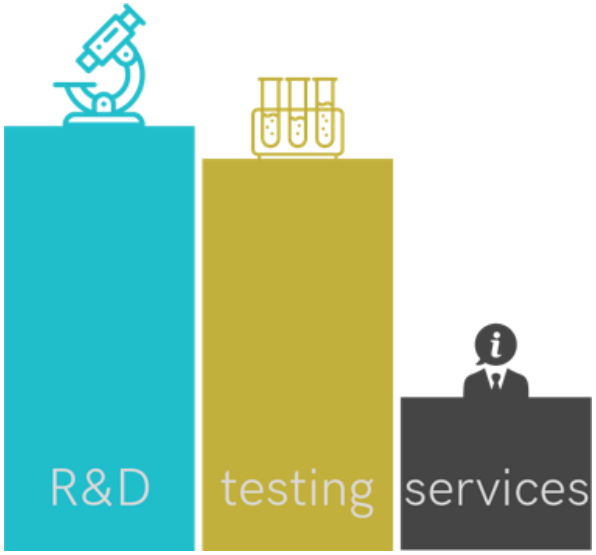
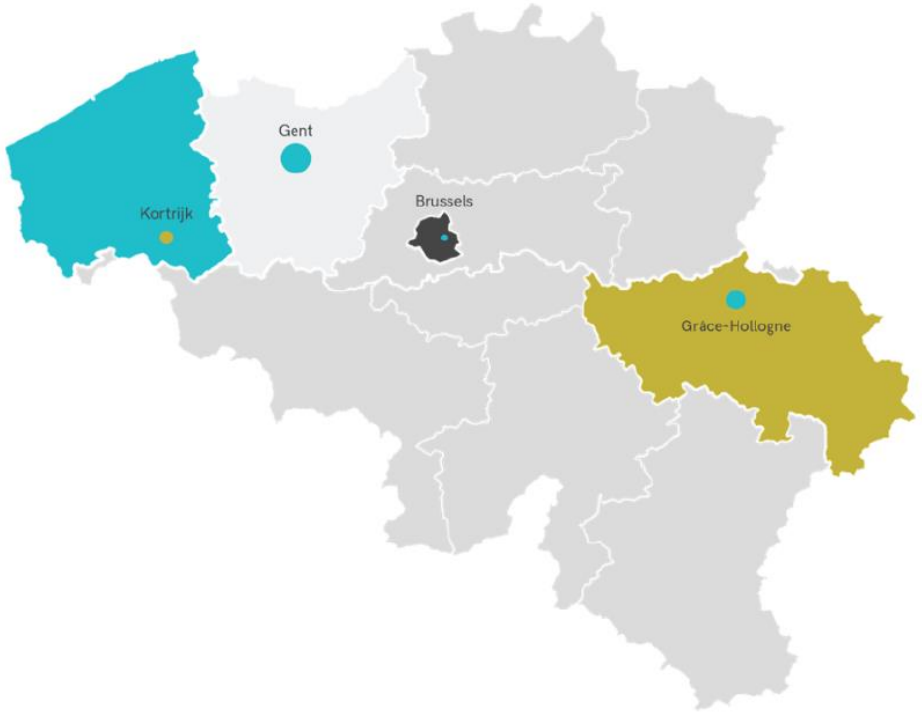
Het potentieel van 3D-print technieken voor de textielindustrie

Sofie Huysman

About Centexbel

- Collective research and technical centre in Belgium
- In service of the textile and plastic converting industry
- Driven by the industry demand
- 180 employees – 3 sites





Research Groups

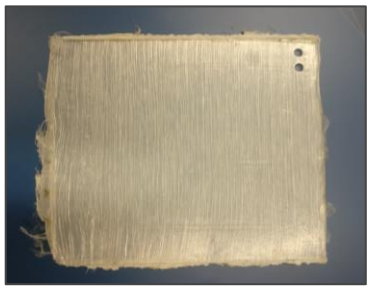
Extrusion & plastic processing

Textile coating & finishing

Technical textiles & composites

Medical & sustainable textiles

Biopolymers



Composites

3D-printing

Recycling

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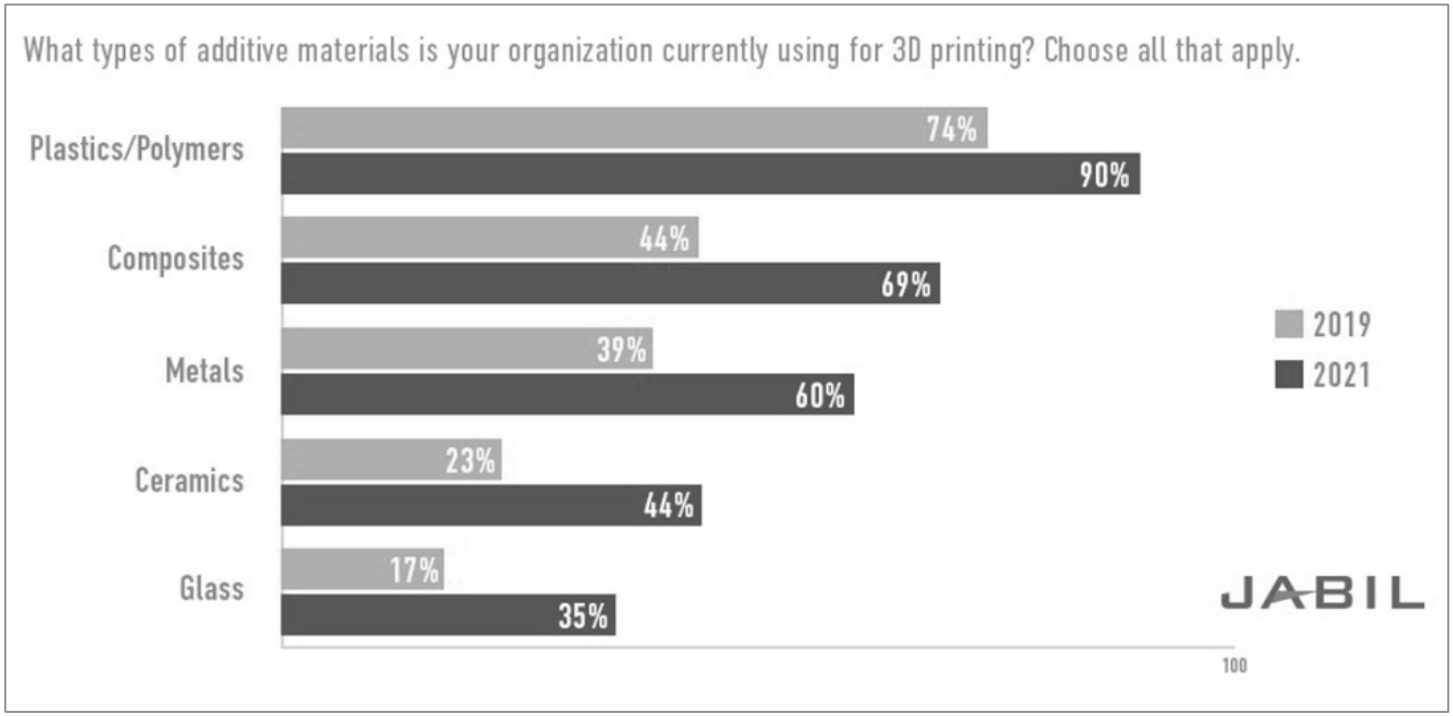
Introduction to 3D-printing

Polymers are the leading materials in the 3D-printing industry



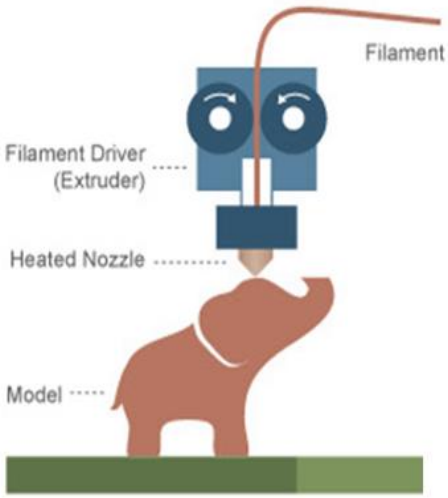
To link 3D-printing & textile applications, polymers are the most obvious choice

Polymer-based techniques

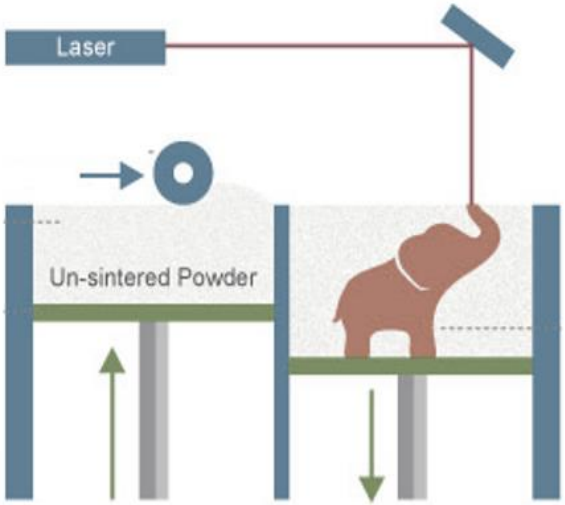
Thermoplastic polymers

Thermosets

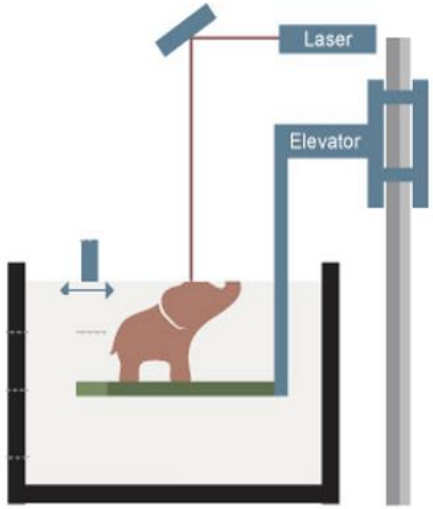
MATERIAL EXTRUSION



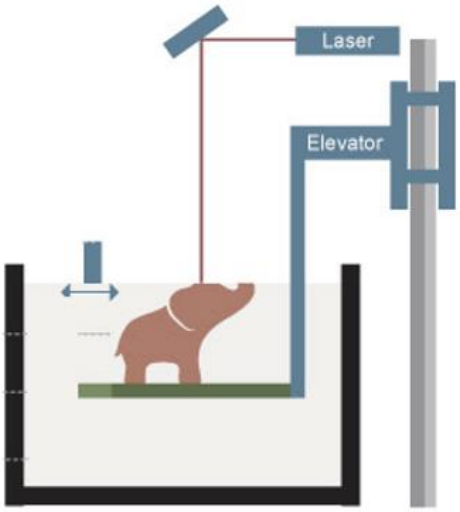
POWDER FUSION



PHOTOPOLYMERISATION



Photopolymerisation



Principle

A liquid photopolymer in a vat is selectively cured by light-activated polymerization

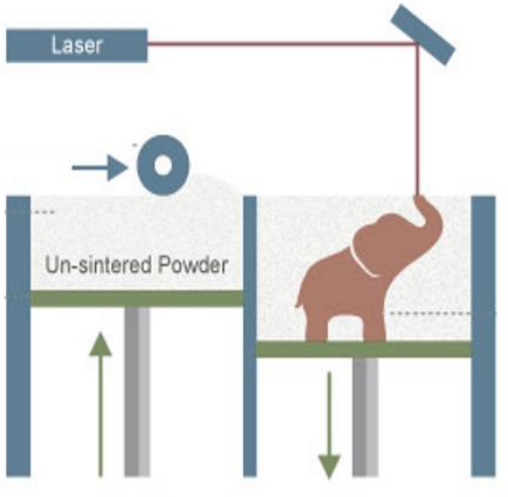
Materials

- Binders + monomers + photoinitiators
- Usually epoxy-based resin systems

Examples of techniques:

- Stereolithography (SLA) → UV-curing through a laser beam
- Digital light processing (DLP) → UV-curing through a project screen
- Polyjet technique: special case, allows multimaterial building

Powder fusion



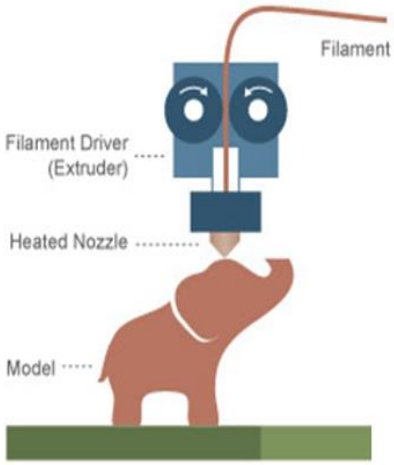
Principle

Regions of a polymer powder bed are fused through a laser beam (SLS) or liquid bonding agent (Binder Jetting)

Materials

- PC: amorphous, gives dimensional accuracy but can only partially consolidate → for applications that do not require strength and durability
- PA: semi-crystalline, can be sintered to dense parts with good mechanical properties.

Material extrusion - basics



Principle

FFF = Fused Filament Fabrication

A thermoplastic filament is pushed through a heated extruder head using a drive wheel, to create objects layer by layer.

Materials

- The material should be extrudable into filaments, not be too flexible to avoid buckling between the drive wheels, and flexible enough to be spooled.
- Common filaments: ABS, PLA, PA, TPU, PET, …
- Combination with fillers is possible

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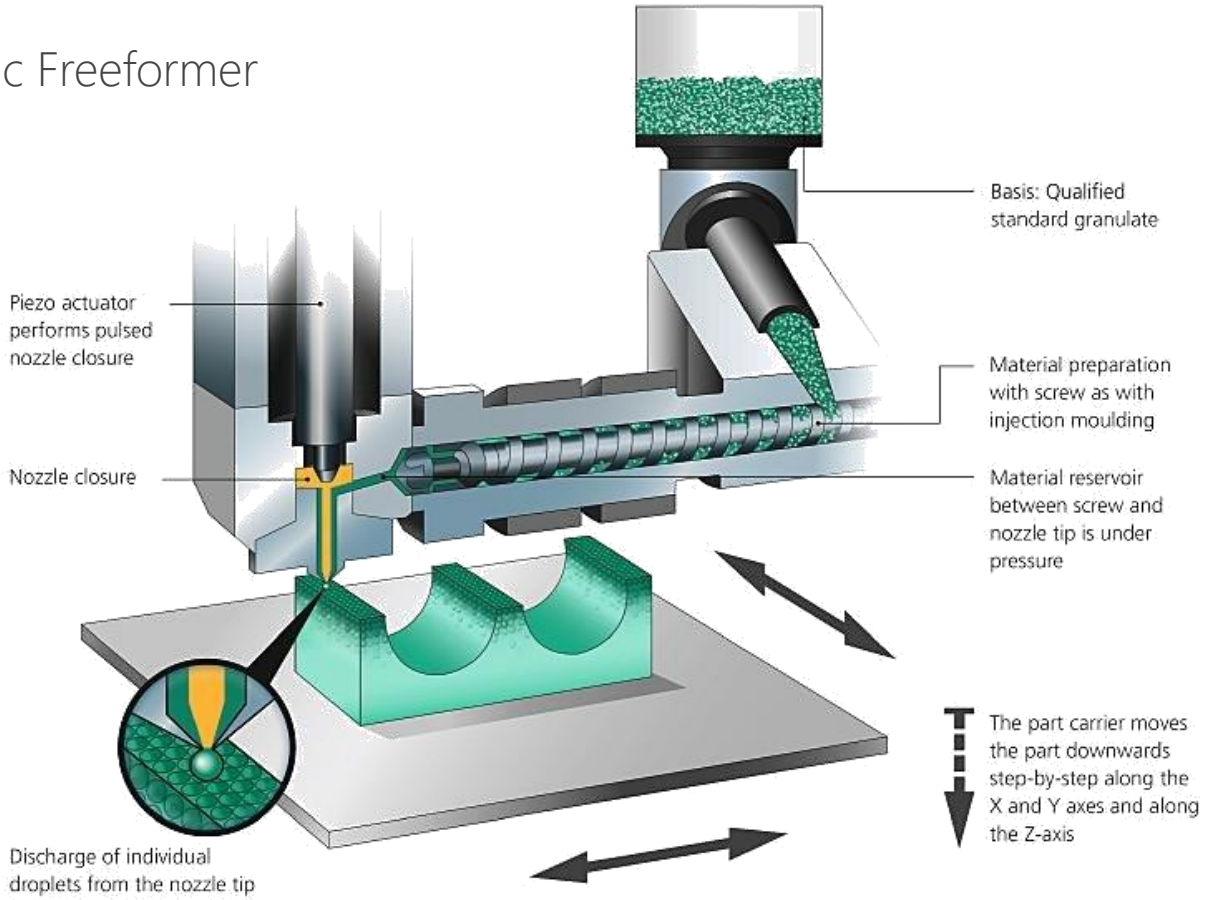
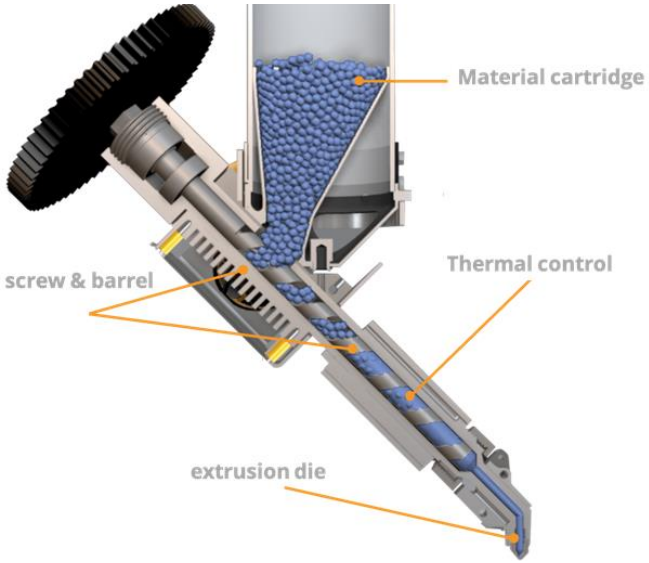
Material extrusion – new trend

Directly from pellets → much wider range of polymers possible!

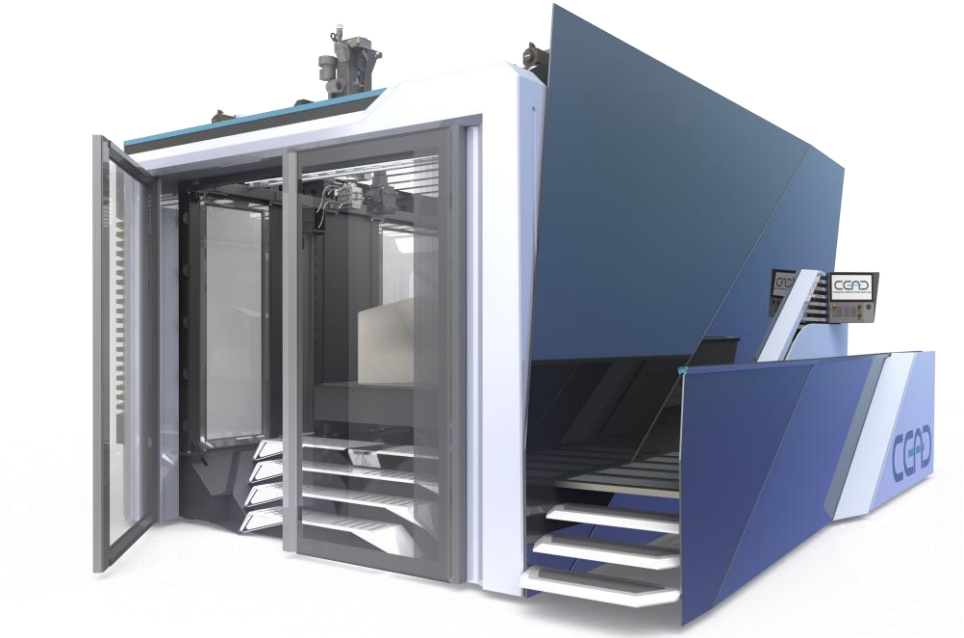
Example 1: Arburg Plastic Freeformer

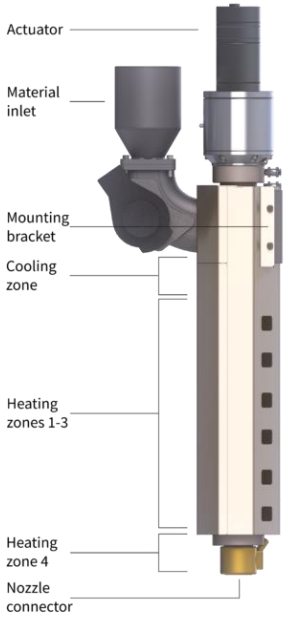


Example 2: Pollen AM



Example 3: CEAD printer for large applications (up to 4 x 2 x 1.5 m)





Summary

	Photo polymerisation	Powder fusion	Extrusion from filament	Extrusion from pellets
Accuracy	high	high	low	low
Machinery cost	high	high	low	high
Open source	no	no	yes	semi
Material cost	high	high	medium	low
Material freedom	low	low	high	very high

Absence of UV light or liquid resins:
Most suitable in combination with textiles

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3D-printing vs. textile

First thing that comes to mind: 3D-printing of entire garments

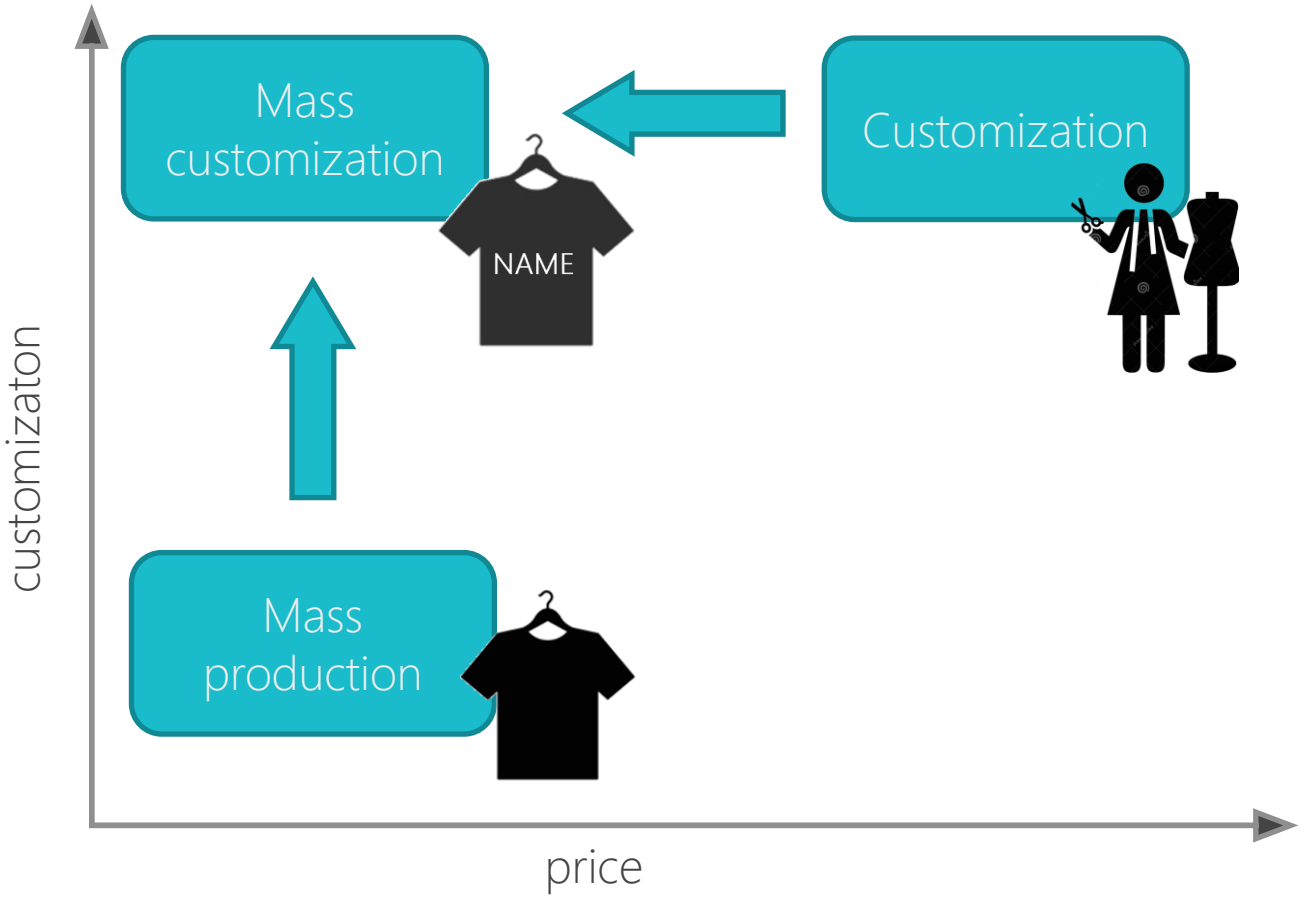
→ Very time-consuming and complex, only in 'haute couture'

Top: by Danit Peleg – FFF technology

Right: by Iris van Herpen – Objet technology

3D-printing vs. textile

Another trend is mass-customization by 3D-printing directly on textile



F3DPrint project

cornet
Collective Research Networking

"Fabrication of functional & custom-fit textiles using 3D printing based on scanning technology"

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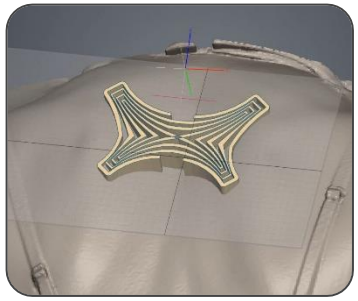
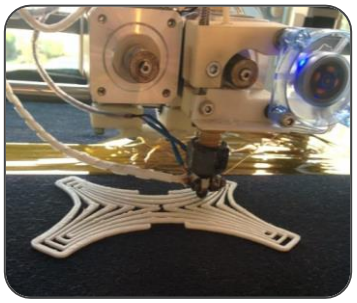
Body scanning



CAD modelling



3D printing on textiles

Customised product

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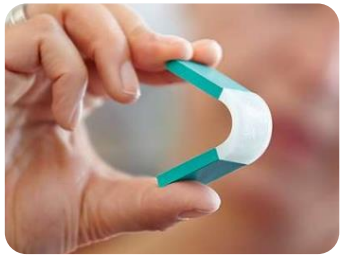
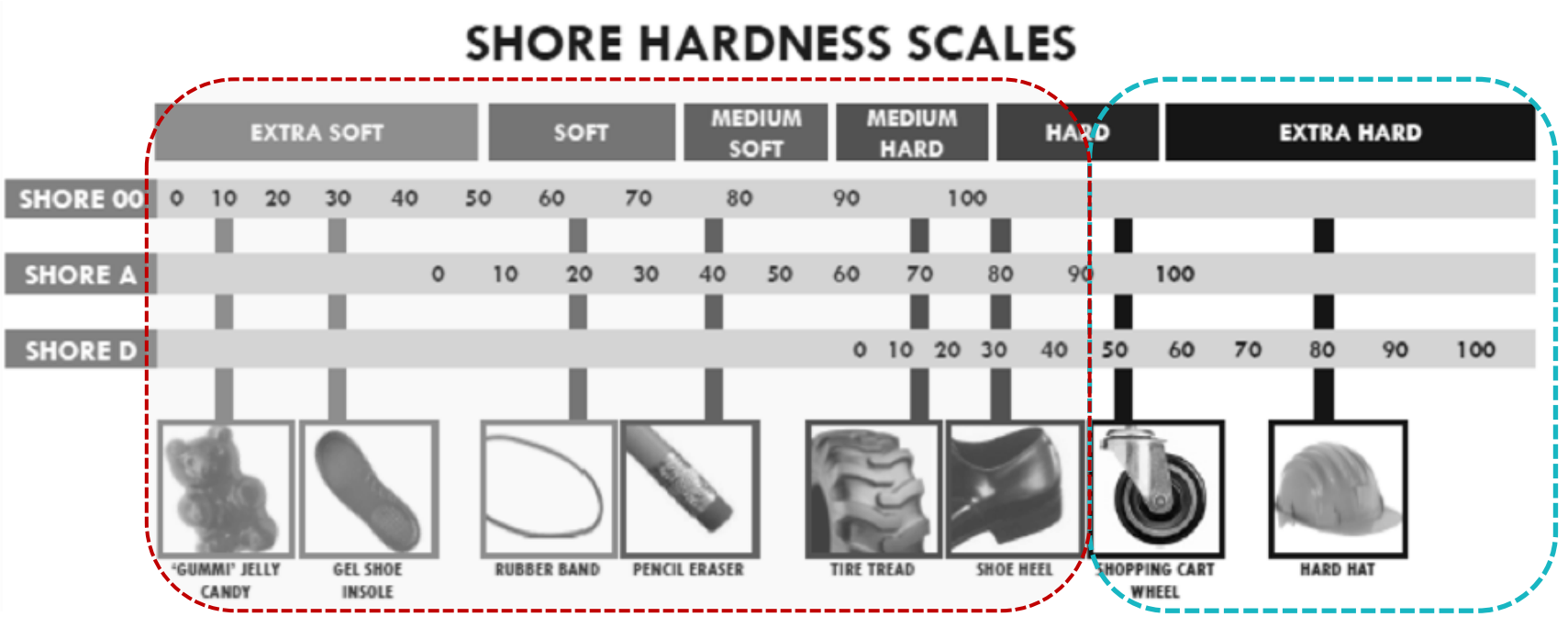
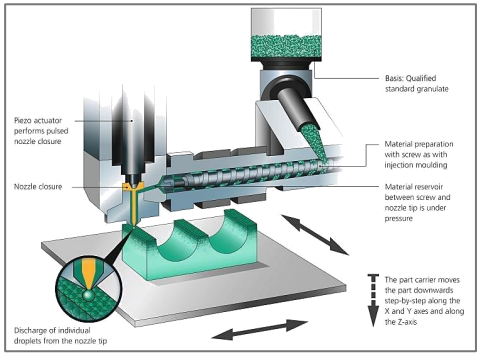
Suitable flexible polymers to 3D-print on textile?



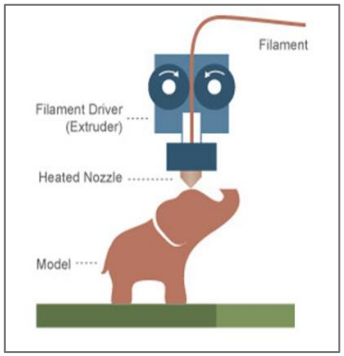
F3DPrint project



3D-printing from pellets

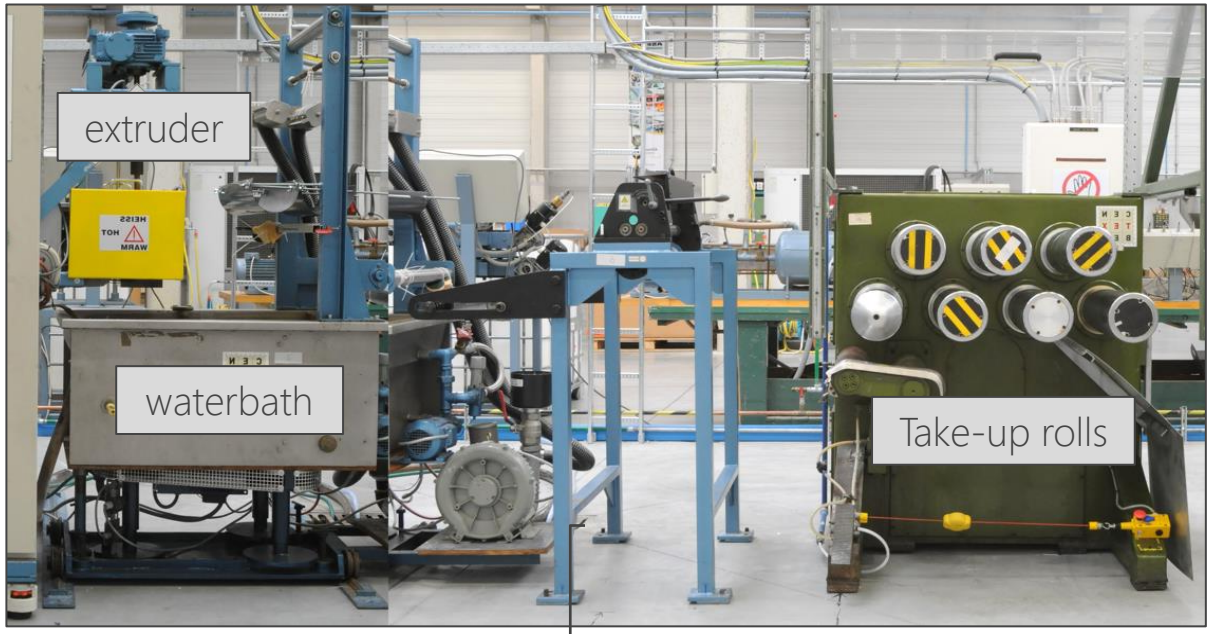


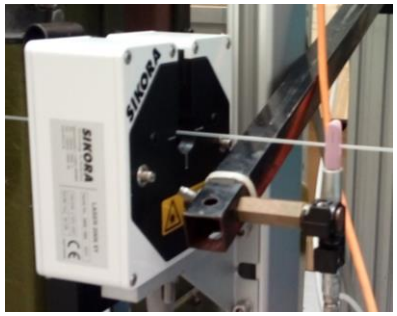
3D-printing from filament



F3DPrint project

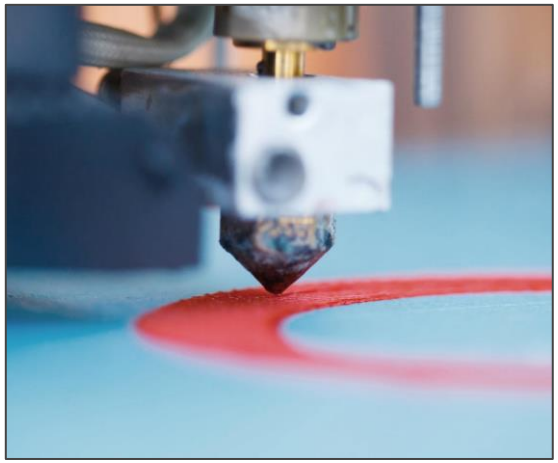
Filament production on monofilament extrusion line at Centexbel

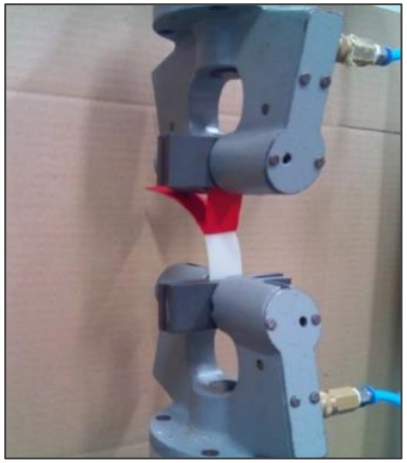




Diameter & roundness control (1.75 or 2.85 mm)

F3DPrint project





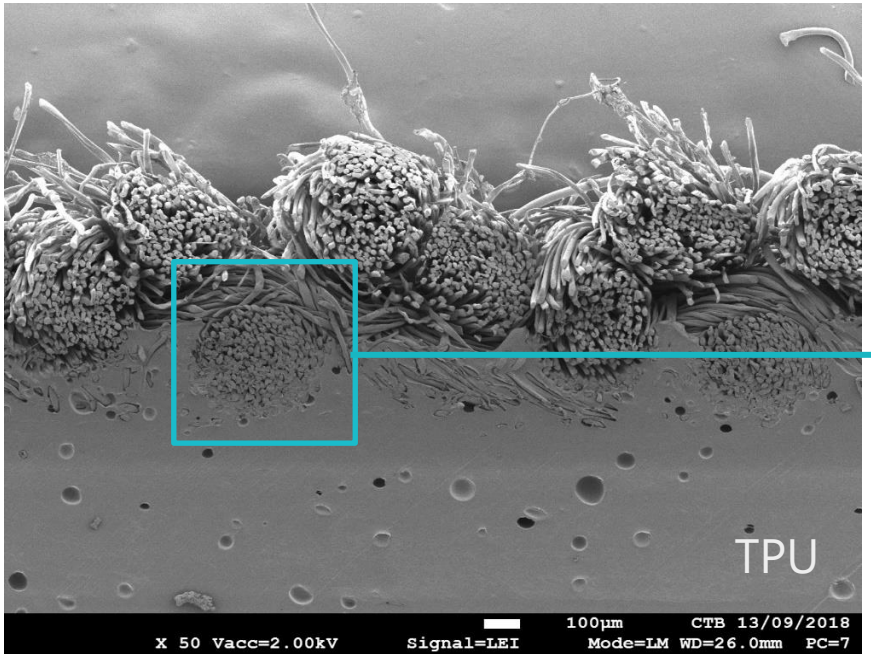
Next step: 3D-printing on fabrics and evaluation of the adhesion

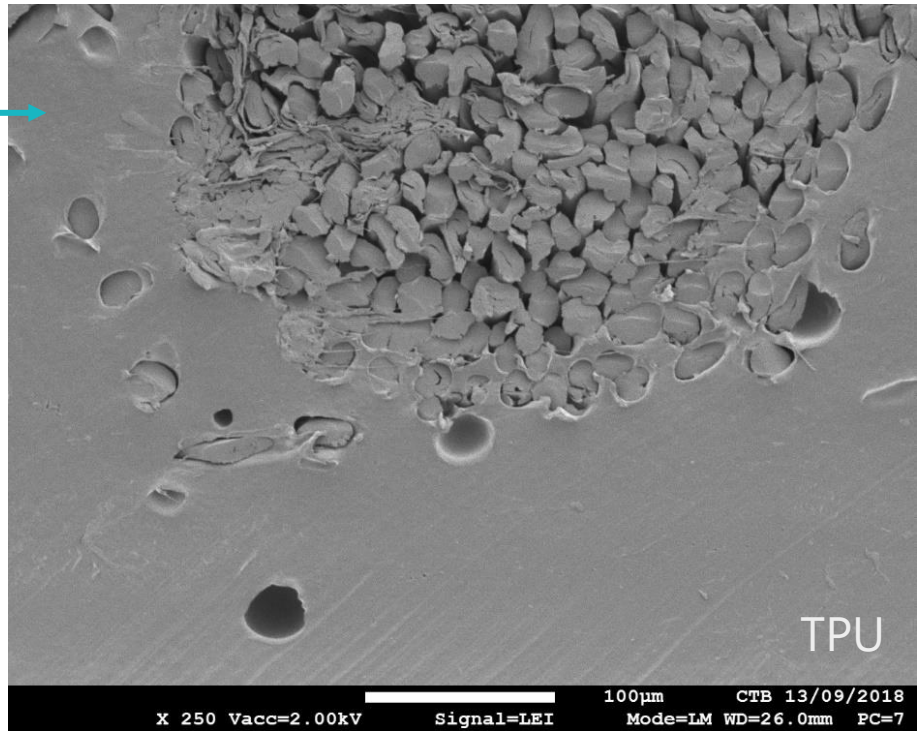
Main observations:

- Adhesion of TPU is better than TPS
- Adhesion can increase by pressing the nozzle deeper into the fabric
- A more open (less dense) woven or knitted structure is favorable
- Samples with good adhesion survived 50 industrial washing cycli at 60°

F3DPrint project

SEM images of TPU printed on 20% PES - 80% CO fabric

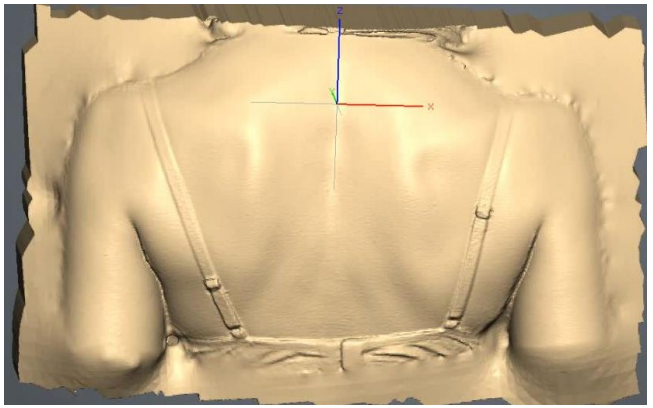


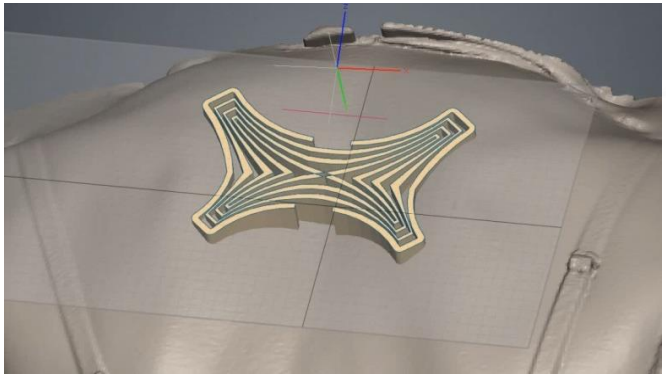


F3DPrint project

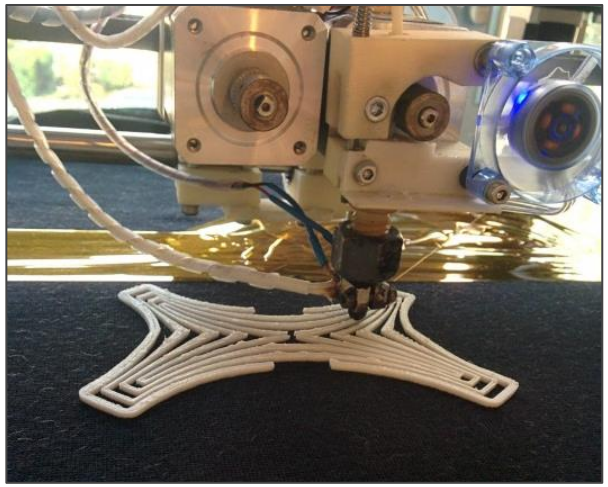
Scanning technology for customization –> back protector demonstrator

1. Scanning of the back with an Eva 3D handscanner.
2. Importing of the data in the software (Freeform Plus)
3. Construction of a 2D shape of the back protector
4. 3D extrusion of this shape to fit with the scanned back





F3DPrint project



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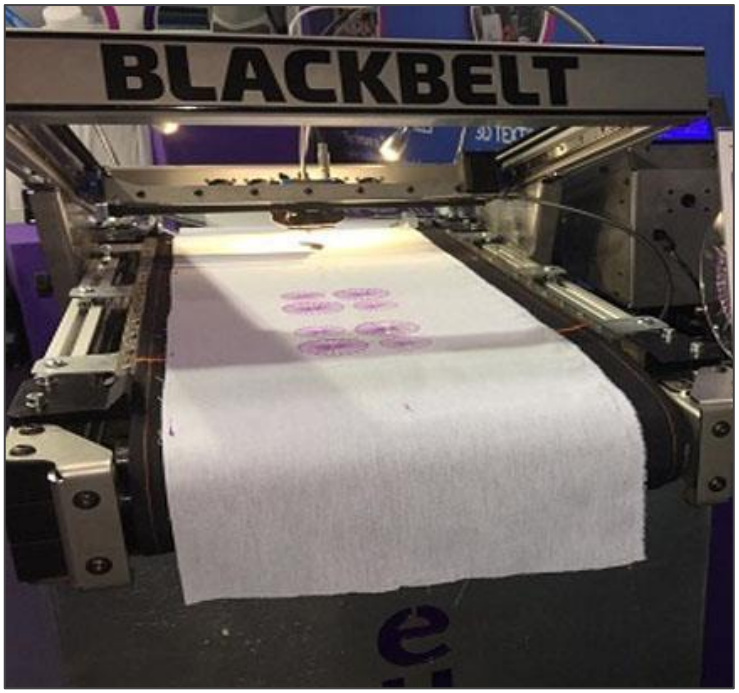
Cleanroom mask

Decorative 3D patterns



Upscaling possibilities with the Blackbelt 3D-printer

Smart3D project

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Collective Research Networking

"Realization of smart textile applications with high customer acceptance by use of 3D printing technologies"

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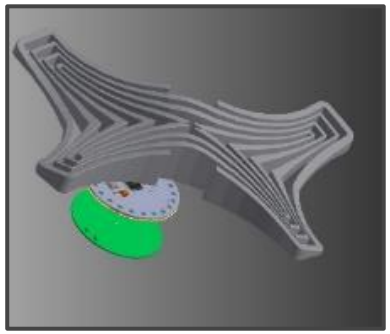
Conductive materials for 3D printing



Encapulsation via 3D printing

Encapsulation via low-pressure molding

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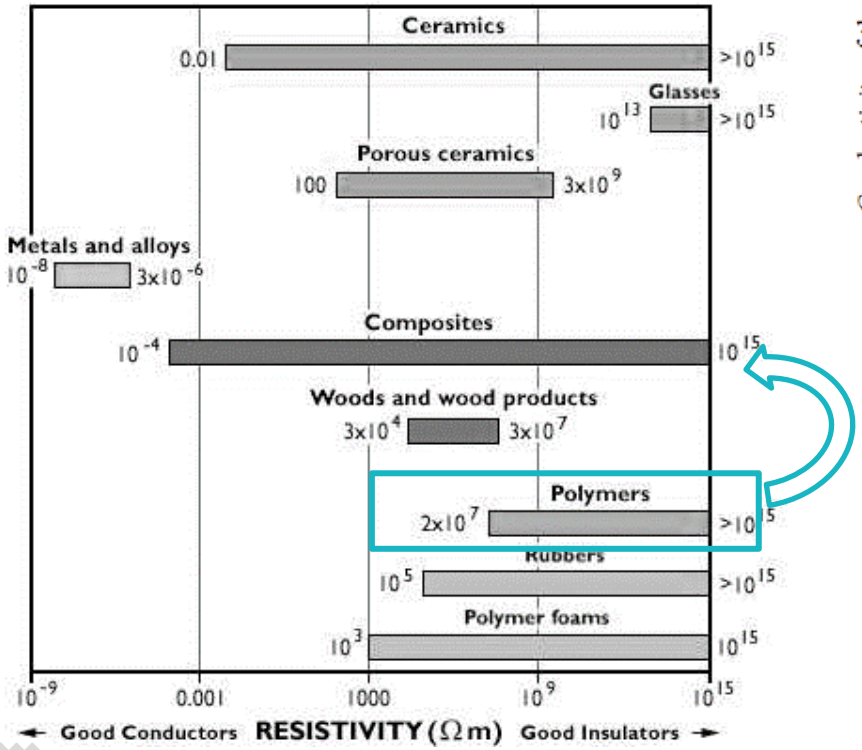
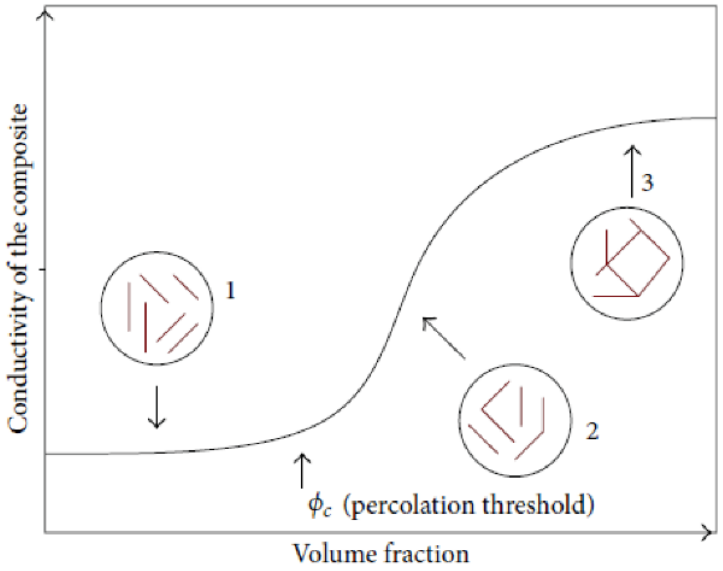
1) Conductive materials for 3D printing





- Carbon-based additives
- Metal-based particles
- *Doped metal oxides*
- *Special conductive polymers*

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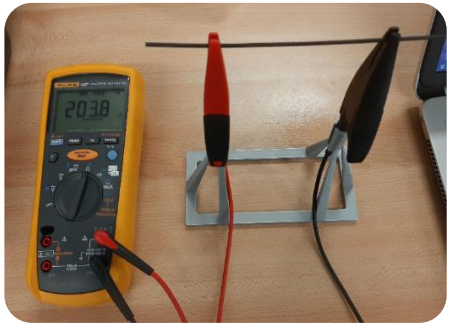
Lab-scale trials:
Mix TPU with additive

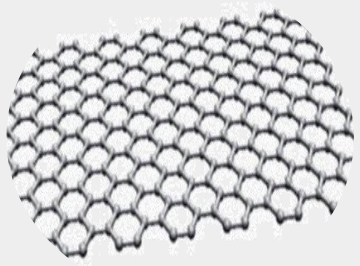
Measure the resistivity
Ohm.cm = $R*A/L$



Carbon black type

10 to 40% load
Off device limits

Graphene

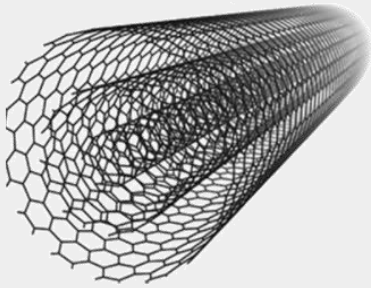


Still ongoing !

Coated stainless steel fiber Beki-Shield®

30 to 40% load
= 100 to 15 Ω.cm

Multiwall CNTs



8 to 17% load
= 3.5 to 0.5 Ω.cm

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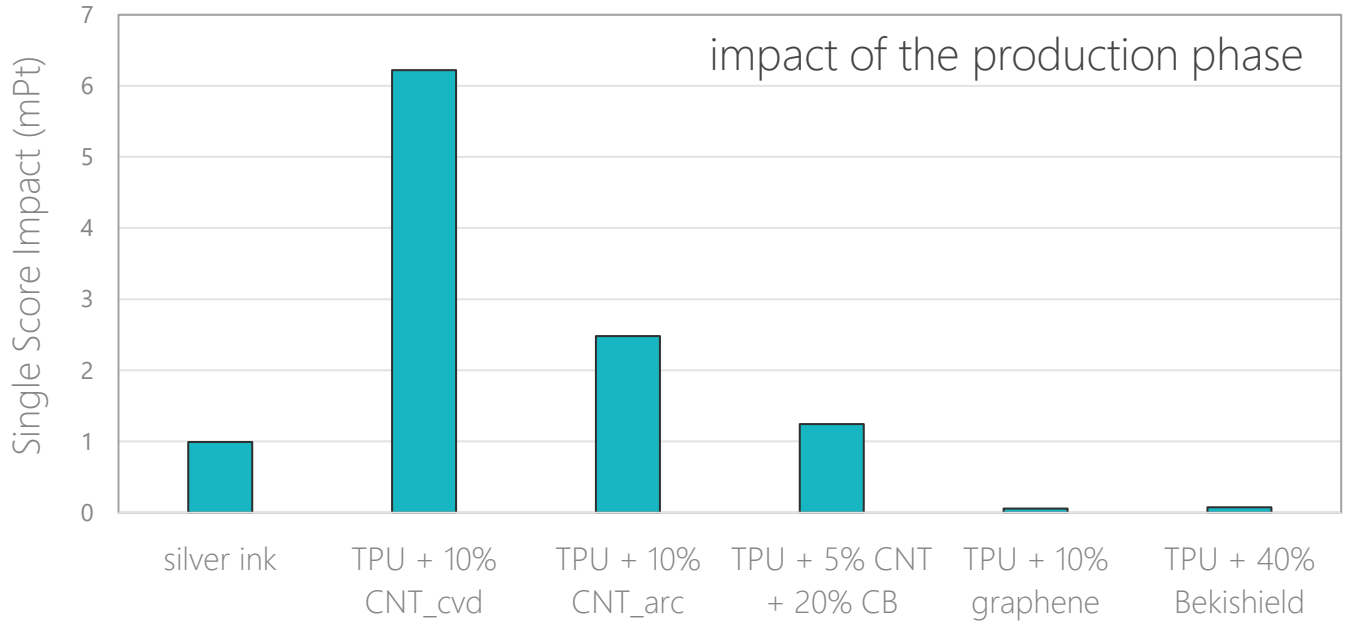
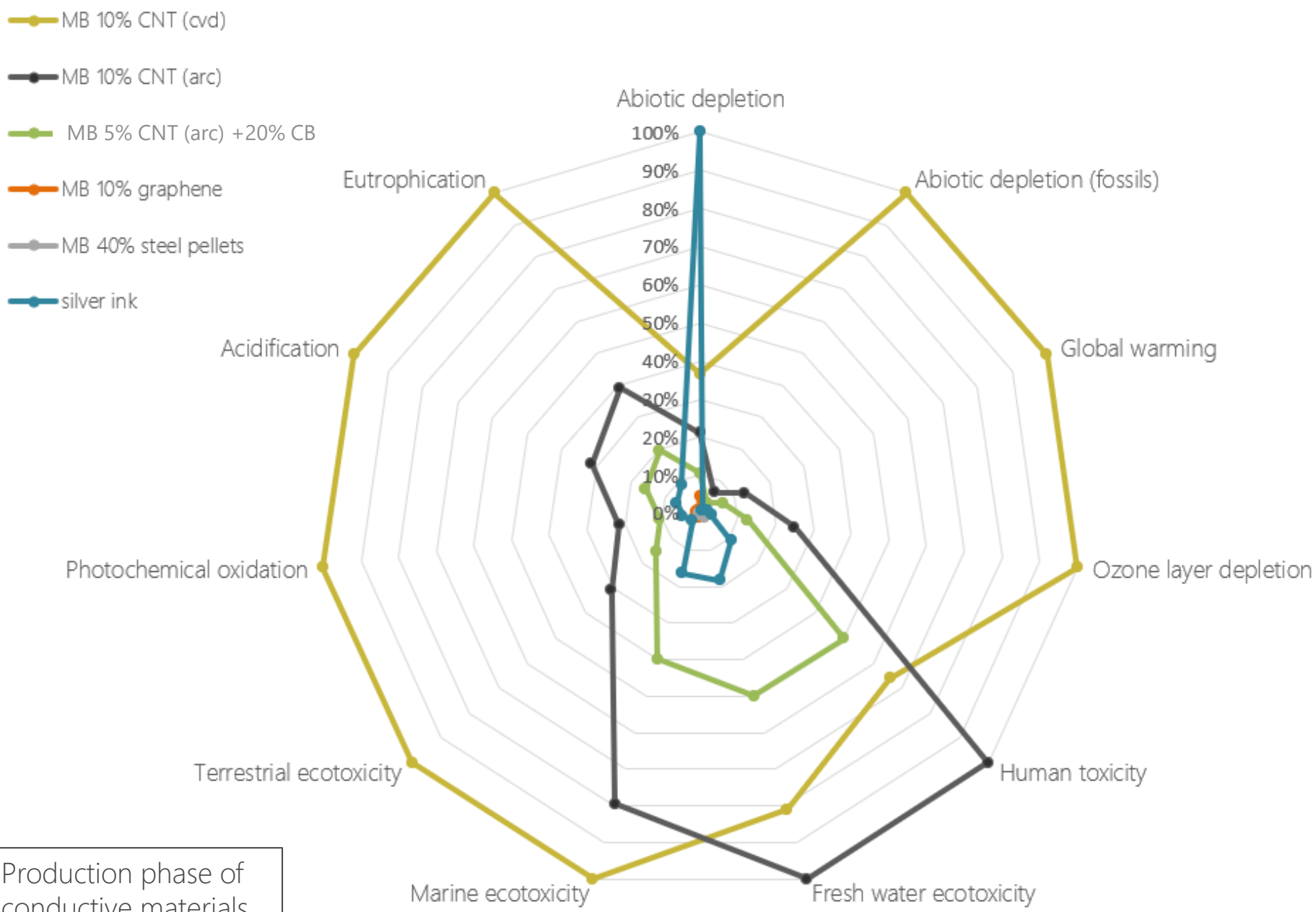
Balancing between:

- Processability
- Technical performance
- Economic cost (price)
- Environmental impact

CNT's	100 €/kg
Carbon Black	10 €/kg
Graphene	TBD
Bekishield	65 €/kg





Production phase of conductive materials

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	Technical performance	Economic cost (price)	Environmental Impact	Processability
CNT's	high	high	high	ok via MB
Carbon black (CB)	low	low	low	ok via MB
Graphene	....	....	low	....
Bekishield	medium	medium	low	difficult, ongoing
CNT + CB	increased ↑	reduced ↓	reduced ↓	ok, via MB
Bekishield + CB	increased ↑	reduced ↓	low	difficult, ongoing

Synergies to achieve improvement in different areas

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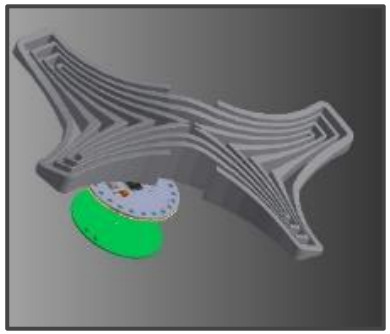

Encapulsation via 3D printing

Encapsulation via low-pressure molding

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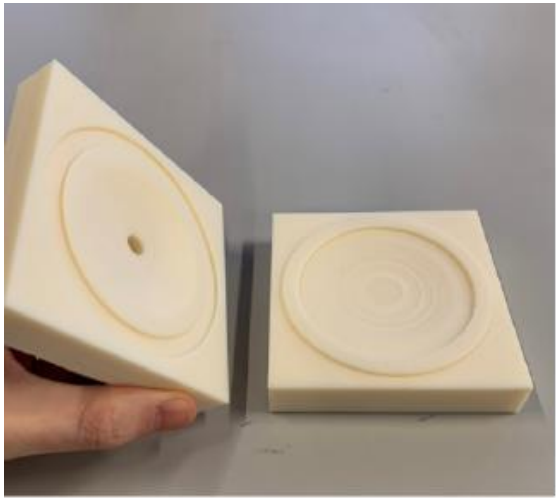
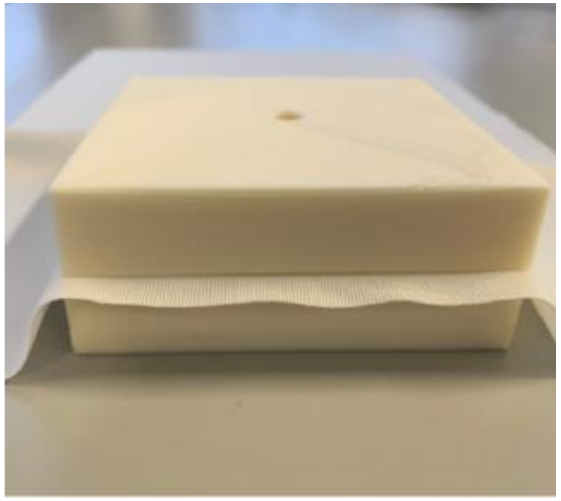
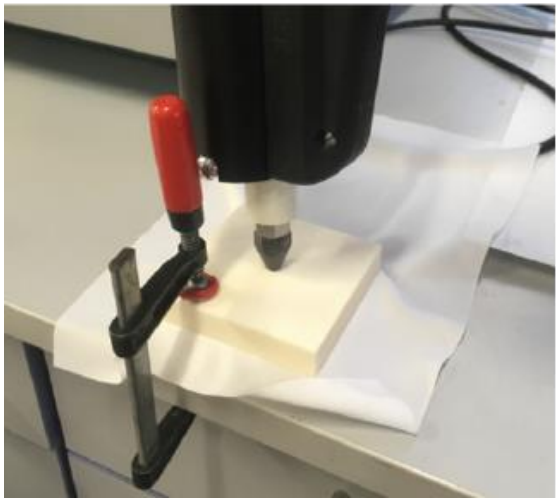
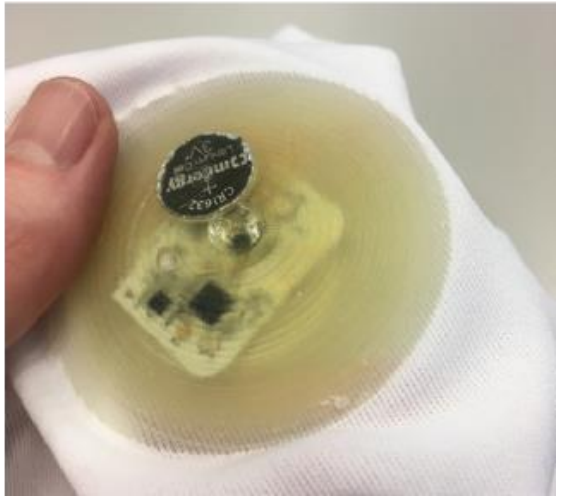
Smart3D project

Low pressure injection molding with 3D-printed molds





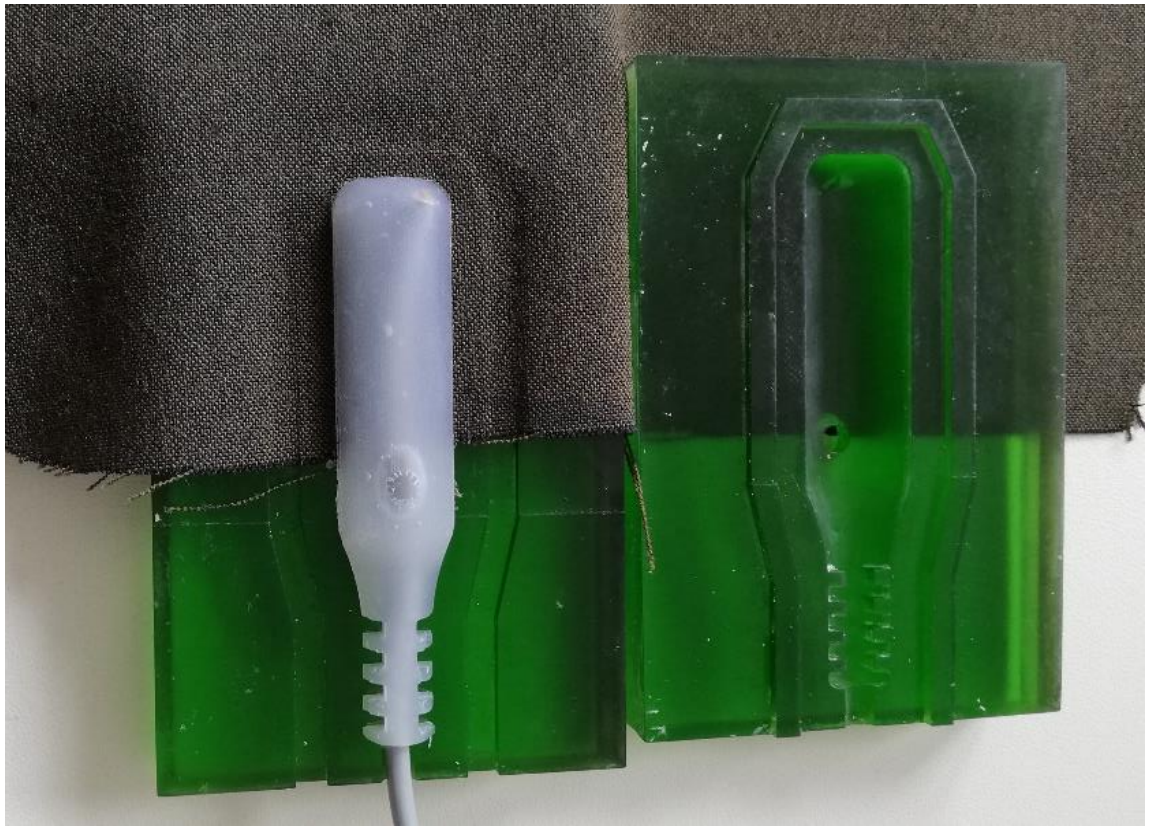




Smart3D project

Customised 3D-printed molds (e.g. from ABS): **cheap and recyclable**

Example of an application: Protection of cable connections in smart textiles



Smart3D project

Which materials for low pressure molding?

Material on picture: co-polyamid (Thermelt 817)

- Applicable at 180-200 °C
- High T is not suitable for batteries
- Quite stiff material

First tests with 2K polyurethanes ongoing

- Applicable at room T but long curing time (1 night)
- Much faster at 70° but catalysts needed
- Viscosity is not on point yet

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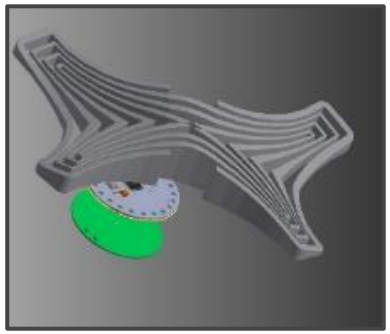
Forschungskuratorium textil

Conductive materials for 3D printing



Encapulsation via 3D printing

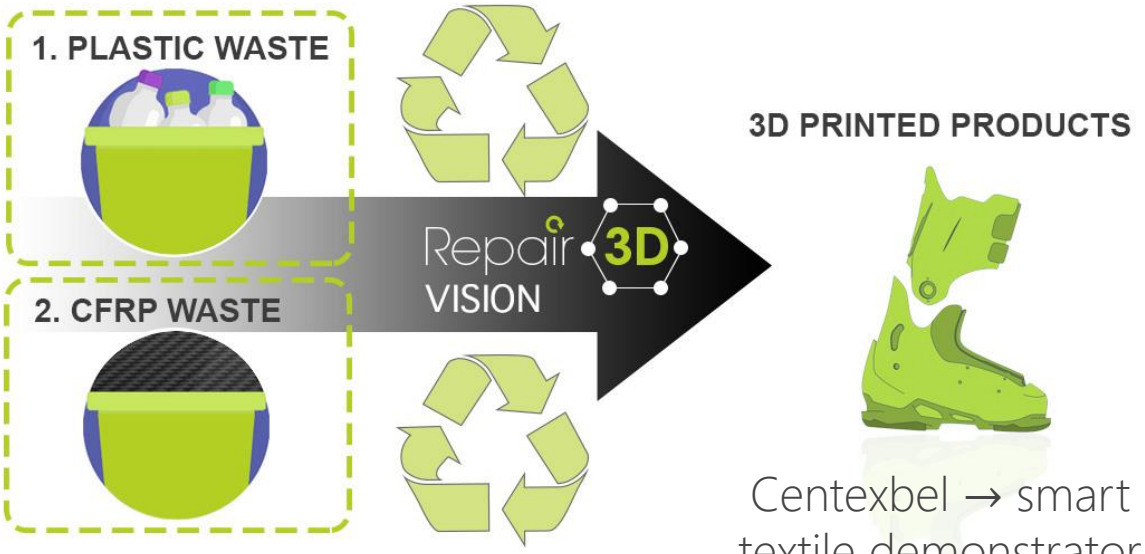
Encapsulation via low-pressure molding

CENTEXBEL

Jump to Repair3D project, with similar task

Repair 3D

"Recycling and repurposing of plastic waste for advanced 3D-printing applications"



Centexbel → smart textile demonstrator

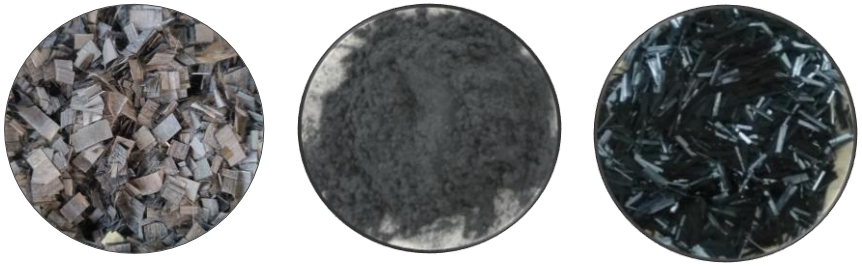
"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814588".

Repair 3D

Polymer + fibres = COMPOSITE

Post-industrial plastic waste

Post-industrial carbon fiber waste



Waste from prepregs, drilling, spools…

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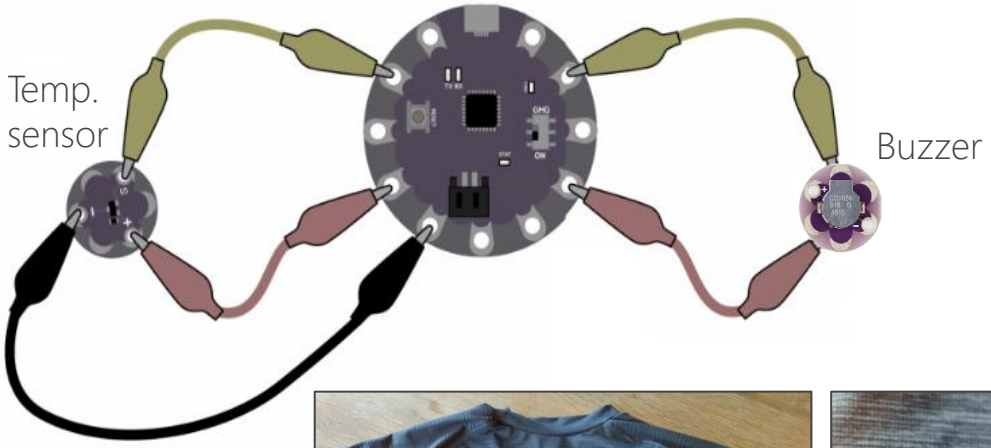
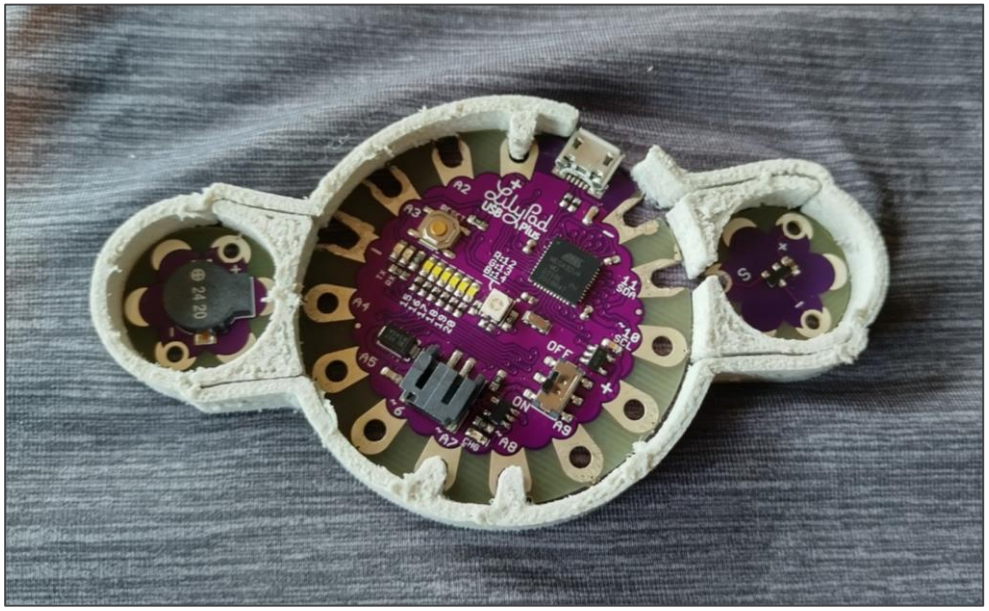
Repair 3D

Encapulsation via 3D printing

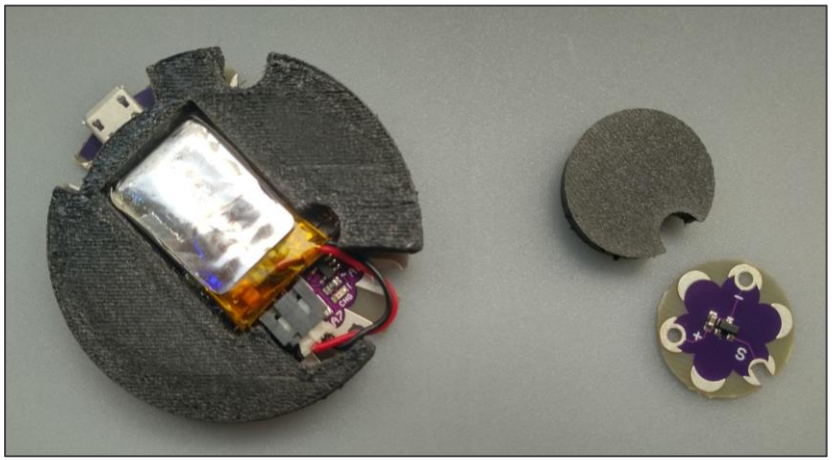
Printed Ciruit Board (PCB)





Repair 3D

Encapulsation via 3D printing



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Project websites:
https://smart3dproject.eu/
https://www.repair3d.net/