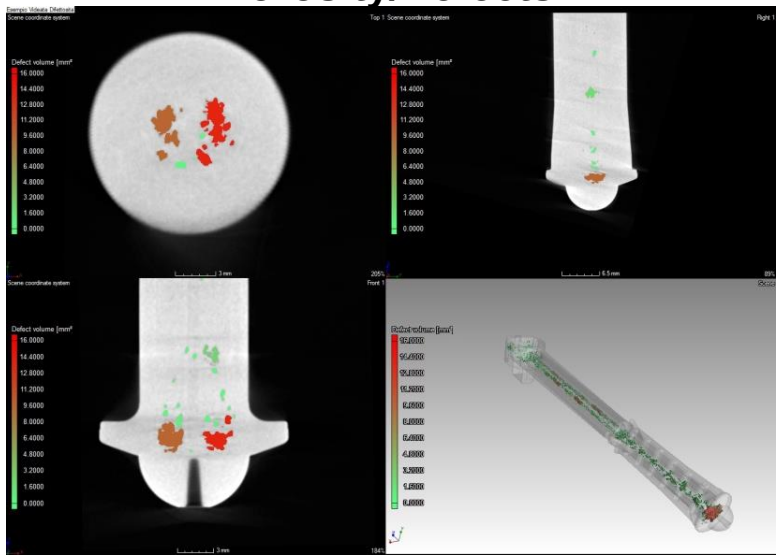


4. Main controls, data post processing and measurements

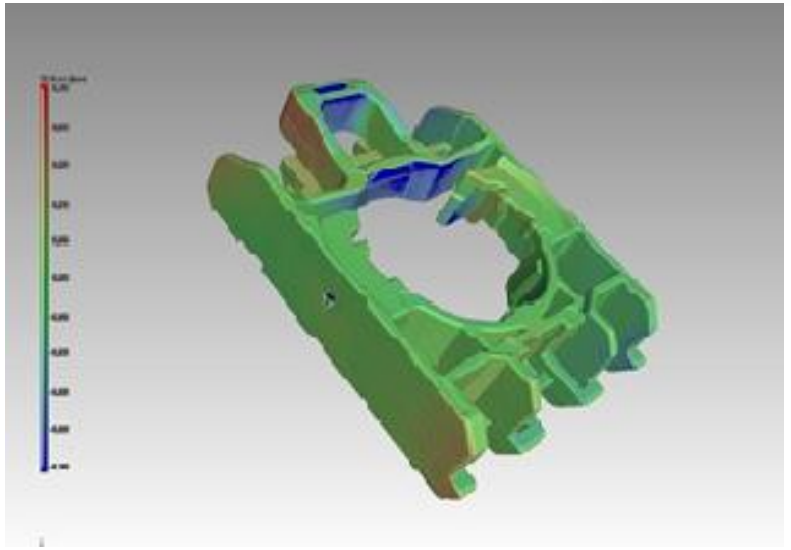
Dimensional analysis



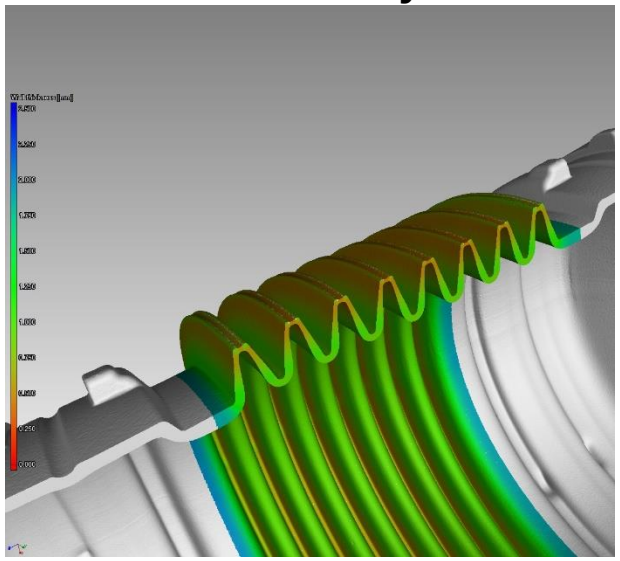
Porosity/Defects



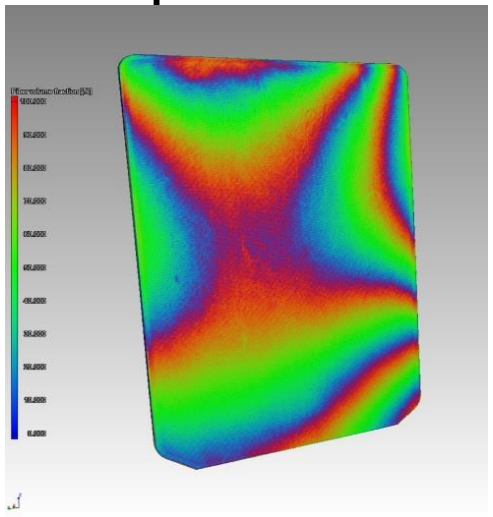
CAD/Nominal vs SCAN



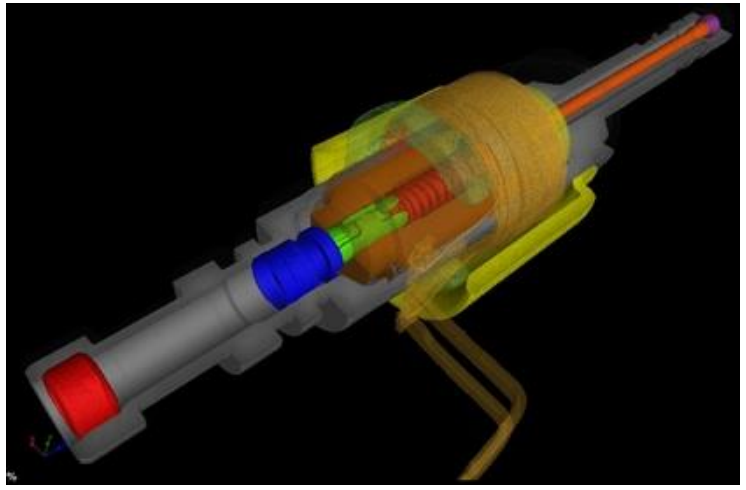
Thickness analysis



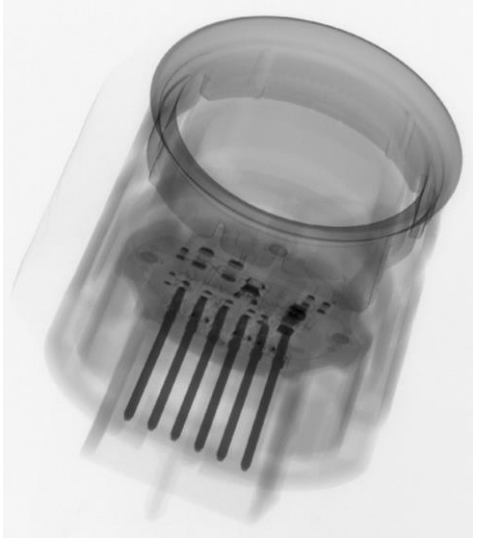
Composite material



Reverse engineering



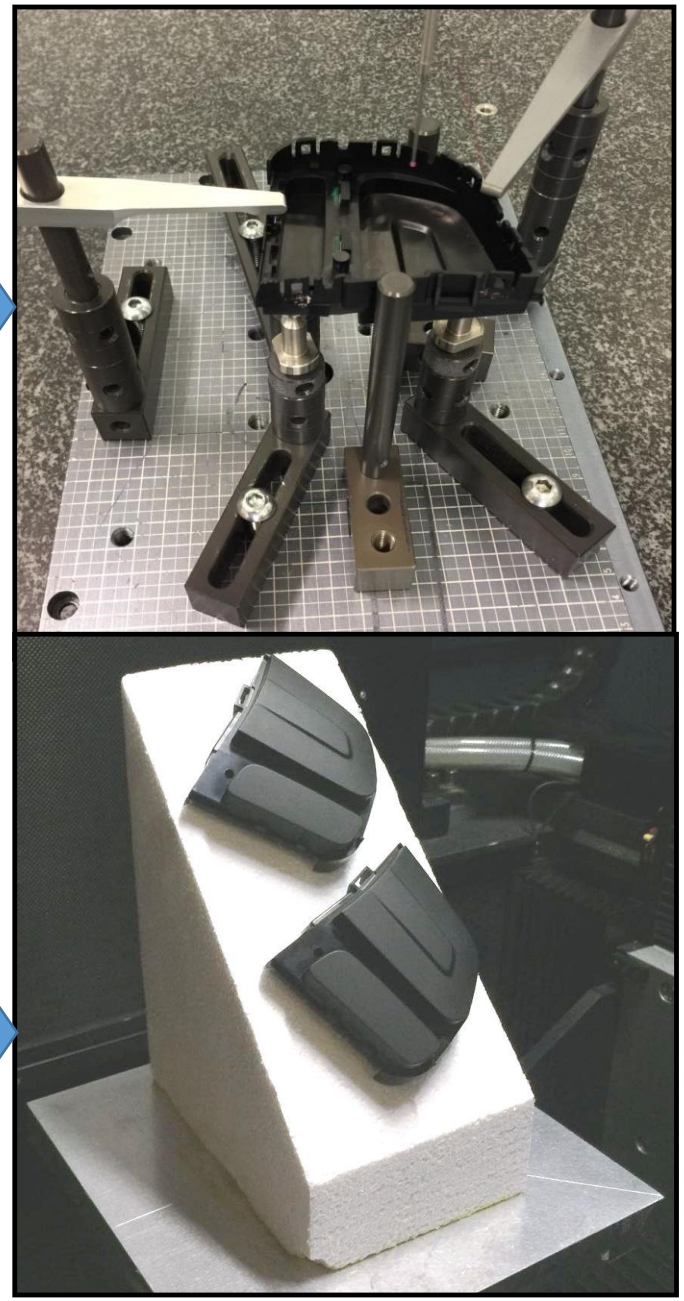
2D X-ray live control



5. Main advantages of industrial CT in dimensional metrology

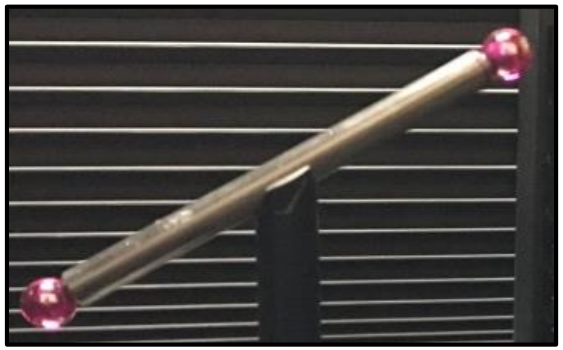
Disadvantages of Conventional Systems	
Dedicated calibers	Sizing of samples for internal control
Optical CMMs available	Use of multiple tools for complete control
Caliper Calibration	Possibili deformazioni durante lo staffaggio
CMM Calibration	Impossibility of comparison after assembly
Probe certification	

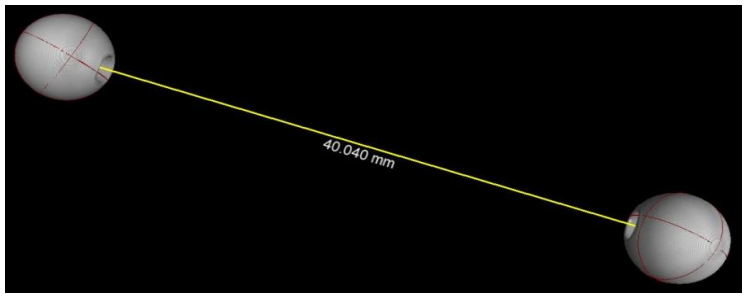
- Low cost of clamping
- No deformation
- Simultaneous control of multiple samples
- Multiple types of control in one cycle

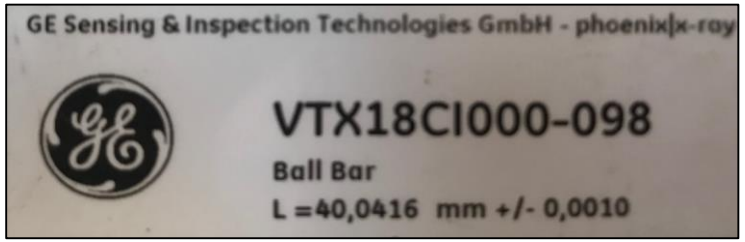


CT Scanner metrological calibration

- ❑ System calibration in the sample scan position
- ❑ Quick, less than 5 minutes

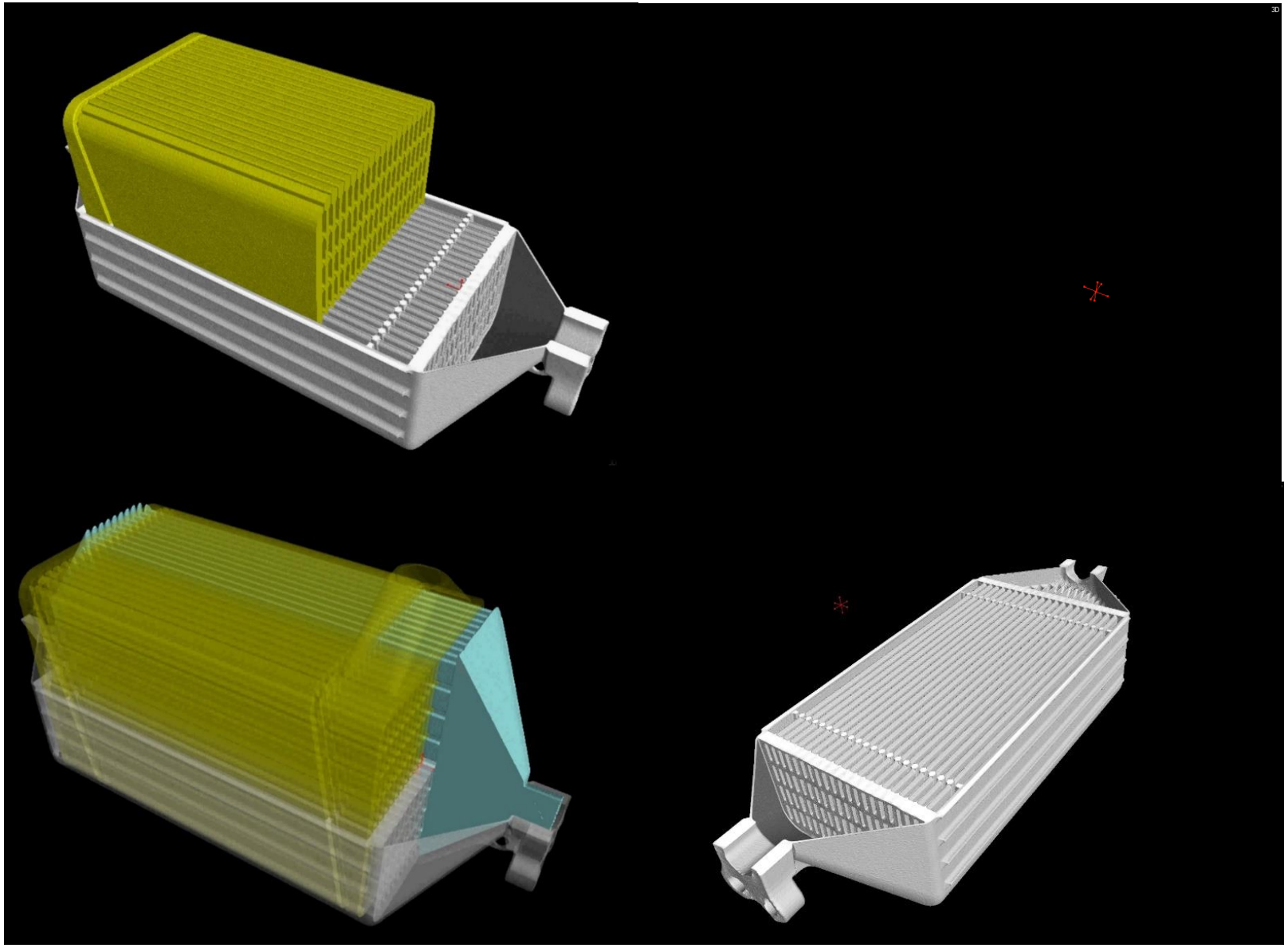






Case 1: Heat Exchanger

Water-oil heat exchanger redesigned and manufactured by SLM in AlSi10Mg



Exchange of 12 kW and compared to its conventional equivalent, it takes up 1/5 of the space. Walls of 0.4 mm thickness

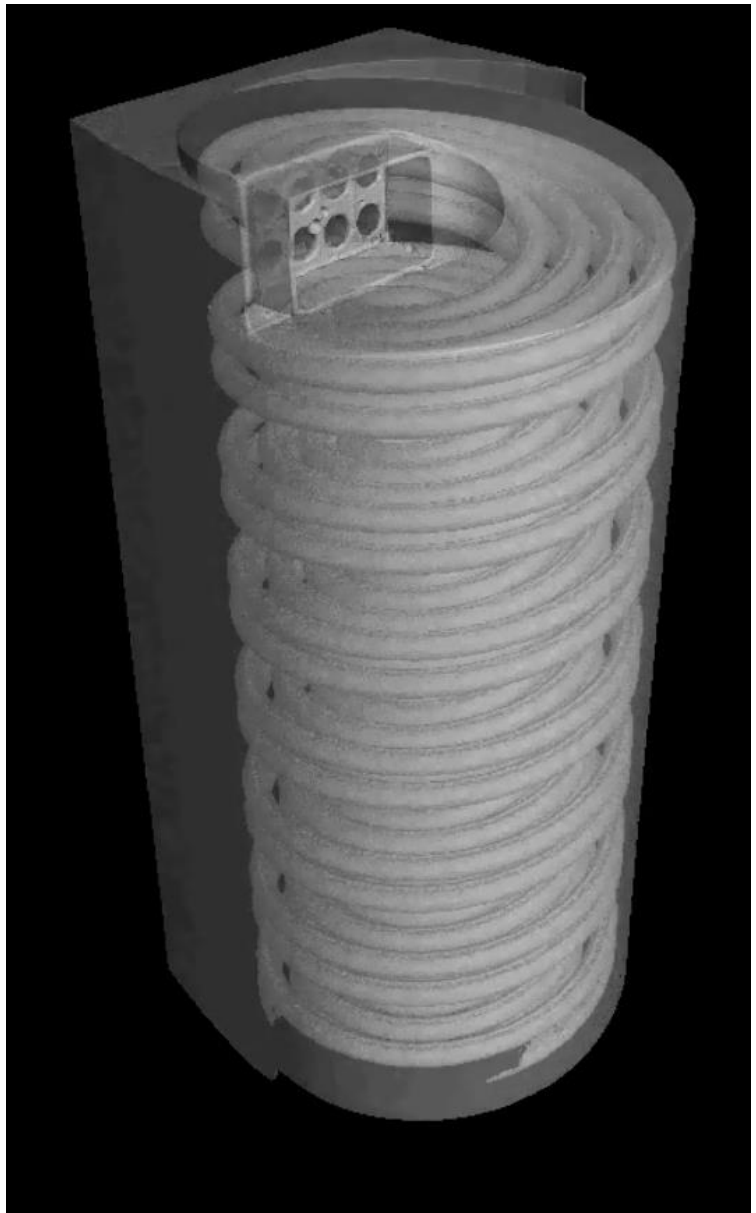
The weight is 85% lower than the analogous traditional model.

Shell and tube heat exchanger

10,8 kg

New design (DfAM)

1,5 kg



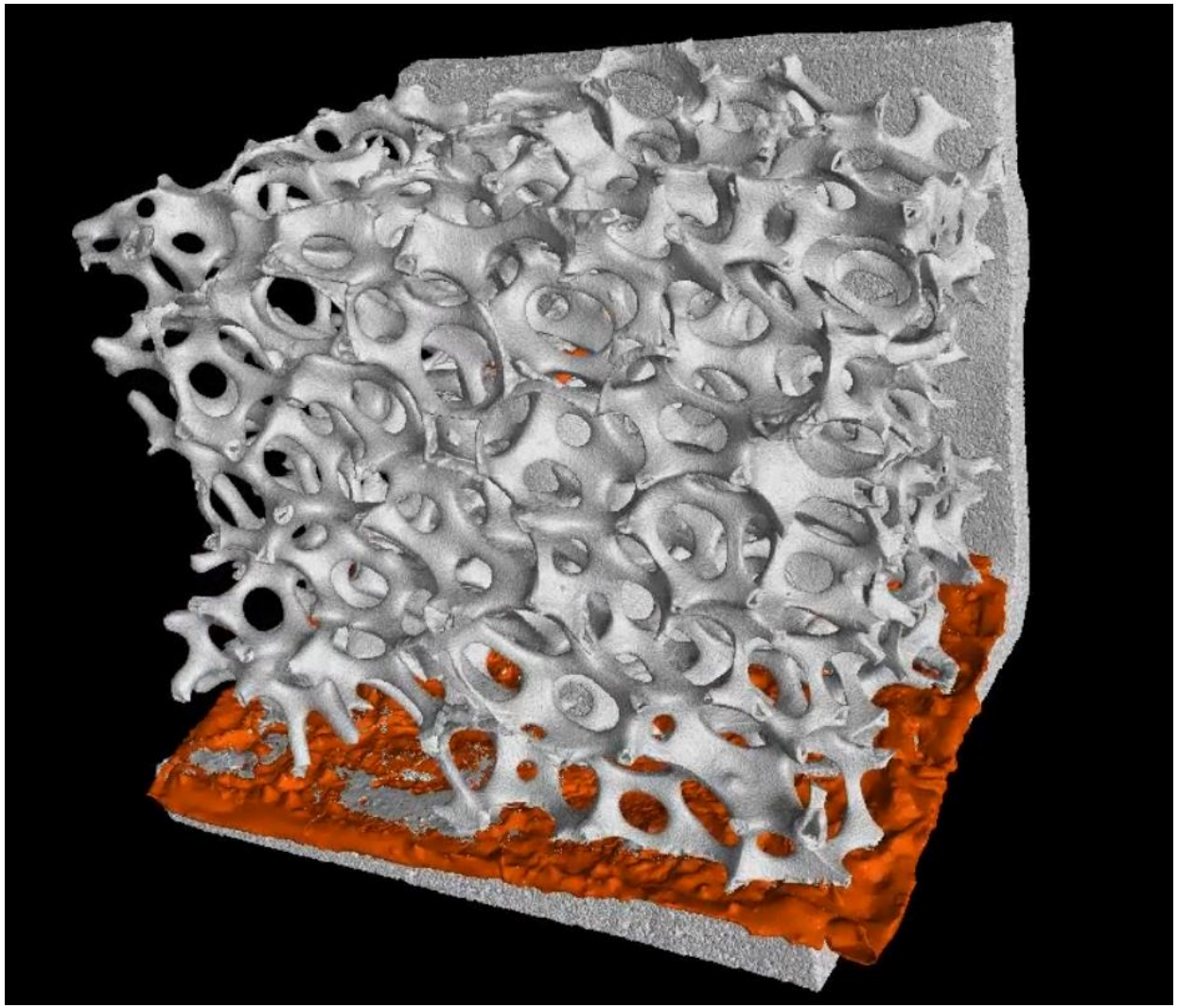
Case 2: Condensing Heat Exchanger

Prototype of an innovative condensing heat exchanger (CHX) which must operate in microgravity and which would perform the function of recovering water directly from the air present in the environment inhabited, on board the space module, or from possible growth chambers of any plants that would produce food for the crew

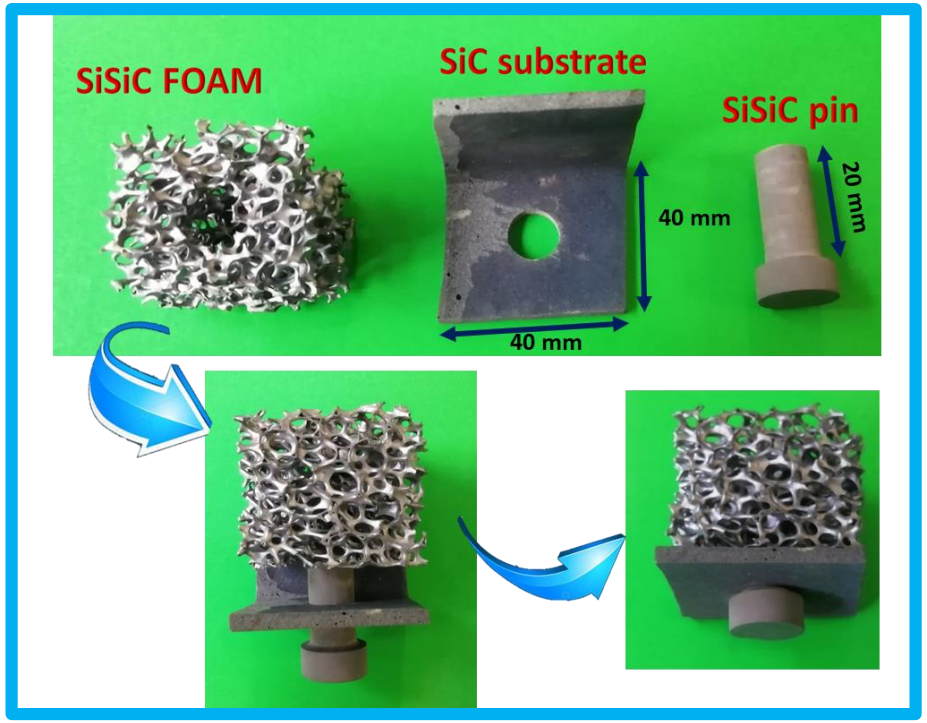
- AM technology: Selective Laser Melting
  - Print Sharp 250 (Prima Additive)
- Material: AlSi10Mg

Courtesy of Prof. Paolo Maggiore (DIMEAS), Polytechnic of Turin.

Case 3: Joint brazing analysis



Courtesy of Prof. Valentina Casalegno (DISAT), Polytechnic of Turin.



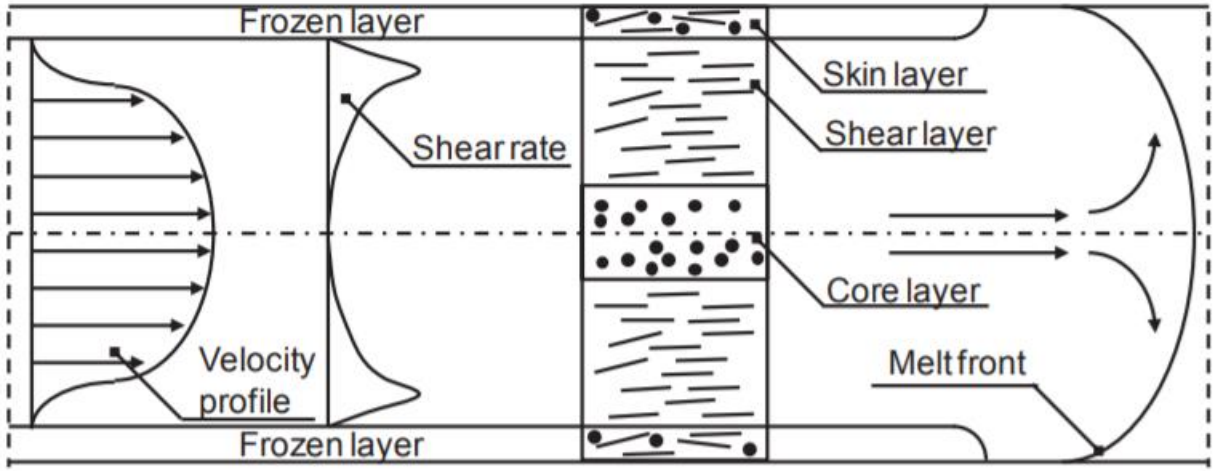
- Solder was put on the surfaces of the L-piece and on the head of the pin inserted into the foam
- The brazing agent is based on silicon and molybdenum

Case 4: µCT for multiscale modeling of fiber-reinforced polymers for CAE

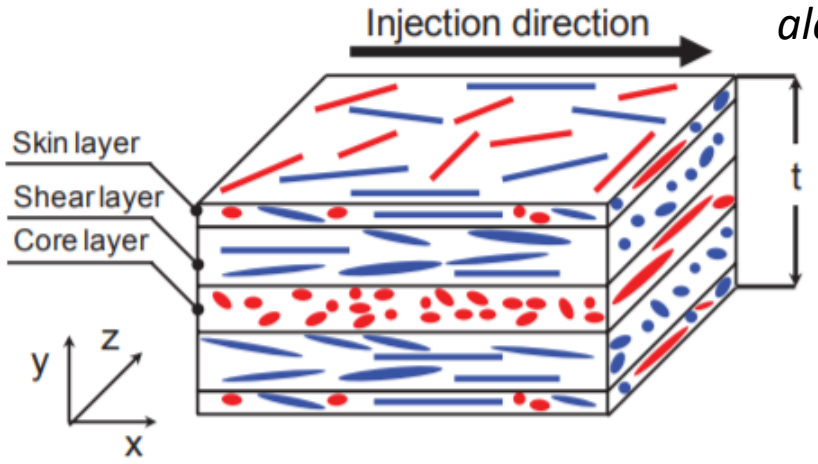
Aim of the work: construction of a multi-scale model of anisotropic material

How: «real» orientation analysis of short glass fiber reinforced plastic fibers and its distribution

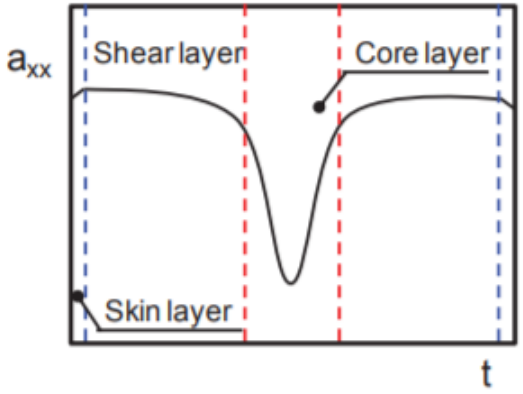
Sectional representation of speed and tension during the injection process in a plate with constant thickness



3D representation of the fiber distribution along the thickness t

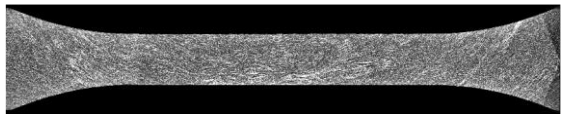


Example of orientation tensor element along thickness t

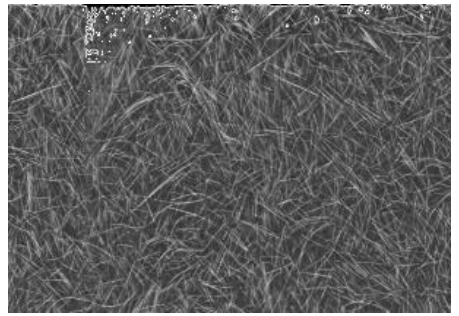


Case 4: µCT for multiscale modeling of fiber-reinforced polymers for CAE

Sample

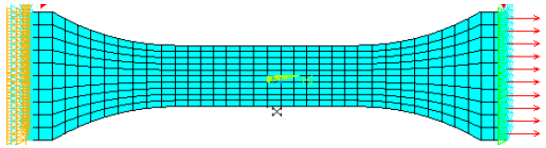


Sample µCT scan



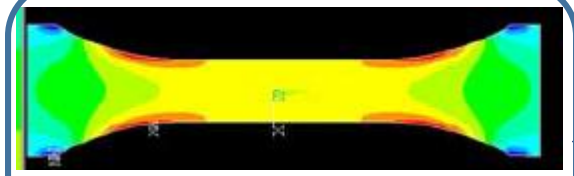
Fiber observation

$$\{\sigma\} = [Q]\{\epsilon\}$$

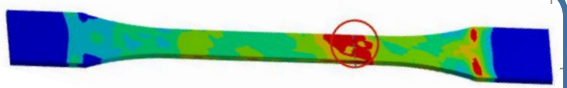


Material and FEM models

Mechanical tests

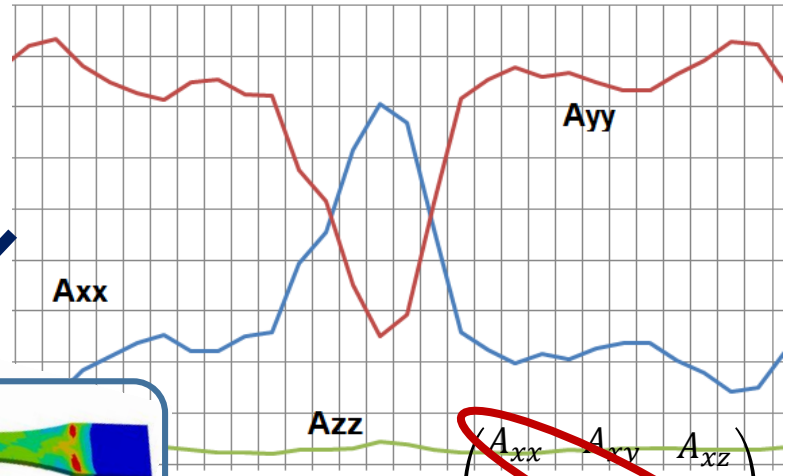


Simulation with theoretical model



Simulation with µCT data

Fiber Orientation tensor



$$A_{ij} = \begin{pmatrix} A_{xx} & A_{xy} & A_{xz} \\ A_{yx} & A_{yy} & A_{yz} \\ A_{zx} & A_{zy} & A_{zz} \end{pmatrix}$$

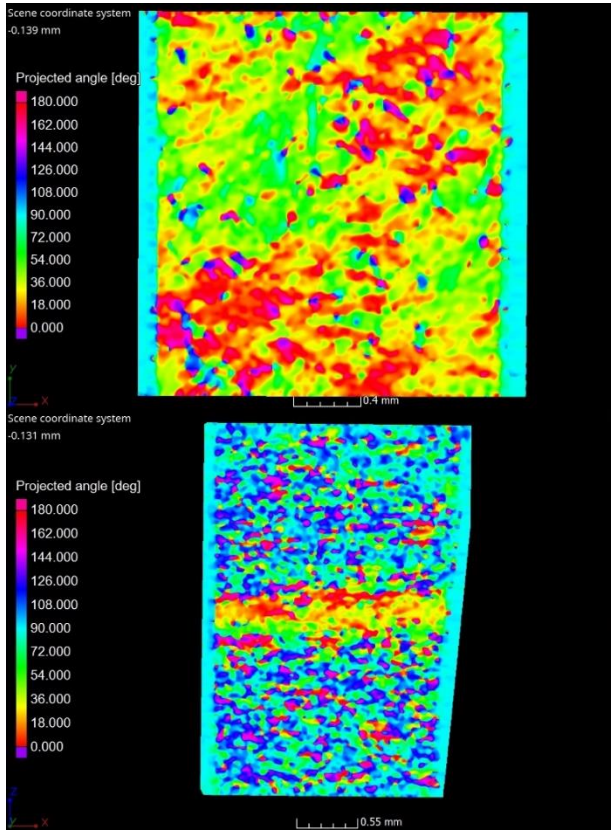
theoretical vs experimental data

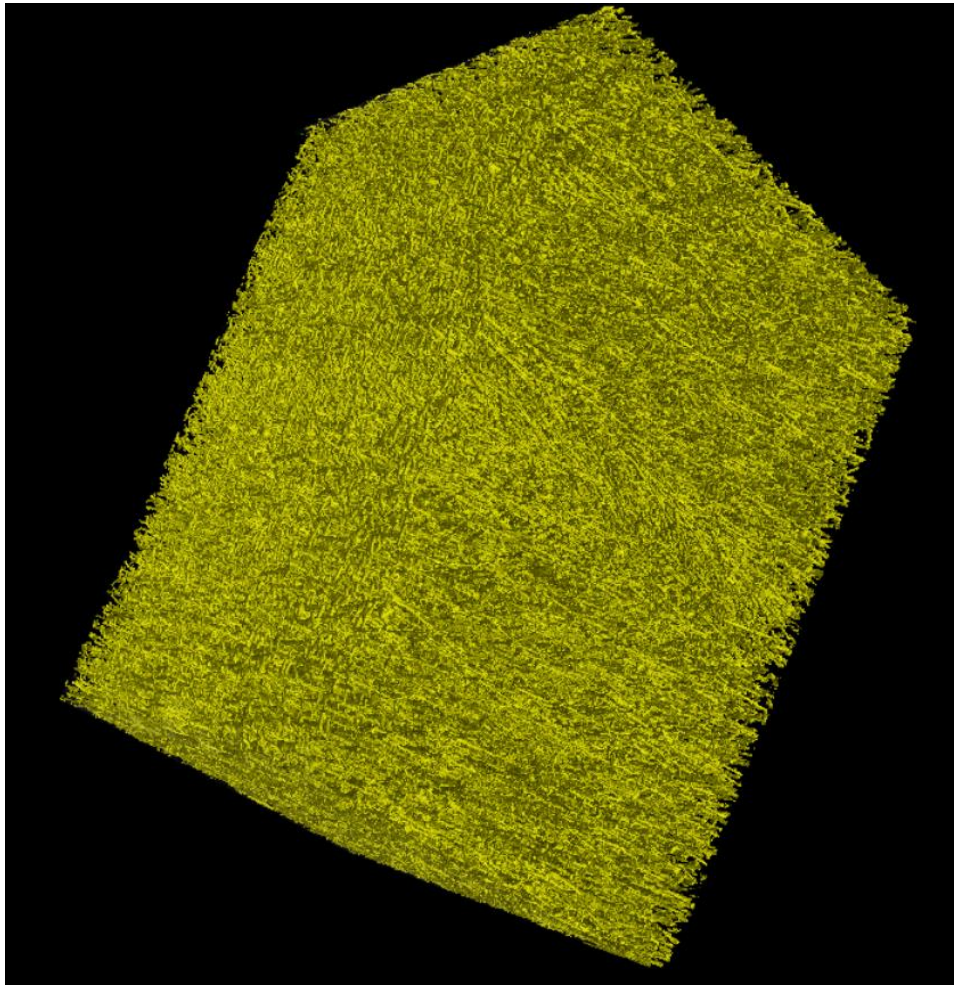
Construction/Calibration of anisotropic material model

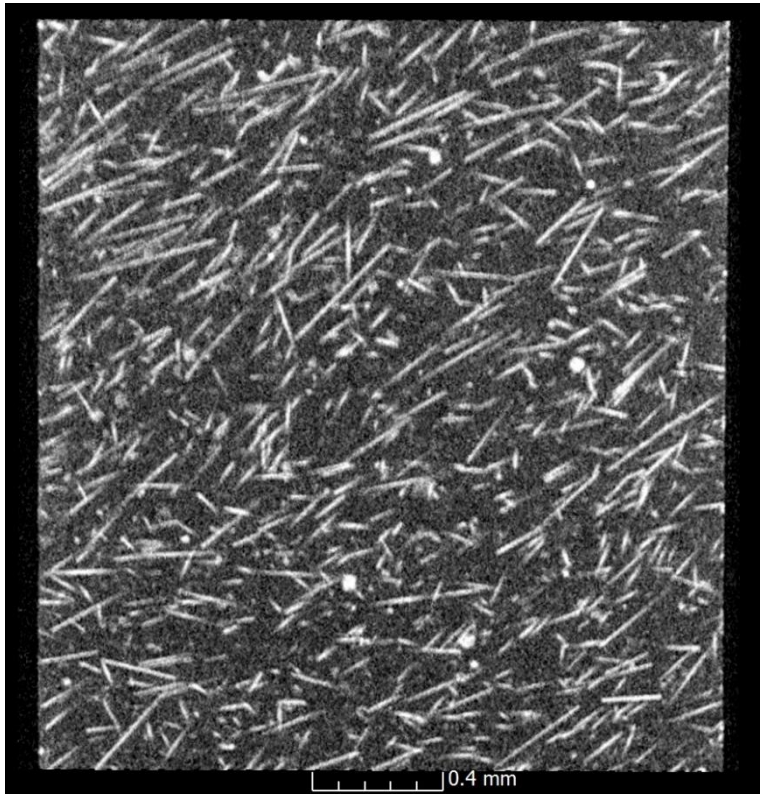
Case 4: µCT for multiscale modeling of fiber-reinforced polymers for CAE

Courtesy of Mr. Grassini CAE Team
Leader of Radici Group

VGStudio MAX output examples







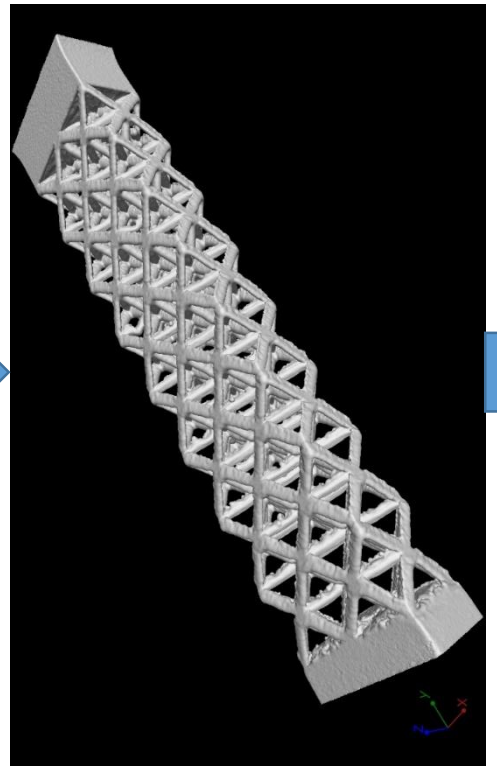
Case 5: lattice structure in 316L stainless steel manufactured in SLM

Purpose: numerical-experimental investigation of correlations between AM process defects and mechanical properties

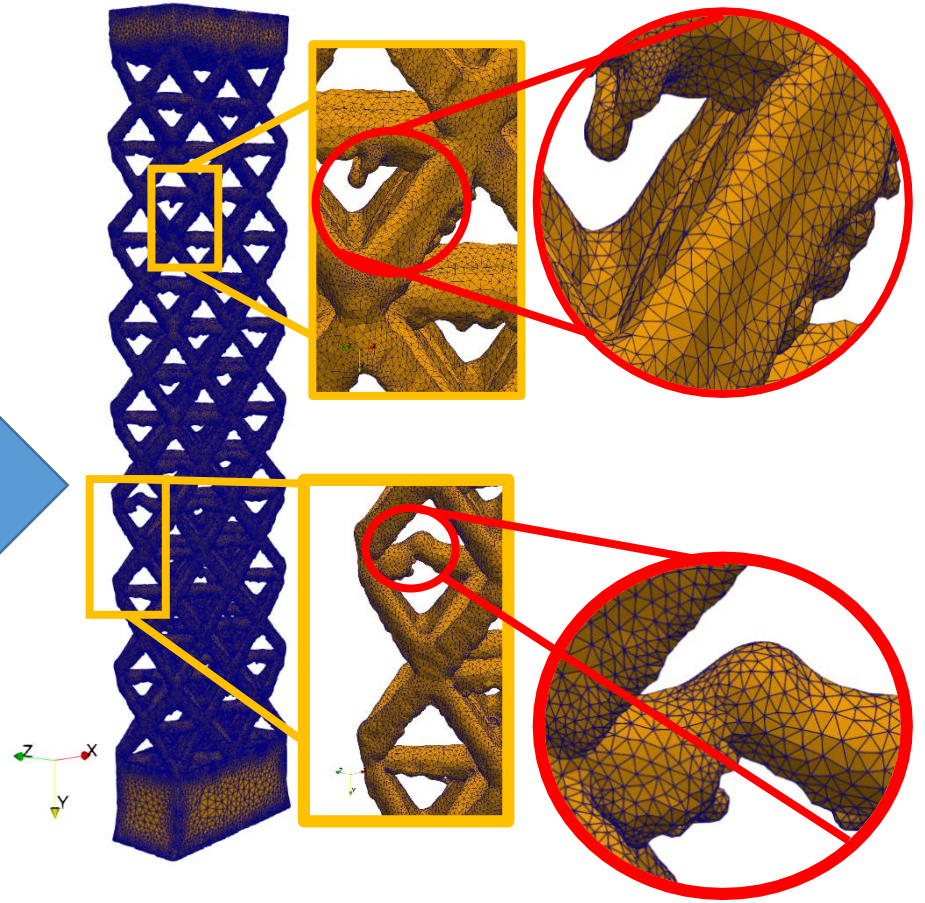
Octet-truss cellular structure

Specimen with gauge length in lattice structure

Tomographic scan of the specimen



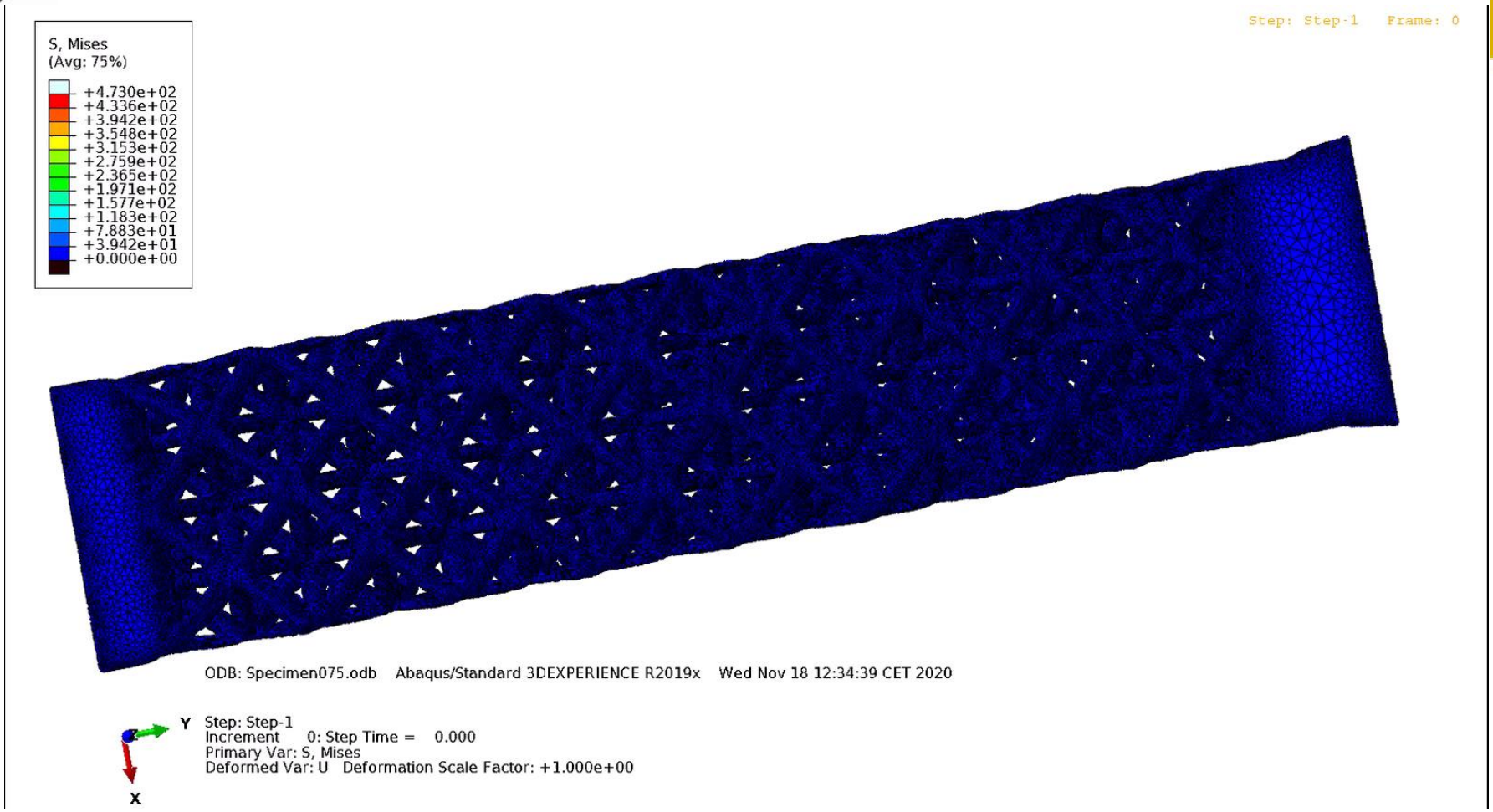
Mesh conversion with 15 µm tolerance



Courtesy of Mr. Carraturo (DICAr), University of Pavia.

M. Carraturo et al. *Experimental and Numerical Evaluation of Mechanical Properties of 3D Printed Stainless Steel 316L Lattice Structures*. Department of Civil Engineering and Architecture, University of Pavia.

Case 5: lattice structure in 316L stainless steel manufactured in SLM

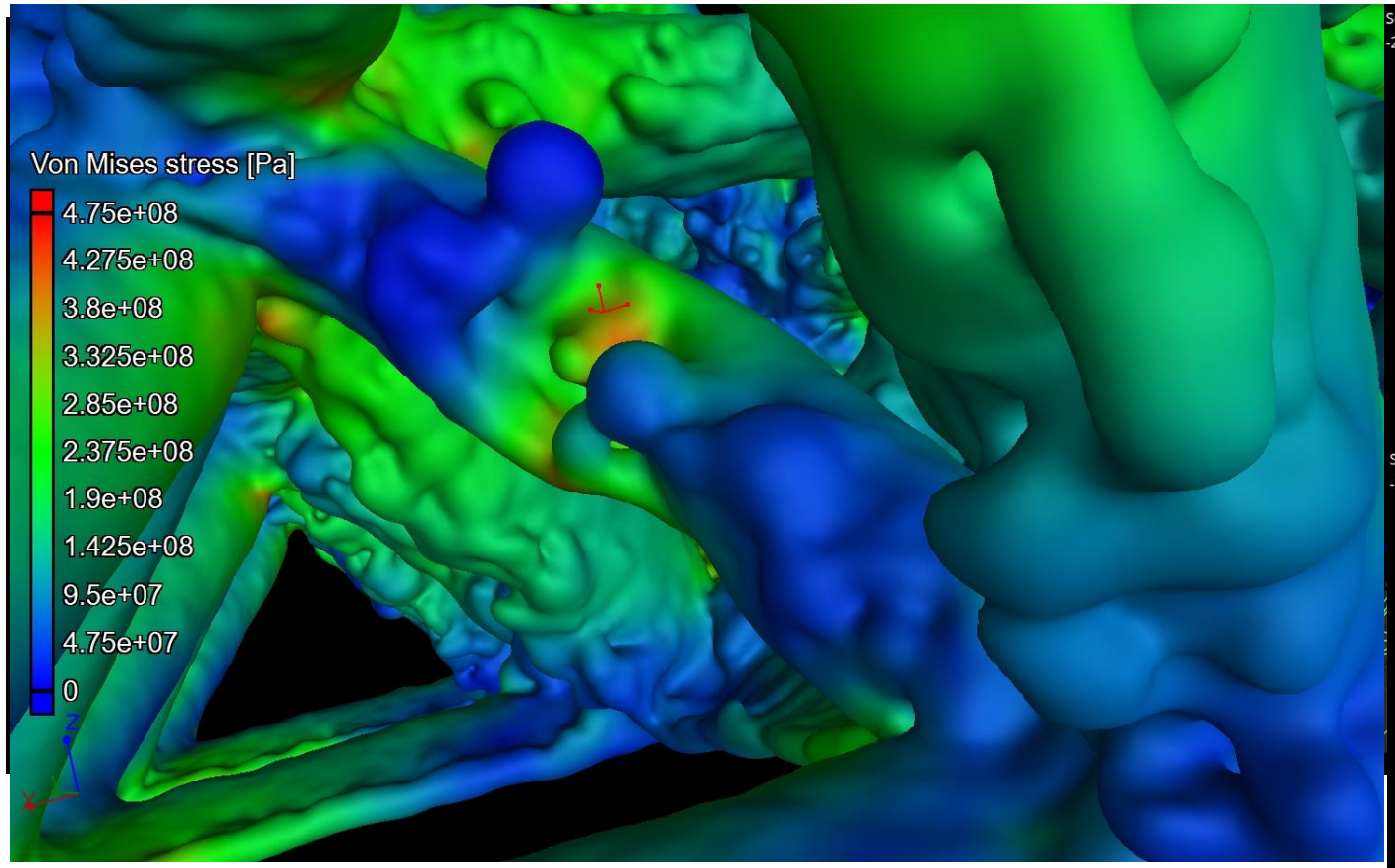


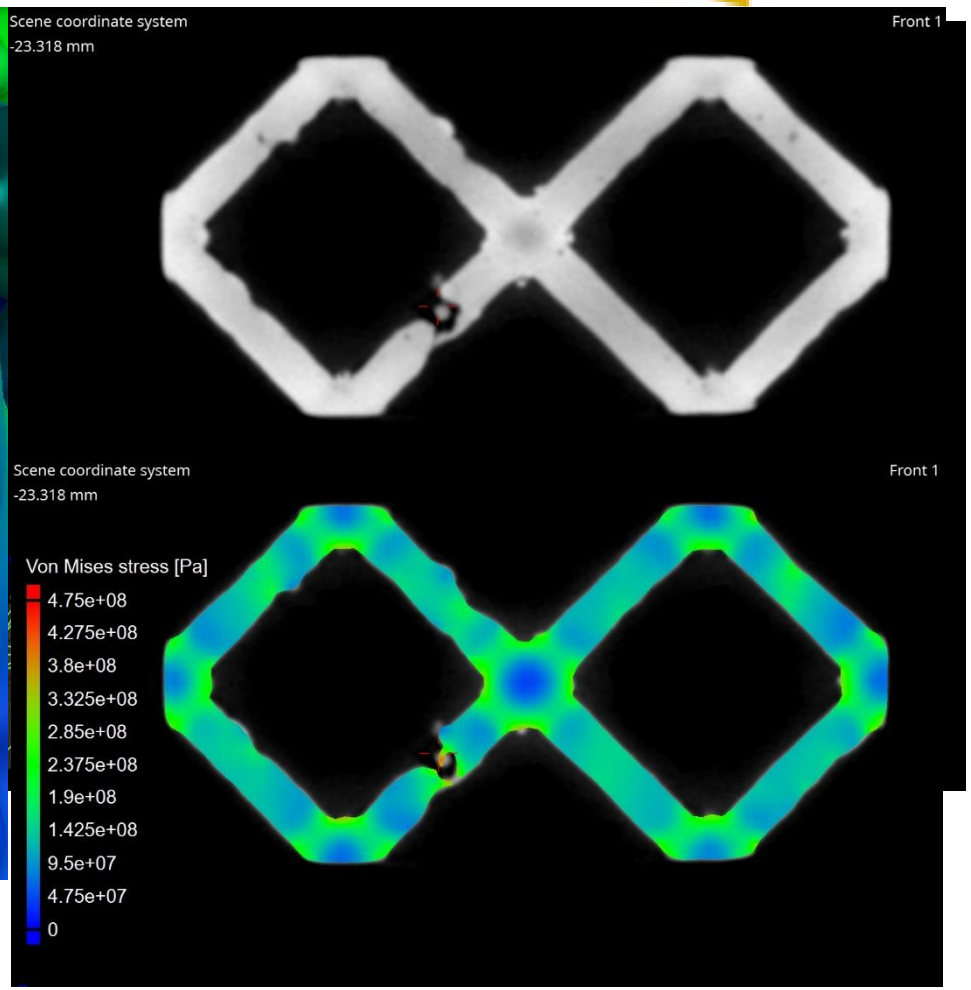
Courtesy of Mr. Carraturo (DICAr), University of Pavia.

M. Carraturo et al. *Experimental and Numerical Evaluation of Mechanical Properties of 3D Printed Stainless Steel 316L Lattice Structures*. Department of Civil Engineering and Architecture, University of Pavia.

Case 5: lattice structure in 316L stainless steel manufactured in SLM

Alternatively, it is possible to compute the tomographic data using special algorithms: immersed boundary



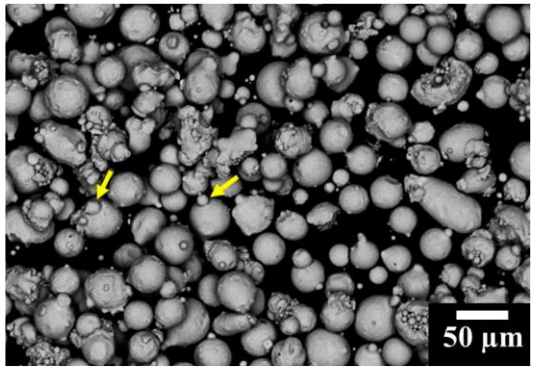


Courtesy of Mr. Carraturo (DICAr), University of Pavia.

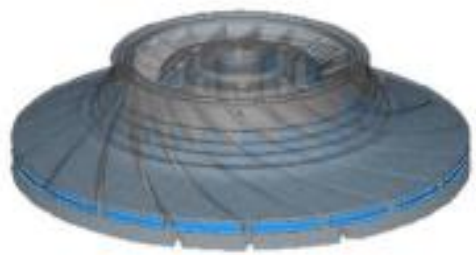
M. Carraturo et al. *Experimental and Numerical Evaluation of Mechanical Properties of 3D Printed Stainless Steel 316L Lattice Structures*. Department of Civil Engineering and Architecture, University of Pavia.

Case 6: Performance analysis of an L-PBF system with Hastelloy X

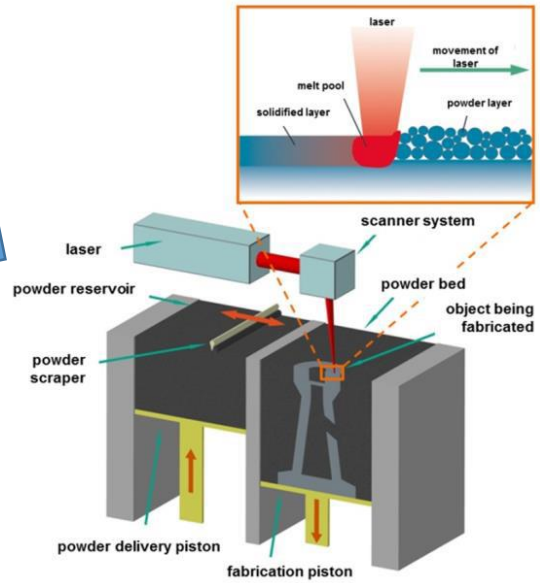
Purpose: to evaluate a set of process parameters from a dimensional and defect point of view



INPUT MATERIAL: Hastelloy X



Reference geometry



AM system: EOS M270 / PROCESS PARAMETERS

AM part outputs

Defects

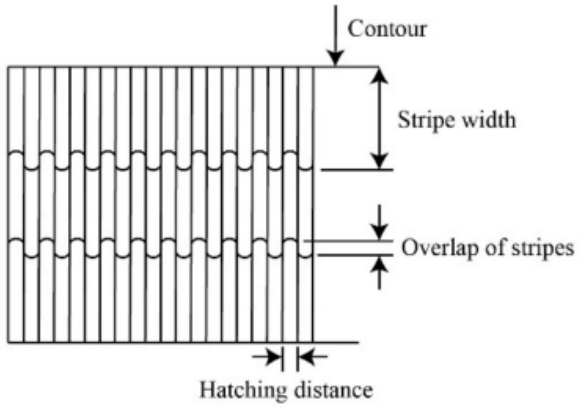
- ❑ **Porosity**
- ❑ Cracks
- ❑ Inclusions
- ❑ …

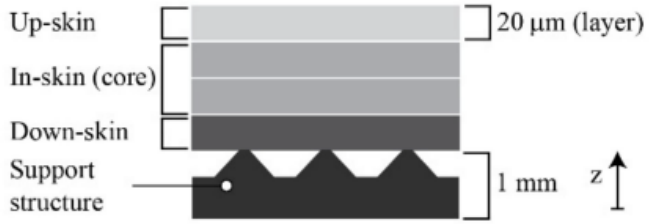
Geometric properties

- ❑ **Dimensional accuracy**
- ❑ **Resolution**
- ❑ Repeatability
- ❑ …

Case 6: Performance analysis of an L-PBF system with Hastelloy X

MAIN PROCESS PARAMETERS [A]		
Laser power		**195 W**
Scan speed		1000 mm/s
Beam spot size		**100 µm**
Layer thickness		**20 µm**
Hatching distance		0,05 mm
Stripe width		5 mm
Overlap if stripes		0,12 mm
Contour	**Laser power**	150 W
	Scan speed	1250 mm/s
Argon atmosphere		Oxygen content < 0,1 %
Building platform heating		80°C





EOSINT M 270 Dual-mode system [B]
Laser type: Yb-fiber laser, 200 W
Variable focus diameter: 100÷500 µm
Layer thickness: 20÷100 µm

Processed Material: Hastelloy X powder [A]

[A] Calignano, F.; Minetola, P. *Influence of Process Parameters on the Porosity, Accuracy, Roughness, and Support Structures of Hastelloy X Produced by Laser Powder Bed Fusion*. Politecnico di Torino, DIGEP, Materials, 2019.
[B] EOS M 270 technical sheet. https://dmlstechnology.com/images/pdf/EOSINT_M_270.pdf

Case 6: Performance analysis of an L-PBF system with Hastelloy X

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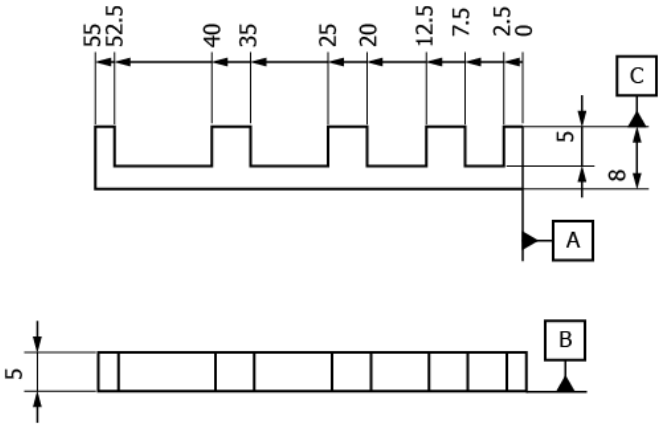
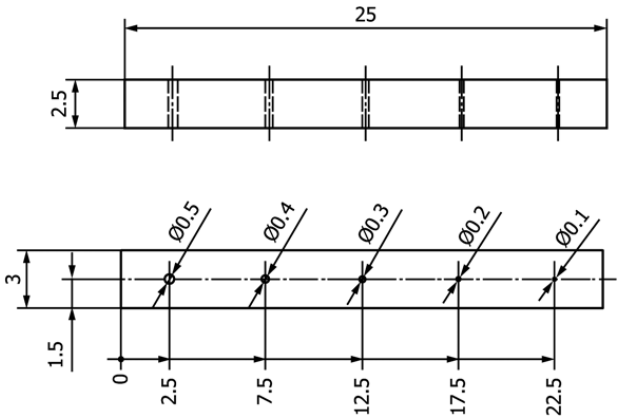
LABORMETDUE – QUALITY TESTING – EQUIPMENT

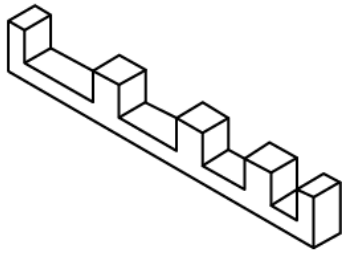
Linear artifact – **accuracy**

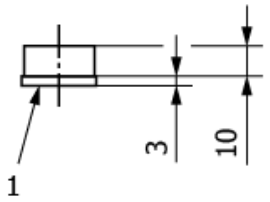


Resolution holes artifact

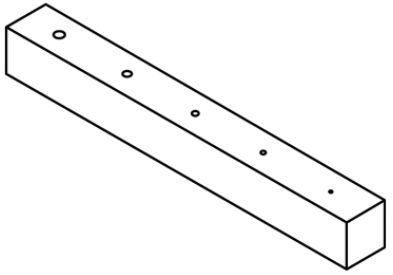


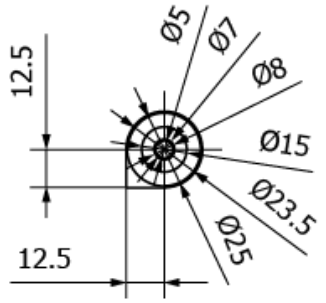
GEOMETRIC TEST ARTIFACT [C]





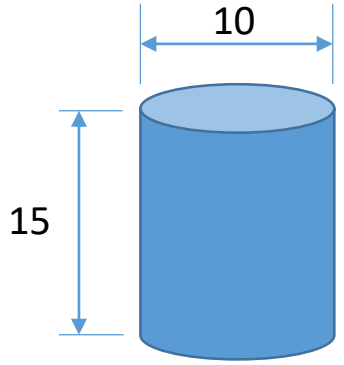
Circular artifact - **accuracy**





a) Fine

POROSITY TEST SAMPLES

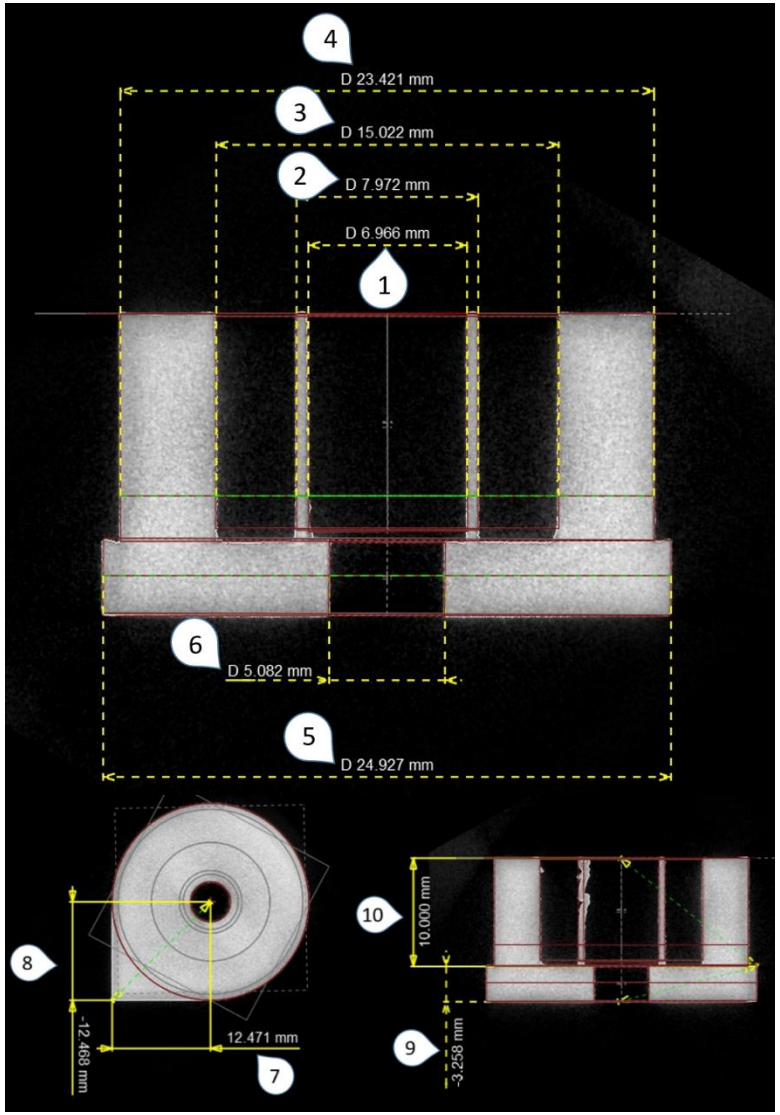


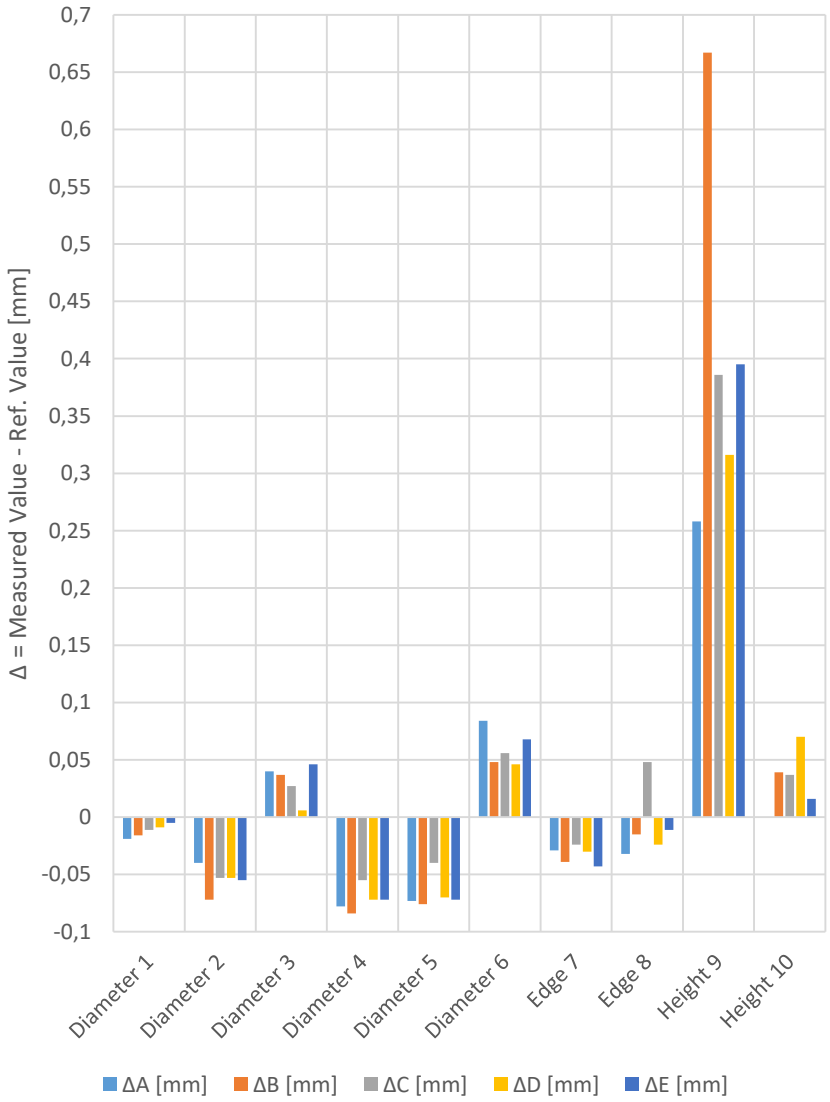
Cylindrical sample

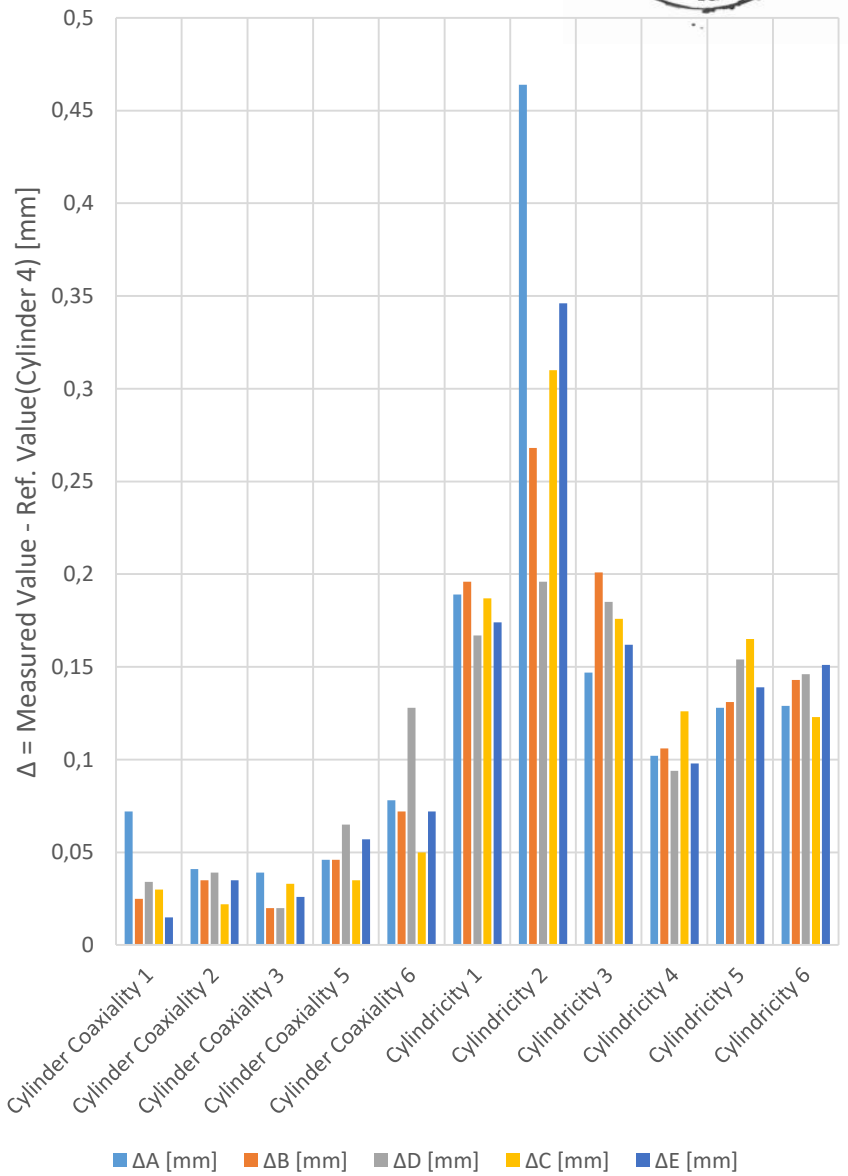
- **ISO/ASTM 52902:2019(E) for geometric test artifact**
- Cylindrical sample to improve CT Scanning performance for porosity evaluation

[C] ISO/ASTM 52902:2019(E). Additive manufacturing - Test artifacts - Geometric capability assessment of additive manufacturing systems

Case 6: Performance analysis of an L-PBF system with Hastelloy X







Note: dimensione voxel 20 µm

Case 6: Performance analysis of an L-PBF system with Hastelloy X

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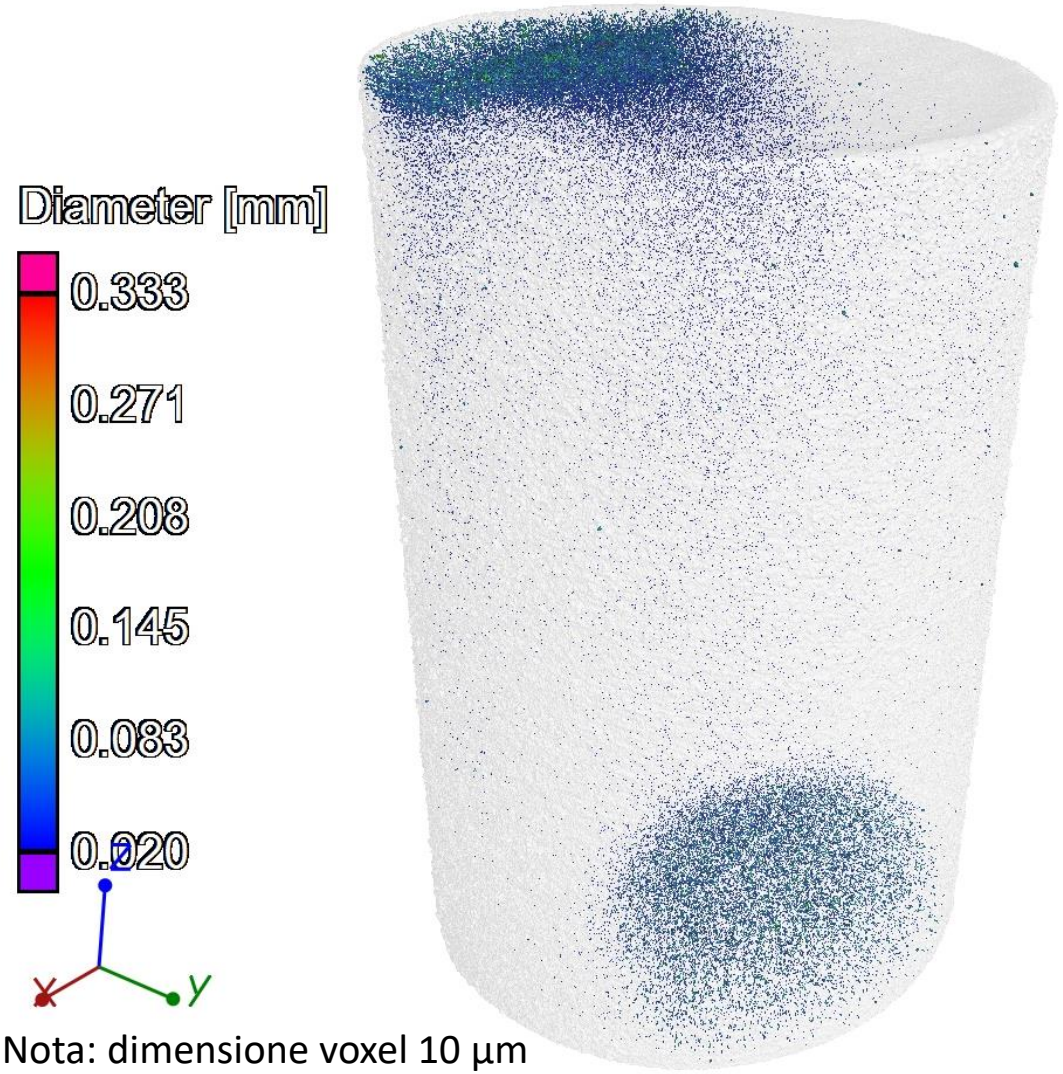
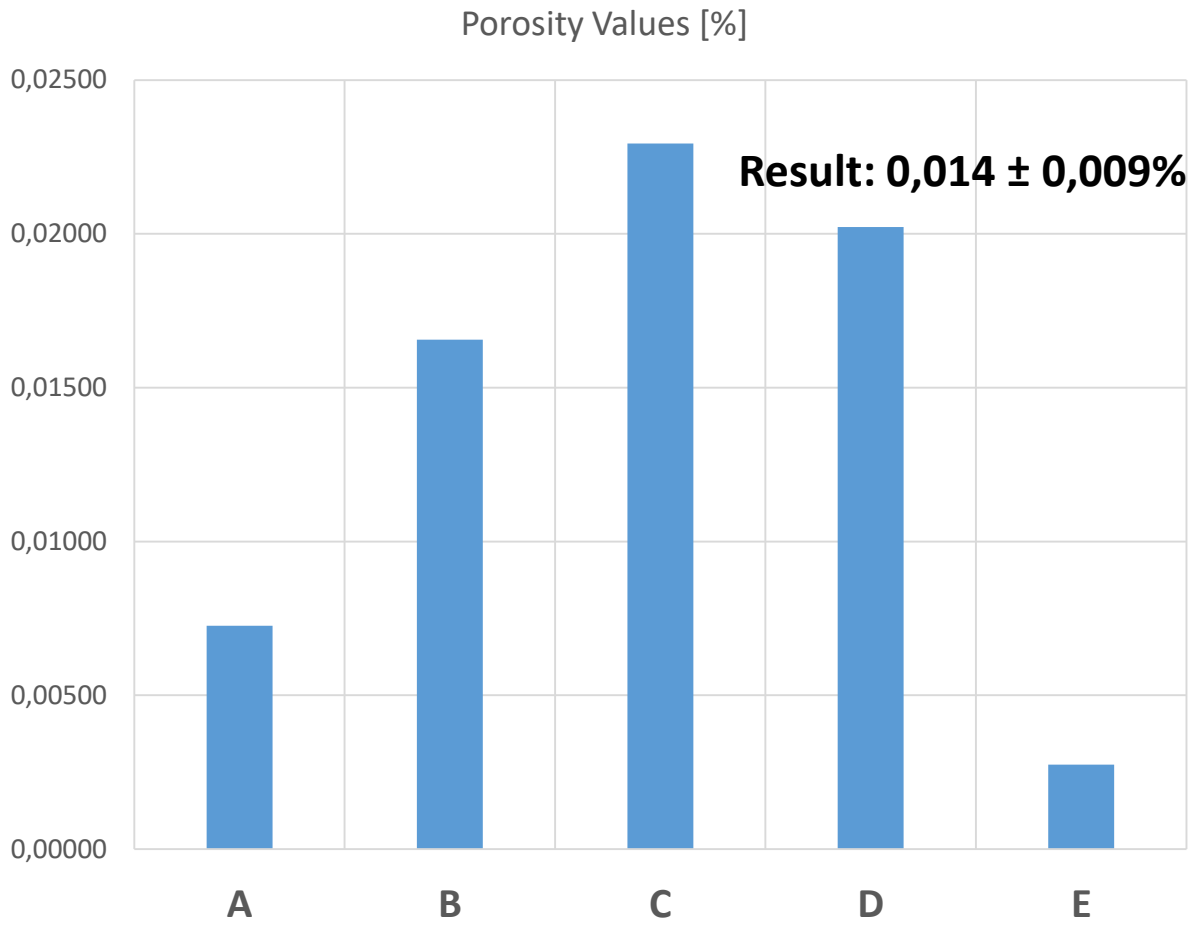
Porosity example





Nota: dimensione voxel 10 µm

THANK YOU FOR YOUR ATTENTION

Edited by

Paolo Fresi

Industrial CT Specialist & Quality Manager

LABORMET DUE Srl

Corso Orbassano 402/18, 10137 Torino

C.E.O. RICCARDO GIRELLI

Phone 011 740905

r.girelli@labormetdue.it

info@labormetdue.it

www.labormetdue.it