



ASSOLOMBARDA
Confindustria Milano Monza e Brianza

La stampa 3D come nuovo sistema manifatturiero per la produzione di componentistica ad alte prestazioni

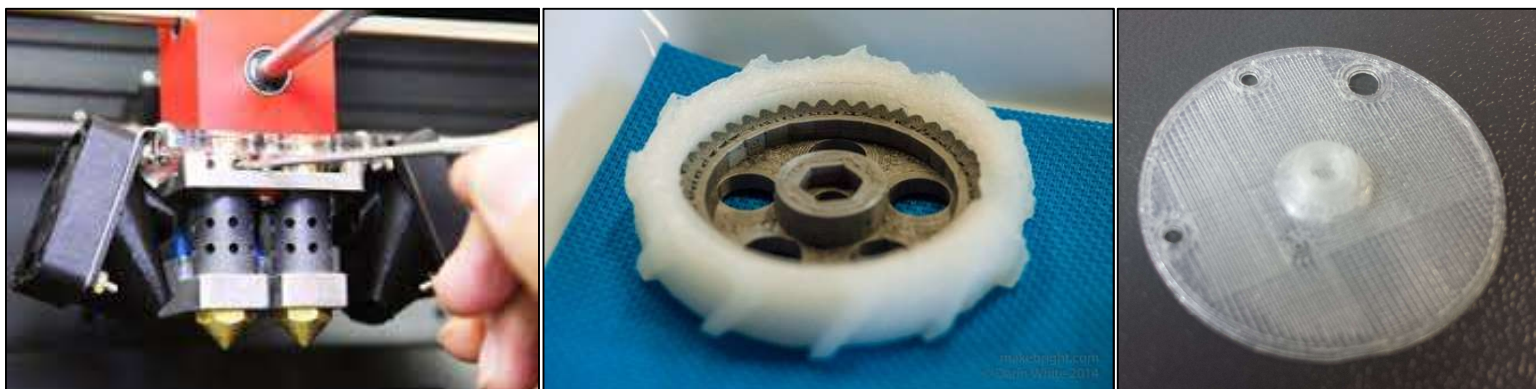
Speaker

Ing. Stefania Marconi, PhD

6 luglio 2016



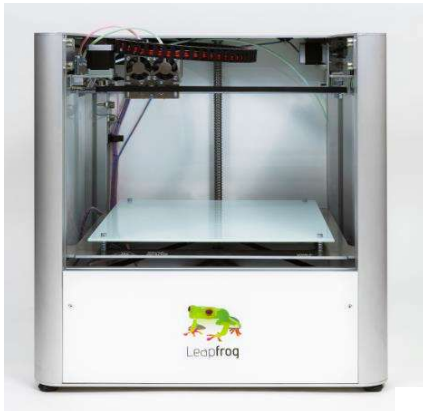
La stampa 3D come nuovo sistema manifatturiero per la produzione di componentistica ad alte prestazioni



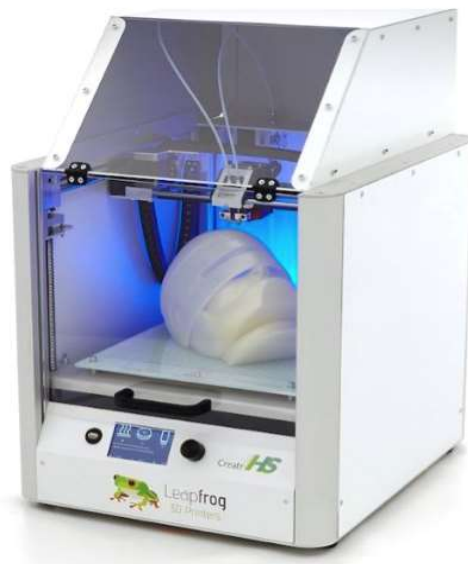
Protolab 3D Printers

FDM Printers

LeapFrog Creatr

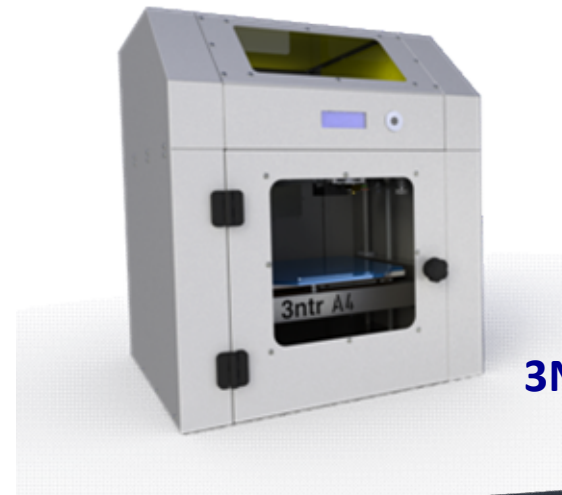


LeapFrog Creatr HS

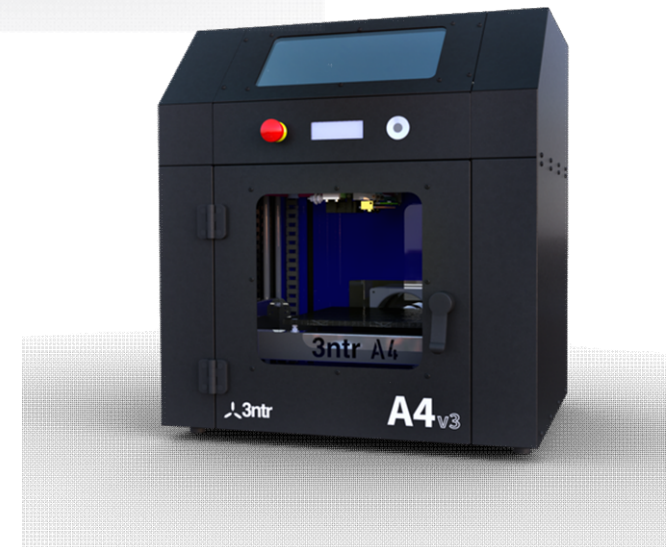


Professional FDM Printers

3NTR A4v2



3NTR A4v3



➤ ProtoLab: <http://www.unipv.it/3d/>

Protolab 3D Printers

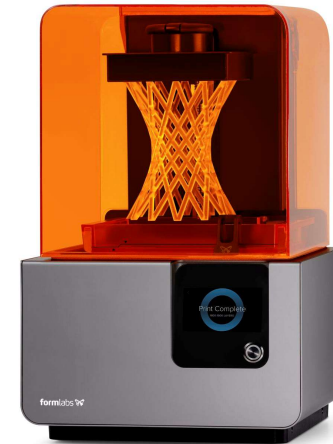
Binder jetting Printer

3DSYSTEMS ProJet 460 Plus

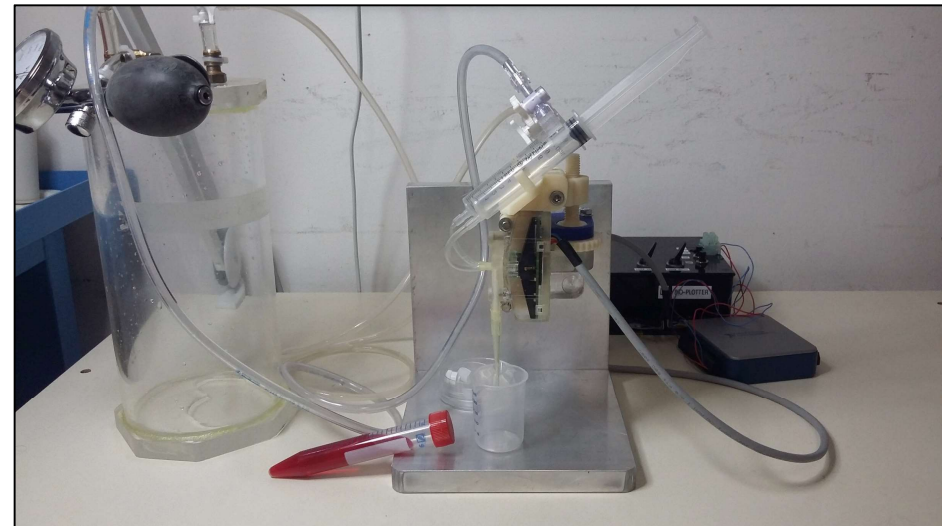


Stereolithography Printer

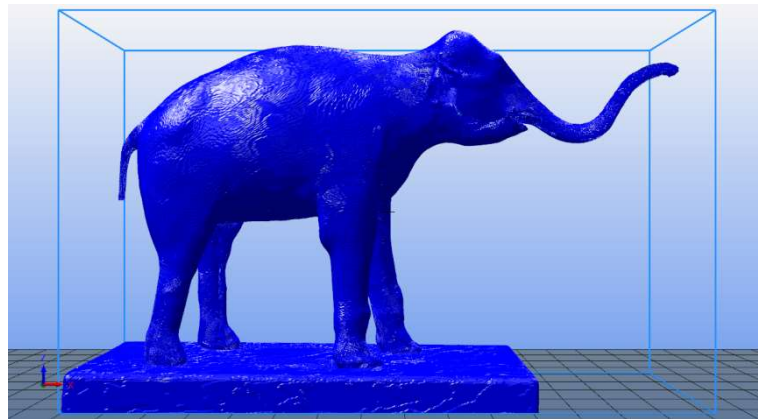
Form 2 Desktop SLA



BioPrinting System

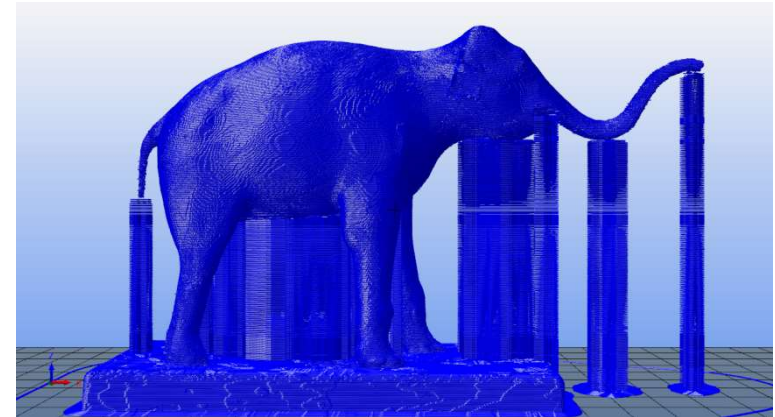


3D printing process



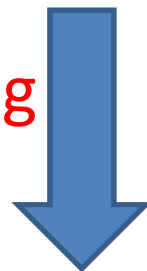
CAD Model

Slicing



Gcode

3D Printing

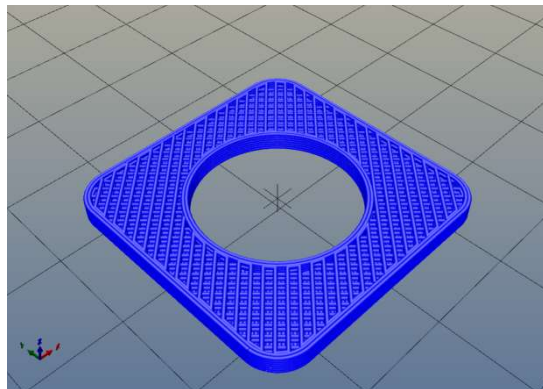
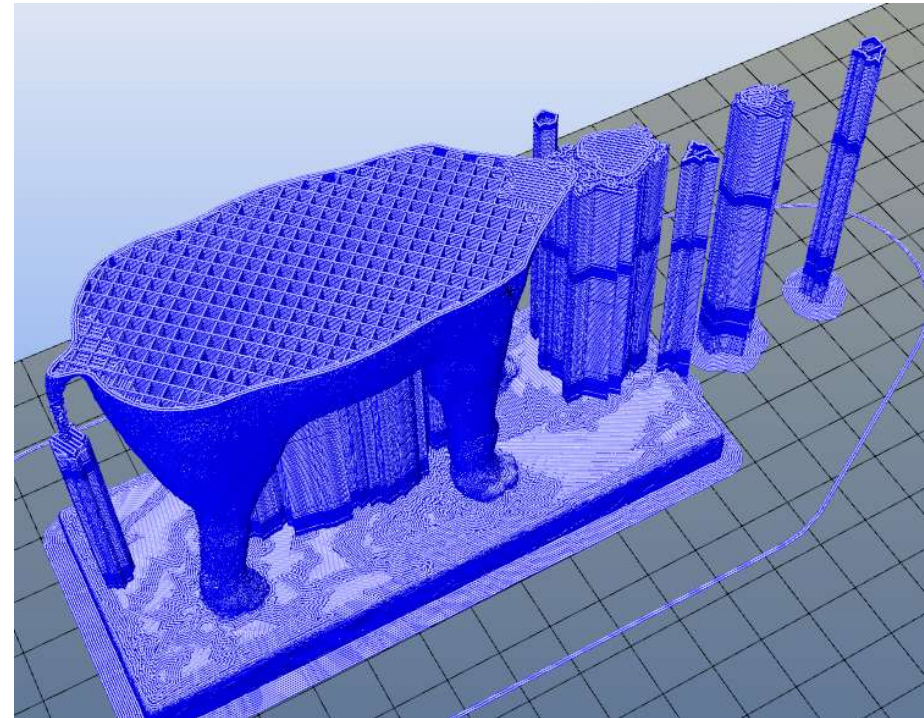


- 3D printing is mainly used to reproduce in a short time just geometrical features.

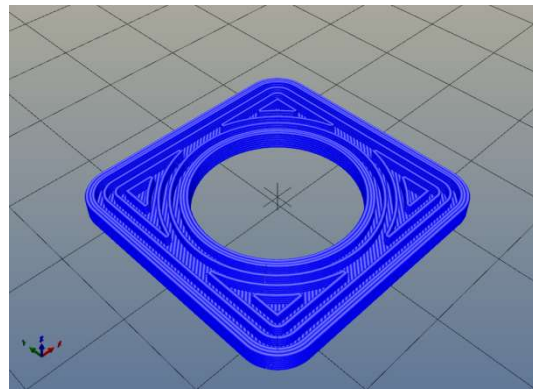
Slicing process

Slicing parameters:

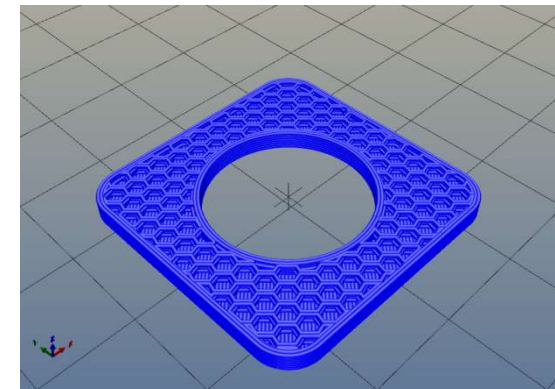
- **Layer:**
 - Height
 - Filament extrusion width
- **Infill**
 - Density
 - Pattern
 - Angle
 - ...



Rectilinear Infill



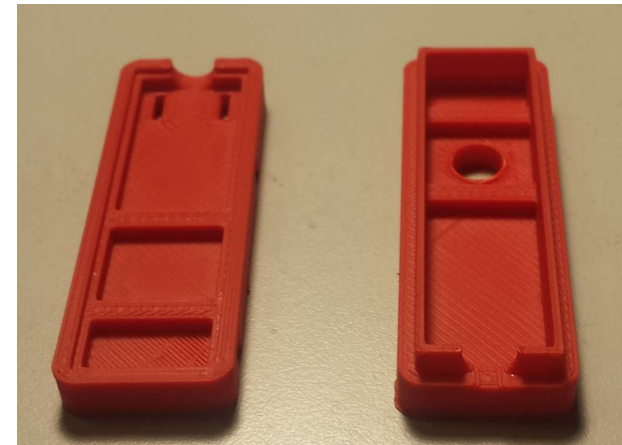
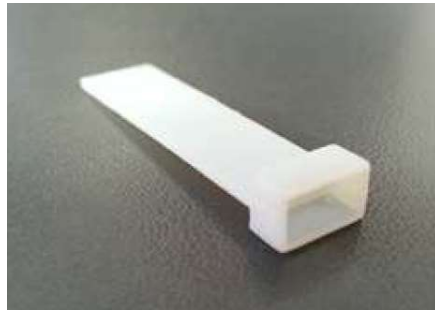
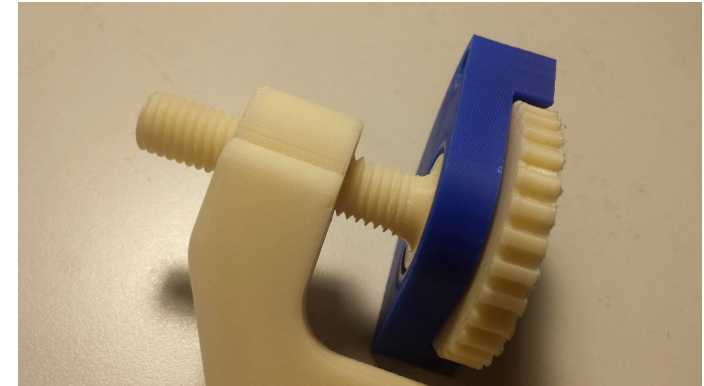
Concentric Infill



Honeycomb Infill

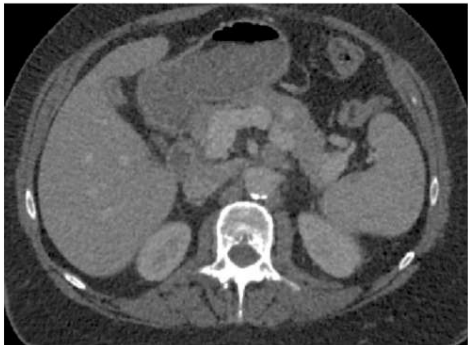
Protolab Activity

Examples:
CAD Design & Prototyping



3D Printing

Examples: Medical Prototyping



MDCT Scan

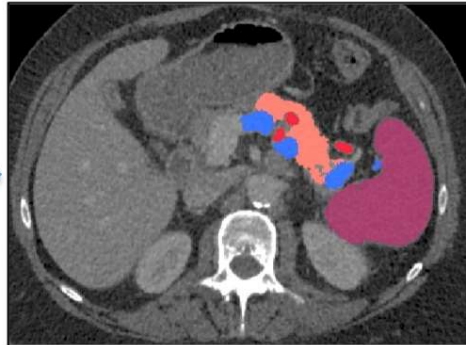
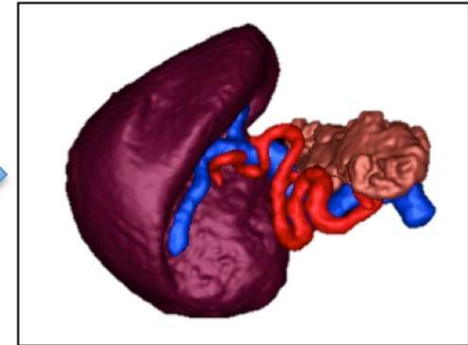
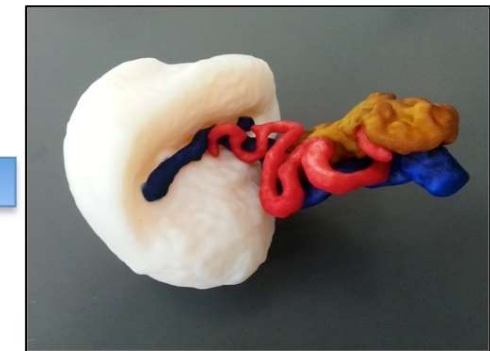


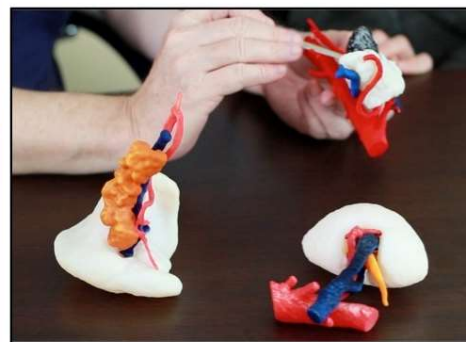
Image
Segmentation



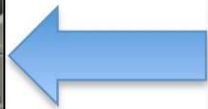
3D Virtual
Model



3D Printed
Model



Surgical
Planning



Minimally
Invasive Surgery

High-performance printing

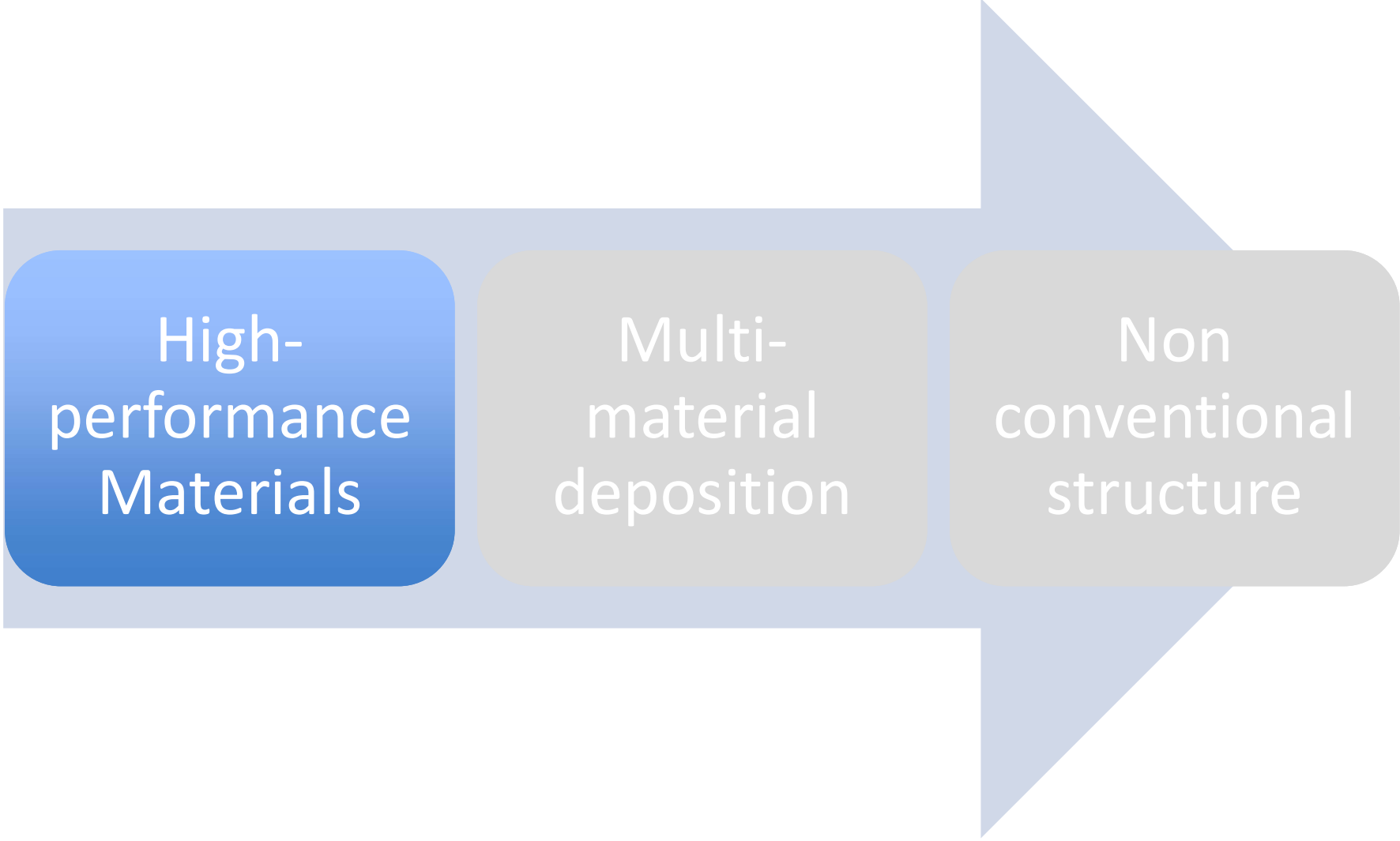
- 3 keywords to gain high-performance 3D printed components

High-
performance
Materials

Multi-
material
deposition

Non
conventional
structure

High-performance printing



High-
performance
Materials

Multi-
material
deposition

Non
conventional
structure

High-performance materials

- High-performance materials (requiring high printing temperature)



- High performance materials like **PEEK** and **ULTEM** used for:
 - Metal replacement in **mechanics**
 - Bioimplantable material in **medicine**

- High-deformable materials (requiring specific extrusion system)

- High deformable materials like:
 - **Silicone**
 - **Latex**
 - **Polymers with low Shore A (<10)**

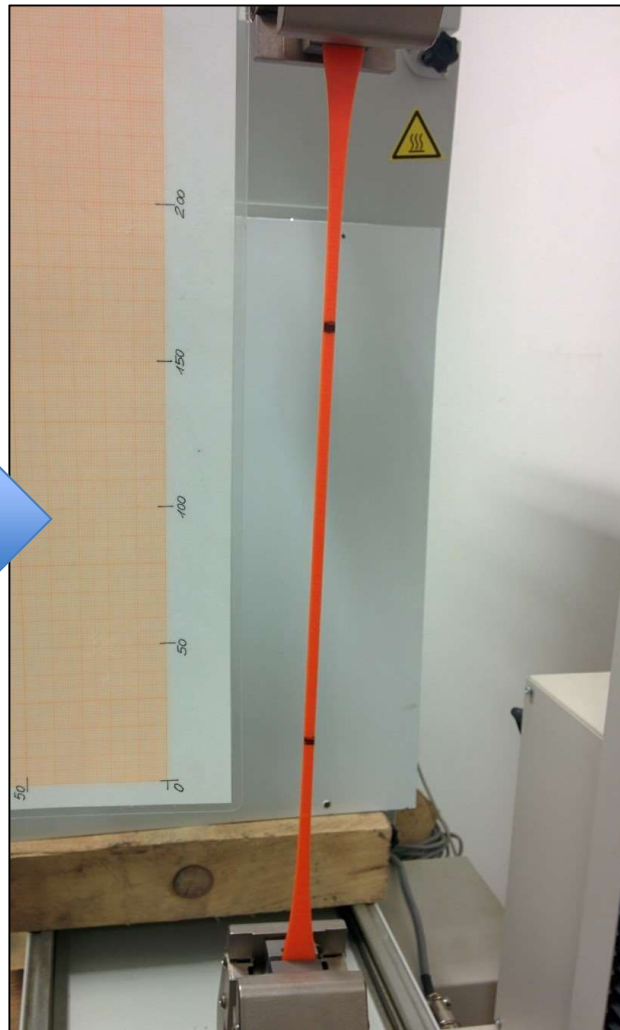
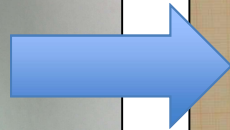
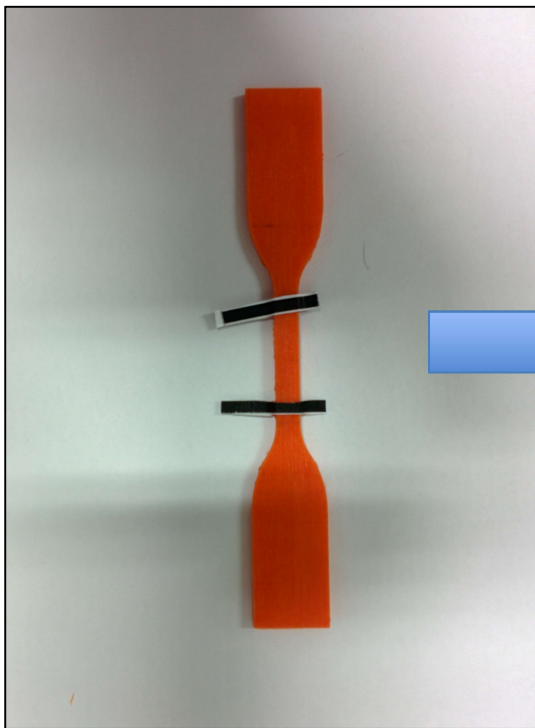


High-performance materials

- Print high-performance materials (requiring high printing temperature)

Mechanical testing of a TPU (Thermoplastic Polyurethane) specimen

- Elongation of 650%

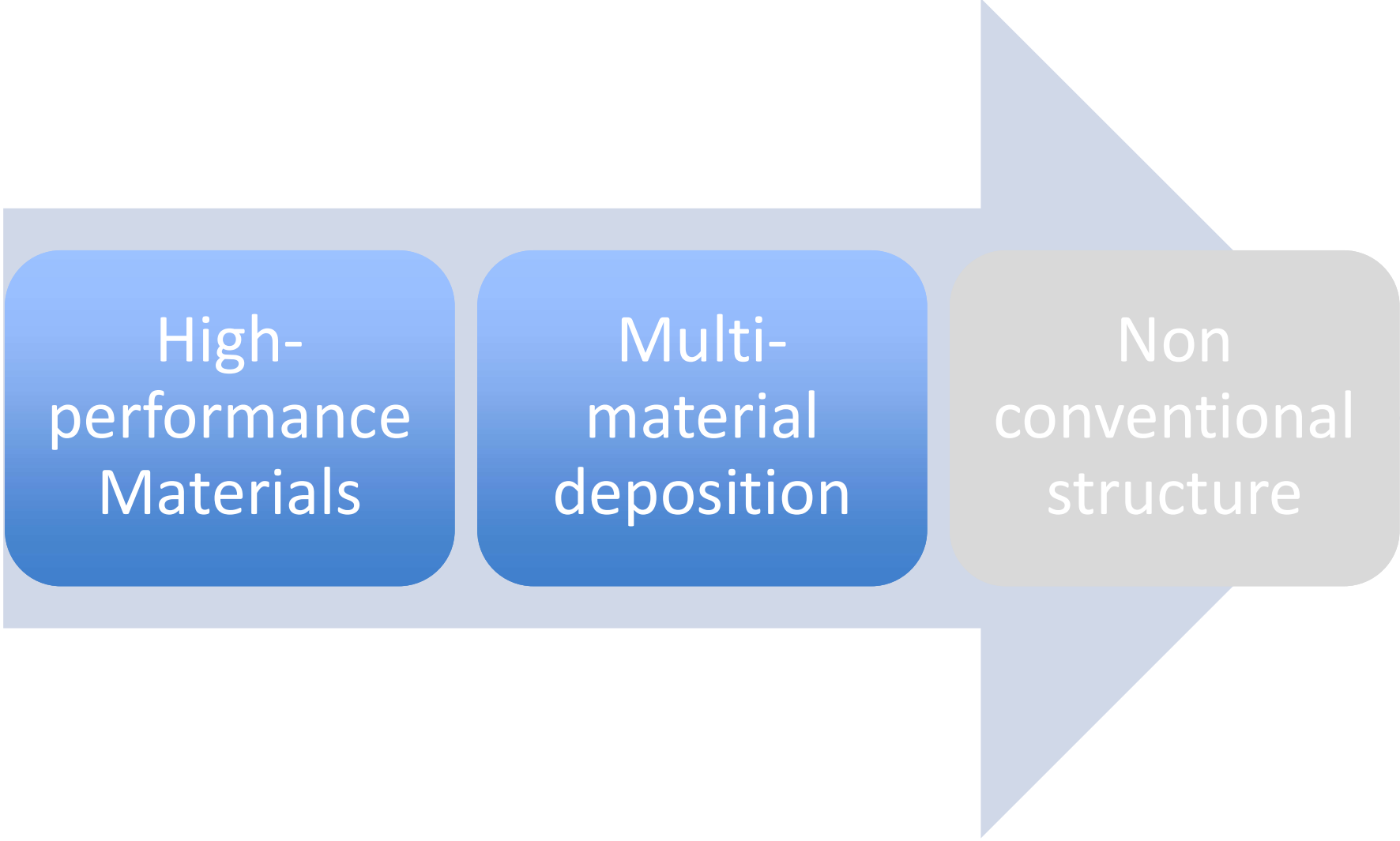


Application of high deformable materials:

- Seals
- Wearable devices
-



High-performance printing



High-
performance
Materials

Multi-
material
deposition

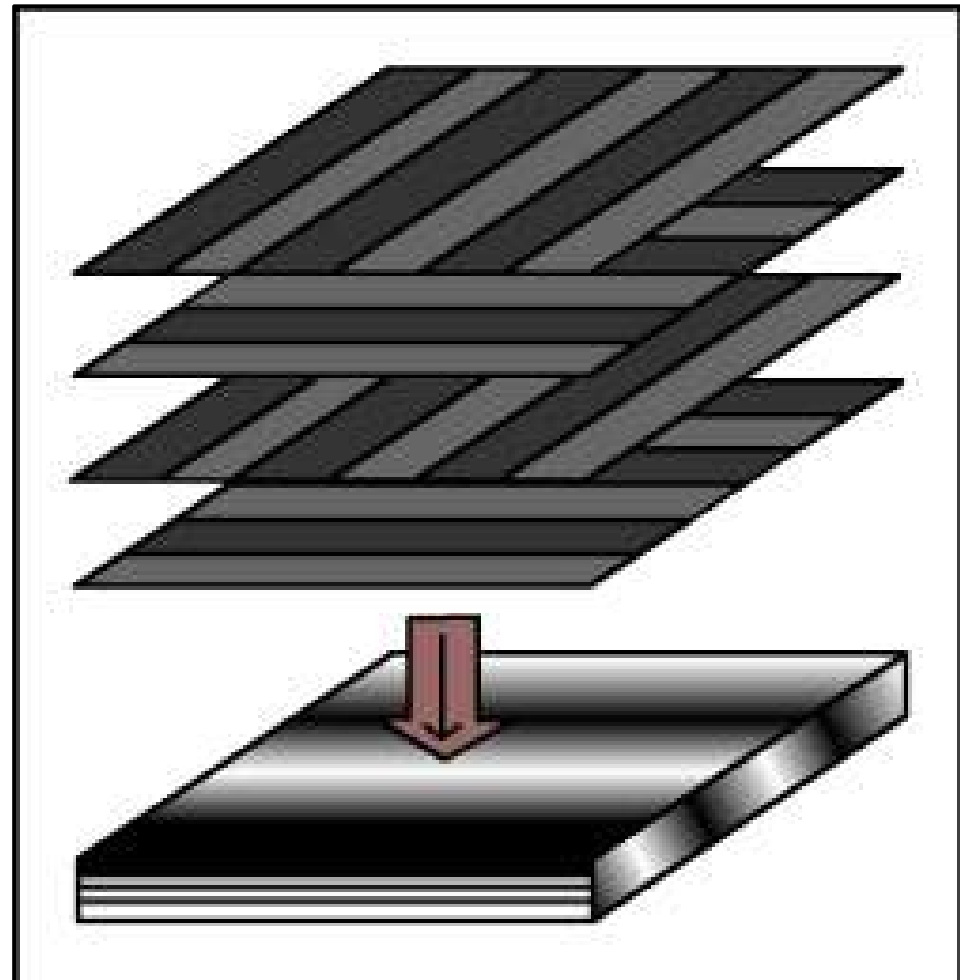
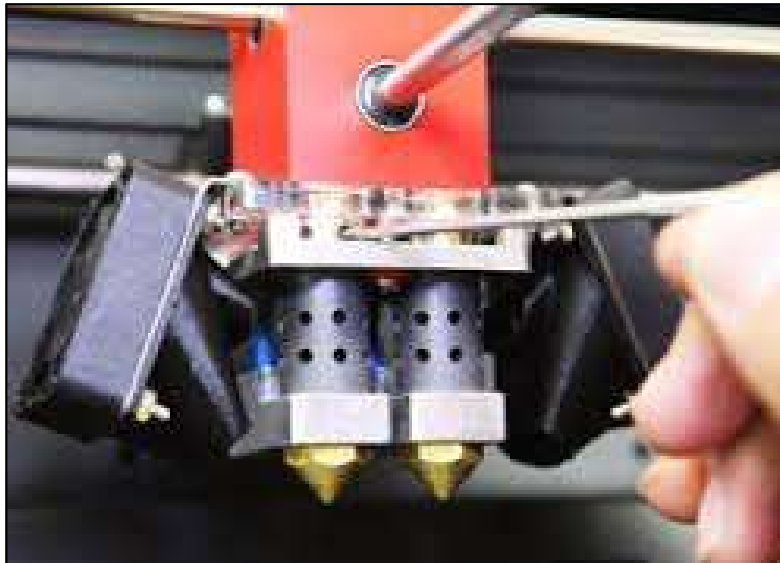
Non
conventional
structure

Multi-material solutions

Combine multiple materials to create composites



Specific mechanical properties
are given by both
materials and **structure**



Multi-material solutions

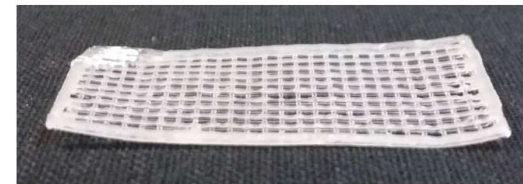
Printing solutions for multi-materials, possibly multi-performing

- Combine different biological properties

Example: PLA-PCL patches for esophageal tissue regeneration



- PLA: impermeabilization
- PCL: elasticity

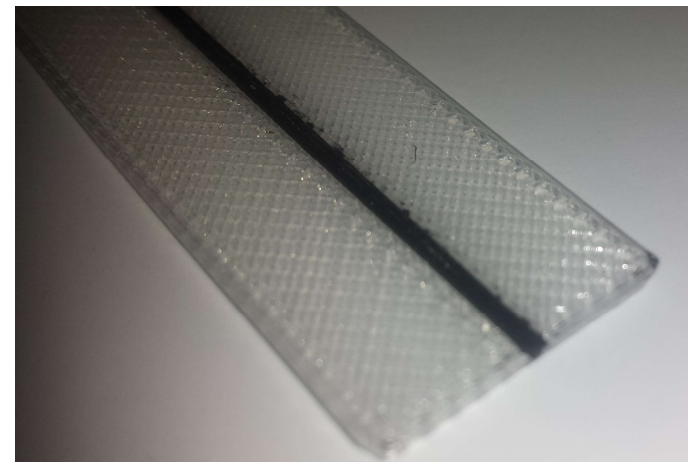


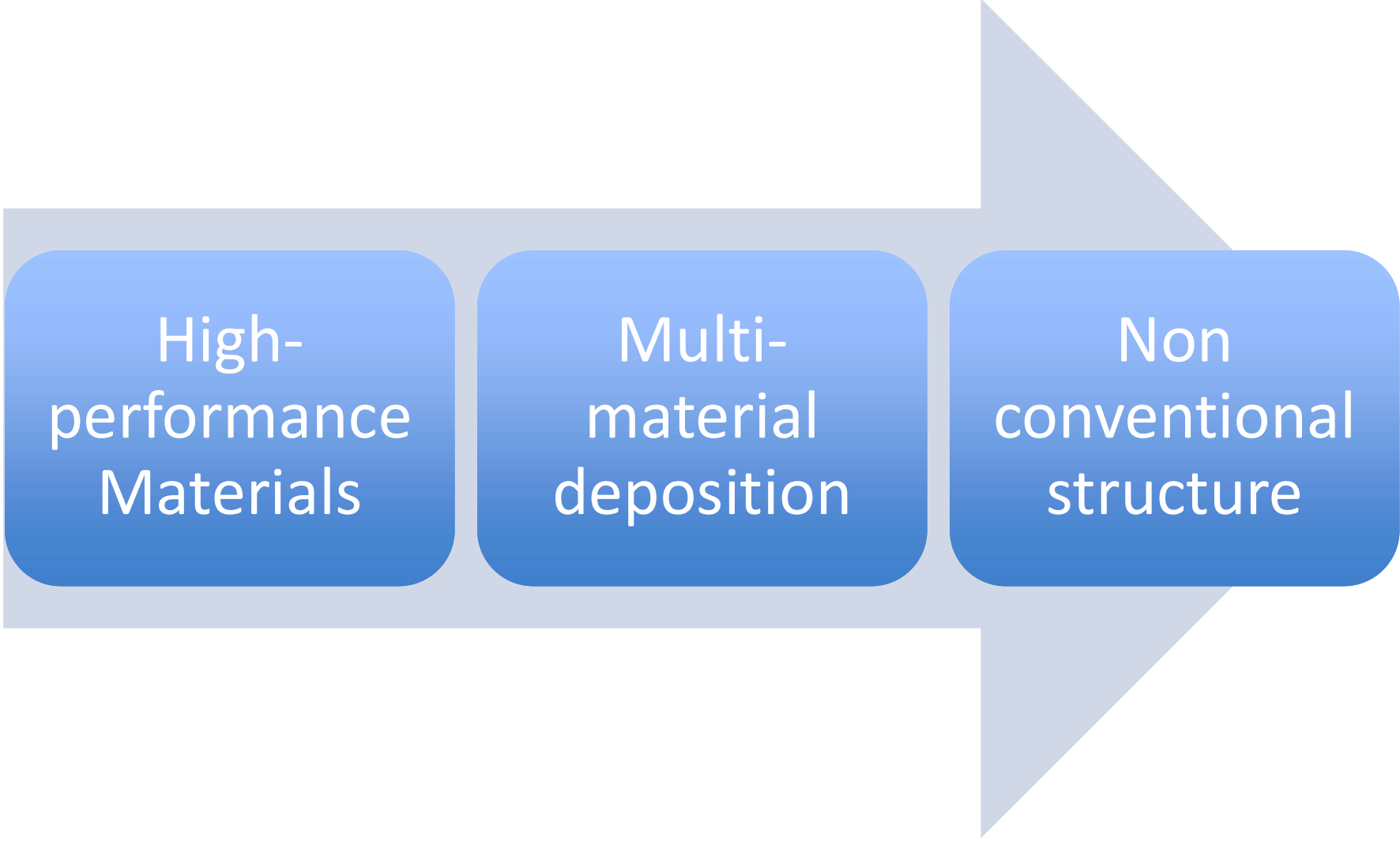
- Combine different electrical properties

Example: deformable and conductive materials for communication systems



Application at different frequencies





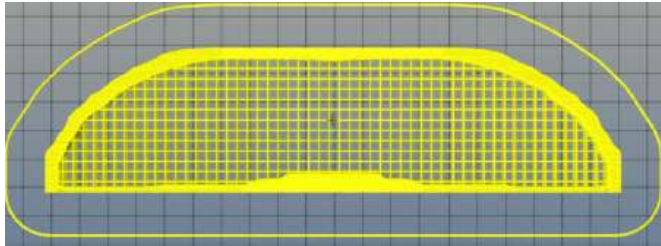
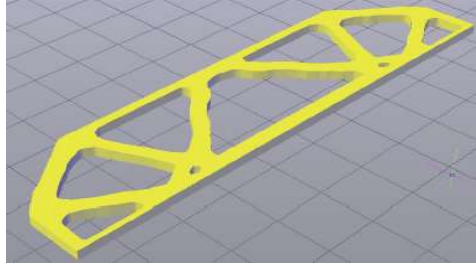
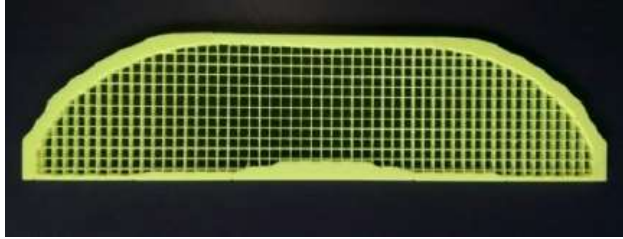
High-
performance
Materials

Multi-
material
deposition

Non
conventional
structure

Structure optimization

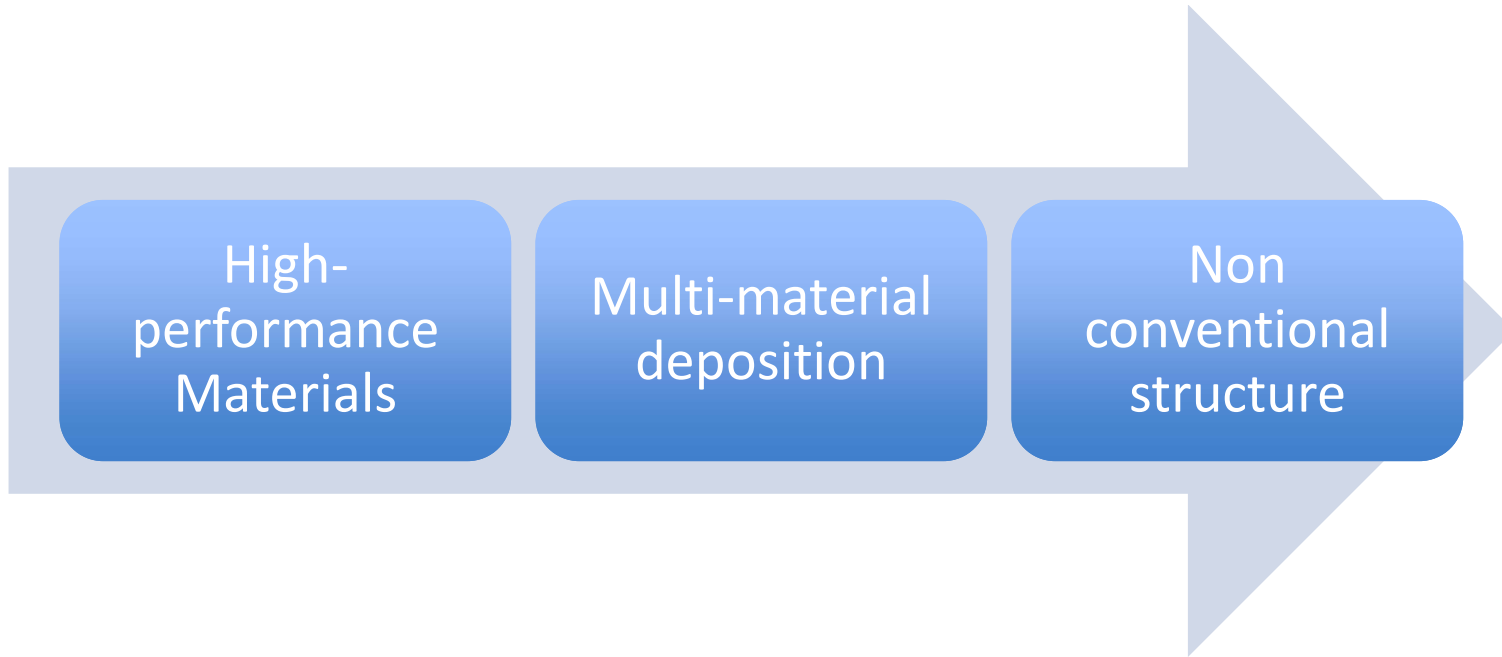
Concept of variable density → inspiration from **lattice material**

OPTIMIZATION	VARIABLE DENSITY	VOID-SOLID
CAD →		
PRINTED OBJECT (PLA) →		

Same level of stress of a non-optimized structure:

-50% mass
-85% vertical displacement

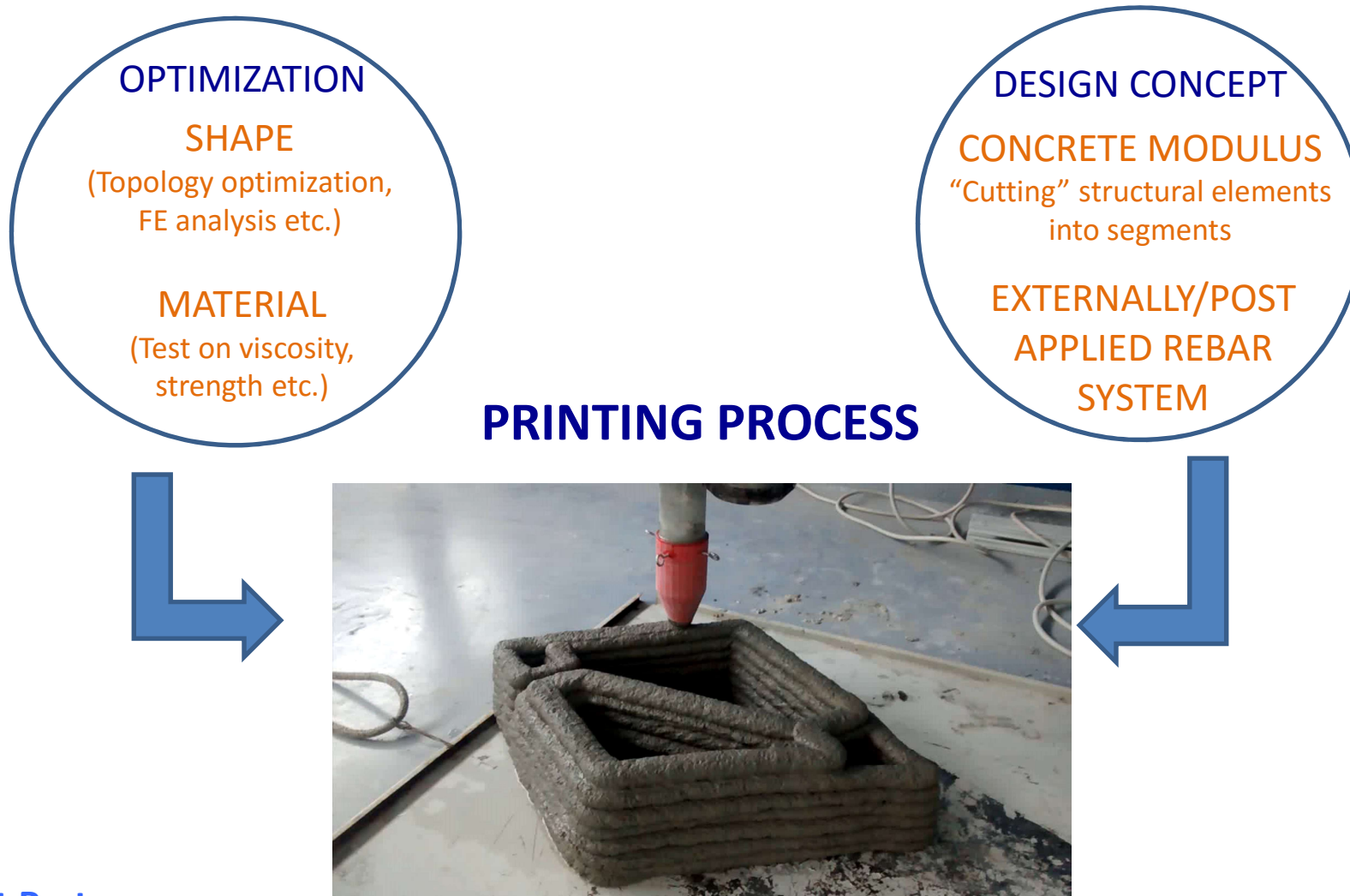
-10% mass
-85% vertical displacement



Example 1 : components for building

1- Components for building

Pilot study for 3D printed prototyping of building components



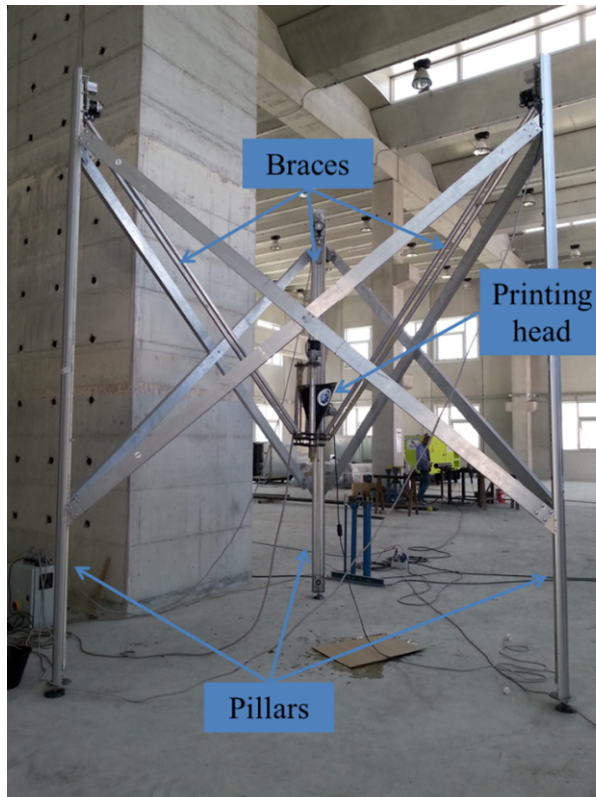
Project Partners

- **Università di Pavia**
- **Università "Federico II" di Napoli**
- **CESMA** (Advanced methodological Services Centre)
- **Stress Consortium** (High-tech Campania district on sustainable building)

1- Components for building

MATERIAL OPTIMIZATION

SLUMP TEST



**The BigDelta WASP
printing machine**



Optimal viscosity material → get an extrudable material

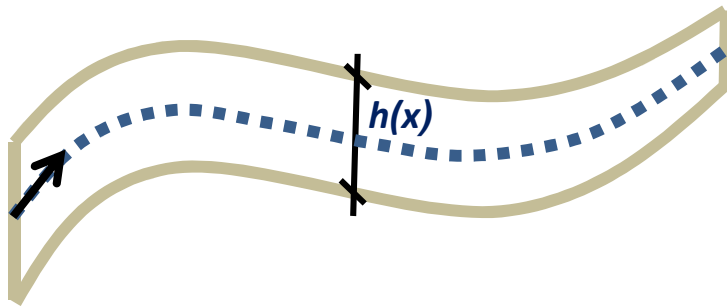


Mixture not too liquid → material capable of being stacked in layers

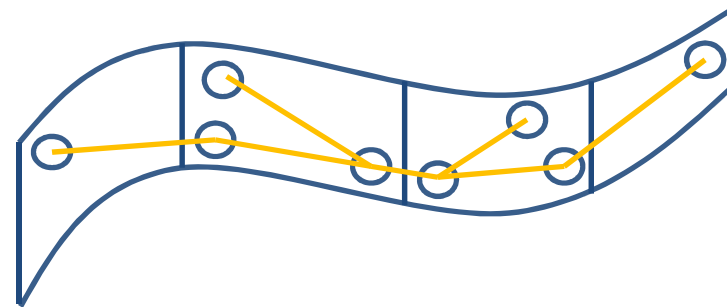
1- Components for building

DESIGN CONCEPT

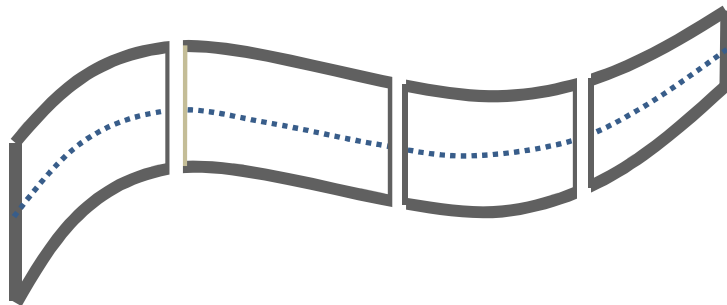
The beam design aims at saving material and guaranteeing adequate mechanical performances against the internal forces acting on it.



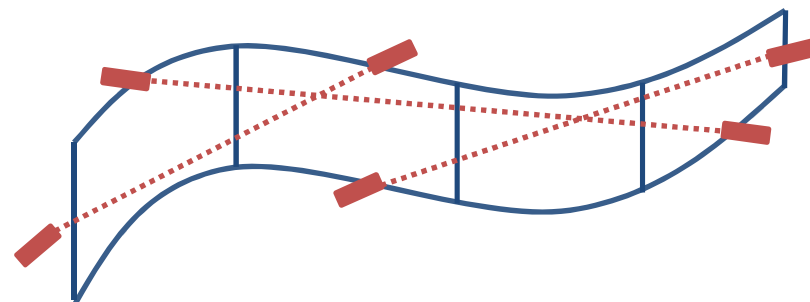
1. The target beam could present a curved longitudinal x axis and a variable cross-section $h(x)$



3. Rebar reinforcement scheme (in yellow)



2. The beam is cut into segments



4. Post-tensioned cable scheme (in orange)

1- Components for building

THE PRINTING



- Printing time / segment ≈ 20 min
- TOTAL printing time ≈ 2 hours
- A number of holes needs to be designed to anchor the rebar.



1- Components for building

THE ASSEMBLY

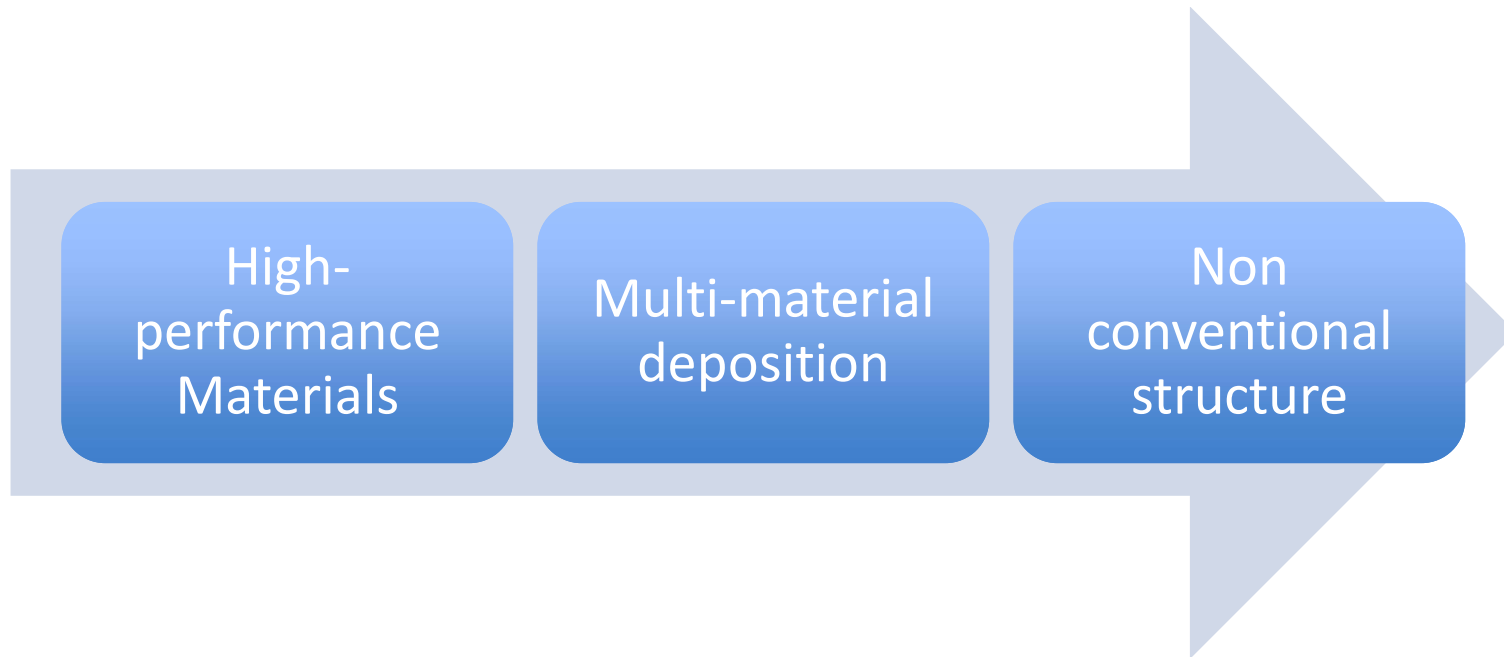


Fixing of rebars: Securing the bar anchorages in the holes with an epoxy resin.

THE FINAL BEAM

Initial TOTAL weight ≈ 29 kN
 ≈ 45 % of the weight of the
equivalent solid beam





Example 2 : ceramics components

2 - Ceramic components

Metals and ceramics printing using low-cost FDM 3D printers

- Design specific (thermal) processes to synthesize components with a complex shape made of advanced carbide ceramics

Preliminary results:



Applications:



Aerospace:
turbine blade



Automotive:
brake booster



Transportation:
high-speed rail



Energy:
Oil pump



Mechanical components:
load bearing system