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The advancement of 3D-Printed Polymer Technologies in Aerospace

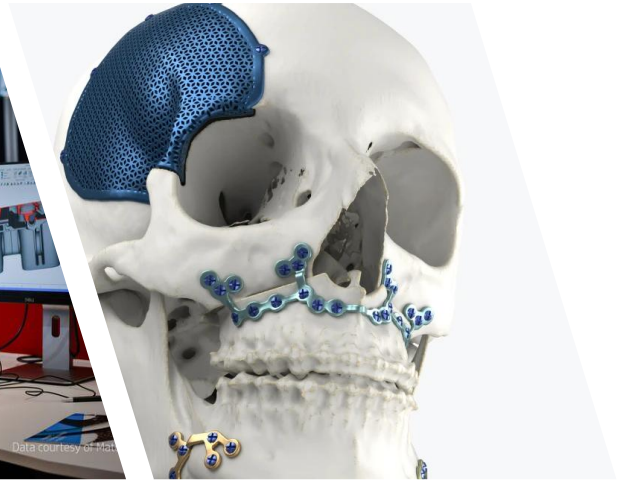
Erik de Zeeuw – May 2025

Agenda

- Context
- Relevant aspects
- From High to low TRL

Materialise at a glance

Materialise Mindware - Advisory services for business success with AM



Manufacturing

Europe's Largest & Most complete Factory for 3D Printing

Software

Leading software to manage & control the entire AM process

Medical

Services that revolutionize patient-specific treatment

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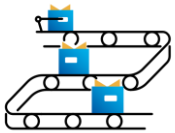
Leading Aero Experience

+500k
Flying parts produced

+4k
Part series per year across diverse aero customers



+20K
In our longest running series of recurring parts

26K
Parts produced per year for the Airbus A350 ecosystem

bsi AS/EN 9100 Aviation Space and Defence CERTIFIED

EASA Part 21G

AIRBUS

Context

Am uptake

Tooling

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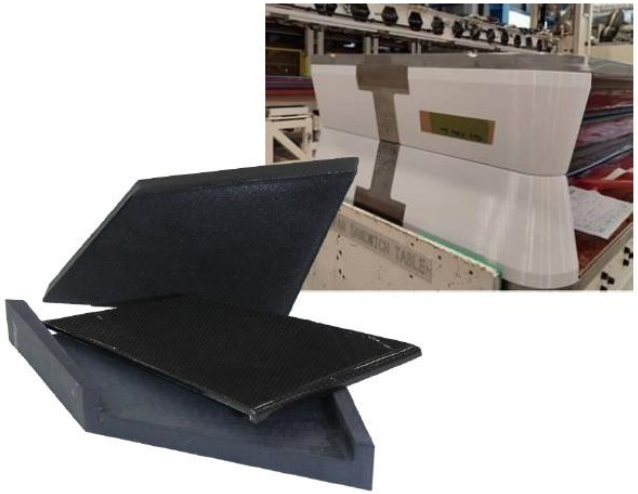
GSE

Autoclave tooling

Roboze



LEONARDO
AEROSTRUCTURES

Context

Am uptake

"AM for space is not rocket science"

Atos titanium Satellite inserts

Applied AM drivers in Aviation

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AM could bring added value to new developments

Complexity

Additive Manufacturing can bring solutions to design challenges that currently occur with tradition technologies.

Lightweight

Creating lightweight components is one of the key drivers of using AM in airospace industry.

Improvements

Due to the design freedom of AM, components can be improved as functionalities are put upfront rather then the producibility .

Personalization

Personalization or customization is often connected to small series. Due to the nature of AM, this becomes economical feasible.

AM could bring a solution on supply chain level

Stock Reduction

Components that aren't ordered frequently but are of strategic importance to have in the portfolio. Reduce high warehousing costs.

Delivery times

Parts that face high delivery times can cause high impact on the supply chain with potential penalty fees as a result.

On demand

Traditional supply chain rely on batch production where AM creates opportunities to order on demand.

Digital supply chain

Due to the digital nature, digital supply chains can be setup to empower decentralized production.

Superhero vs unsung hero applicatios

AM for Aviation : the guidance

EASA
European Union Aviation Safety Agency

EASA CM No.: CM-S-008 Issue 03

Certification Memorandum

Additive Manufacturing

EASA CM No.: CM–S-008 Issue 03 issued 30 April 2021

The Important aspects

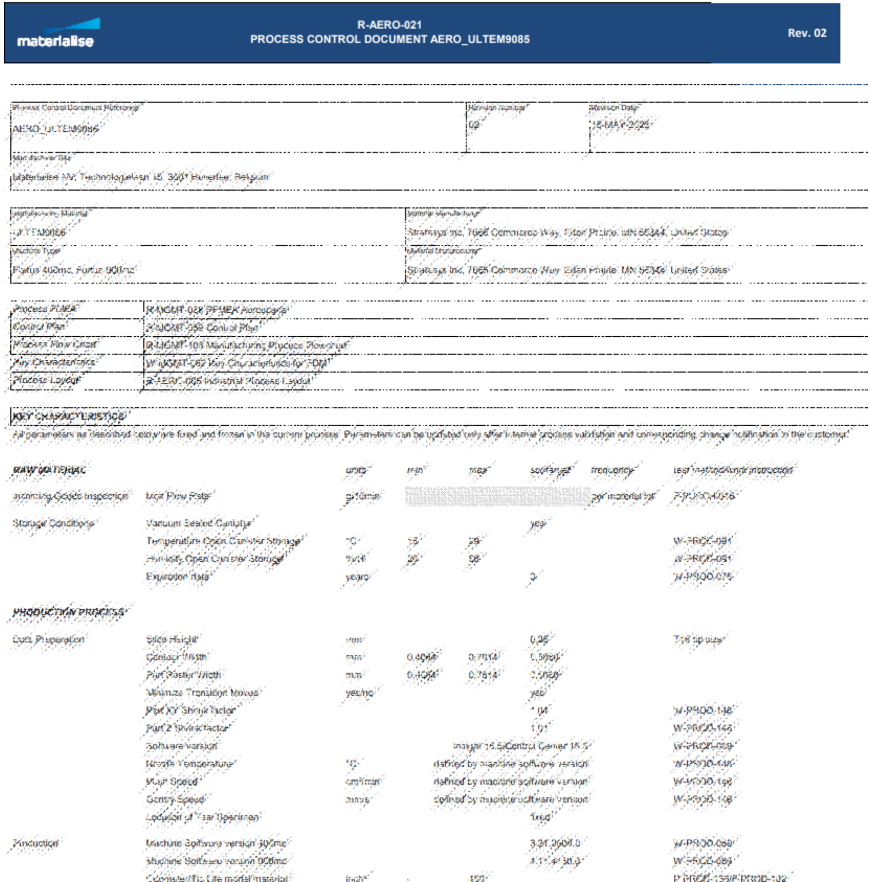
- Proces control requirement
- Material qualification : flammability
- Other substantation aspects : Real performance data
- Applications

Process control requirement

- “Process intensive technologies” :

  properties defined while you are printing

→ Process control required, regardless of criticality



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R-AERO-021

PROCESS CONTROL DOCUMENT AERO_ULTEM9085

Rev. 02

Process Control Document Reference: AERO_ULTEM9085	Revision Number: 02	Revision Date: 15-MAY-2023
Manufacturer Site: Materialise NV, Technologielaan 15, 3001 Heverlee, Belgium		

Manufacturing Material: ULTEM9085	Material Manufacturer: Stratasys Inc, 7665 Commerce Way, Eden Prairie, MN 55344, United States
Machine Type: Fortus 400mc, Fortus 900mc	Material Distributor: Stratasys Inc, 7665 Commerce Way, Eden Prairie, MN 55344, United States

Process PFMEA	R-MGMT-028 PFMEA Aerospace
Control Plan	R-MGMT-058 Control Plan
Process Flow Chart	R-MGMT-103 Manufacturing Process Flowchart
Key Characteristics	W-MGMT-082 Key Characteristics for FDM
Process Layout	R-AERO-005 Industrial Process Layout

KEY CHARACTERISTICS

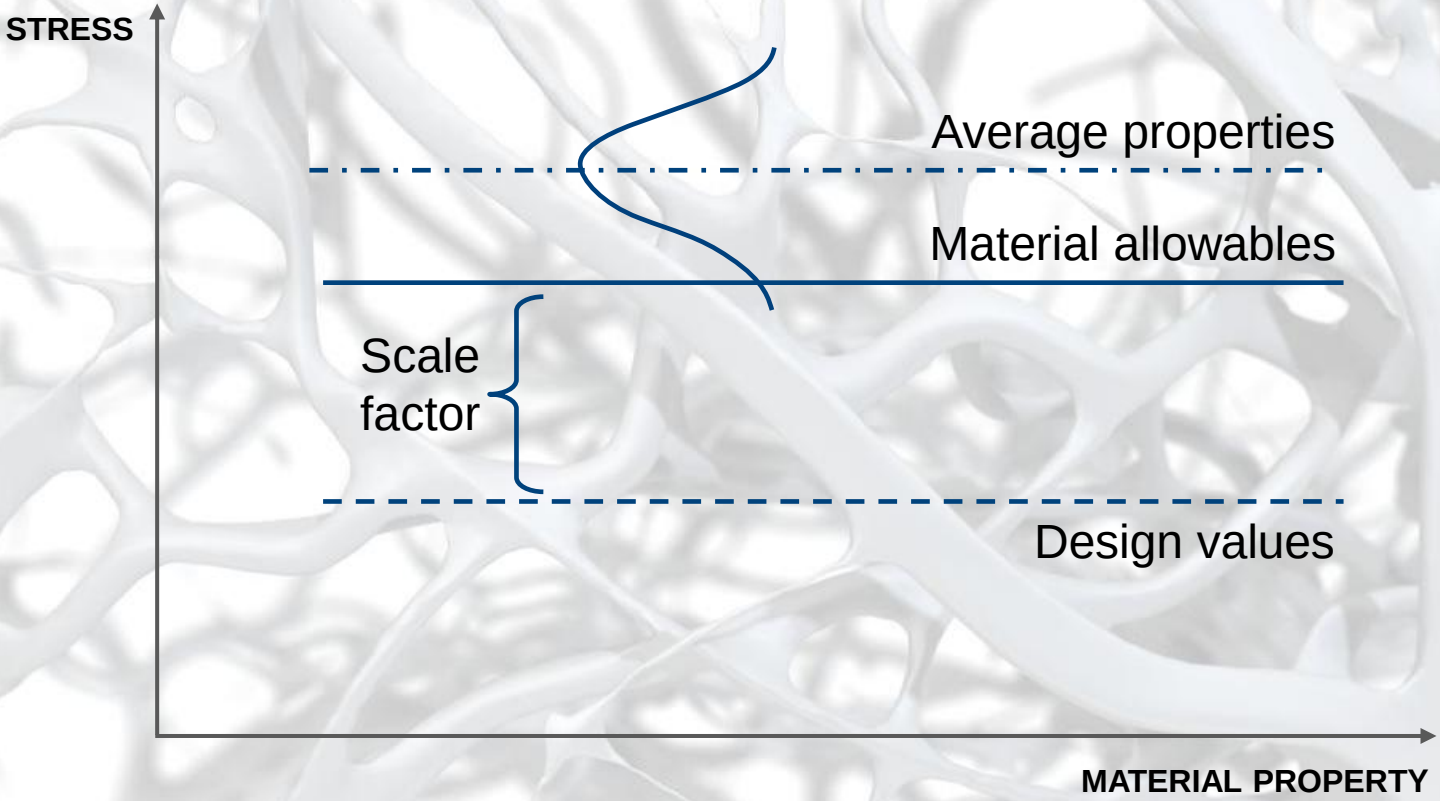
All parameters as described below are fixed and frozen in the current process. Parameters can be updated only after internal process validation and corresponding change notification to the customer.

RAW MATERIAL		units	min	max	sp/target	frequency	test method/work instruction
Incoming Goods Inspection	Melt Flow Rate	g/10min				per material lot	F-PURCH-016
Storage Conditions	Vacuum Sealed Canister				yes		
	Temperature Open Canister Storage	°C	15	28			W-PROD-091
	Humidity Open Canister Storage	%rH	20	58			W-PROD-091
	Expiration date	years			3		W-PROD-075

PRODUCTION PROCESS		units	min	max	sp/target	frequency	test method/work instruction
Data Preparation	Slice Height	mm			0.25		T16 tip size
	Contour Width	mm	0.4064	0.7814	0.5080		
	Part Raster Width	mm	0.4064	0.7814	0.5080		
	Minimize Transition Moves	yes/no			yes		
	Part XY Shrink factor				1.01		W-PROD-148
	Part Z Shrink factor				1.01		W-PROD-148
	Software version		Insight 15.5/Control Center 15.5				W-PROD-089
	Nozzle Temperature	°C	defined by machine software version				W-PROD-148
	Plot Speed	cm³/min	defined by machine software version				W-PROD-198
	Gantry Speed	mm/s	defined by machine software version				W-PROD-198
	Location of Test Specimen				fixed		
Production	Machine Software version 400mc				3.31.2607.0		W-PROD-089
	Machine Software version 900mc				4.11.4130.0		W-PROD-089
	Canister/Tip Life model material	inch³		150			P-PROD-136/P-PROD-132

Flammability

Source : Adam Savage's Tested



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The usual suspects

Fused Deposit Modeling
FDM

Ultem 9085
Ultem 9085CG

Strong, lightweight and flame retardant

Superior mechanical performance and strength-to-weight ratio

UL 94 V-0, FAR 25.853

Airbus-certified grade (Ultem 9085CG), according to **AIPI 03-02-029**

Airbus cabin interior finish according to **AIPI 05-02-006**

Support structures needed

Smoothing, painting, and coating

914 x 610 x 914 mm

Selective Laser Sintering
SLS
PA

PA 2241 FR

Flame-retardant

High long-term stability

Good chemical resistance

CS/FAR 25.853

Airbus-certified grade, according to AIPI 03-07-022

No support structures needed

Smoothing, color dyeing, and coating

630 x 330 x 560 mm

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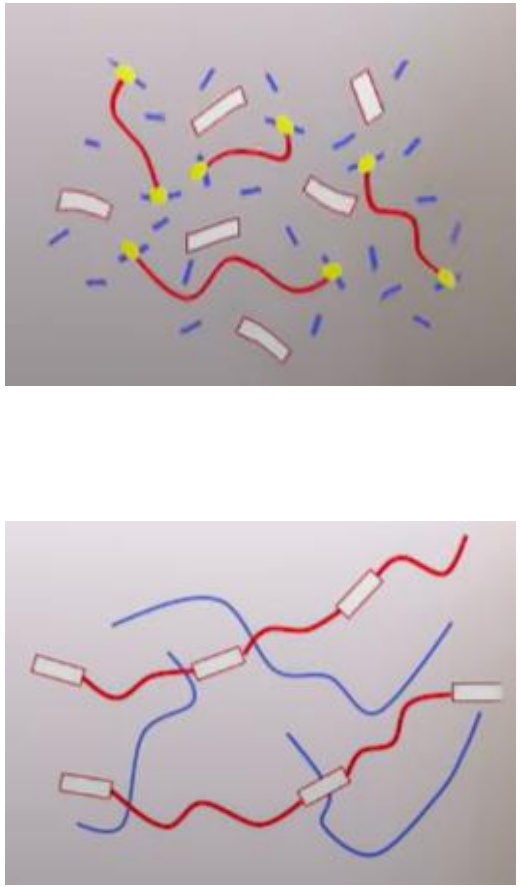
Ultem PAfr

Photopolymers : overcoming limitations

- UV cured
- Thermal stability
- Limited properties

- The solution : add thermal monomers
- => printed part is the green state
- Postcuring opens wide range of properties



Images : Adam Savage's Tested

Photopolymer

Ultem PAfr

Moving up the performance pyramid

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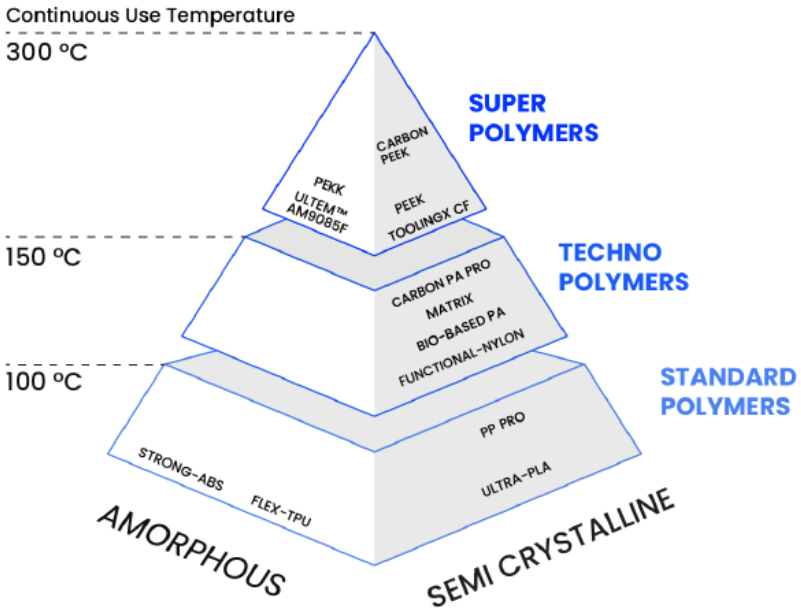

Many options – little penetration

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HT-23

The HT-23 is based on a PEKK resin with 23% Carbon Fiber compounded in and ground to a fine powder.

VIDEO

Introducing a new 3DP performance polymer

Watch our video and explore the benefits of VICTREX AM 200 PAEK filament.

Moving up the performance pyramid

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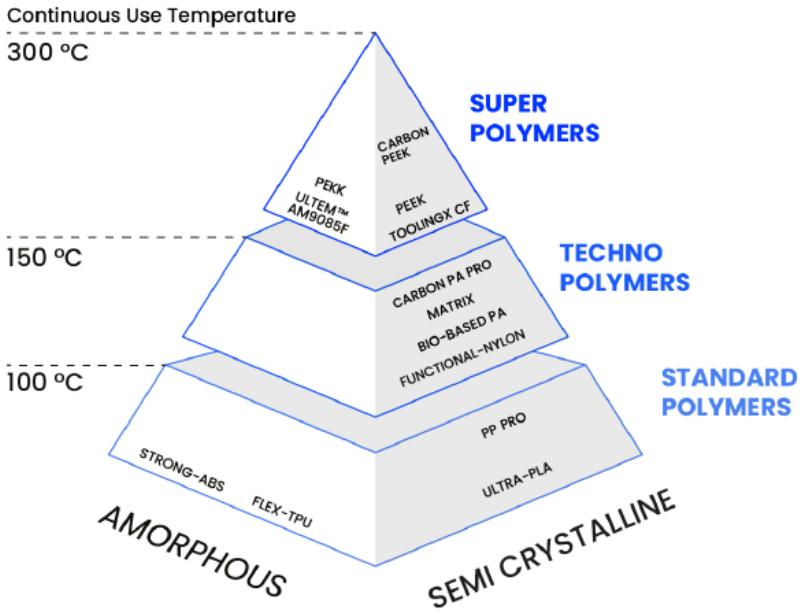

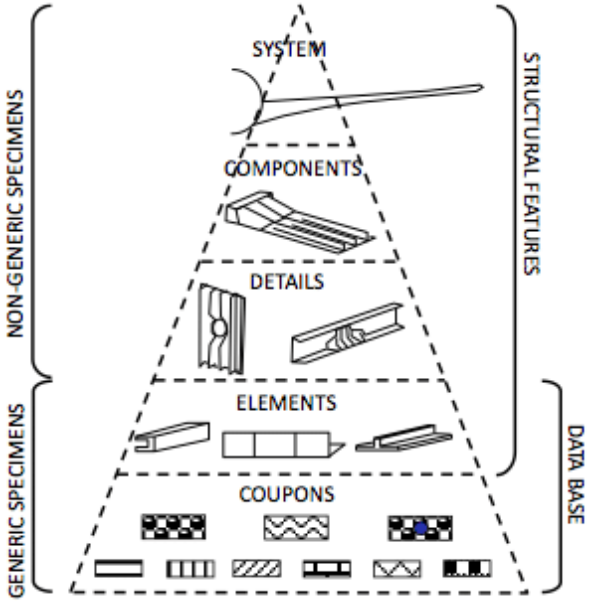

Standardistation efforts Niar institute – CMH 17

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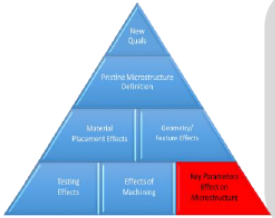
P-U9085 ULTEM 9085 Follow-On Activities



- Leverage completed ULTEM 9085 qualification for additional research studies to facilitate the understanding and application of ULTEM.
- Complete statistical analysis on equivalency studies.
- Provide guidelines on best practices on developing material specifications for extrusion.
- Develop standards that document best practices on testing material extrusion specimens.

P-MONYX Markforged Qualification

Markforged

P-AN8X0 Antero 800 & 840 Qualifications

stratasys

P-HPEKK HexPEKK Qualification

- To develop a framework for the qualification of PBAM (LPBF) materials including guidelines and recommendations for their characterization, testing, design, and utilization using the NCAMP process.
- Transition of the test data and guidelines generated into shared databases such as Composite Materials Handbook-17 (CMH-17).

- Enhance the framework for the qualification of PBAM (FDM) materials including guidelines and recommendations for their characterization, testing, design, and utilization using the NCAMP process.
- Transition of the test data and guidelines generated into shared databases such as Composite Materials Handbook-17 (CMH-17).

HEXCEL

Source : NIAR Wichita State University

High performance material

Photopolymer

Ultem PAfr

ARBURG

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- open
- tunable
- Process control ready

REINFORCE 3D

Arburg freeformer

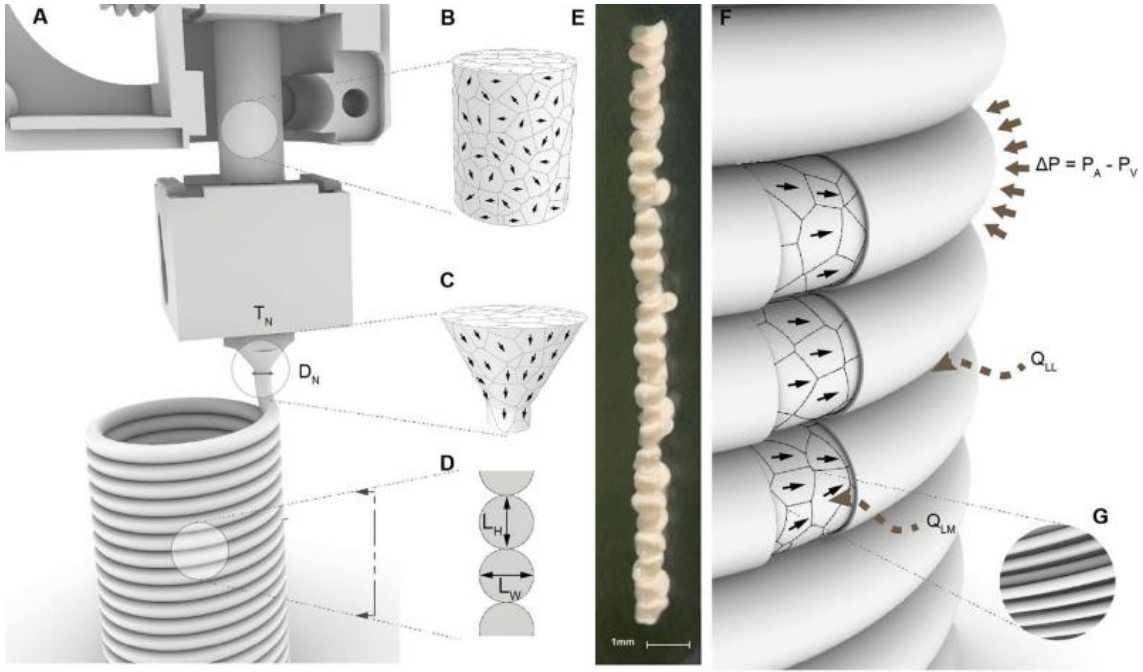
High performance material

Ultem PAfr

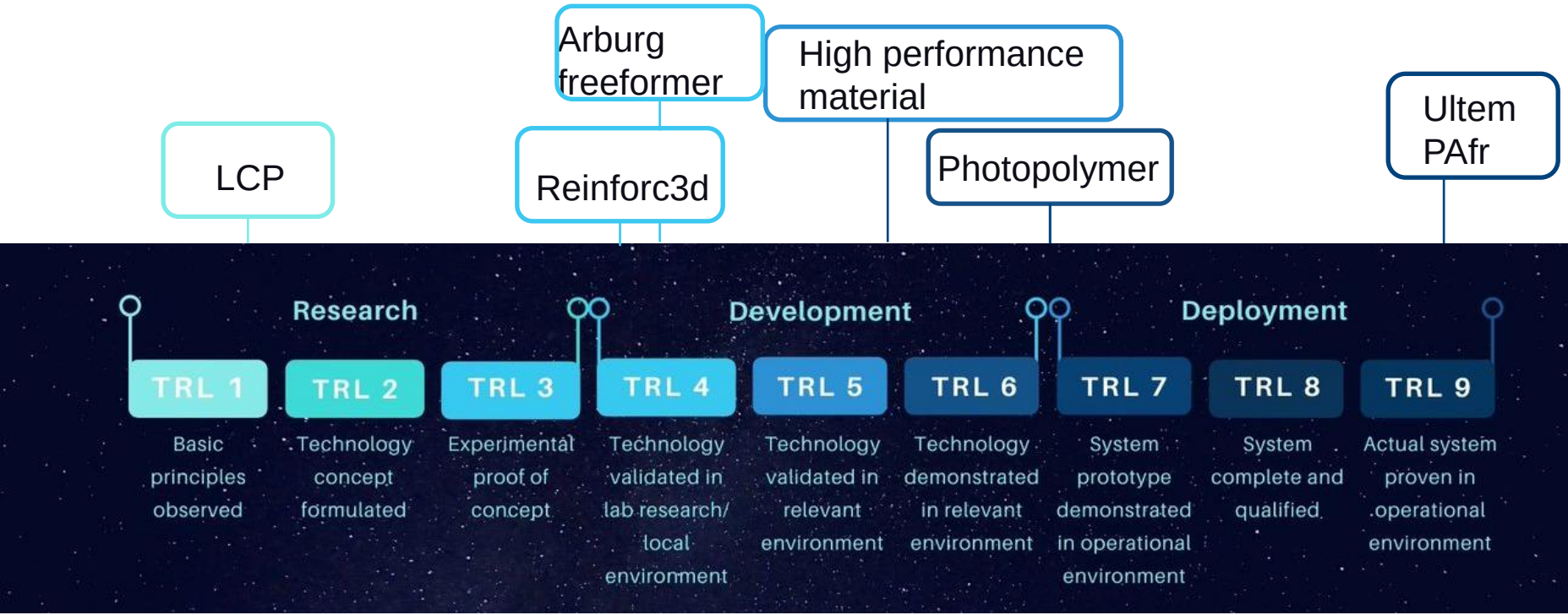
Photopolymer

Reinforc3d

A low TRL example : liquid crystal FFF



- Advanced polymer
- Highly ordered structure
  - mechanical strength
  - temperature resistance
  - flame resistance
- Orientation of polymers can be tuned


Arburg freeformer
High performance material
Ultem PAfr
LCP
Reinforc3d
Photopolymer
Research
Development
Deployment
TRL 1
TRL 2
TRL 3
TRL 4
TRL 5
TRL 6
TRL 7
TRL 8
TRL 9
Basic principles observed
Technology concept formulated
Experimental proof of concept
Technology validated in lab research/ local environment
Technology validated in relevant environment
Technology demonstrated in relevant environment
System prototype demonstrated in operational environment
System complete and qualified
Actual system proven in operational environment

Summary

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- Ultem and PA remain dominant, increasing supply options
- Photopolymers enter the field
- Peak variants have a though breakthrough
- Plenty of development still


Questions ?