anisoprint

3D PRINTING OF COMPOSITES

Lightweight, flexible, sustainable

anisoprint.com ↗

ANISOPRINTING: UNIQUE TECHNOLOGY OF COMPOSITE 3D PRINTING

Disruptive solution
for $500B emerging market

40 experts in composites,
3D printing, marketing and sales

$2.6 mln revenue in 2021

IP portfolio of 25 patents/applications,
software and knowhows

2 times annual
revenue growth

$5 mln funding needed

AGENDA

→ problem & solution

→ anisoprinting technology

→ solutions

→ use cases

→ market and business model

→ team

→ competitors

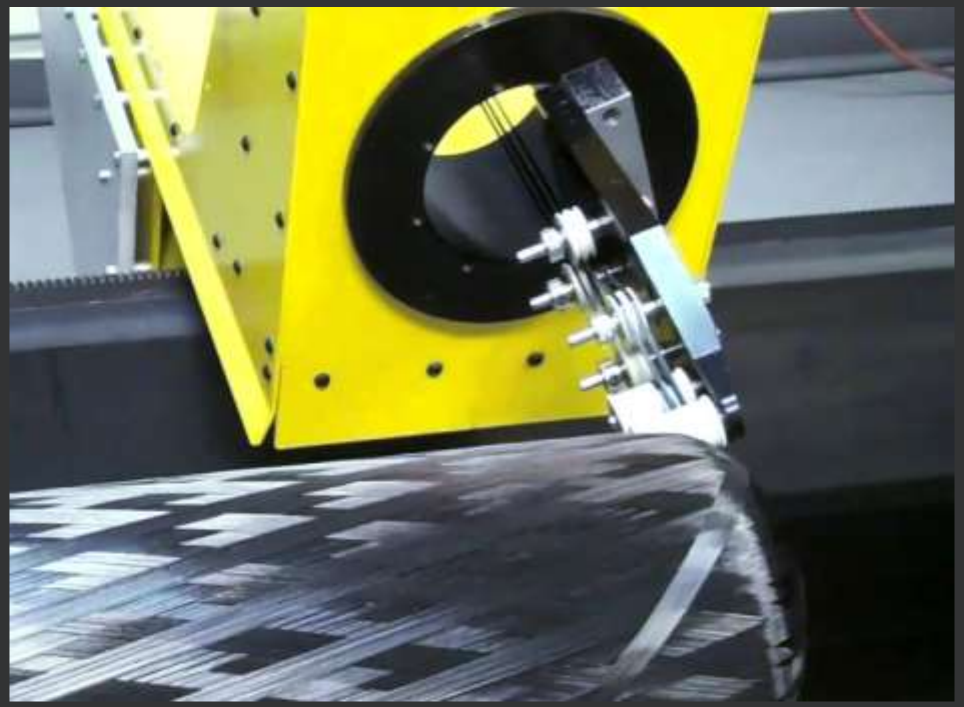
→ investment opportunity

DEMAND FOR FLEXIBILITY AND LIGHTWEIGHT SOLUTION?

3D printing

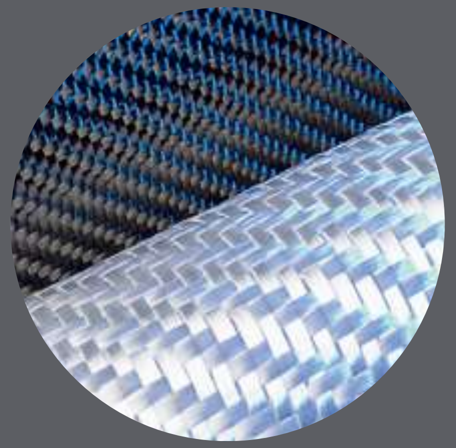
→ on-demand
→ digital
→ automated

Composites



→ high strength
→ lightweight
→ anisotropic

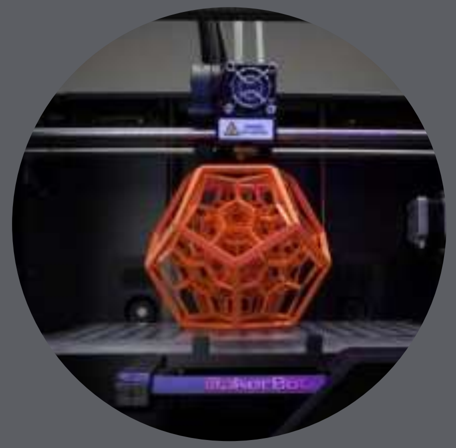
3D PRINTING COMPOSITES. SYNERGY FOR DISRUPTION



Composites

strong and light

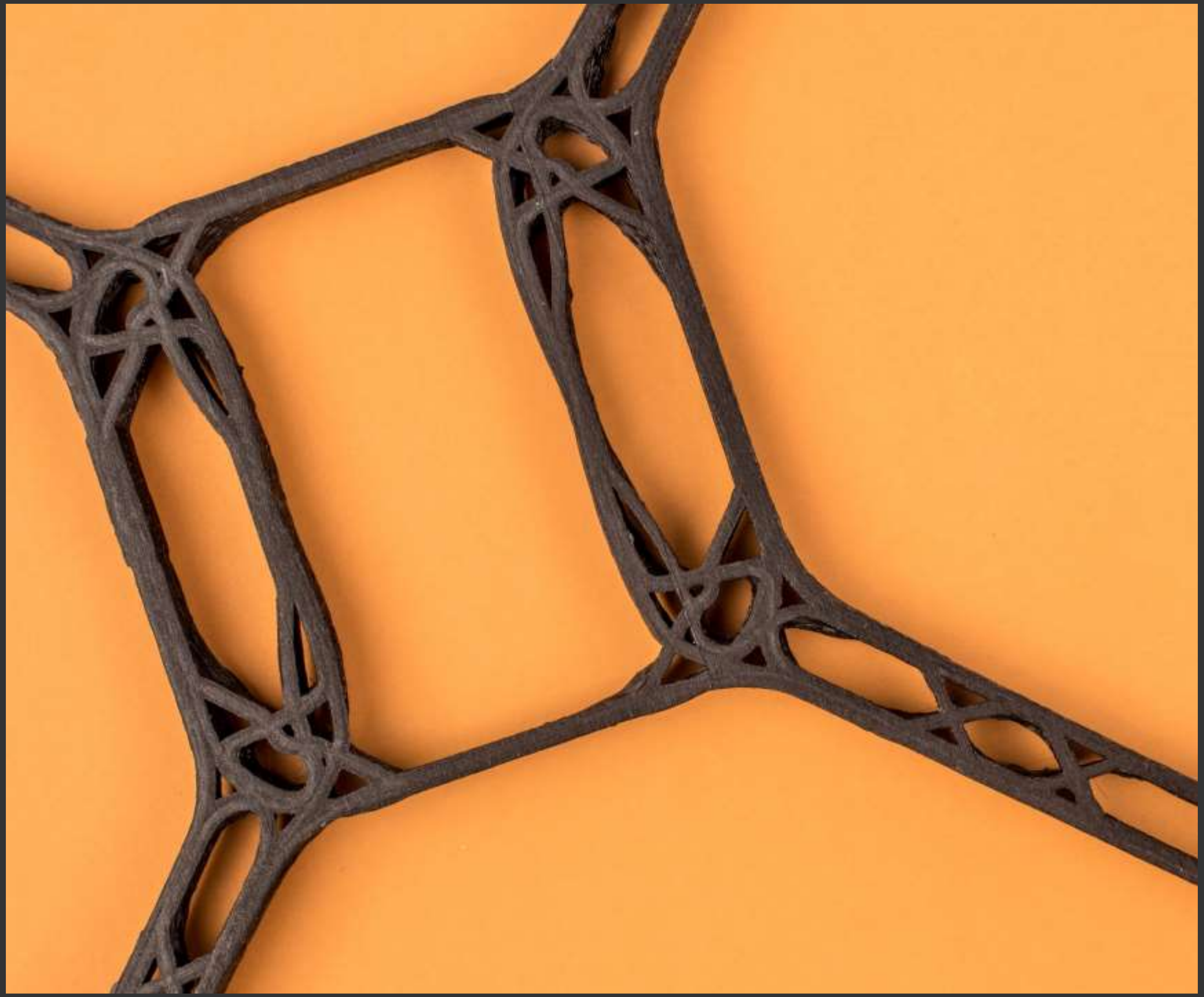
Generative design



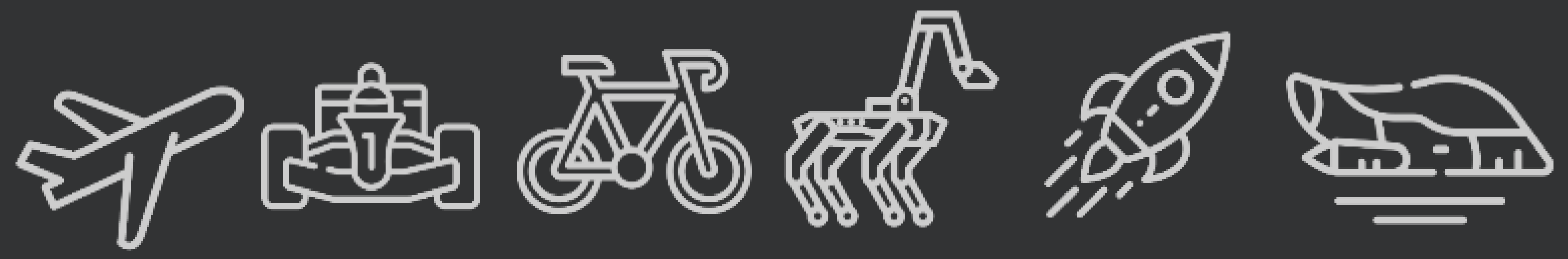
3D printing

flexible and on-demand

ANISOPRINTING



3d printing of optimal composites for:

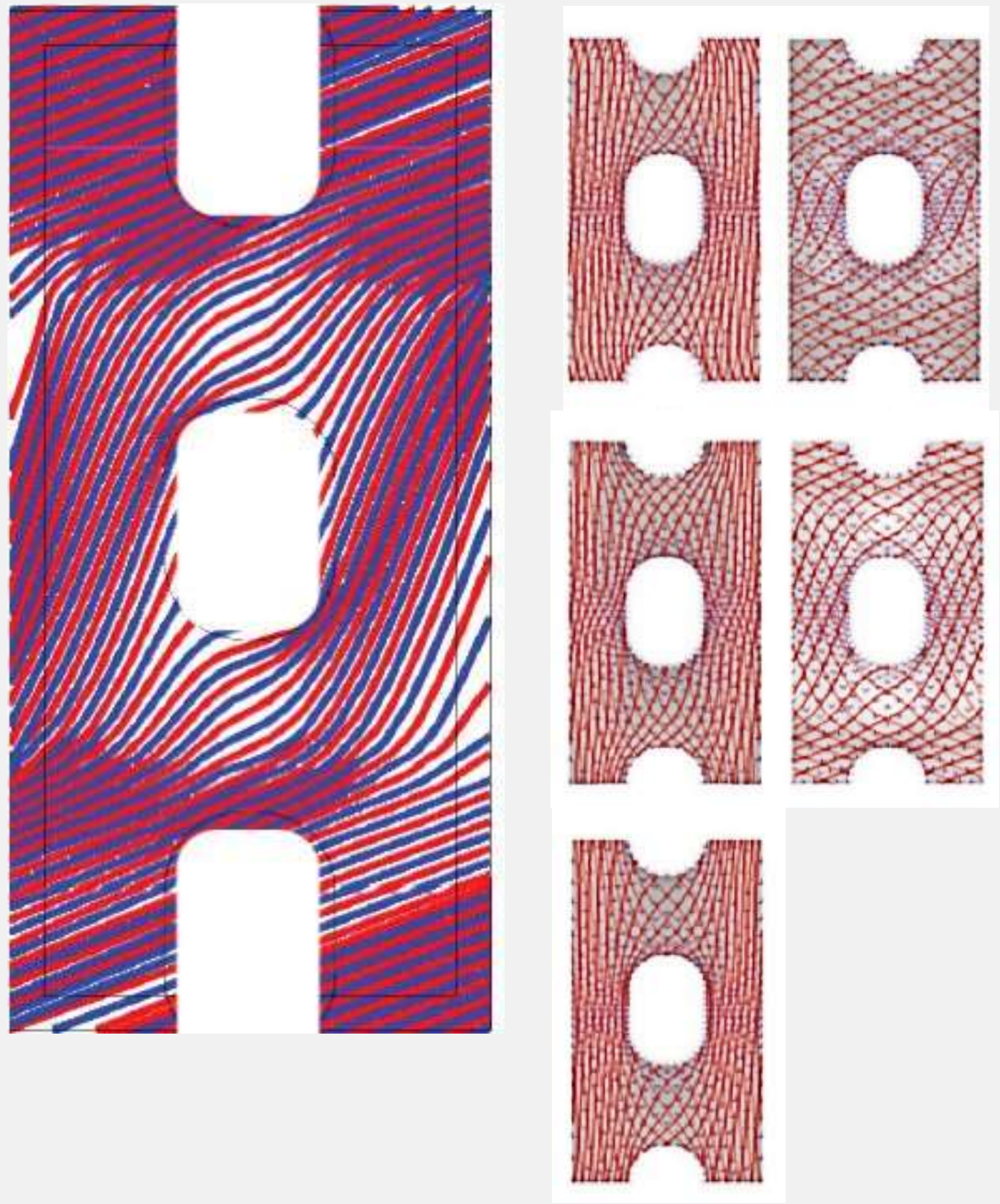


ANISOPRINTING TECHNOLOGY

COMPOSITE FIBER CO-EXTRUSION

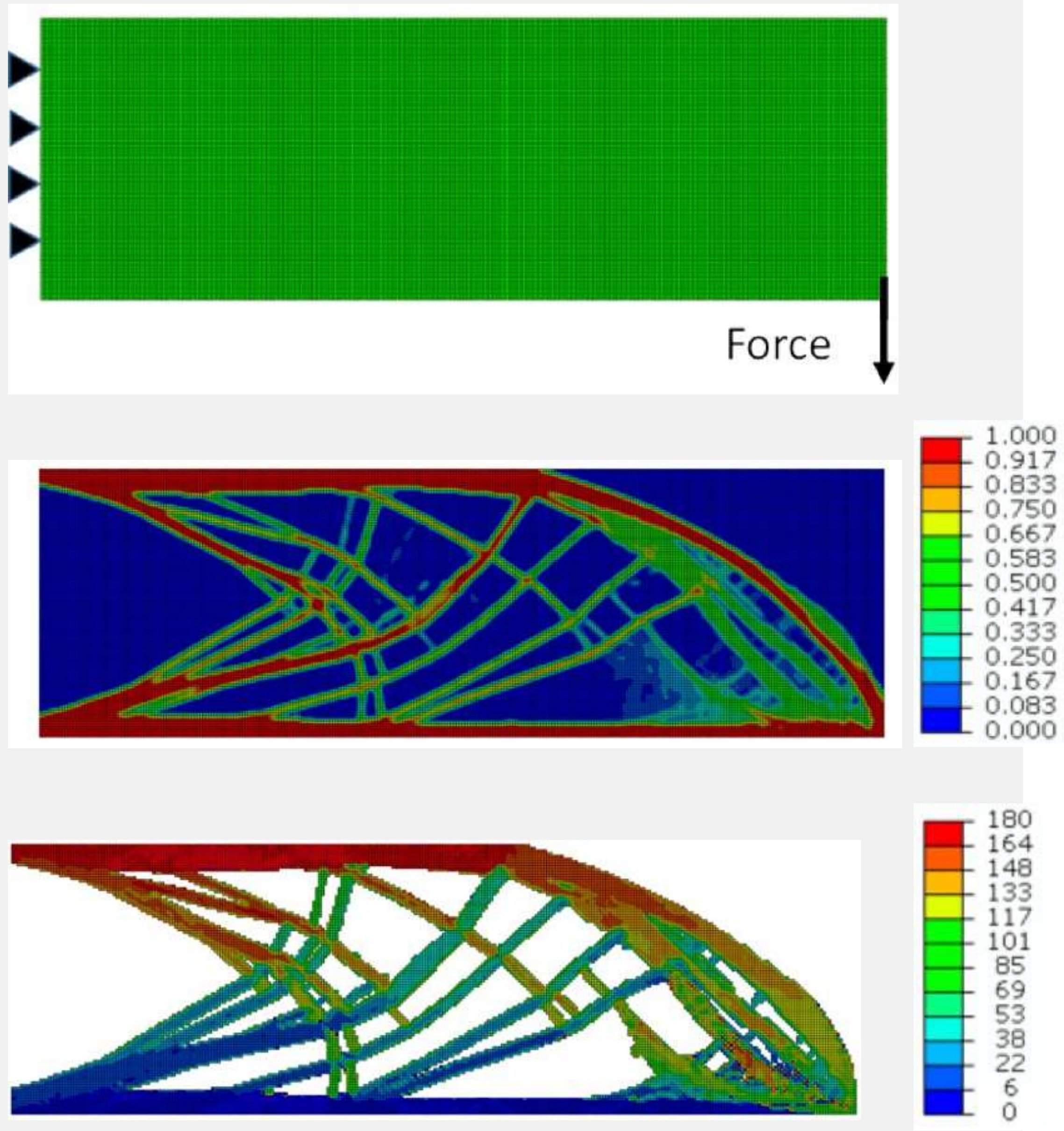
Lattice structures

+



Fiber steering

+



Topology optimization

CONTINUOUS CARBON FIBER 3D PRINTING TECHNOLOGIES

Prepreg based

or

Prepreg filament

Prepreg tape (AFP)

Before 3D printing*

Co-extrusion based

Dry fibers + molten plastic

During 3D printing*

*Composite material is created

PROS & CONS

Prepreg based

✓Good impregnation and adhesion
✗Limited shapes
✗Constant fiber volume ratio
✗Matrix material is predefined

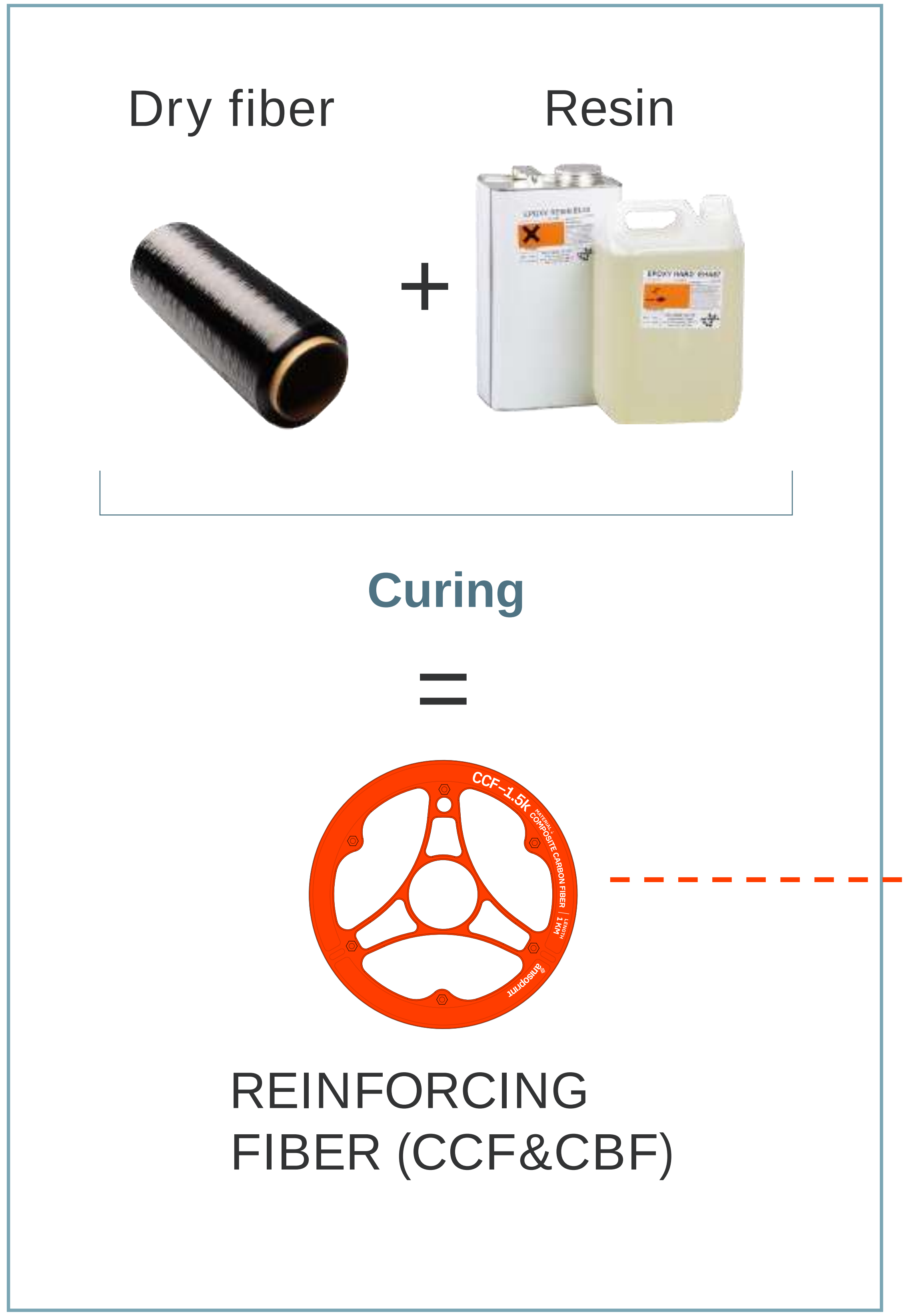
→ BETTER MATERIAL QUALITY

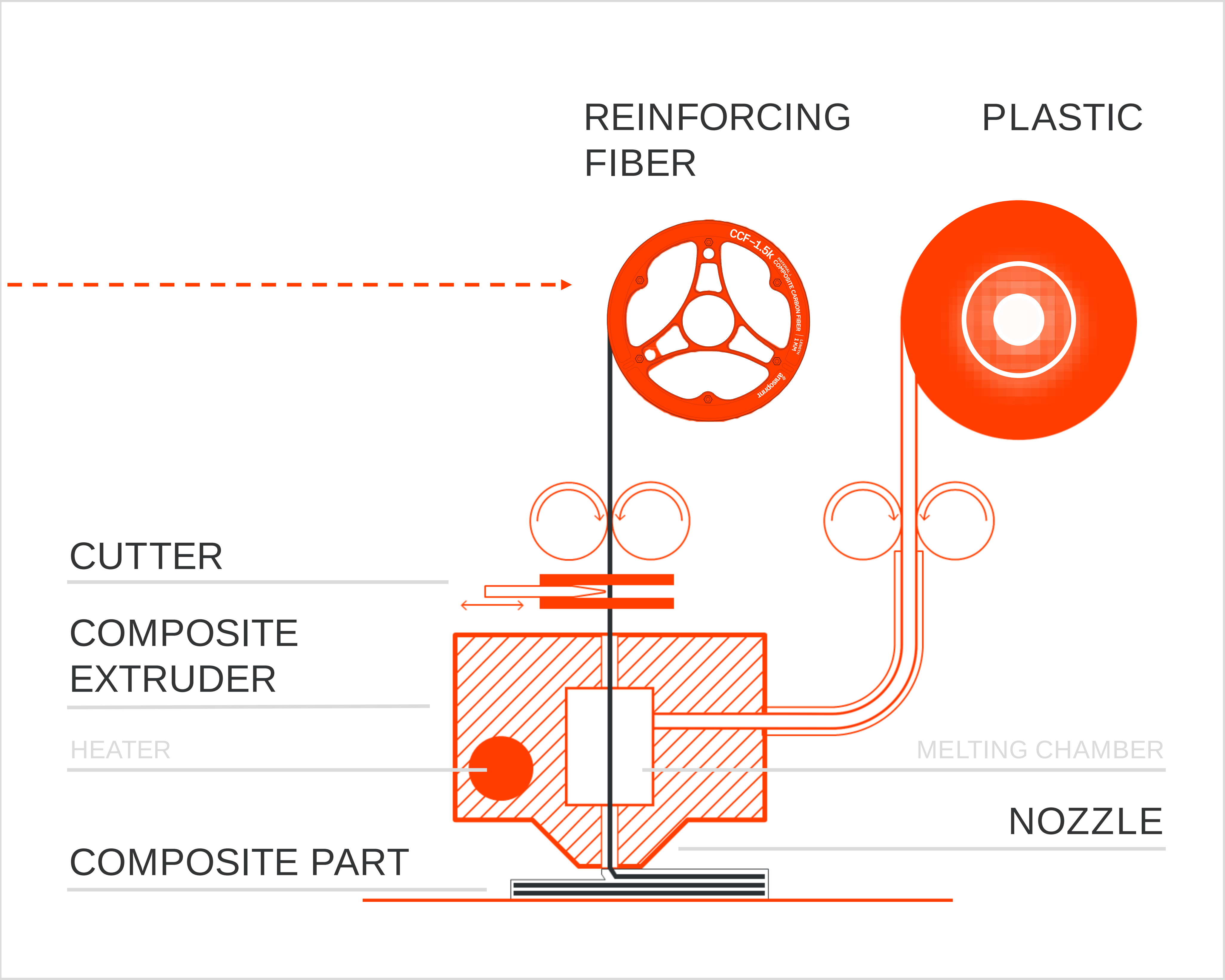
Co-extrusion based

✗Bad impregnation and adhesion
✓Complex shapes
✓Flexible fiber volume ratio
✓Wide range of matrixes

→ FLEXIBILITY: COMPLEX SHAPES, WIDE RANGE OR PROPERTIES

BEST OF BOTH WORLDS

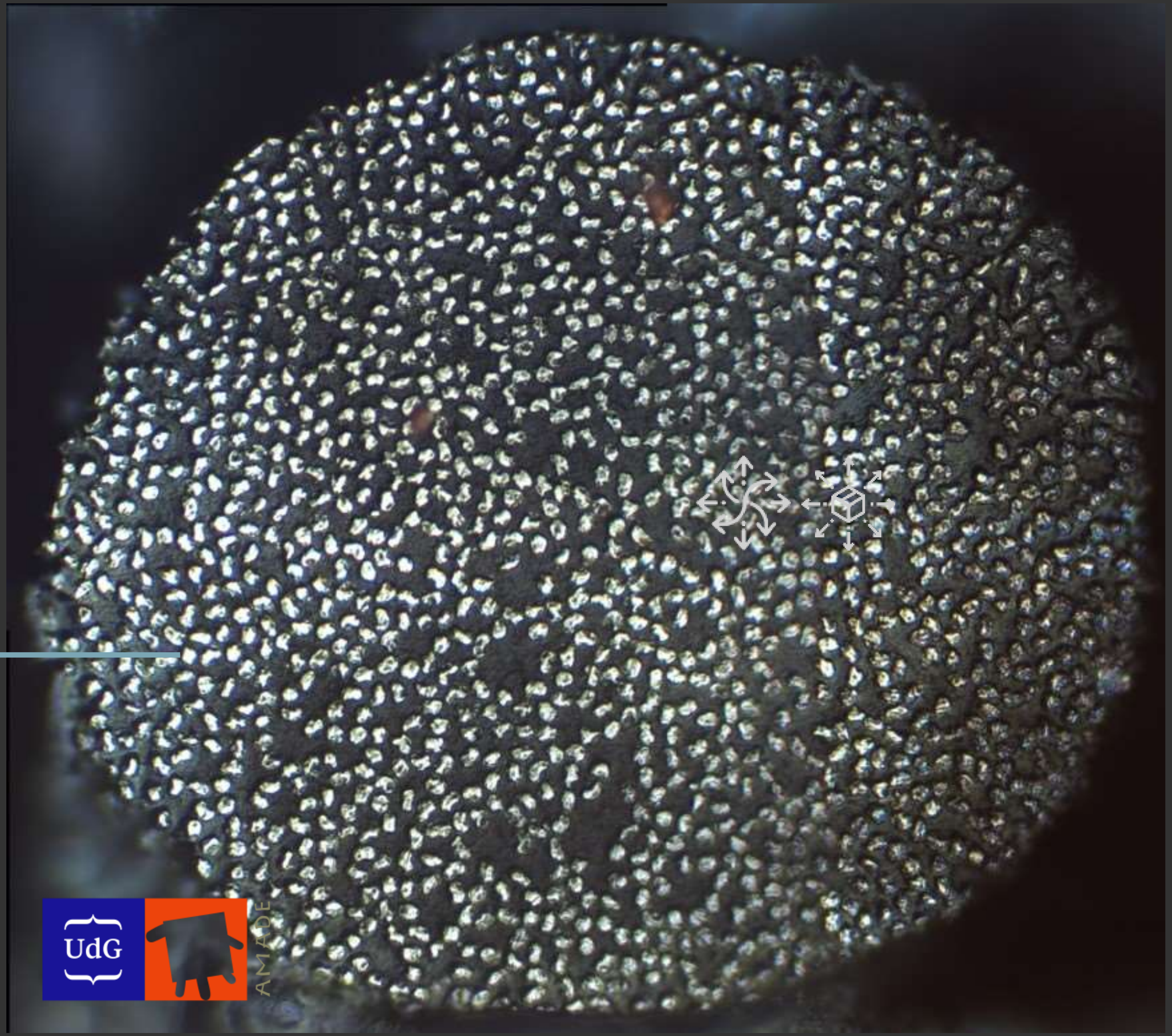




LOW POROSITY — BETTER MATERIAL QUALITY

Fiber volume fraction 60%

Carbon fibers



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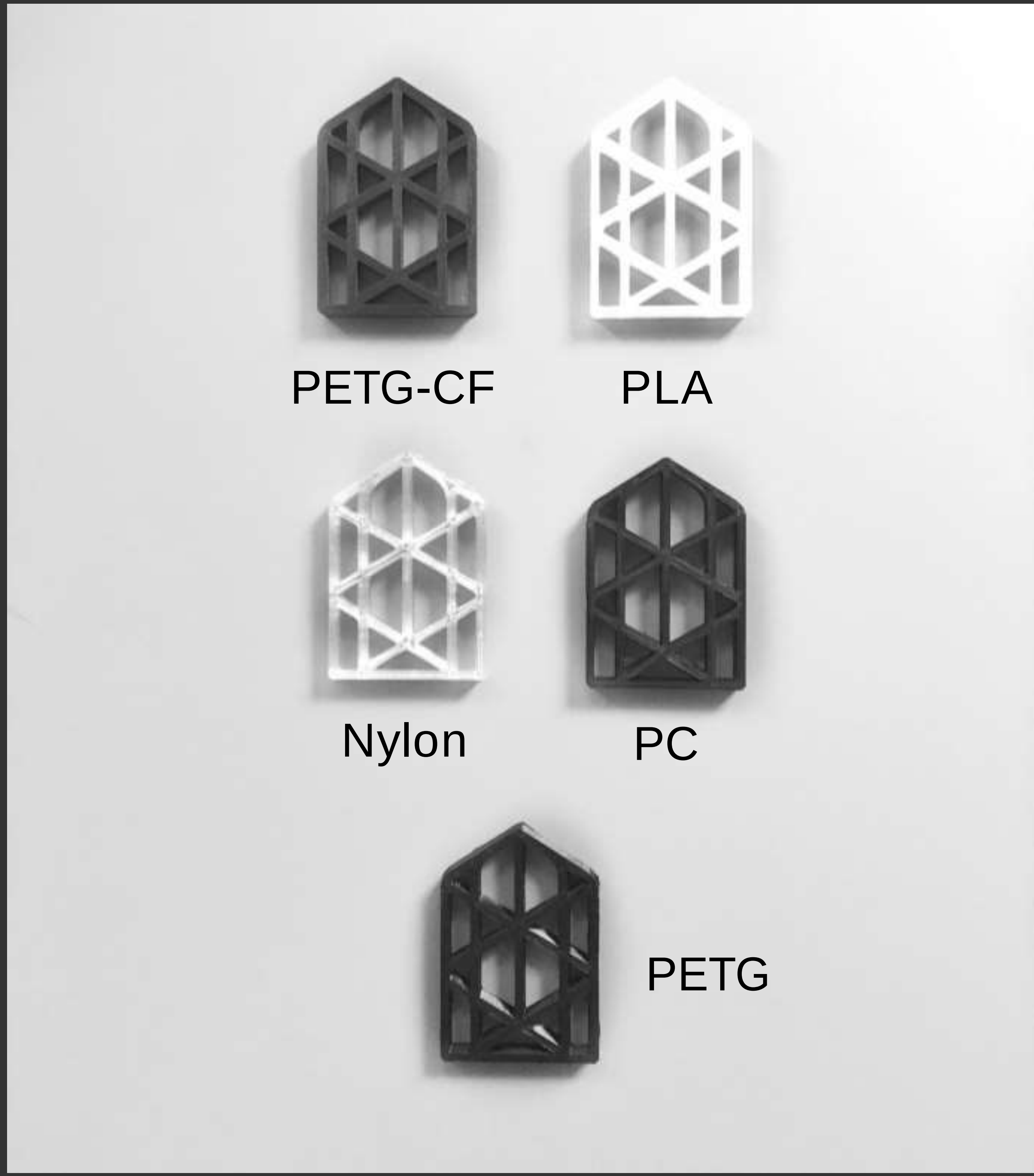
COMPLEXITY & FREEDOM

Complex shapes, curvilinear trajectories of fiber laying

ANY PLASTIC AS MATRIX

Composites with any property you need

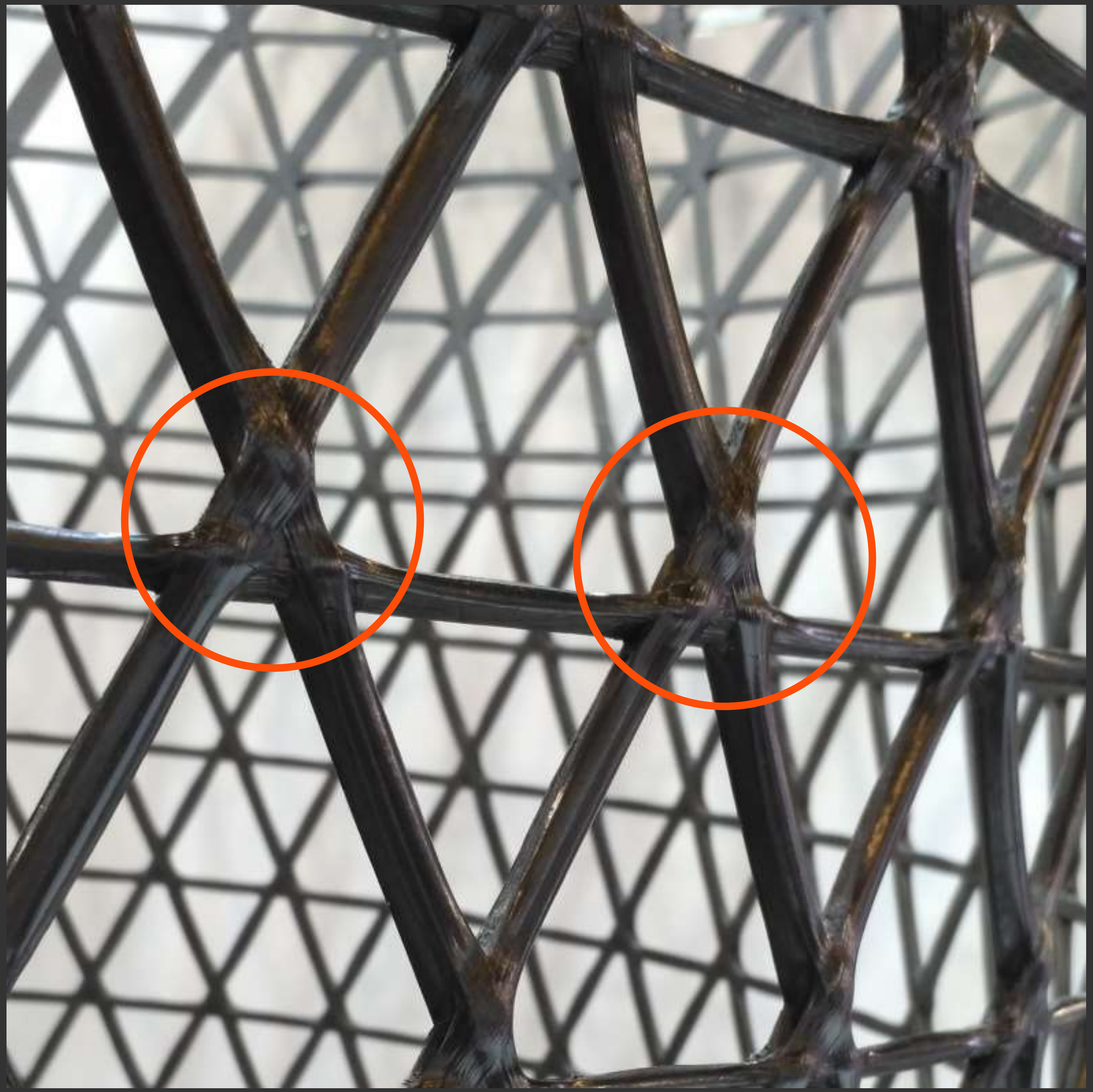


FLEXIBLE FIBER VOLUME RATIO

Printing lattices with constant material volume in the junctions

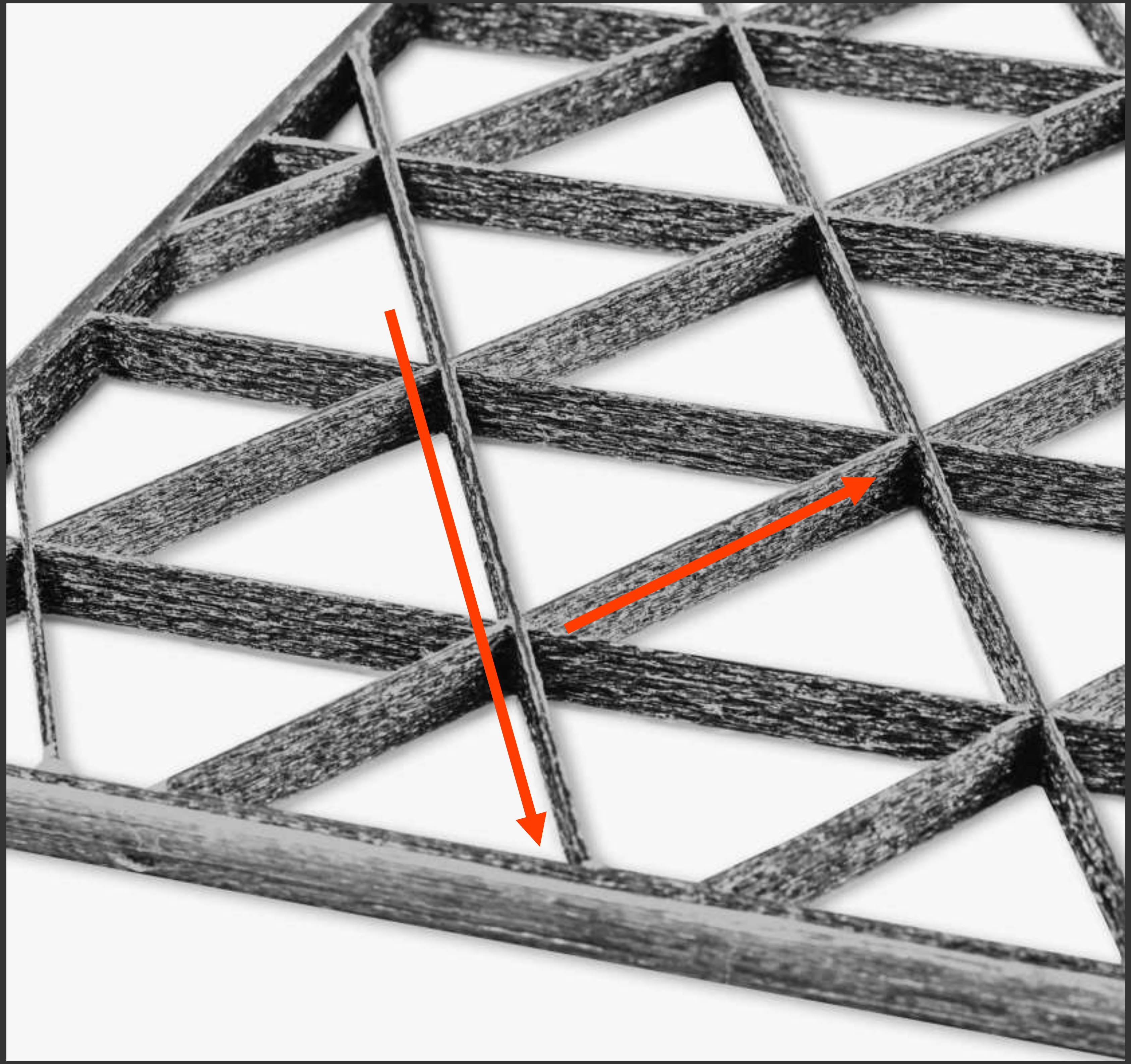
WHRN FIBER VOLUME RATIO FIXED

Thickness variations
in junctions

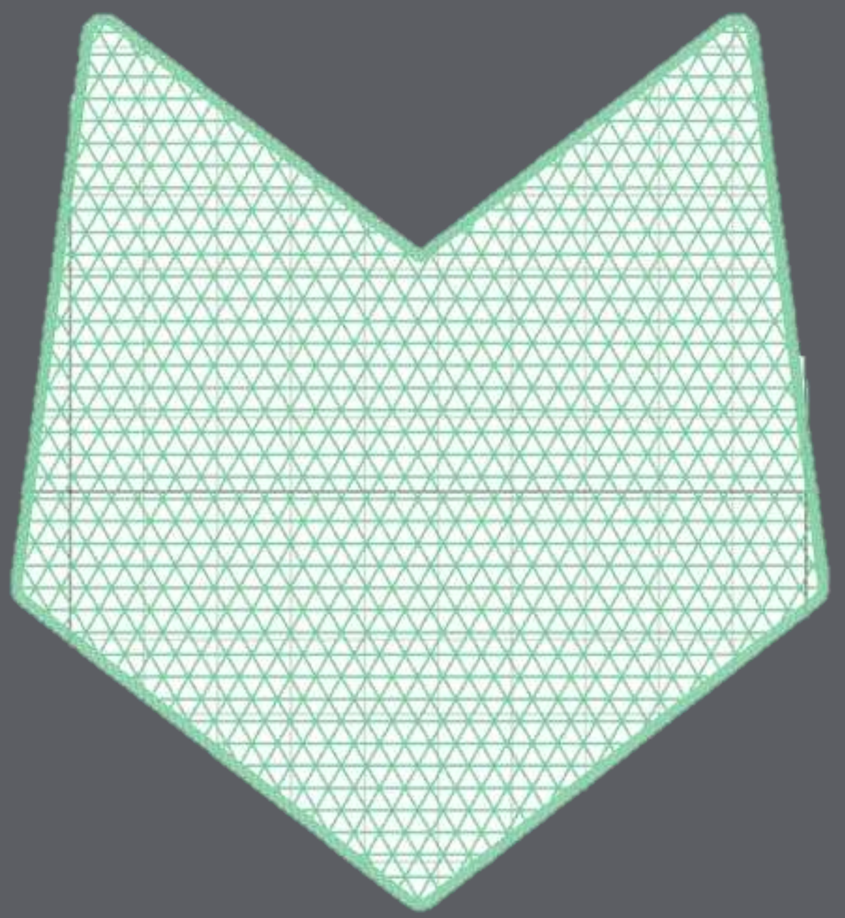


BUT COMPOSITES ARE UNIDIRECTIONAL

Load distribution in the 1D ribs:
always along the fiber

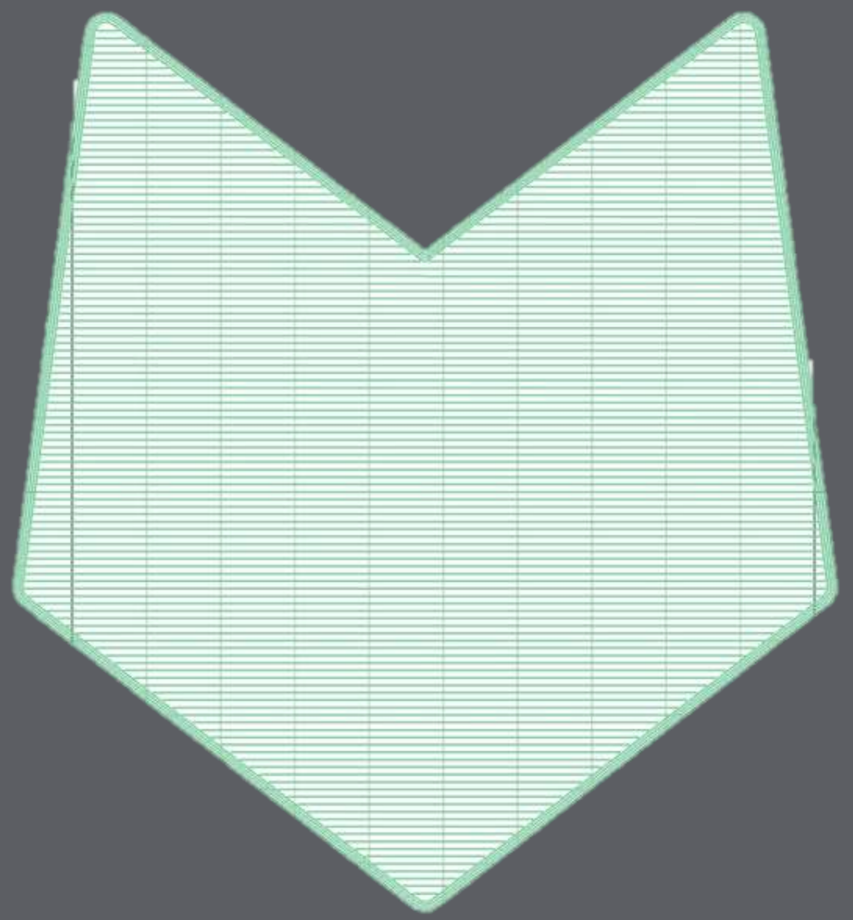


OPTIMAL SHARE FOR COMPOSITES



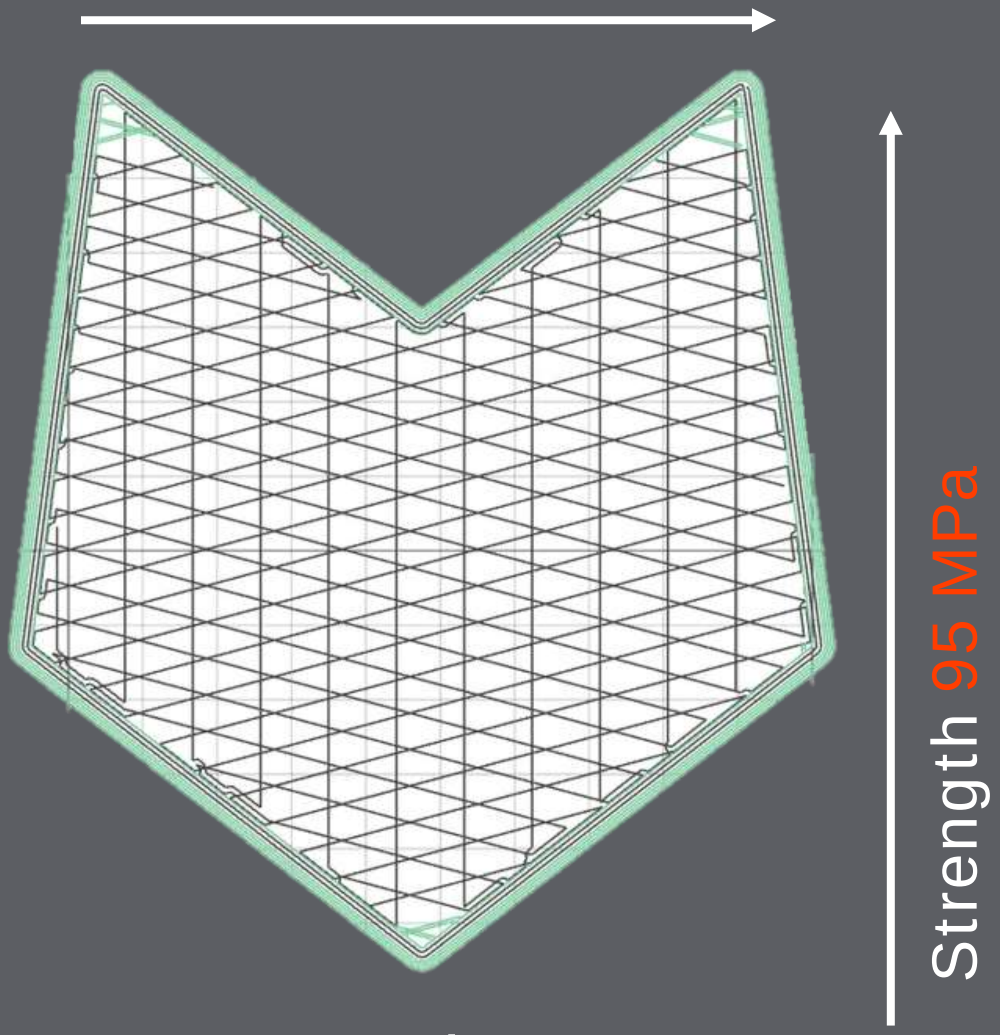
Plastic 50% lattice infill

Strength 20 MPa
50% weight
50% strength



Plastic solid infill

Strength 40 MPa
100% weight
100% strength



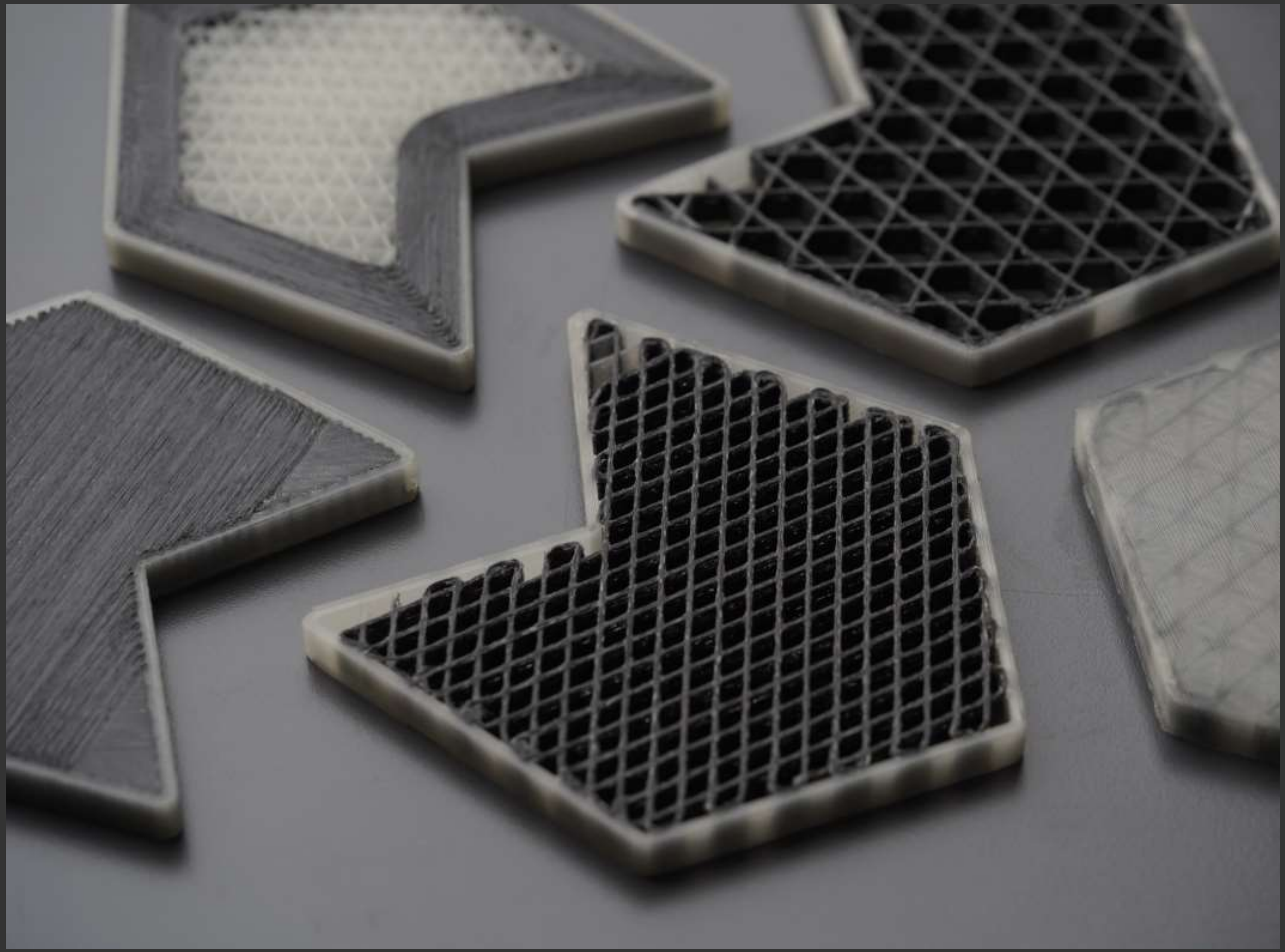
Composite 30% lattice infill

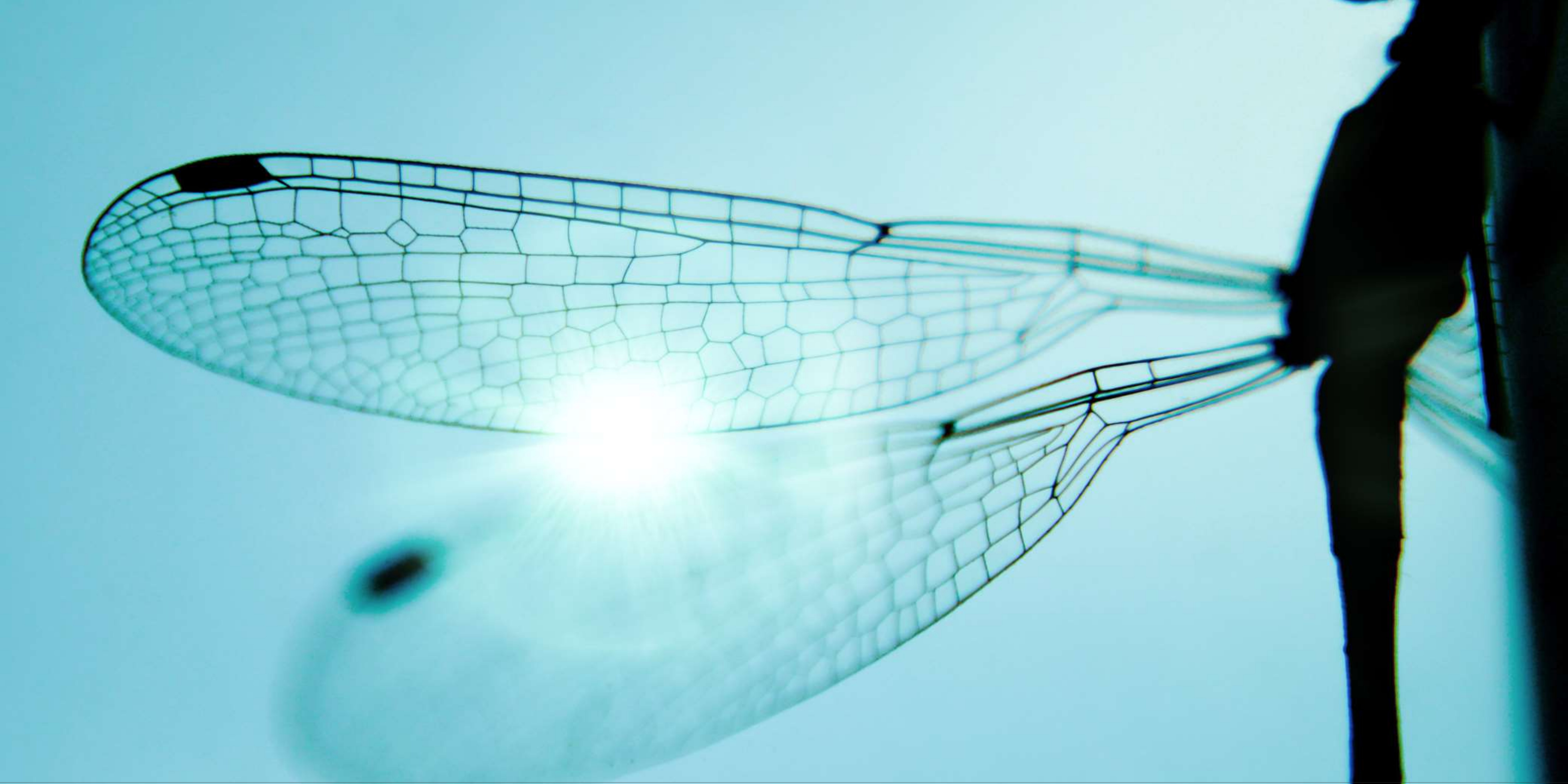
35% weight
350% strength

WEIGHT AND PRODUCTION TIME SAVINGS

ANISOPRINTED LATTICE COMPOSITES

→ solid
→ rhombic
→ isogrid
→ anisogrid



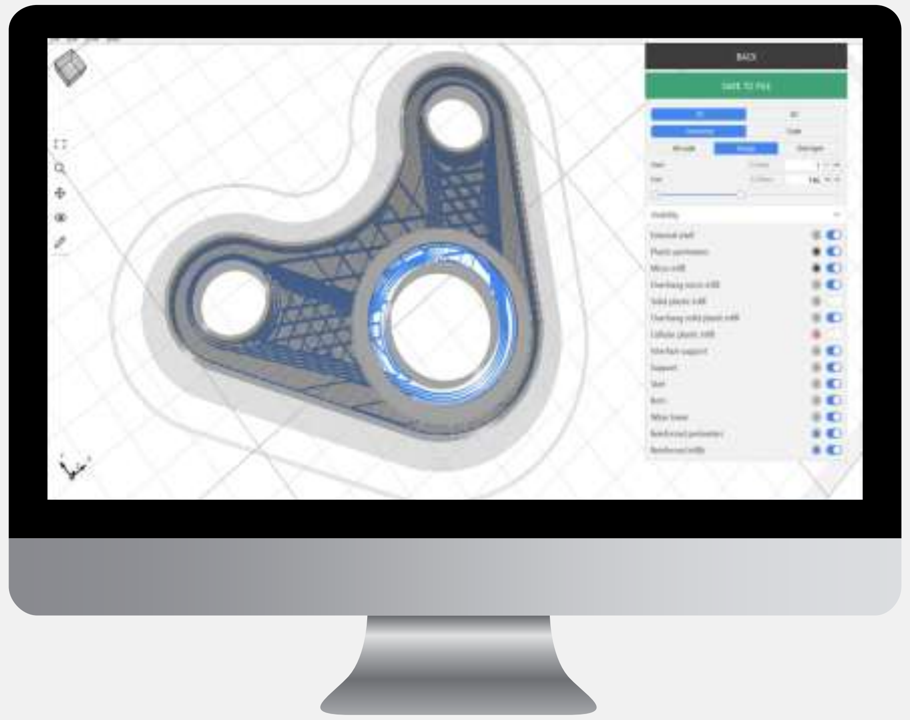


THE FUTURE IS LIGHTWEIGHT. COMPOSITE. ANISOPRINTED.

SOLUTIONS

Hardware

Software

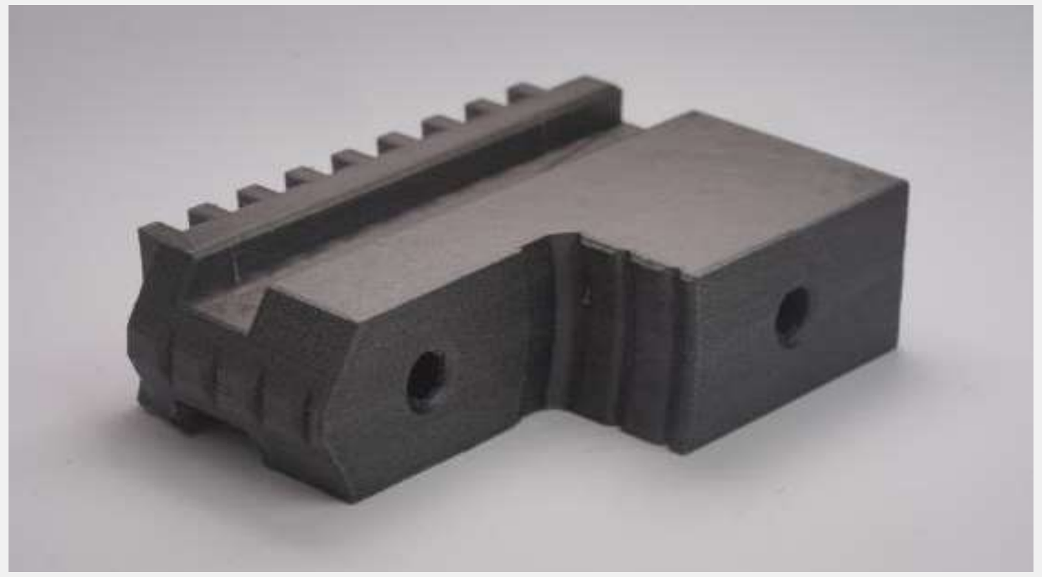


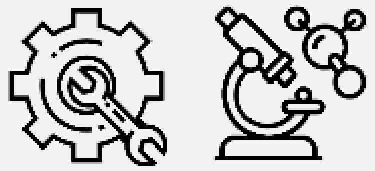
Materials

Recurring revenue

PRODUCTS PORTFOLIO

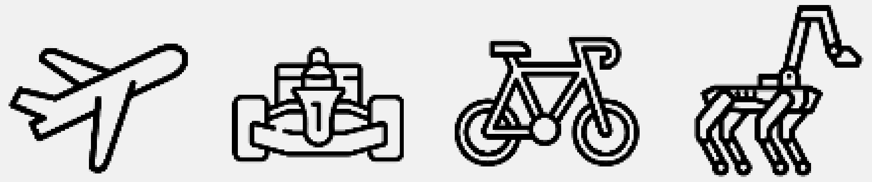
2020





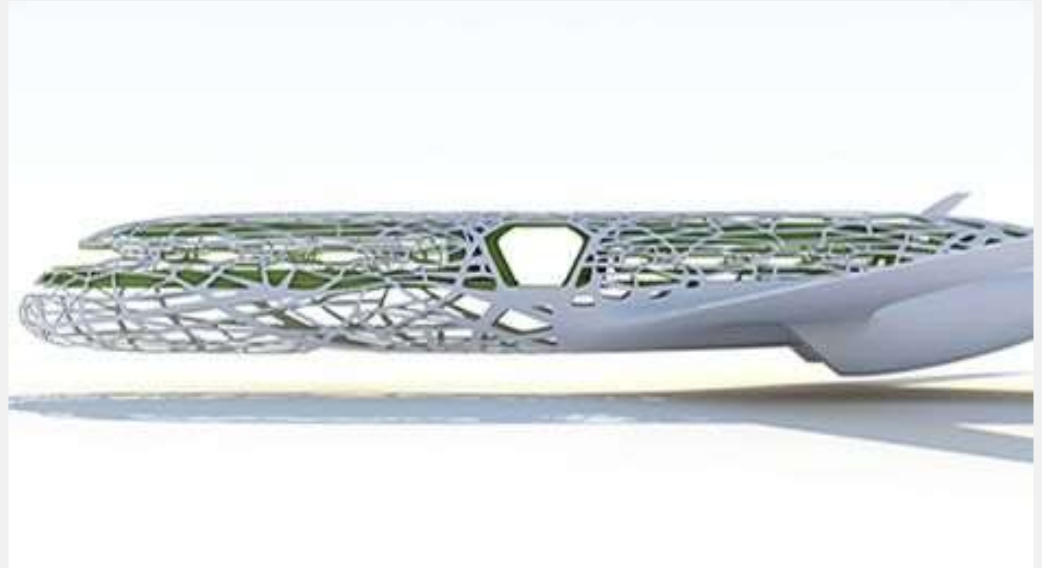
Desktop anisoprinting

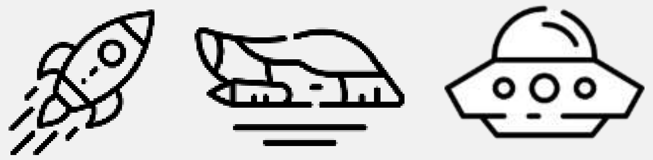
2022



Industrial anisoprinting

2030





Anisoprtinig future

HARDWARE

PRODUCTS

COMPOSER: DESKTOP 3D PRINTER

Continuous fiber reinforced composites
30 stronger than pure plastic
2 stronger & lighter than aluminum

Available formats
A4 297x210x140mm
A3 460x297x210mm

Open system
flexible materials choice, fiber volume ratio, parts complexity and fiber laying trajectories;

Optimal composite structures
lattice reinforcement — minimum weight, price and production time for the required strength

R&D

- Open System
- Design freedom
- Clear VP
- Educated customers
- Easy service
- Low material usage

FUNCTIONAL PROTOTYPING

- On demand manufacturing of tools and spare parts
- Low cost, efficient solution
- Minimum training required

INDUSTRY ENTRY-LEVEL

- Fast production
- No tooling
- Easy & affordable
- Custom
- Digital

PROM IS 500: INDUSTRIAL 3D PRINTER

High temperature plastics
(up to 450°c) as a matrix

PEEK, PEKK, PEI

Large build volume

600mm x 420mm x 300mm

Heated chamber

up to 160°C, material dryer up to 100°C

Tool changer

for up to 4 independent tools

Industrial reliabilty

made for 24/7 run in a factory environment with industrial CNC and beltless mechanics

PROM IS 500 APPLICATIONS

TOOLS, JIGS AND FIXTURES

- For assembly, bending, welding, milling, stamping
- For automated lines
- Lightweight, stiff & strong
- On demand on site manufacturing
- Recyclable

SPARE PARTS

- For service shops: airplane, automotive interiors and service tools, bikes, motorcycles, etc.
- On demand on site production
- No tools or molds
- Digital manufacturing

SMALL BATCH PRODUCTION

- Rapid functional prototyping for automotive, aerospace, robotics
- Batch up to 1000/y
- High tolerance and repeatability
- Fully functional parts

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INDUSTRIAL ROADMAP

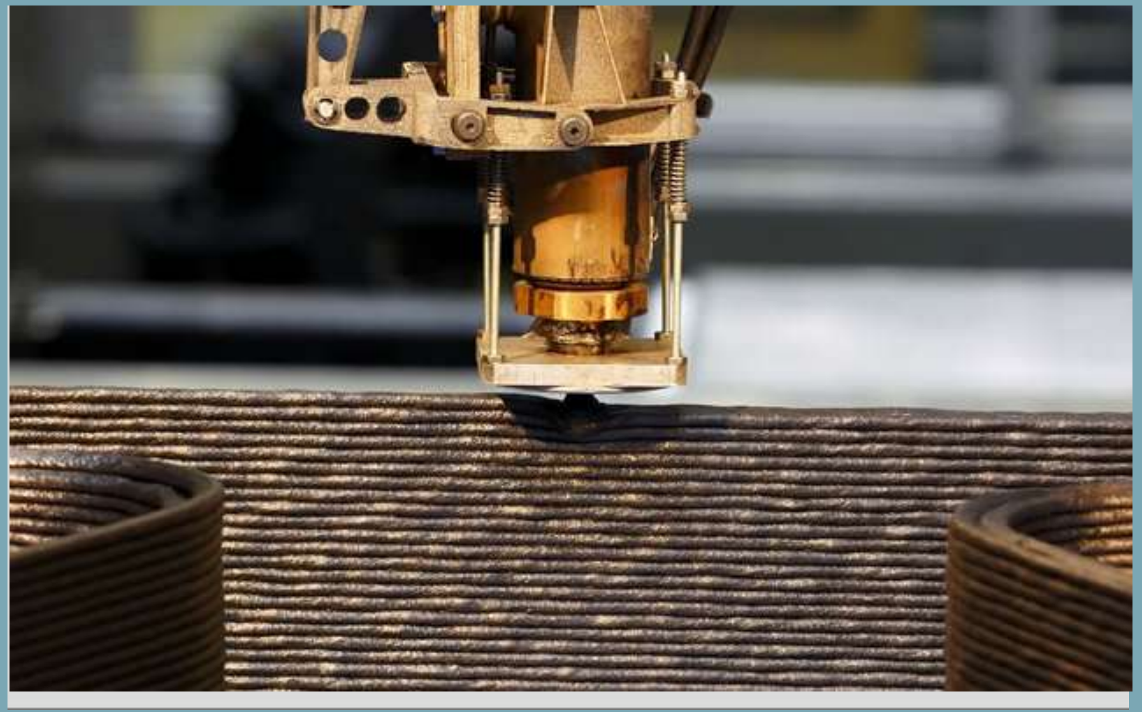
Product	Features
PROM-IS 3 axial gantry Heated chamber Sales: 2021	Up to 500x500 mm build area High temperature plastics: PEI, PS, PEEK
PROM-PT 6 axial robotic cell Sales: 2023	Up to 1100x1100 mm build area Complex shape parts Engineering polymers: PA6/66, PC
PROM-IN 6 axial gantry Heated chamber Sales: 2025	Up to 800x800 mm build area Complex shape parts High temperature plastics: PEI, PS, PEEK

MATERIALS

MATERIALS OPTIONS

INDUSTRIAL

- HT Fibers – Carbon (1K, 3K), Glass
- LT Fibers – Carbon, Glass
- HT Plastics –PEKK, PEEK, PEI
- LT Plastics – PA, PC
- Support HT&LT Plastics
- ECO Plastics & Fiber



DESKTOP

- CCF, CBF
- Smooth PA, CCF PA
- ECO Plastics & Fiber

CUSTOM

- High performance fibers – Carbon (1K, 3K, 6k, 12K, High modulus, Pitch....)
- Polymers for Metal matrix composites (MMCs)
- Polymers for Ceramic matrix composites (CMCs)
- Polymers for Carbon reinforced carbon

REINFORCING FIBERS: CCF AND CBF

60% DRY FIBER

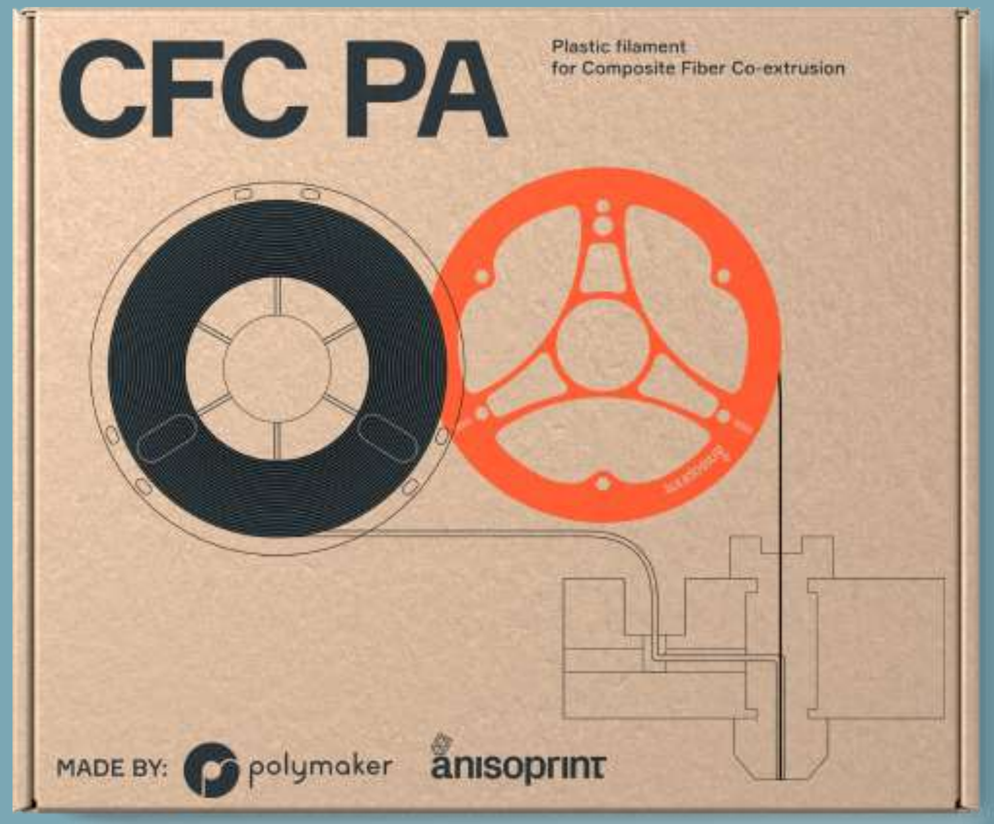
+ 40% SPECIAL RESIN =

Composite fiber

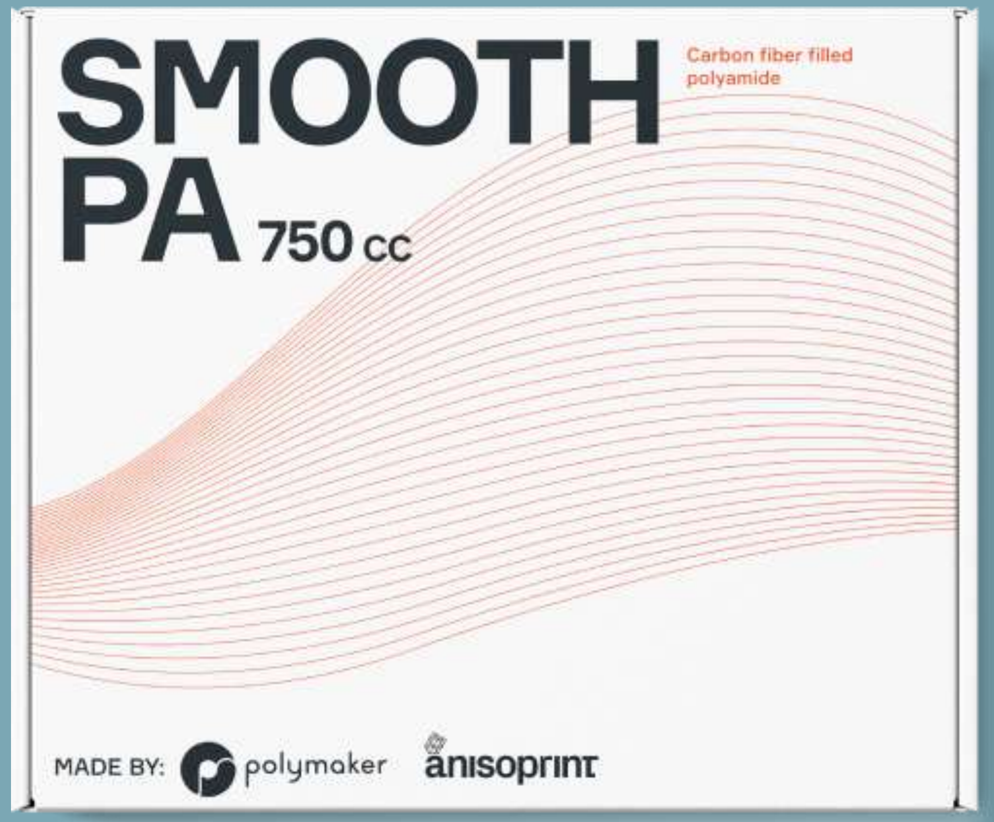
Cross-section area microscopy

	CCF-1.5K	CBF
Effective Diameter, mm	0.35	0.3
Fiber Volume, %	60	57
Elastic Modulus, GPa	150	50
Tensile Strength, MPa	2200	1560
Linear Density, tex	149	146

MATERIALS: PLASTICS

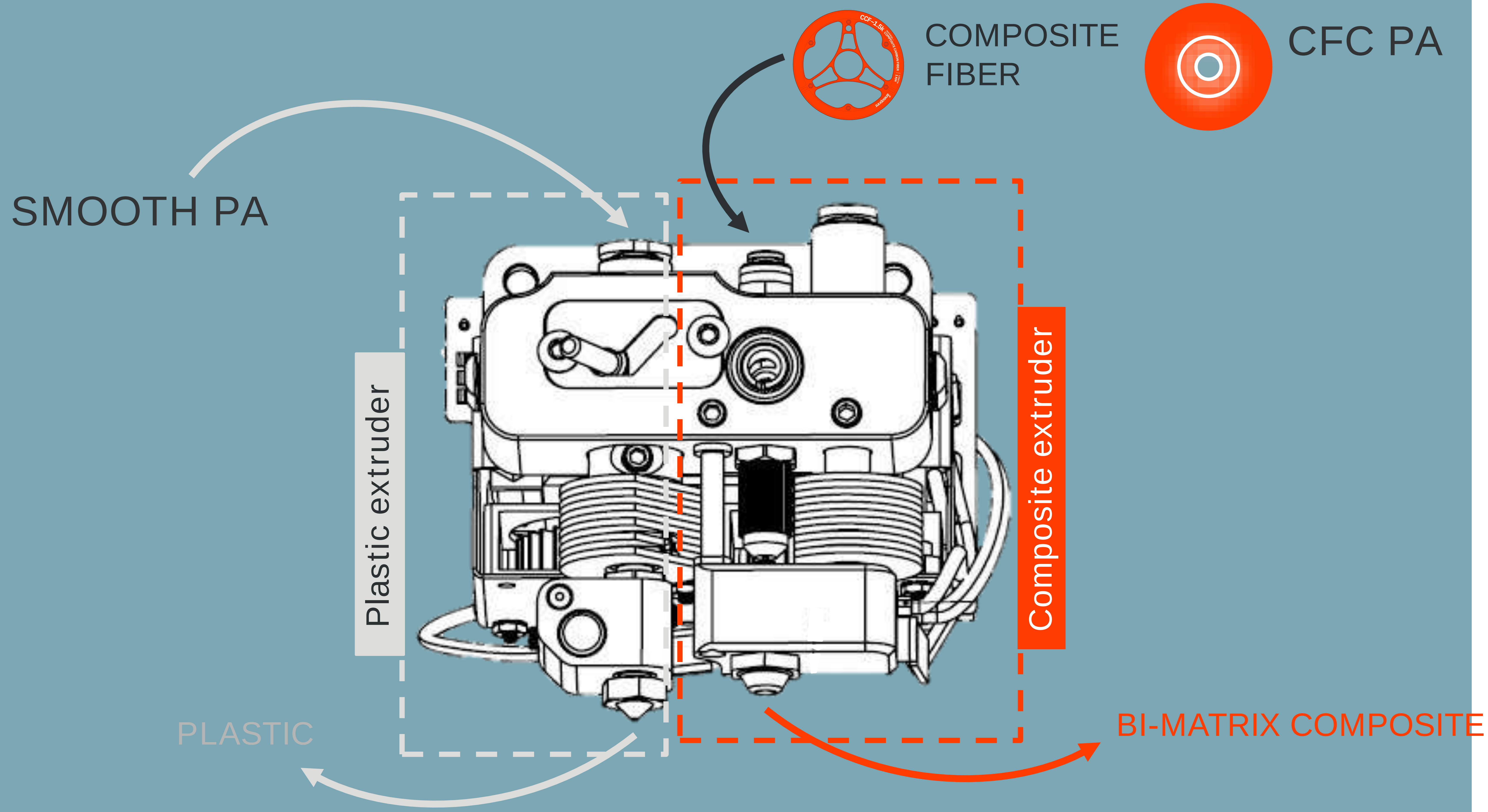


For better composite mechanics
and perfect adhesion to reinforcing fiber



Carbon fiber filled polyamide.
For perfect surface quality and ease
of use. Can be printed without a dryer.

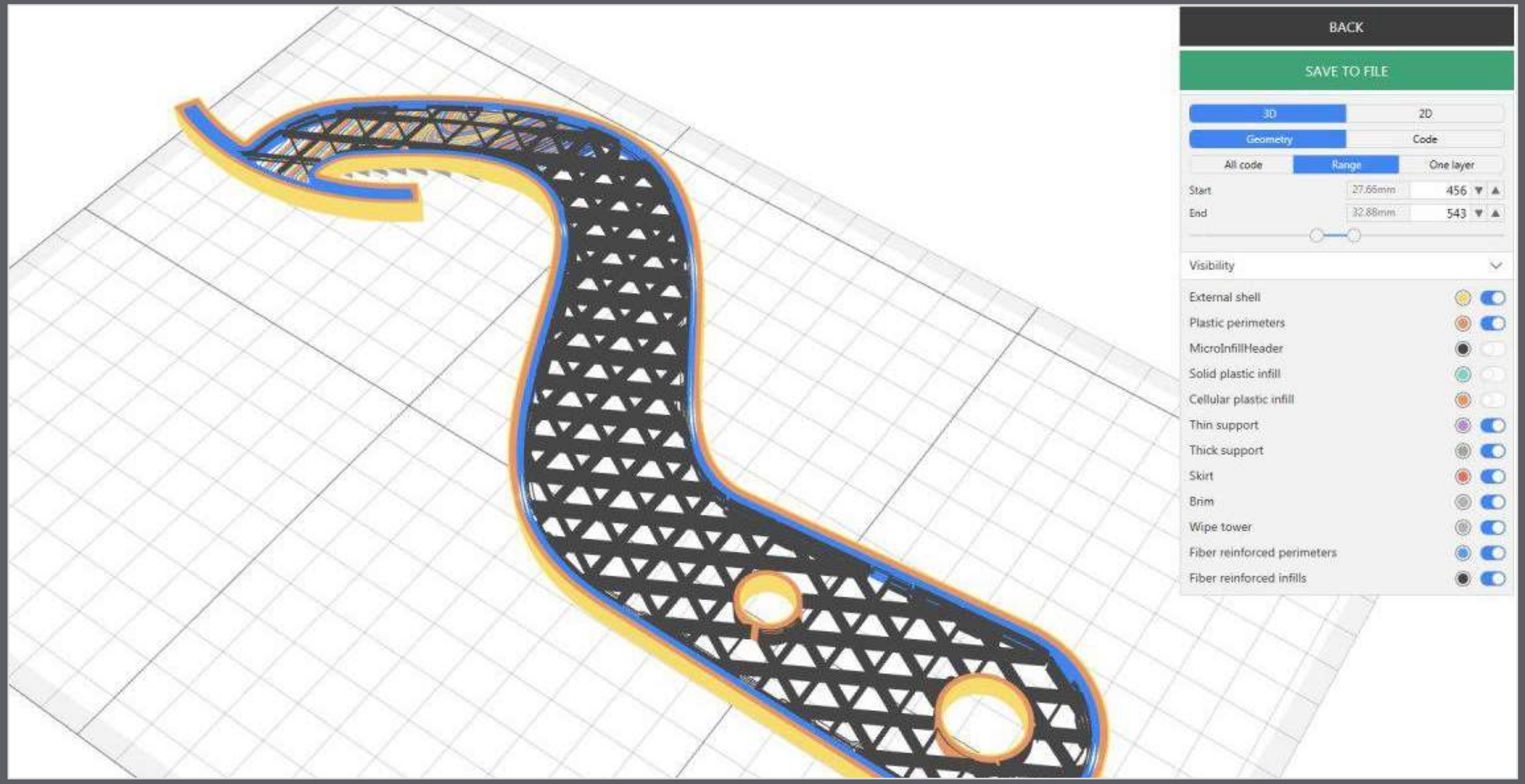
SPECIALY FORMULATED FOR CFC TECHNOLOGY

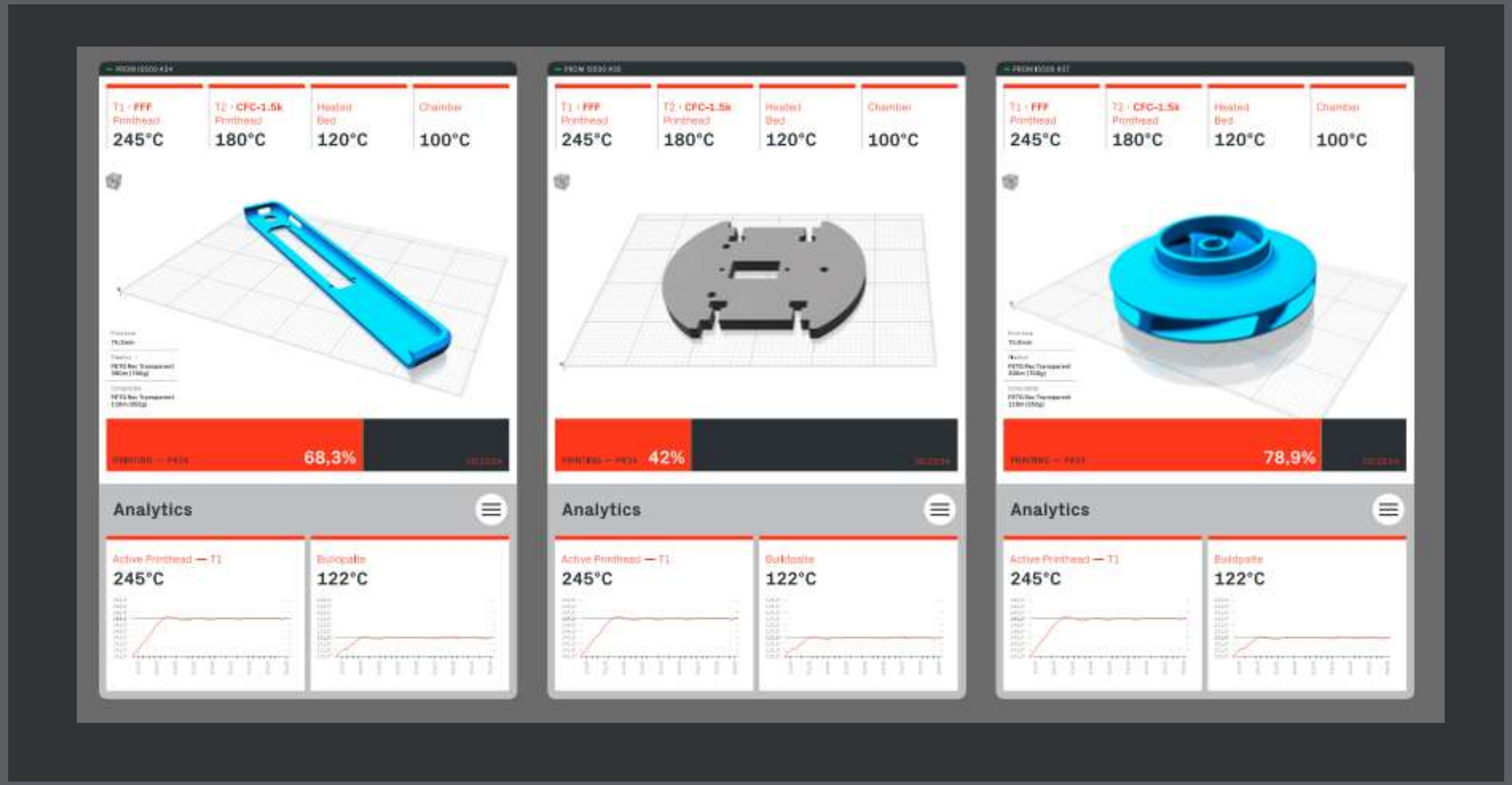


SOFTWARE

PRODUCTS

AURA: SLICER SOFTWARE FOR COMPOSITE PRINTING





DESKTOP

→ support for STL and CAD formats: .stp, .3ds, .obj;

→ model saved on a local PC;

→ G-code generalization, geometry-view;

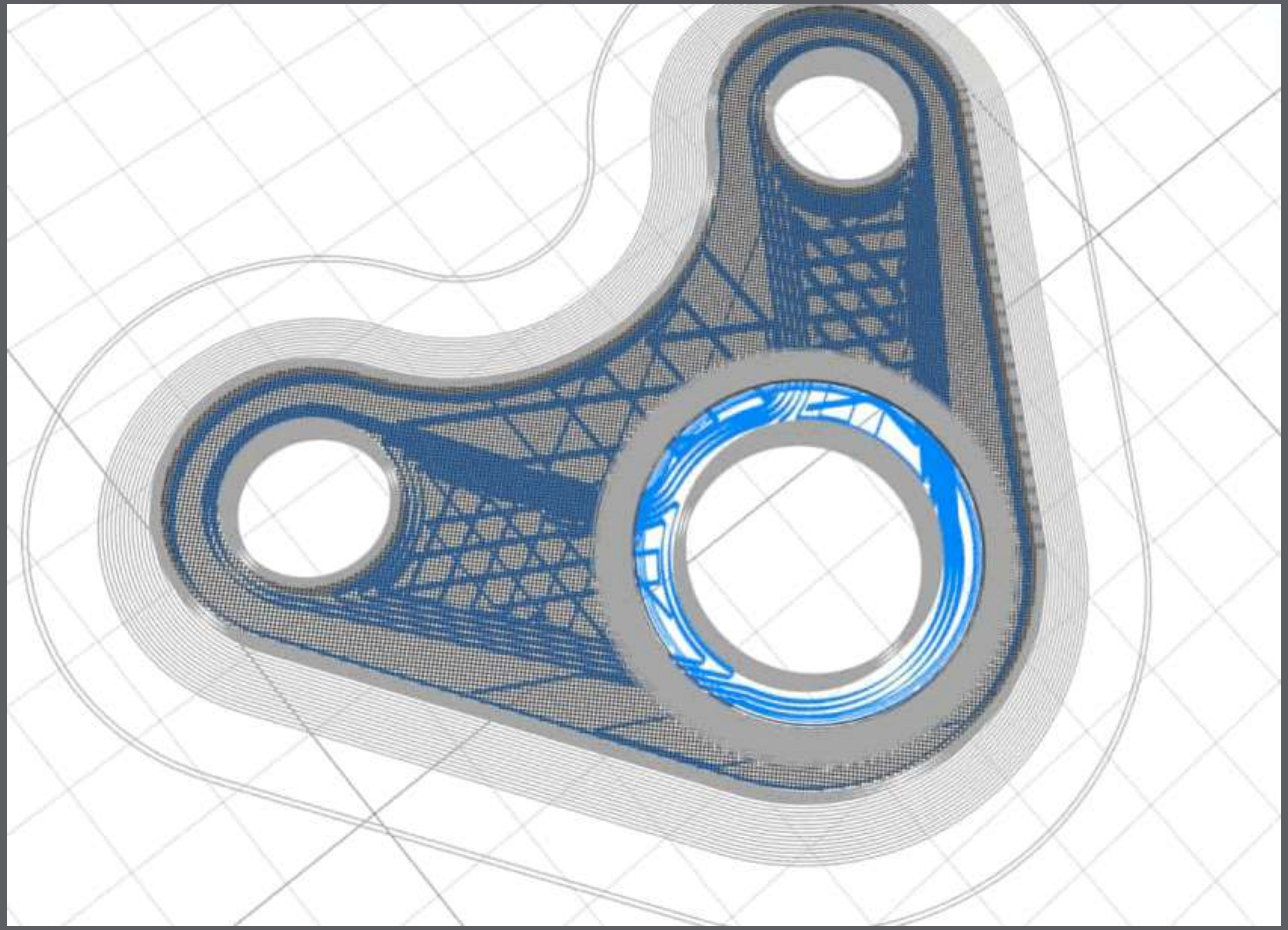
INDUSTRIAL

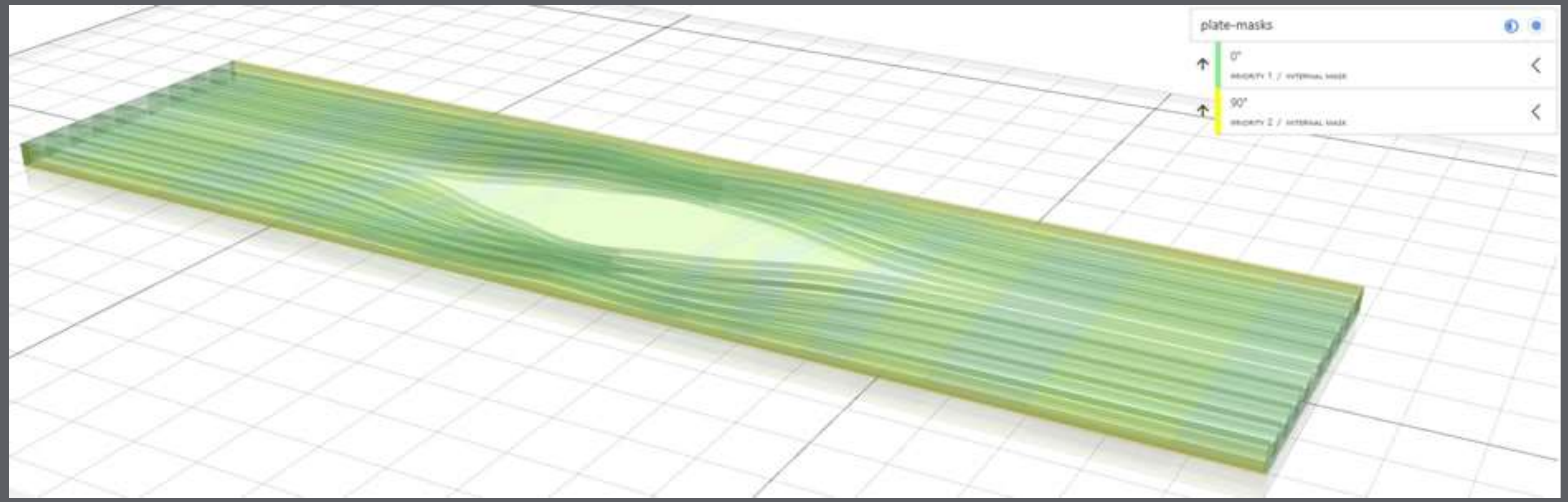
→ separate setting and combining of printers, plastics and profiles;

→ microlayering.

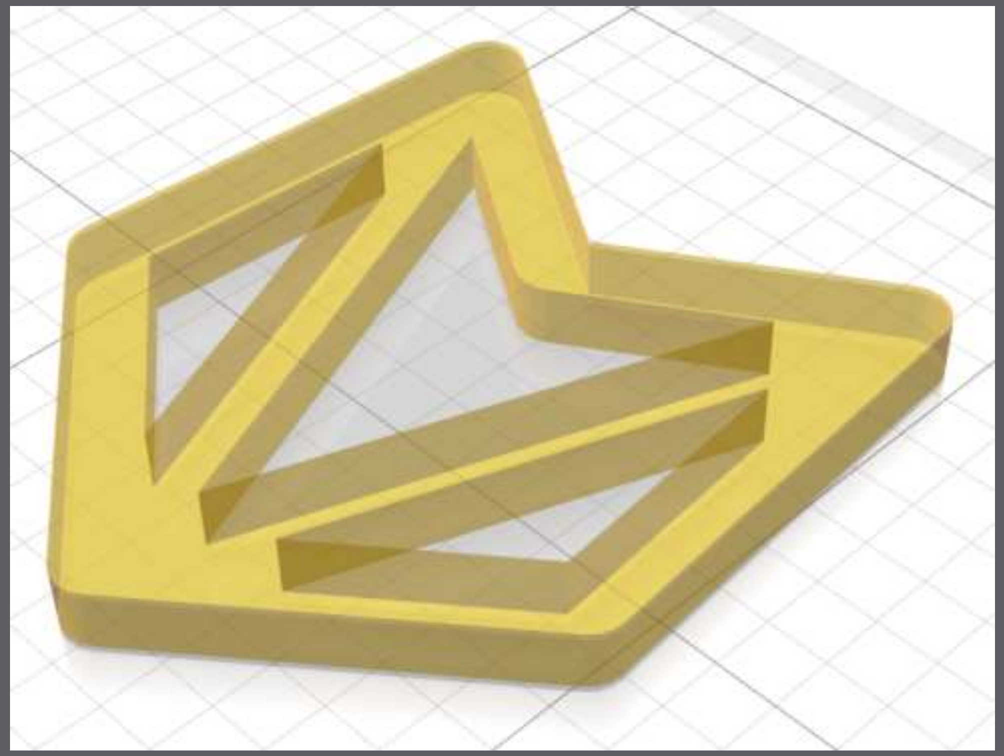
AURA PREMIUM

→ masks
→ Support blockers and Enforcers
→ CLI

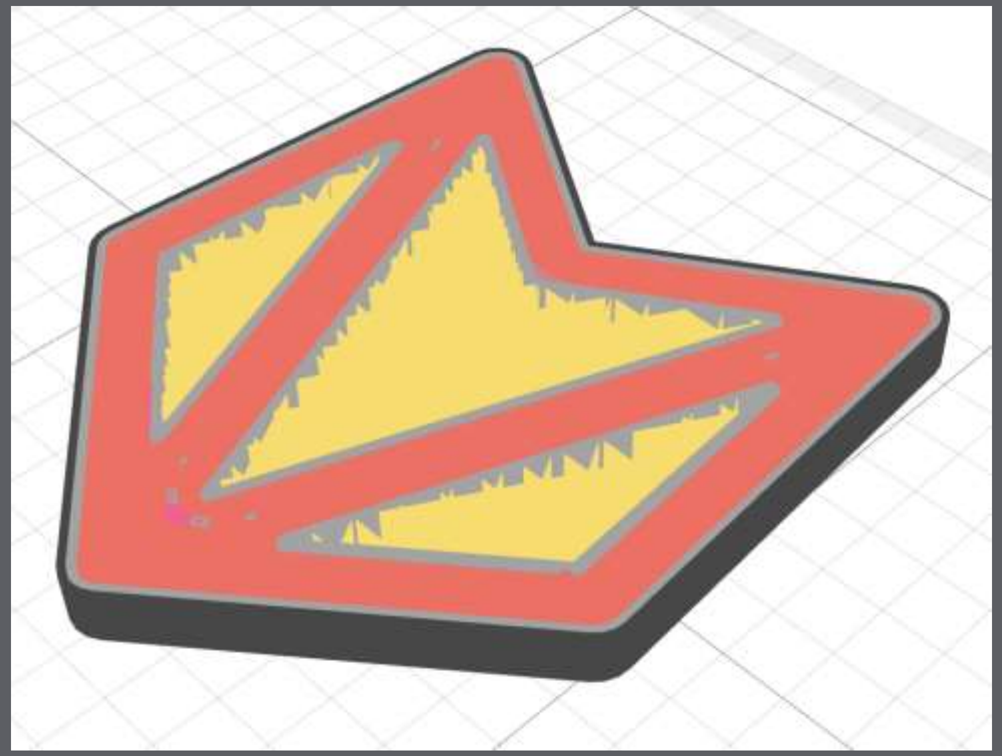




MASKS



Model with mask



Slicing result

Slicing result

Part masks allow setting the custom internal structure in different volumes of the part

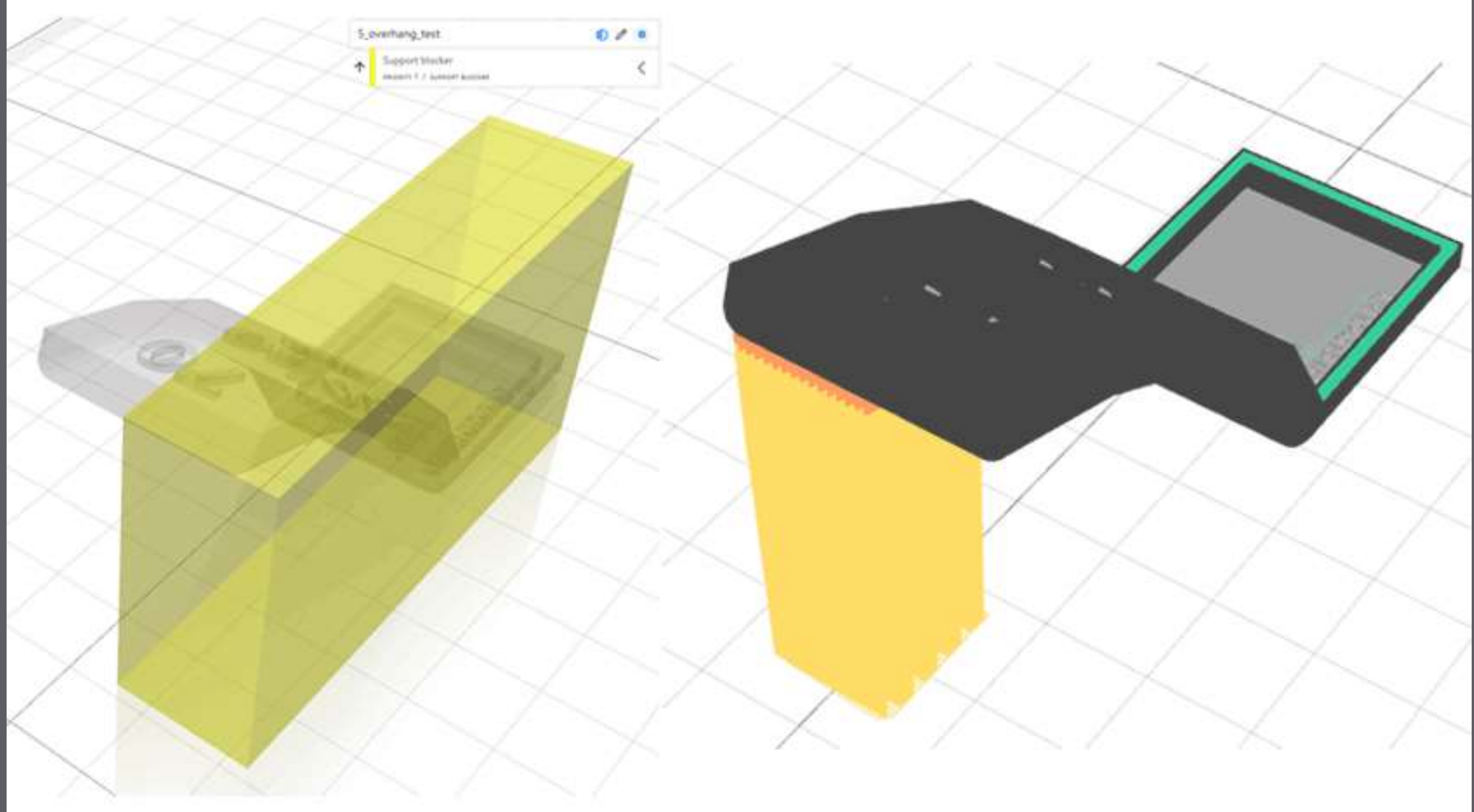
Two types of masks are available – internal masks and full masks

Internal masks allow setting internal structure parameters such as perimeter count, infill type, density, etc

Full masks additionally allow changing the number of external shell perimeters and top/bottom solid layers

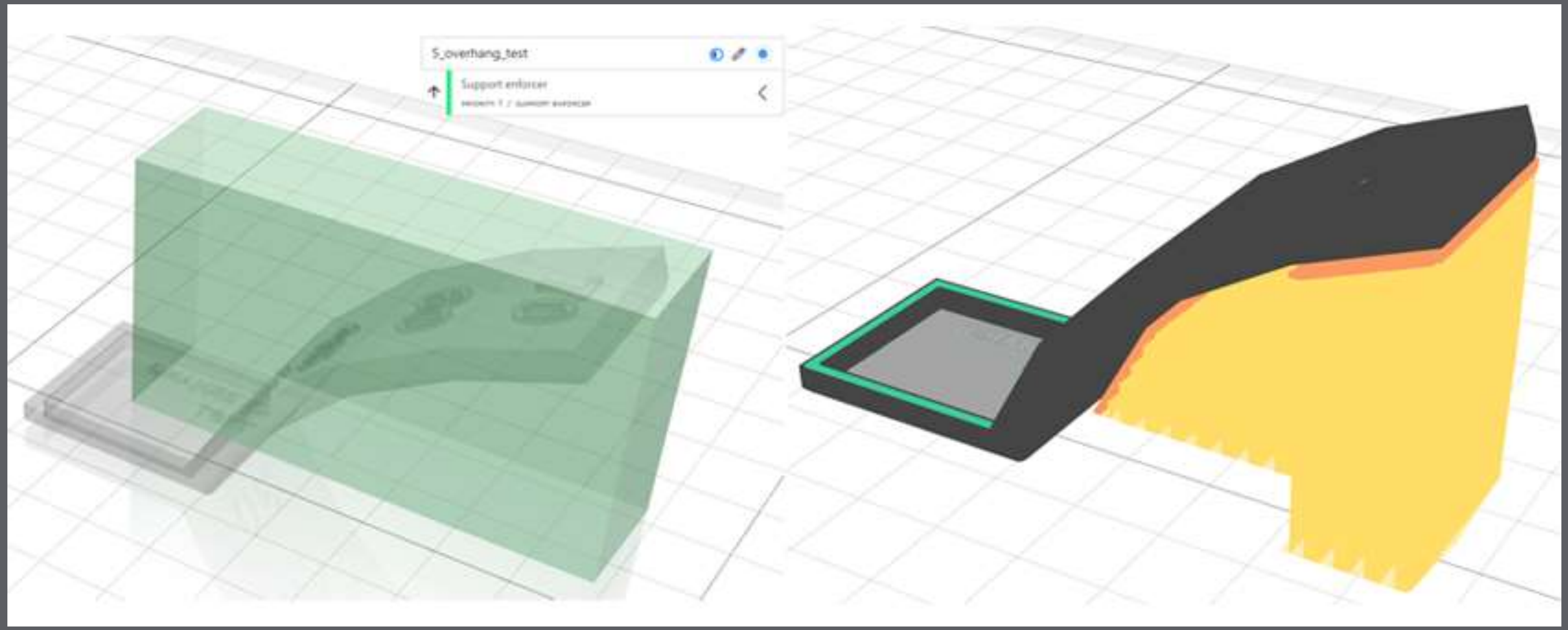
SUPPORT BLOCKERS

Allow preventing the generation of supports under the surfaces that are inside the support blocker volume

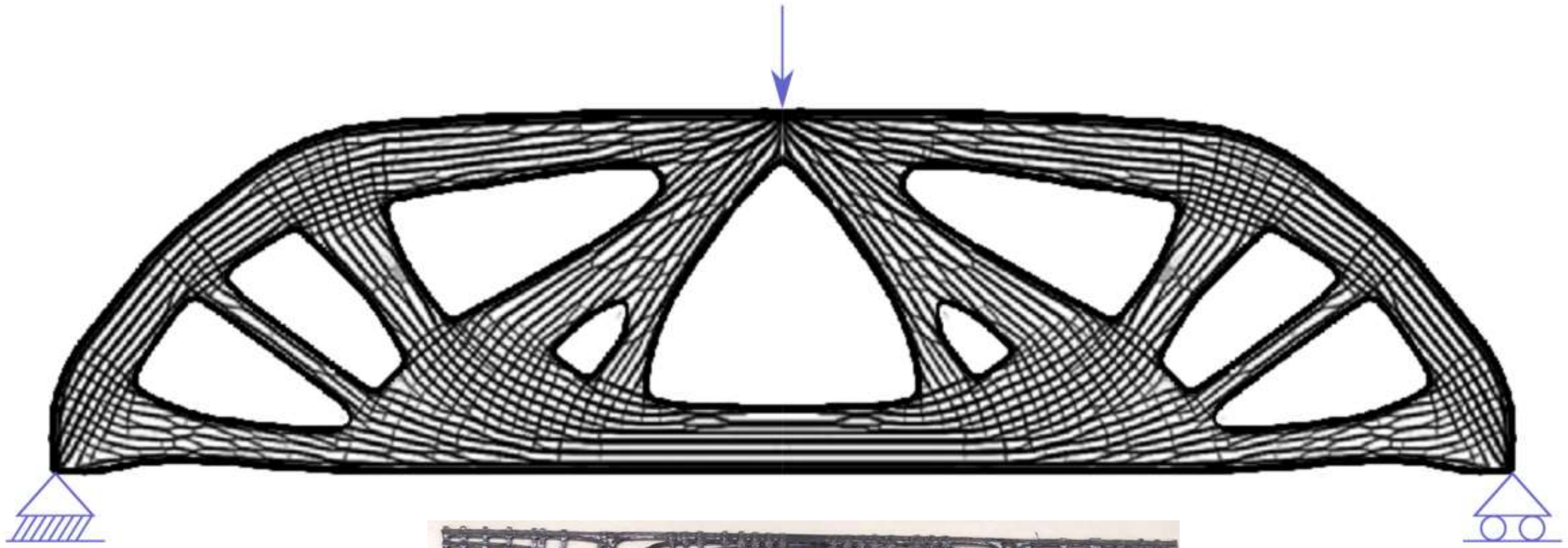


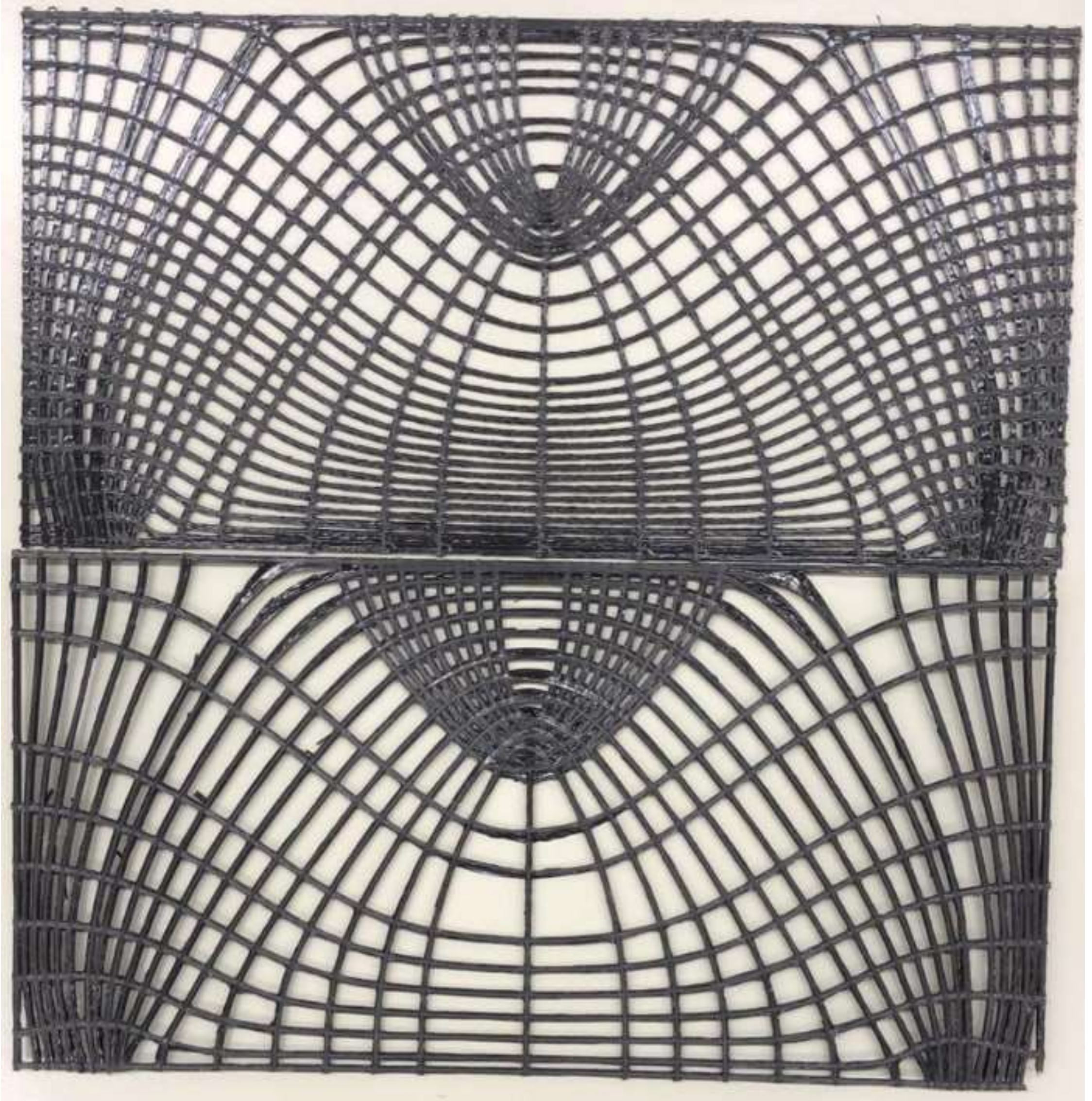
SUPPORT ENFORCERS

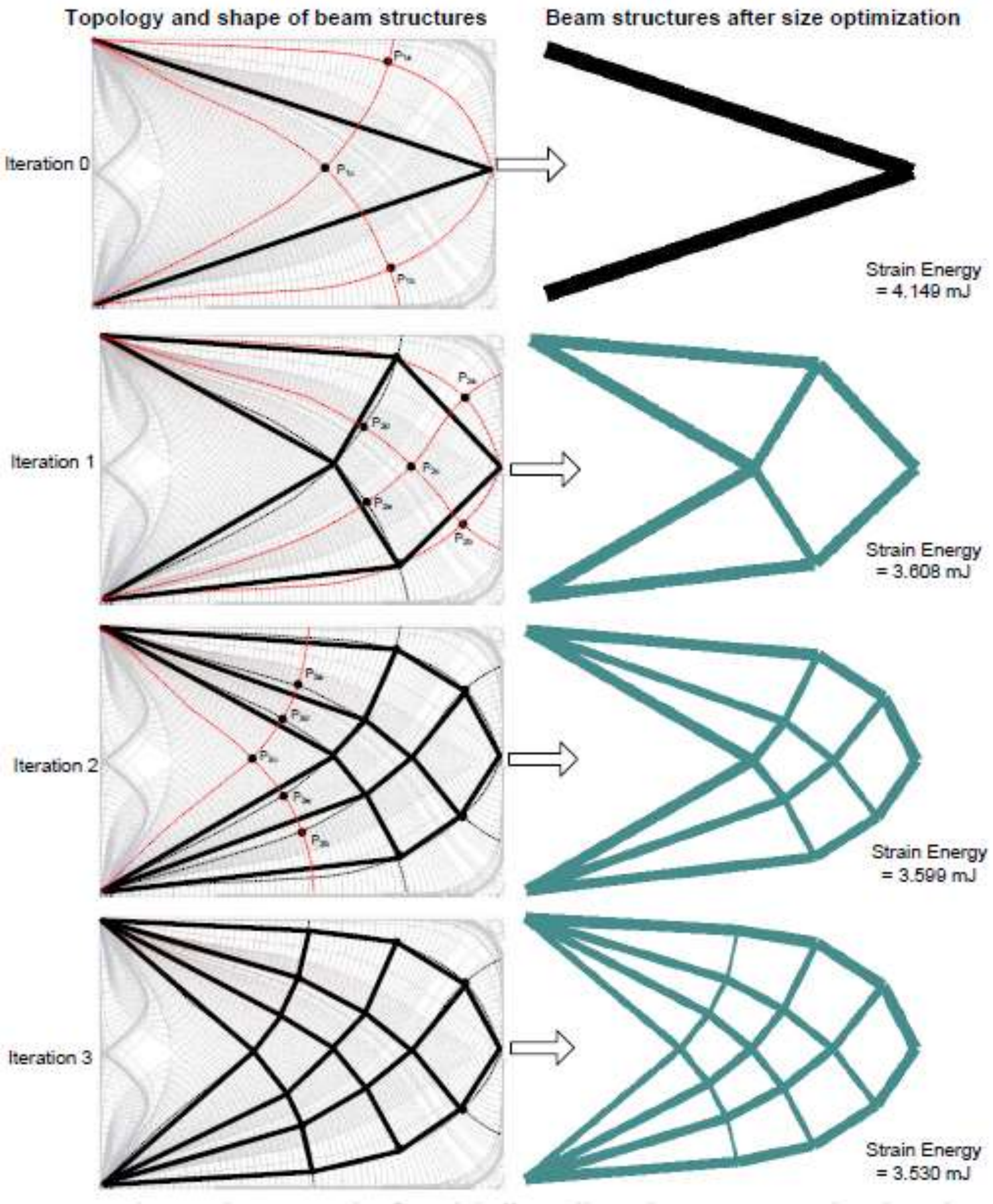
Allow forcing the generation of supports under the surfaces that are inside the support enforcer volume



GENERATIVE DESIGN AND TOPOLOGY OPTIMIZATION







TRUSS OPTIMIZATION

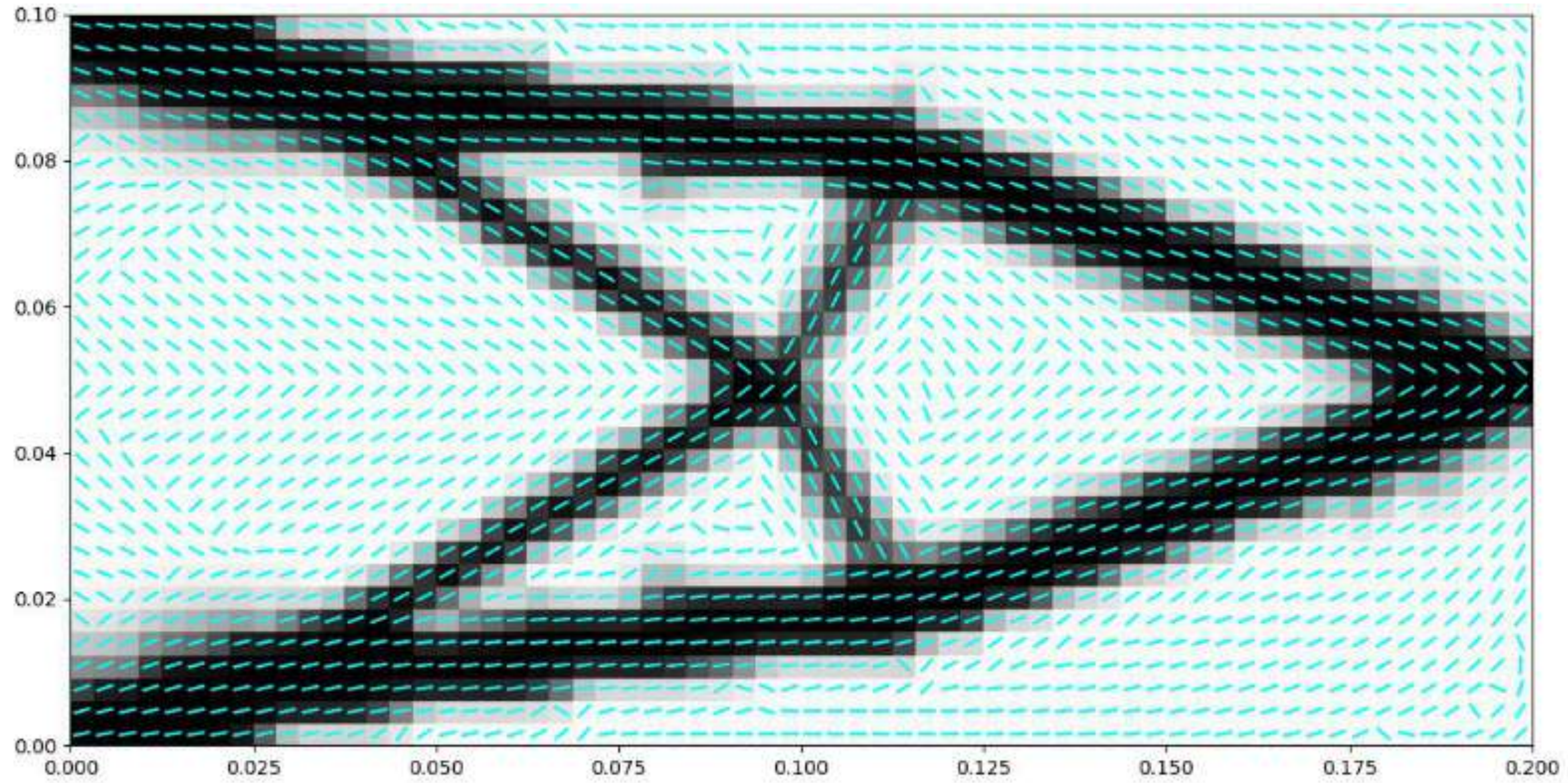
• Problem formulation

$$\min_{\boldsymbol{\rho}} c = \min_{\boldsymbol{\rho}} \boldsymbol{U}_{num}^{T} \boldsymbol{K} \boldsymbol{U}_{num}$$

$$\sum_{e=1}^{N} \rho_e V_e < f.$$

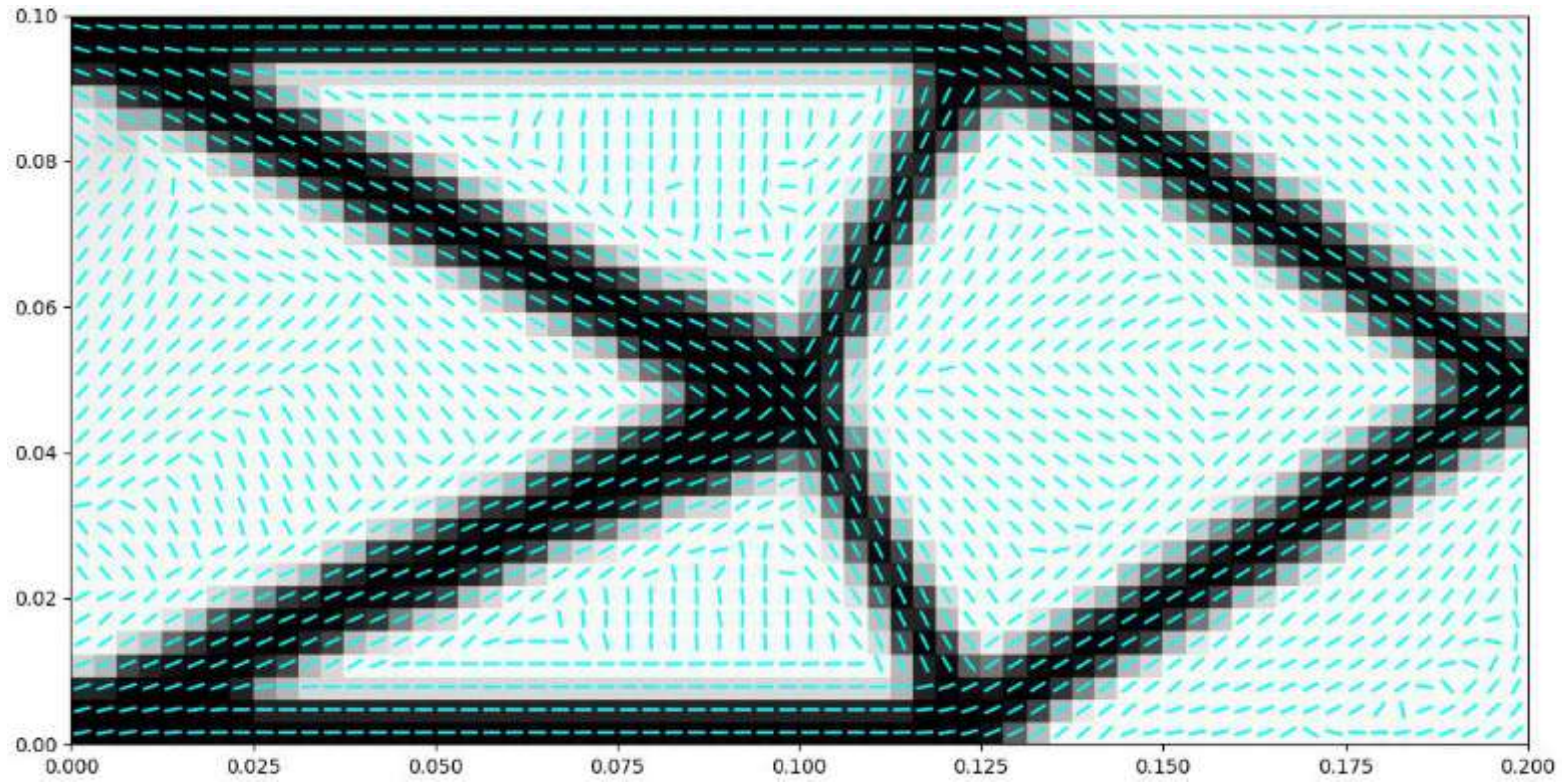
volume constrain: 0.3

• Results



p = 3, with filter, initial angles: 0

c = 0.179



p = 3, with filter, initial angles are chosen as principal directions in isotropic material

c = 0.157

• Densities update

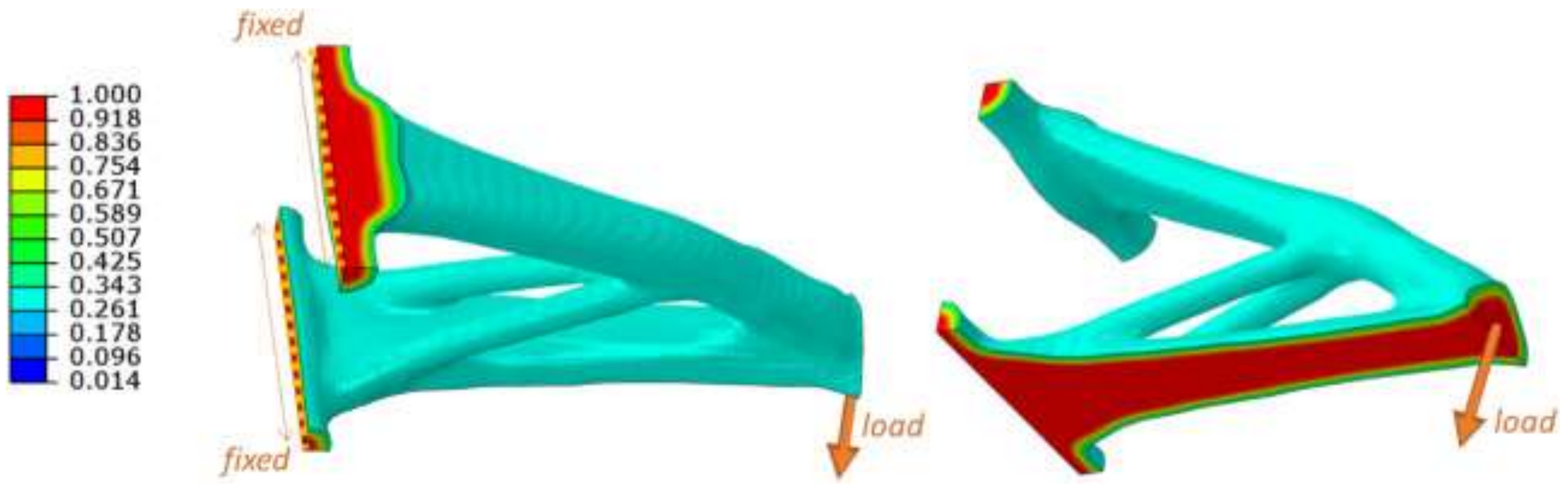
$$\rho_e^{k+1} = \rho_e^k + q\left(\frac{p\left(\rho_e^k\right)^{p-1} \boldsymbol{u}_{num\ e}^{T} \boldsymbol{k}^0 \boldsymbol{u}_{num\ e}}{V_e} - \mu^n\right)$$

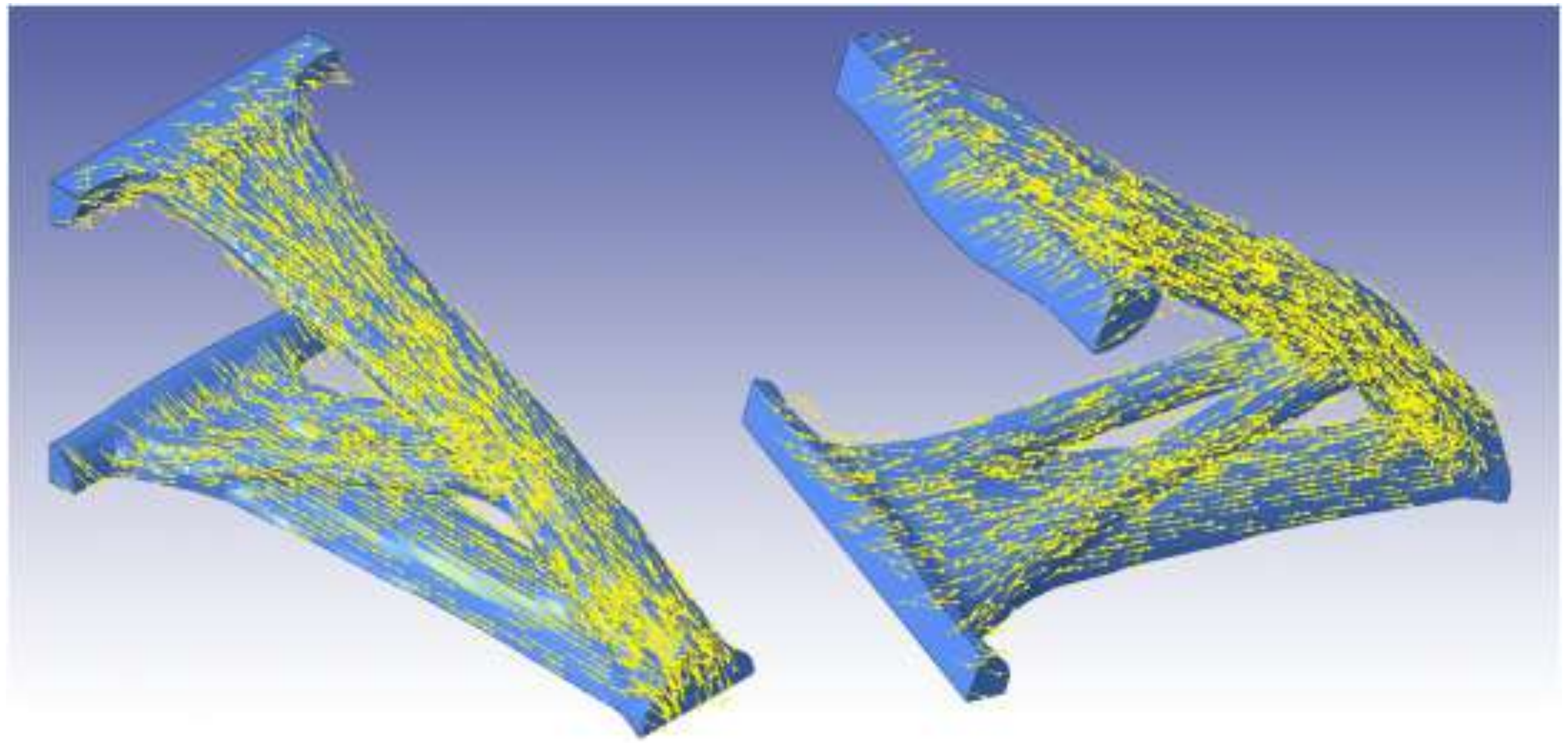
• Choice of reinforcement direction

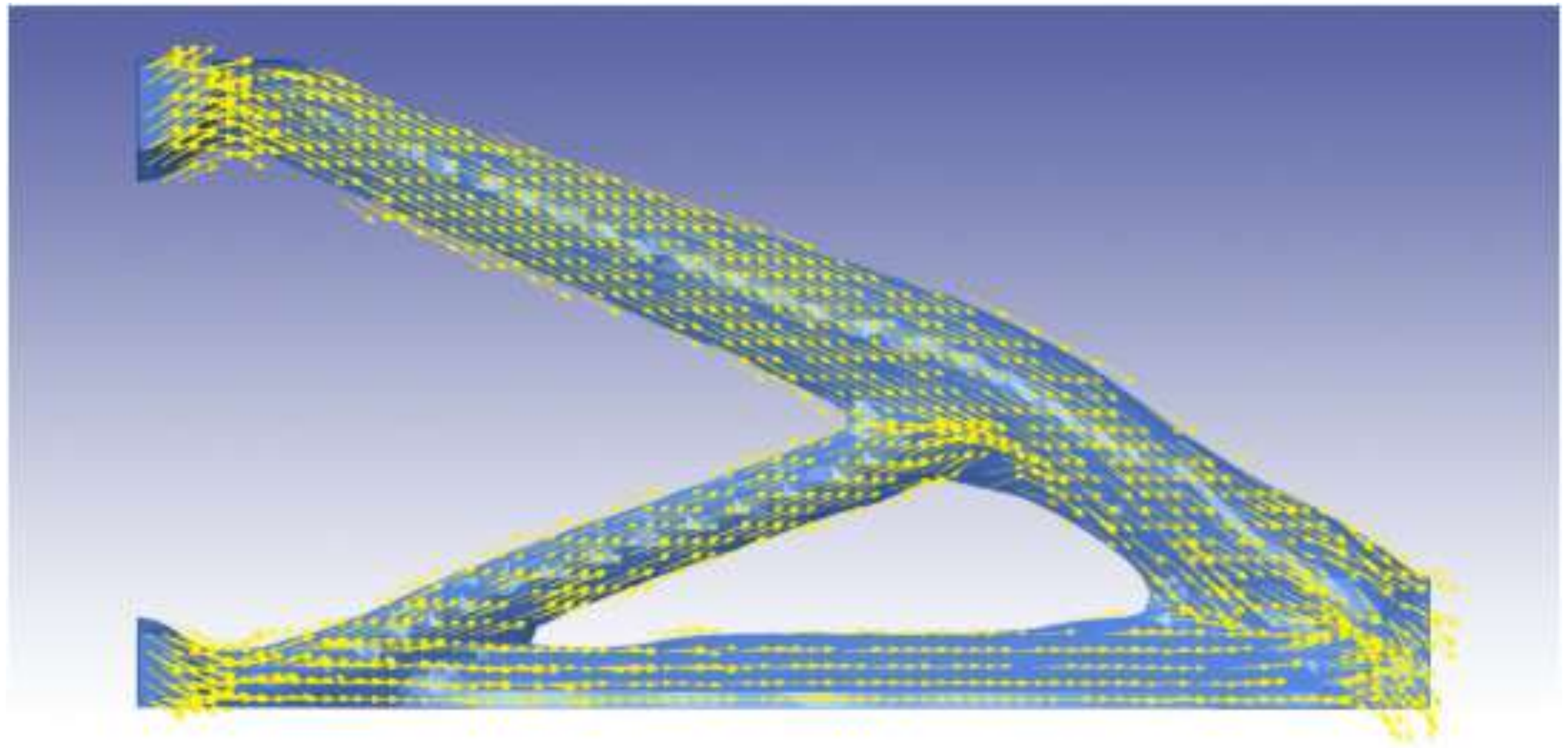
Direction of principal stress with minimum local compliance

$$n_{p_i}^{iter} = argmin_{n_{\alpha_i}^{iter}}\left(\frac{1}{2}\{\sigma_{xyz}\}^T \cdot \left[E^*\left(\rho_i^{iter}, n_{\alpha_i}^{iter}\right)\right]^{-1} \cdot \{\sigma_{xyz}\}\right)$$

$$\alpha = 1,2,3$$

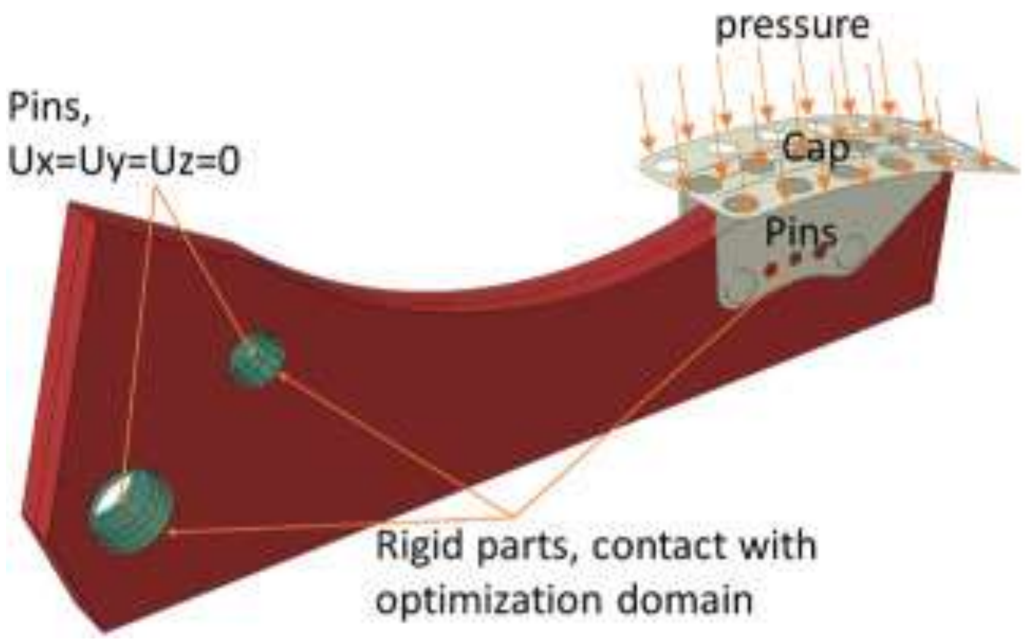


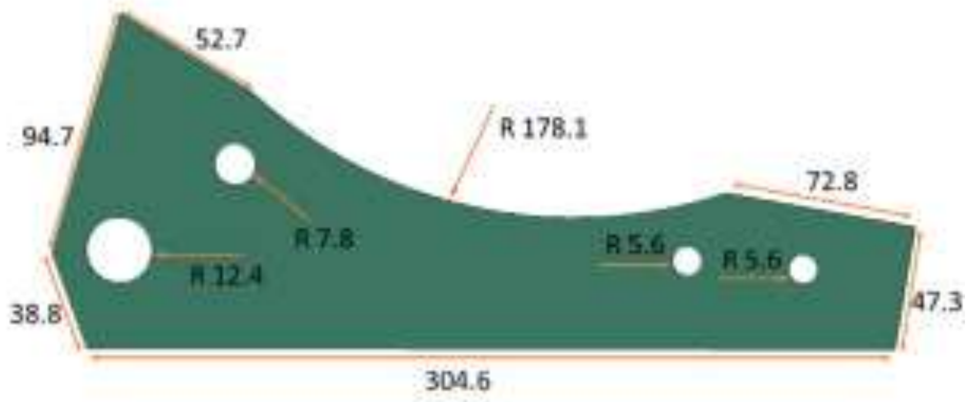


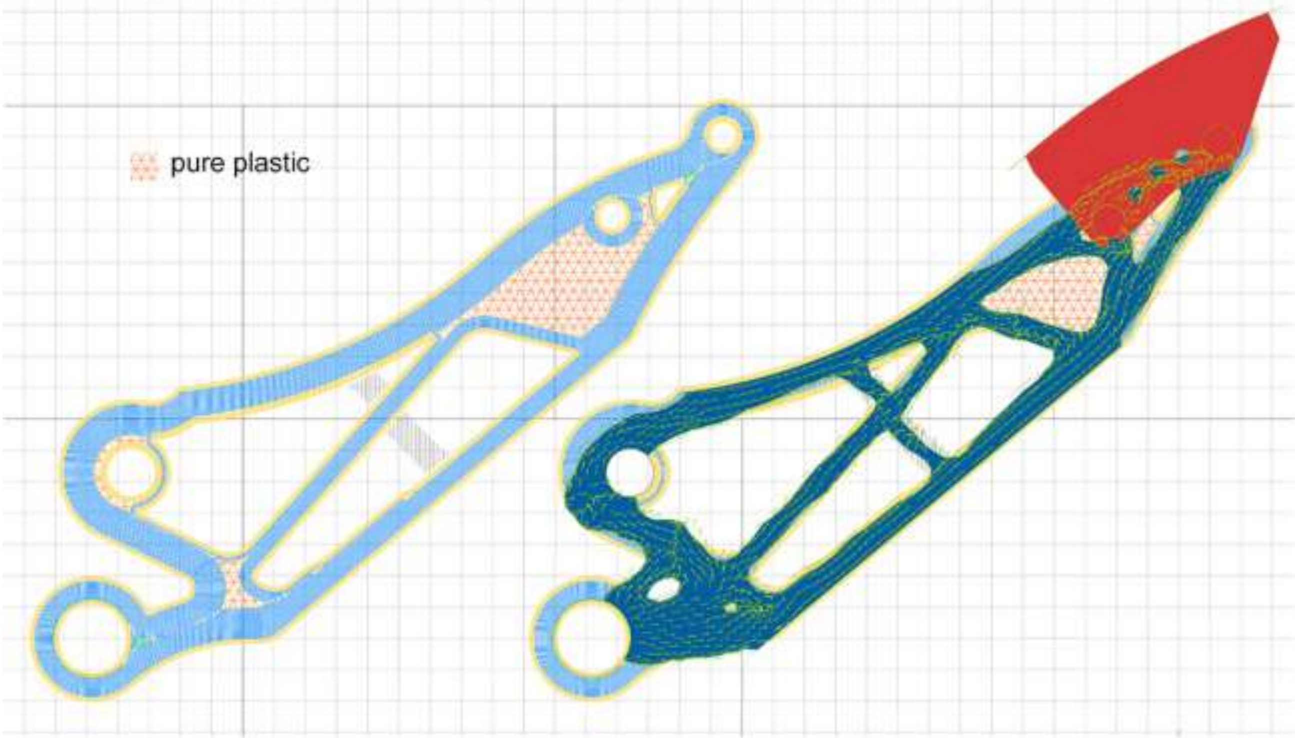


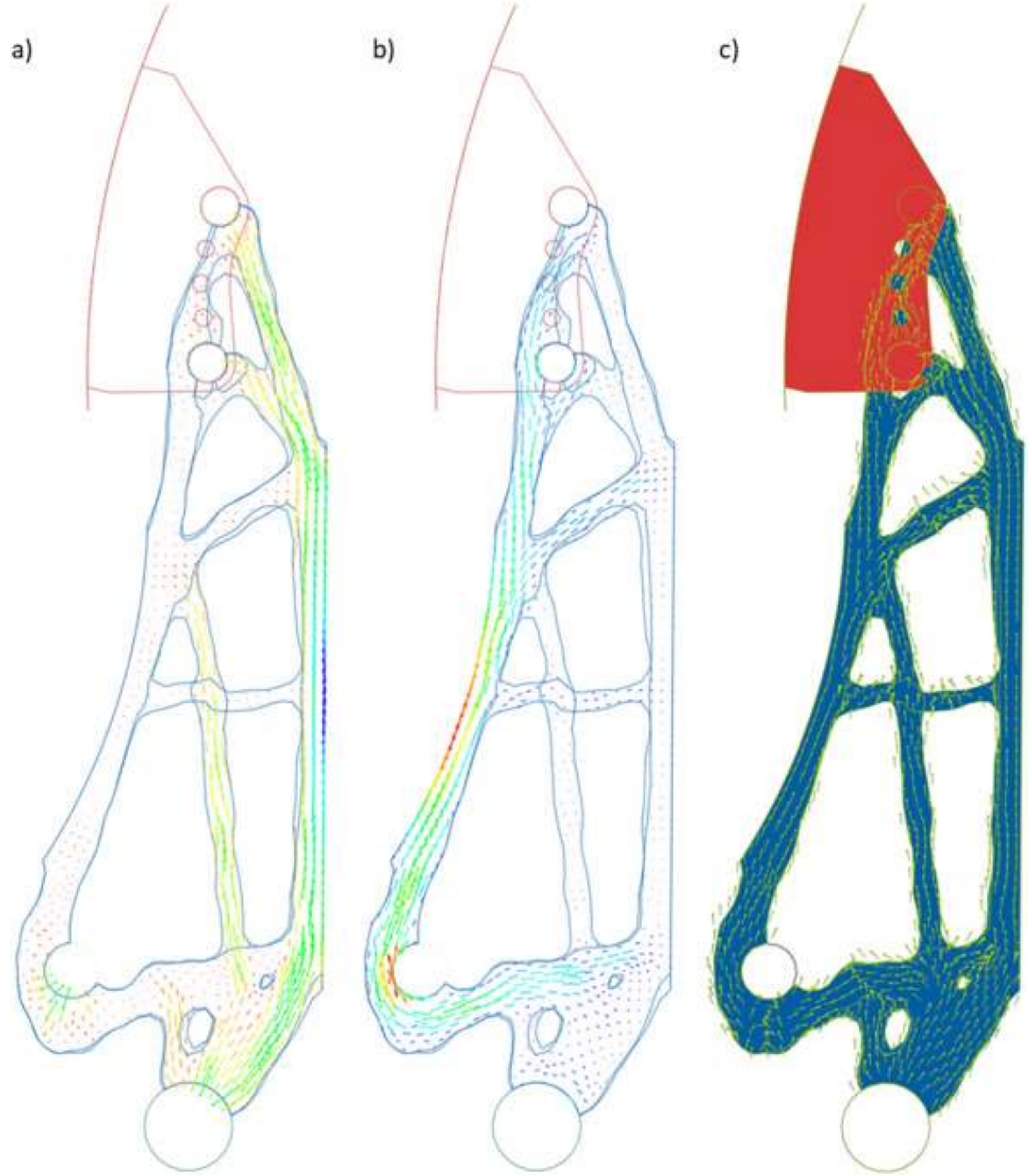
Boris Fedulov, Alexey Fedorenko, Aleksey Khaziev, Fedor Antonov, Optimization of parts manufactured using continuous fiber three-dimensional printing technology, Composites Part B: Engineering, Volume 227, 2021, 109406, ISSN 1359-8368, https://authors.elsevier.com/c/1dxNh4rCEkgosQ

TOPOLOGY & FIBER PATH OPTIMIZATION









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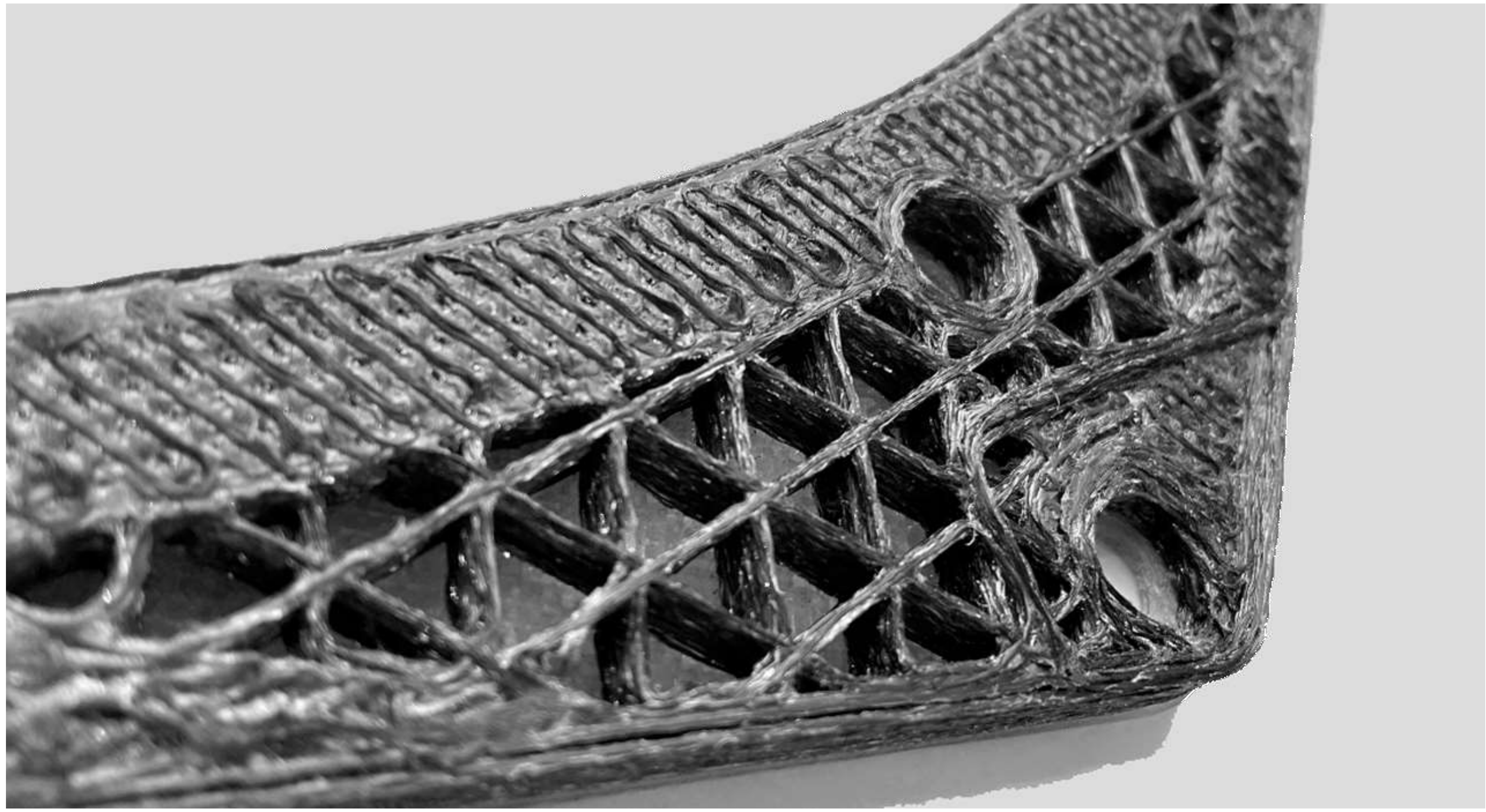
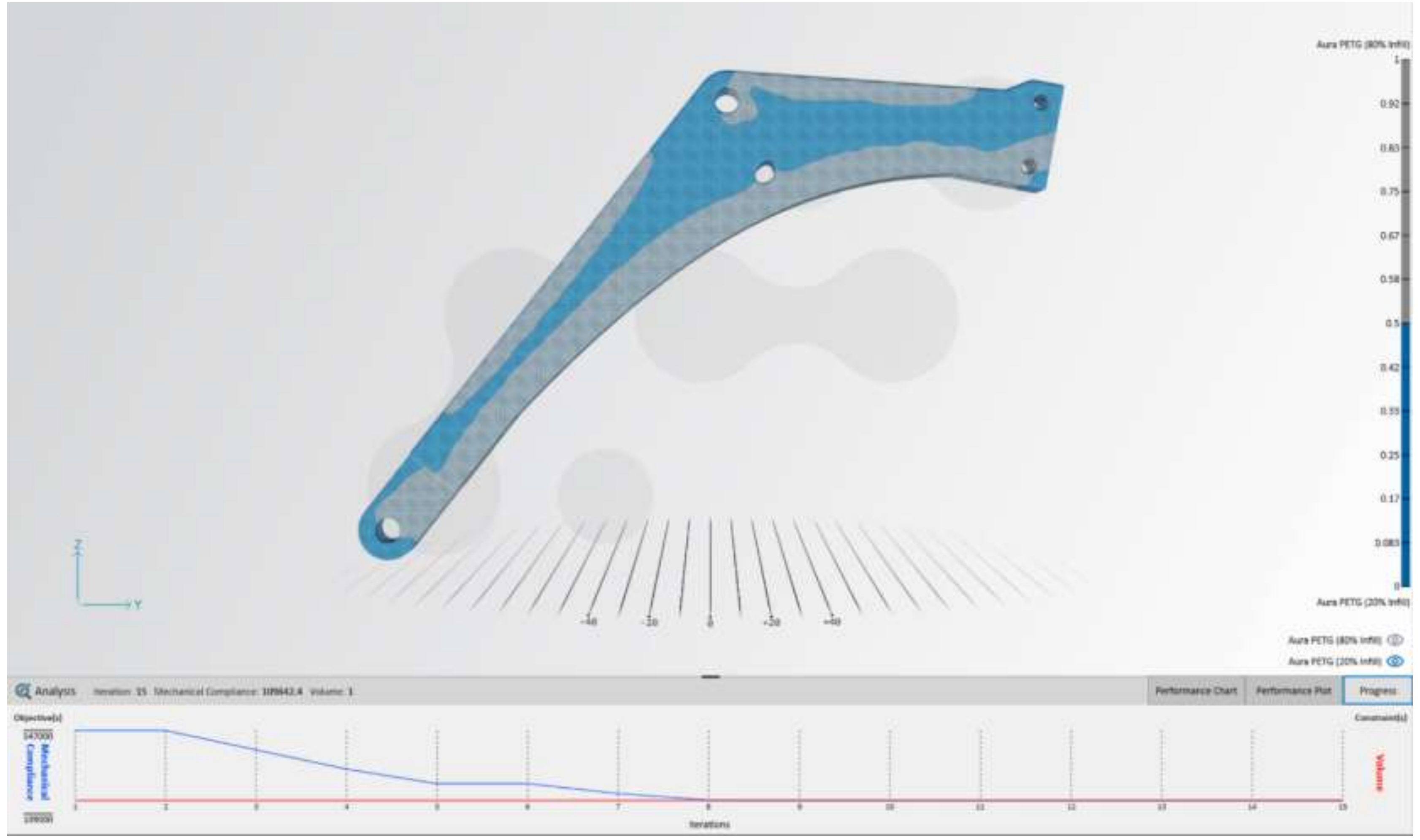
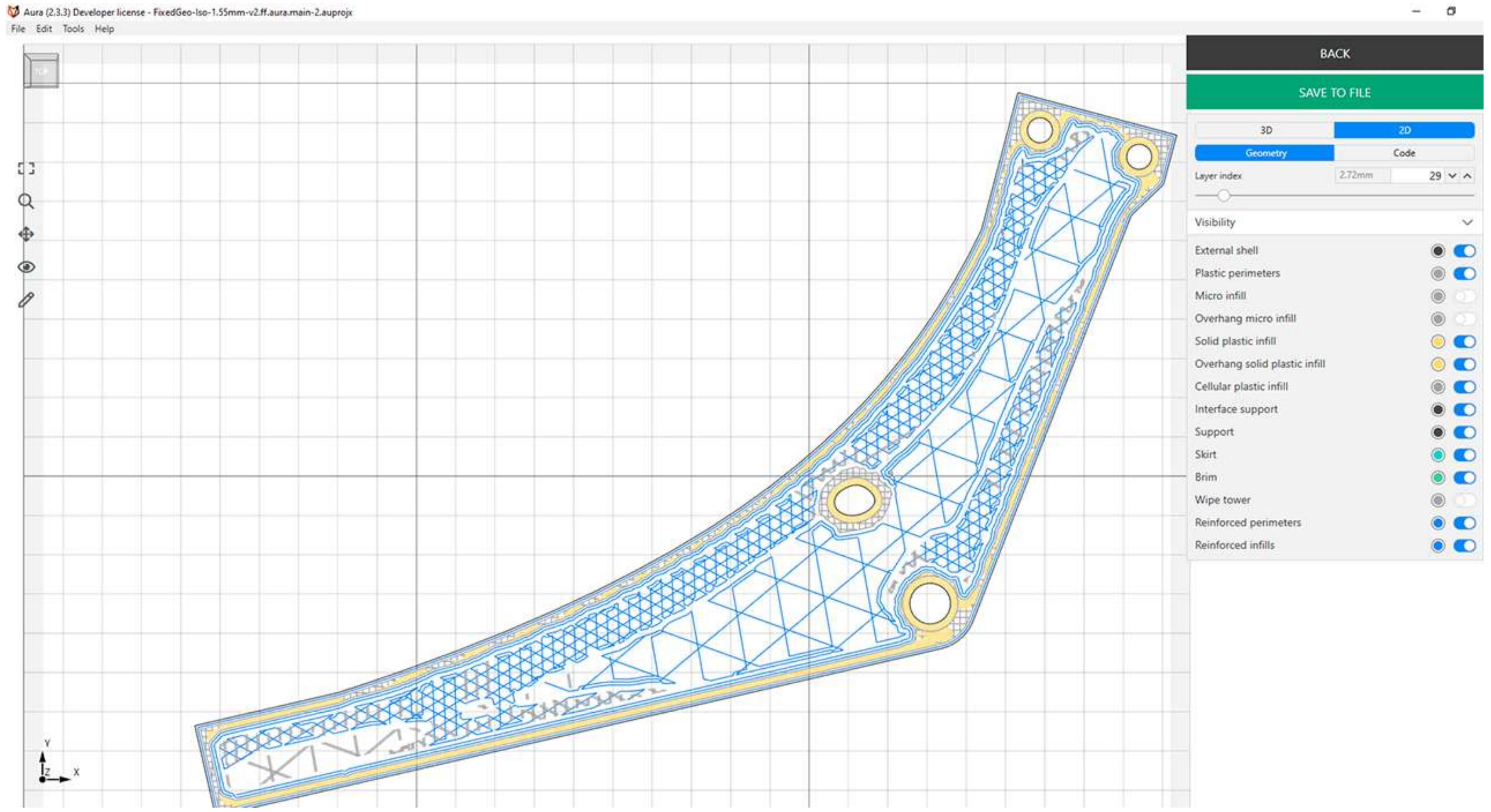
AURA

- Full scale multilateral topology optimization
- We can use as much material as needed exactly at the right regions making the model suitable for its purpose and highly customizable

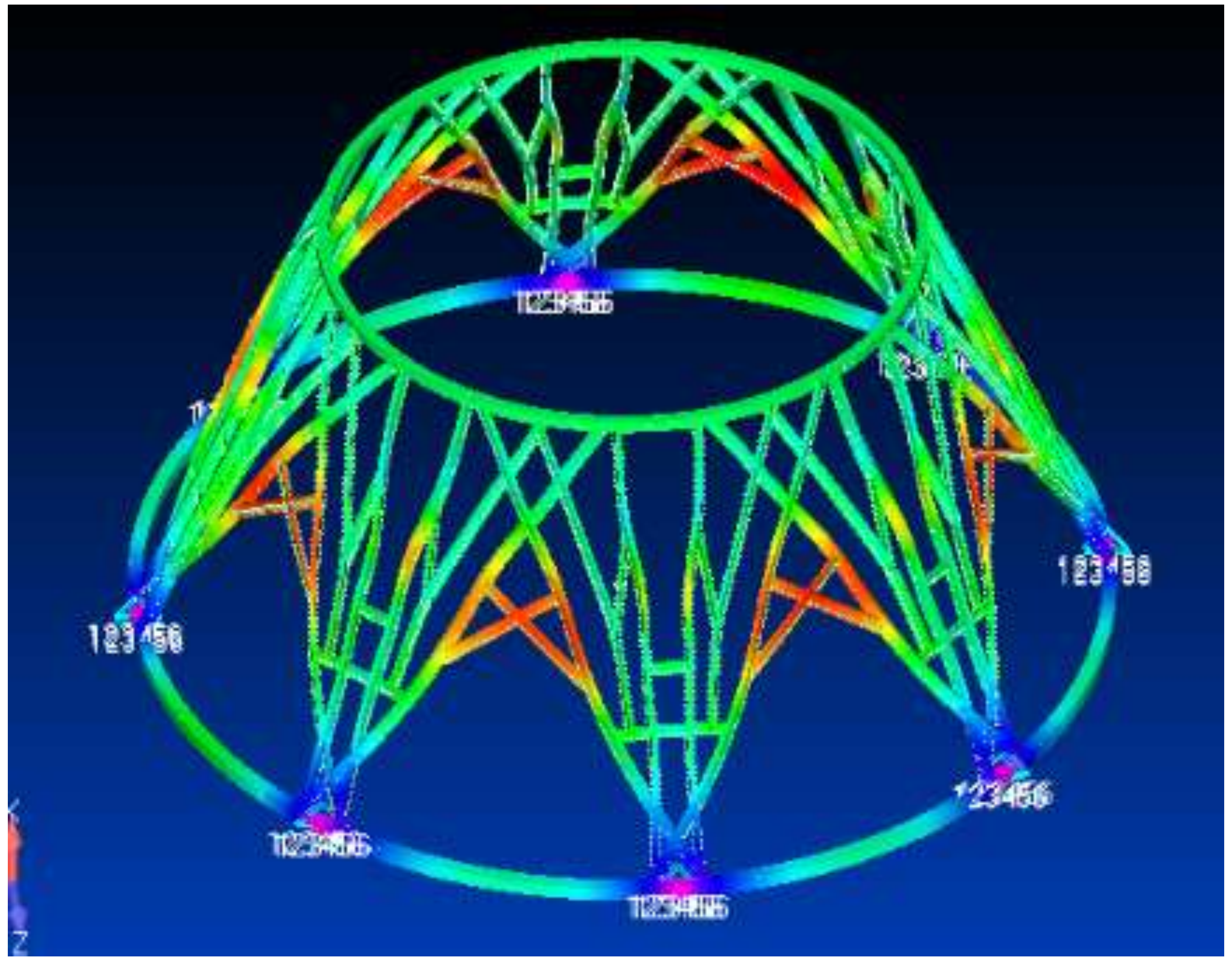




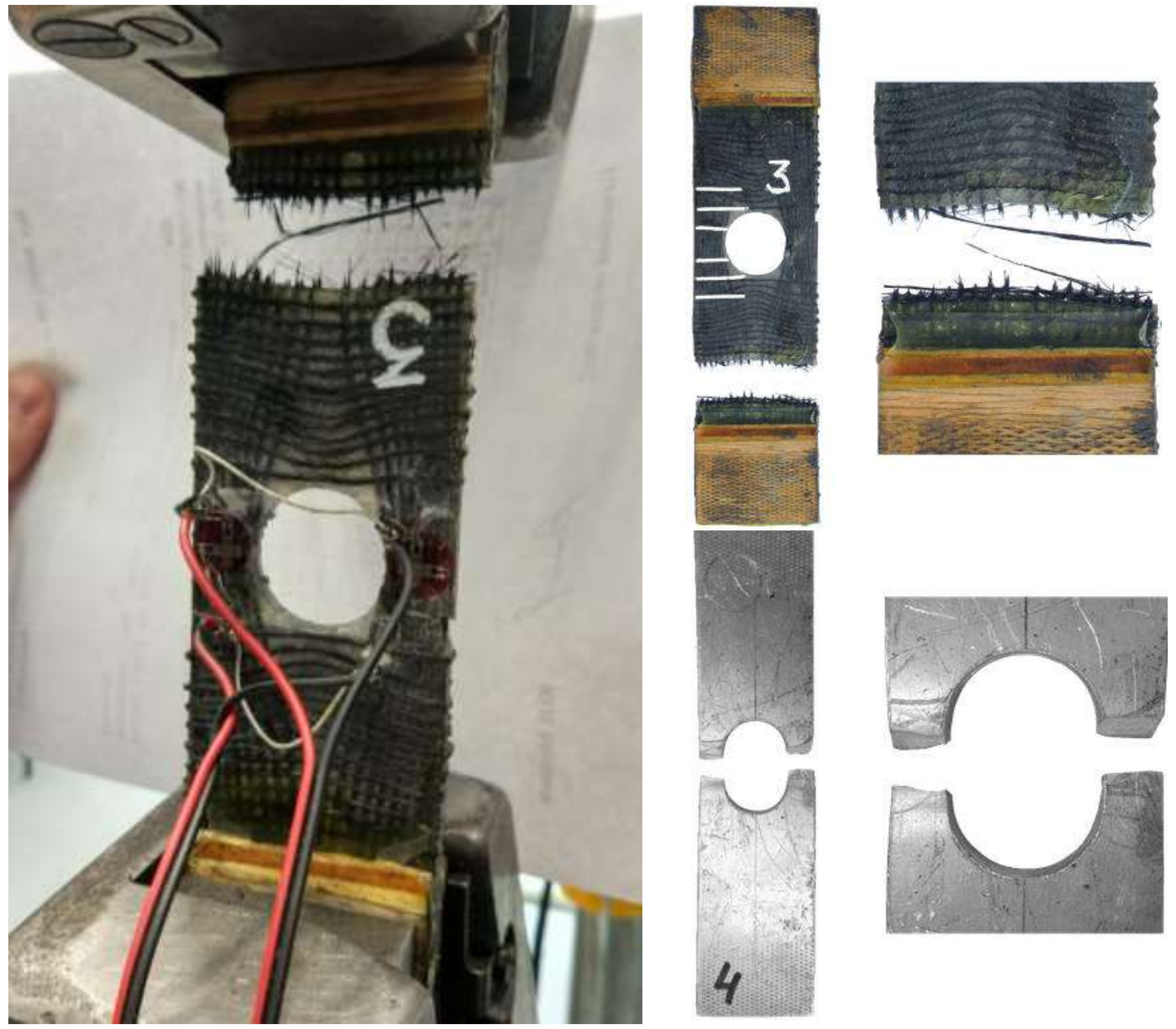


MULTIMATERIAL (LATTICE) TOPOLOGY OPTIMIZATION

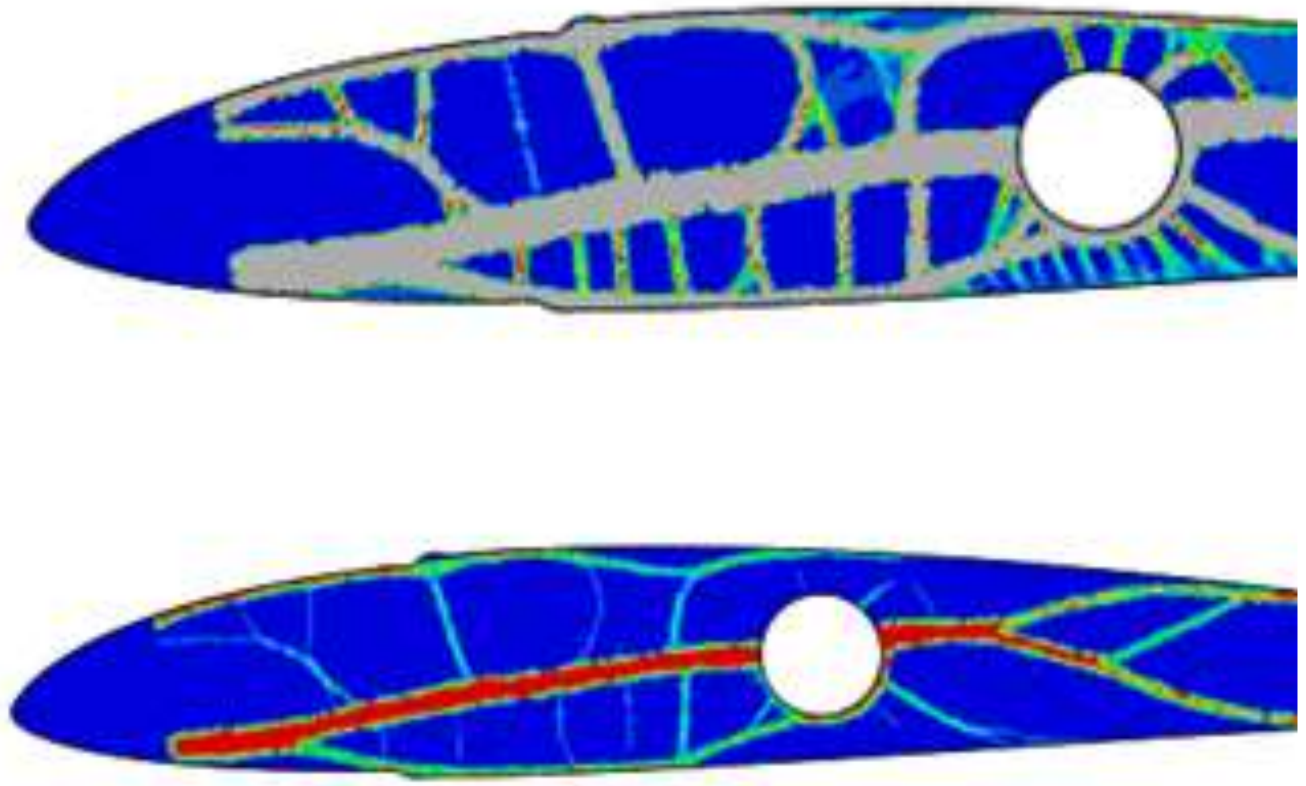
- Topology optimized anisogrid lattice structures



- Stress concentration avoidance



- Topology optimization of anisotropic media

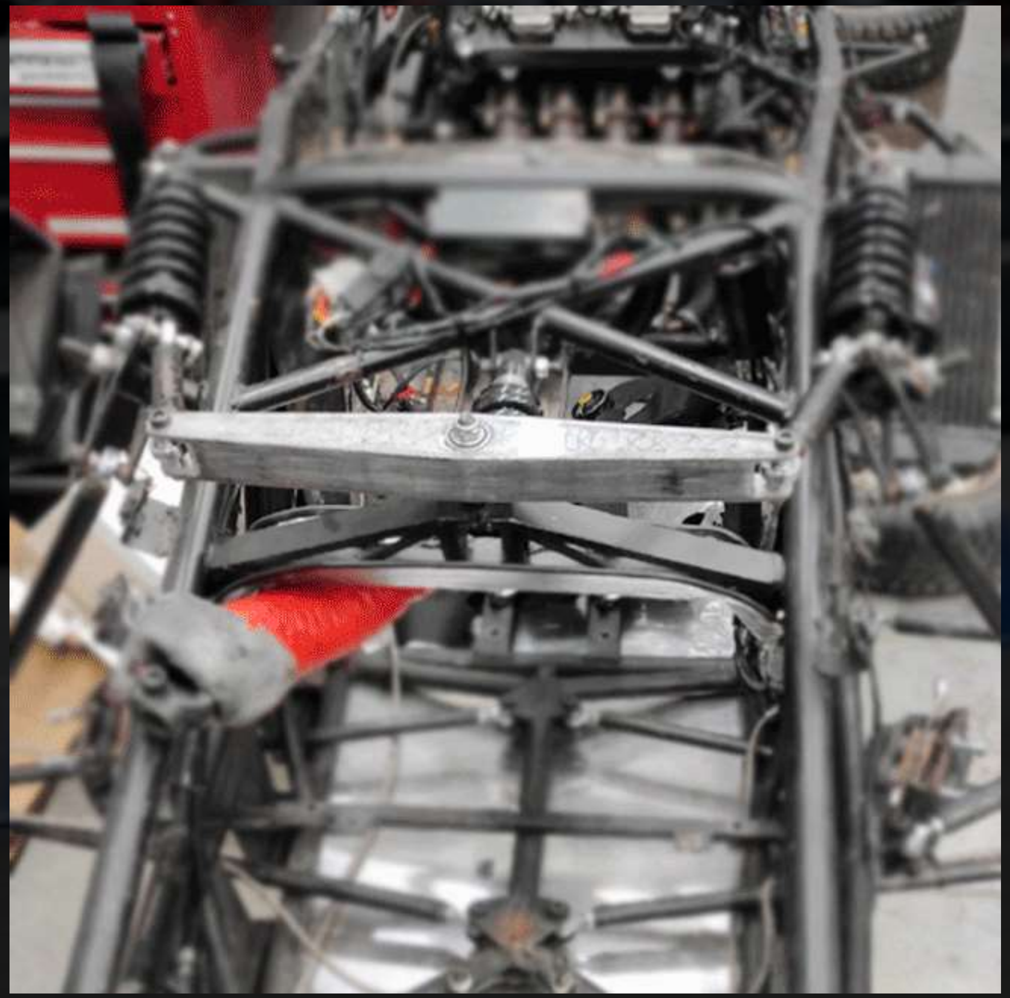


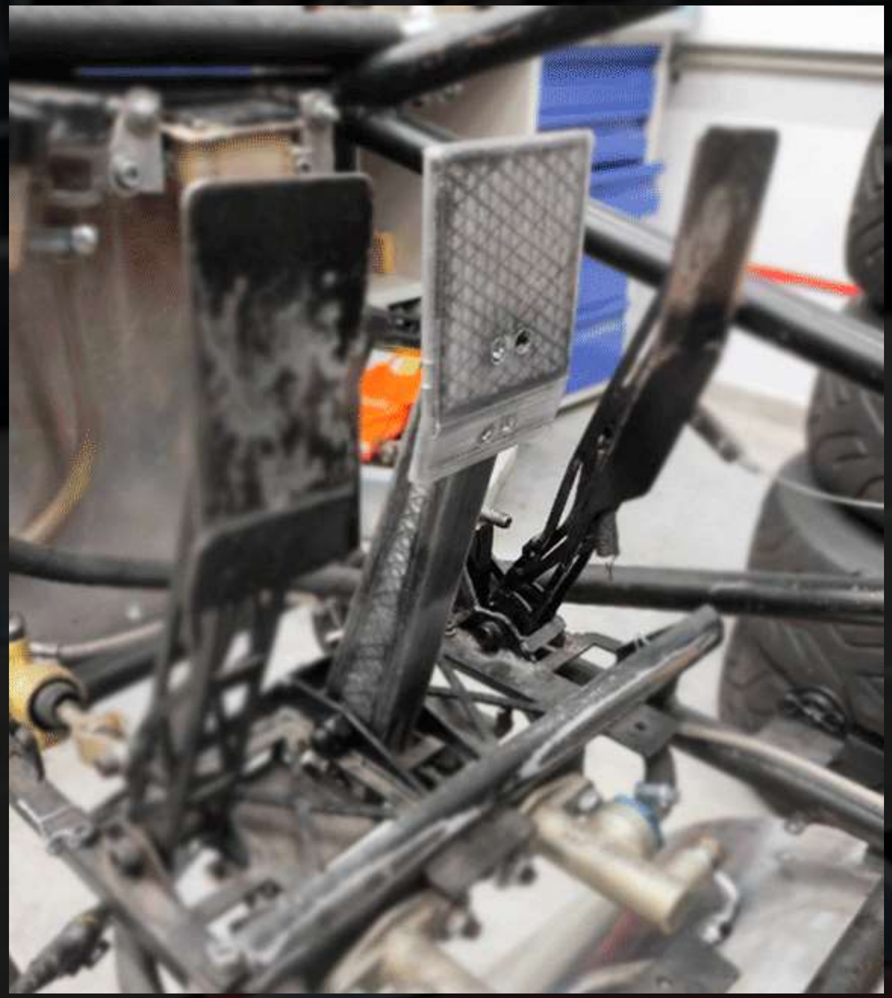
MULTIMATERIAL (LATTICE) TOPOLOGY OPTIMIZATION

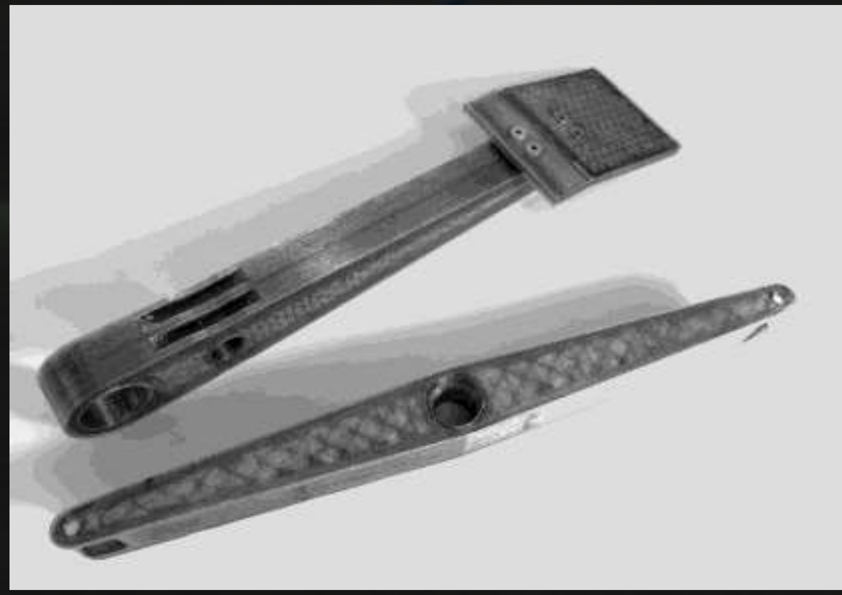
USE CASES

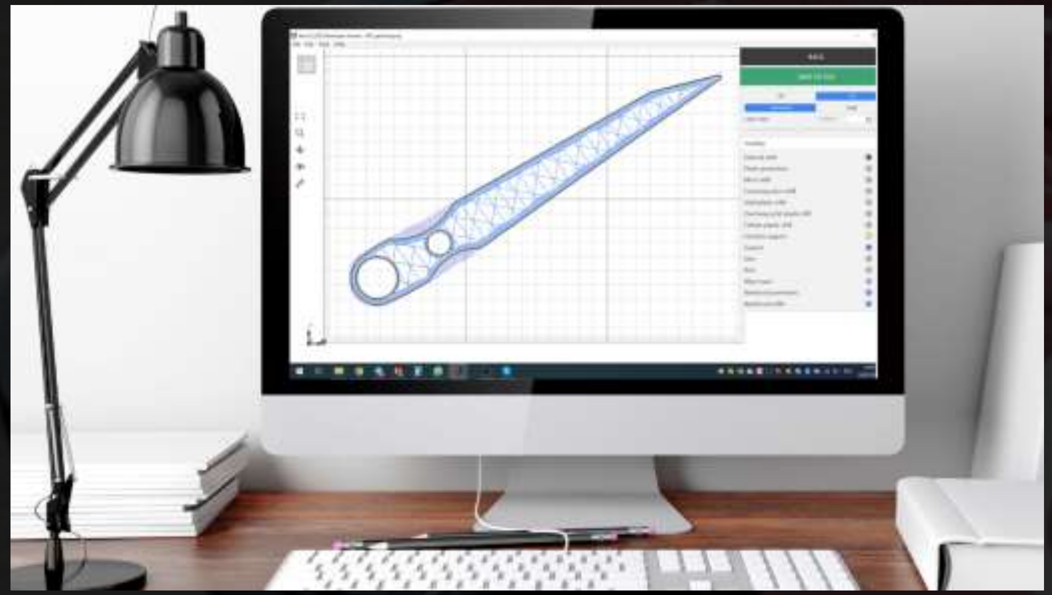
A RACE CAR BREAK PEDAL & A ROCKET ARM FOR MOTORSPORT

2.6 weight reduction, production automation, new design opportunities









	CNC metal	Anisoprinting
Weight	858 g	327 g
Savings	62%	

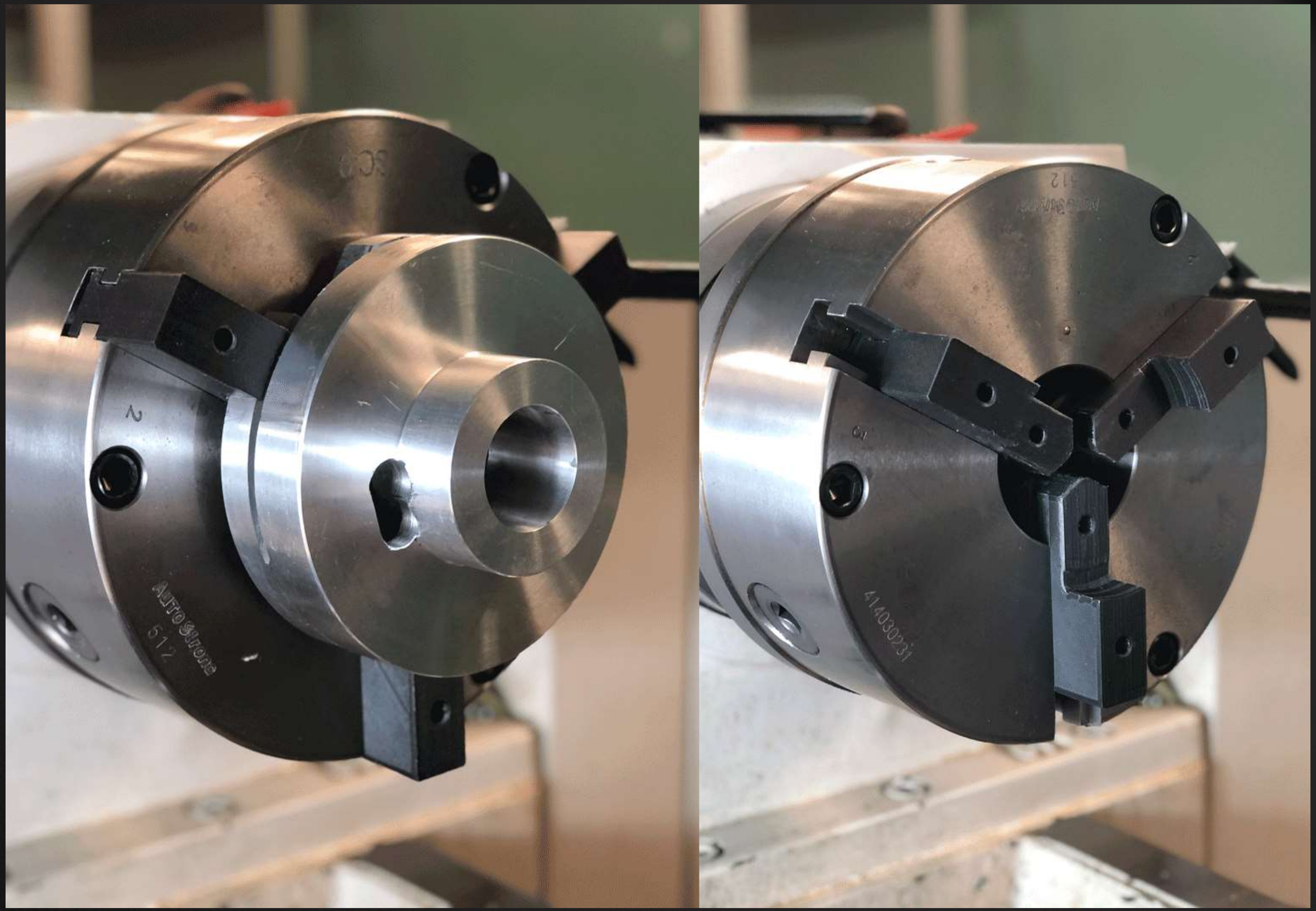
SCOTT GAMBLER DOWNHILL BIKE ROCKER

40% manufacturing costs decrease, 35% weight decrease, smart load-oriented reinforcement

	CNC metal	Anisoprinting
Weight	500 g	325 g
Price	€380	€250

SOFT JAWS FOR A TECHNOLOGICAL PARTS PRODUCTION COMPANY

35% weight reduction, 40% lower manufacturing costs, non-standard shape



	CNC Metal	Anisoprinting
Weight	600 g	251g
Price	€113	€45

LEGS OF MOBILE ROBOT FOR SENSING, INSPECTION, AND REMOTE OPERATION

70% weight reduction, 40% lower manufacturing costs, flexible prototyping

	Aluminum	Anisoprinting	Savings
Weight	1225 g	350g	70%
Price	€460	€260	40%

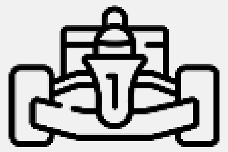
MARKET

~$1.6B in 2019*

Aerospace AM

Interior parts
Tooling
Spareparts

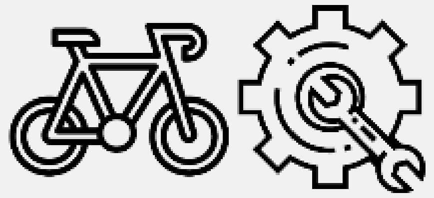
~$1.4B in 2019**



Automotive AM

End-use parts
Tooling
Spareparts

~$1B

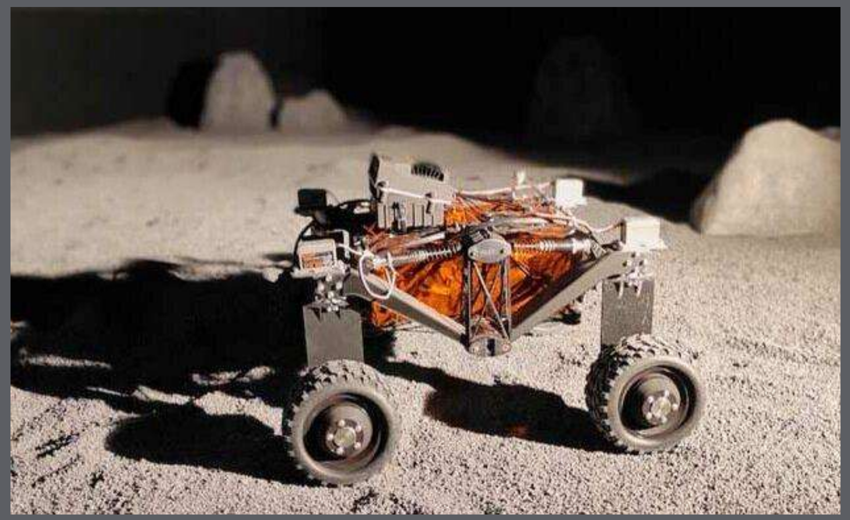


Consumer & industrial goods

End-use parts
Tooling
Spareparts

*https://www.stratviewresearch.com/toc/346/Aerospace-3D-Printing-Market.html
**https://www.smartechanalysis.com/reports/additive-manufacturing-automotive-part-production-2019/

COMMERCIAL SPACE



~$500B by 2026.

DRONES & UAVS

~$50B by 2025

SERVICE ROBOTICS

~$100B by 2025

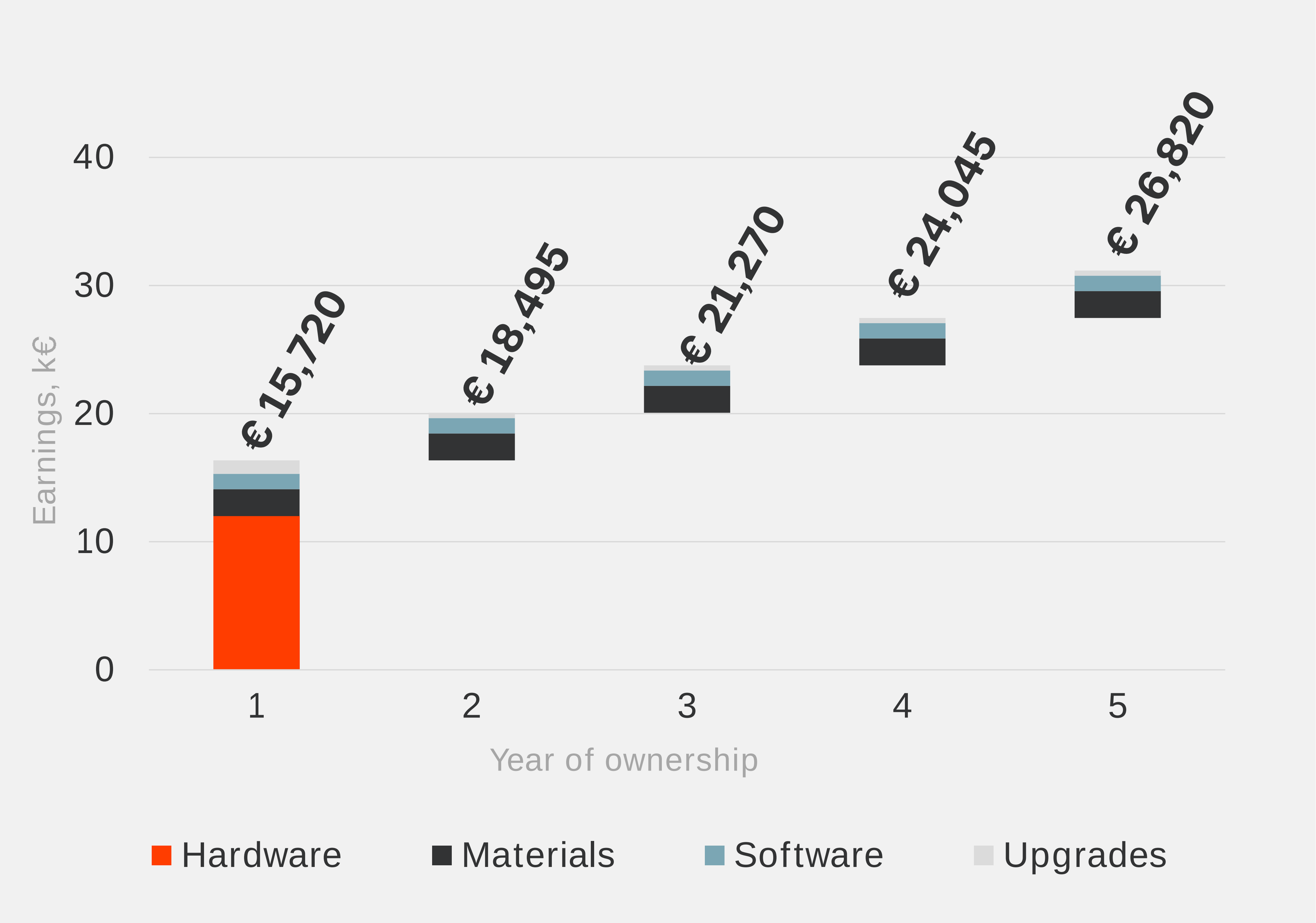
URBAN MOBILTY

~$200B by 2027

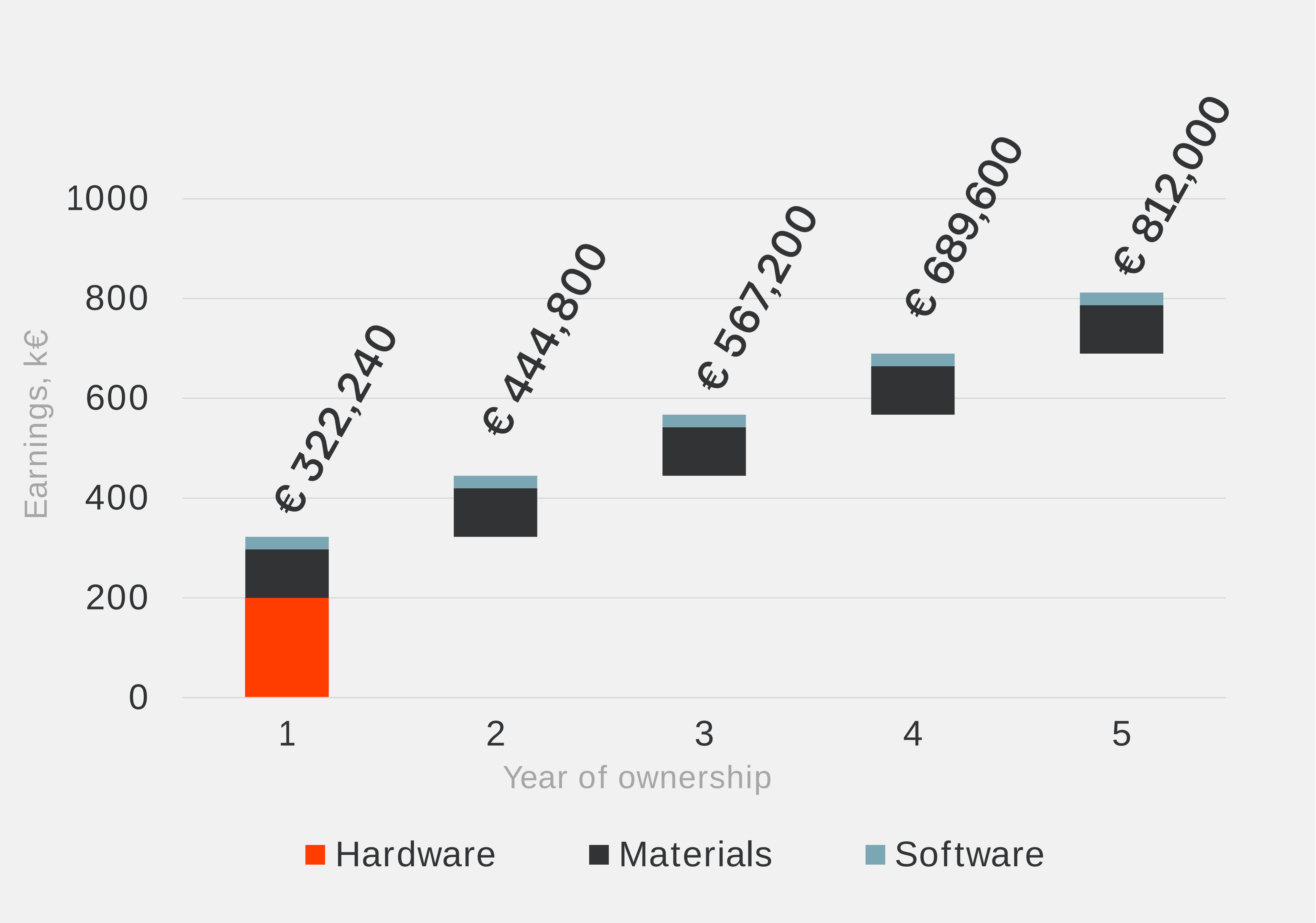
*Source: SmarTech

EMERGING MARKETS FOR ANISOPRINTING — FOCUS VERTICALS

Desktop systems ARPU



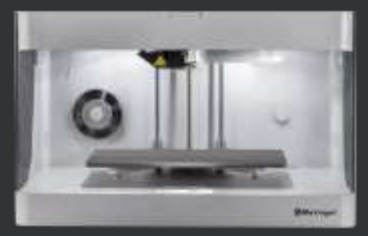
Industrial systems ARPU



Gross margin	Desktop	Industrial
Hardware	60%	52%
Materials	78%	73%

COMPETITORS

COMPARED TO COMPETITORS

	Desktop Metal	Markforged		anisoprint	
Matrix material	Nylon (PA6), PEEK, PEKK	Nylon only		Any plastic	
Reinforcing schemes	Solid infill only	Solid infill, perimeters		Solid infill, perimeters, 4 types of lattice infill	
Fiber steering	No	Perimeters only		Arbitrary	
Hardware	Desktop 	Desktop 	Industrial 	Desktop 	Industrial 
Build volume	310 x 240 x 270 mm	Up to 525 x 400 x 400 mm		Up to 600 x 420 x 300 mm	
Printer cost	\$3,495 / year \$17,475 / 5 years	Desktop: \$18,000	Industrial: \$300,000	Desktop: up to €24,000	Industrial: €200,000
Material cost, 50cc	Carbon: from \$149	Carbon: from \$150 Fiberglass: from \$80		Carbon: from €100 Basalt: from €60	Carbon: from €40 Basalt: from €25

IPO

2021 TOP3 3D Printing IPOs

Company	Valuation
Desktop Metal	$4.6 bln *(IPO)*
VELO 3D	$1,6 bln *(IPO)*
Markforged	$2,1 bln *(IPO)*

Strategic sale

2021 3D Printing Acquisitions

Desktop Metal

covestro

envisionTEC

stratasys

DSM

ORIGIN

3D HUBS

PROTOLABS

3D Printing Is Growing Up: Market Consolidation Picks Up In Additive Manufacturing
Newly listed companies will pursue M&A activities
Large industrial manufacturing and chemical corporations (GE, Siemens, BASF, Sabic) will have to catch up

https://www.fabbaloo.com/news/2021-the-year-of-additive-manufacturing-market-consolidation
https://www.forbes.com/sites/sarahgoehrke/2021/02/26/3d-printing-is-growing-up-market-consolidation-picks-up-in-additive-manufacturing

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