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CUBIC – Open Training Session, 25<sup>th</sup> March 2026

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# Advancements in polylactide in foam extrusion and particle foaming for enhanced applications

# Fraunhofer-Gesellschaft

## At a Glance

Applied research organization prioritizing key future-relevant technologies and commercializing its findings in business and industry. A trailblazer and trendsetter in innovative developments and research excellence.



30 000 staff



76 institutes and research units

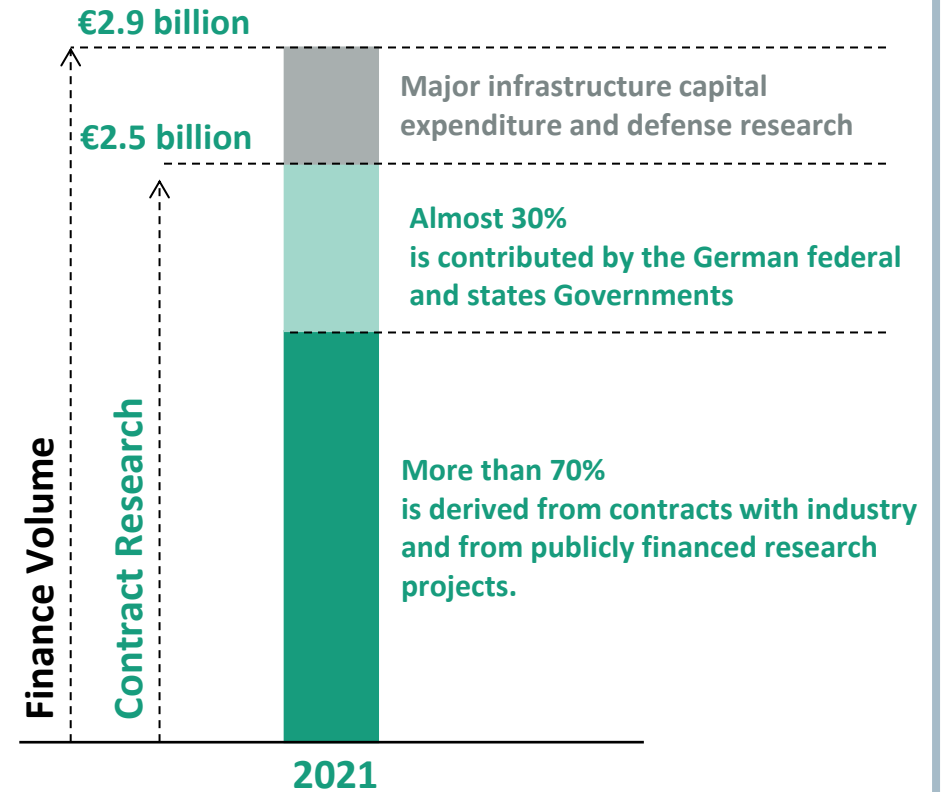


Foto by [Demian Tejeda-Benitez](#)



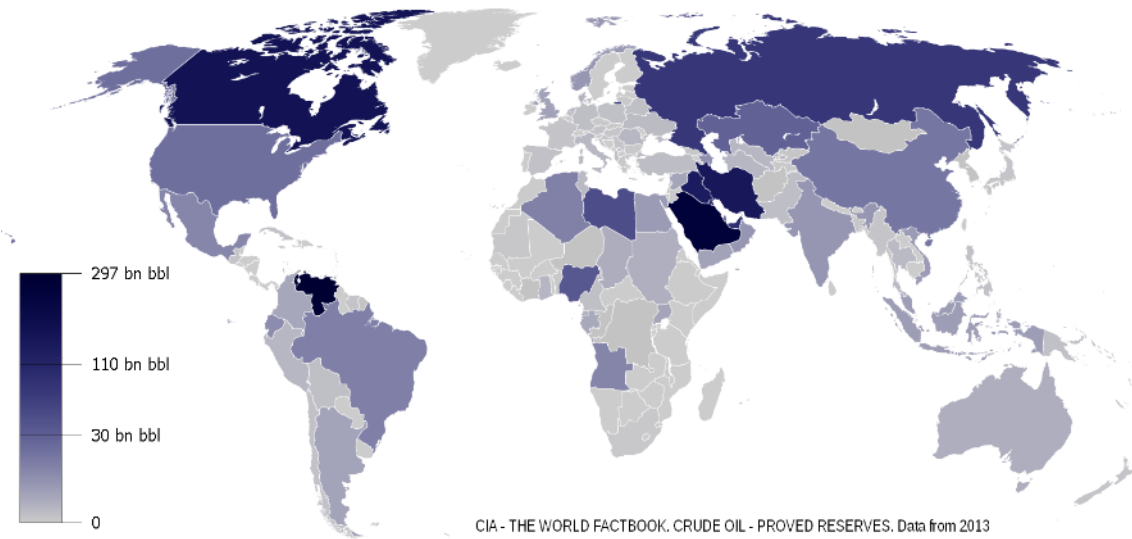
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# Why a plantbased bead foam?

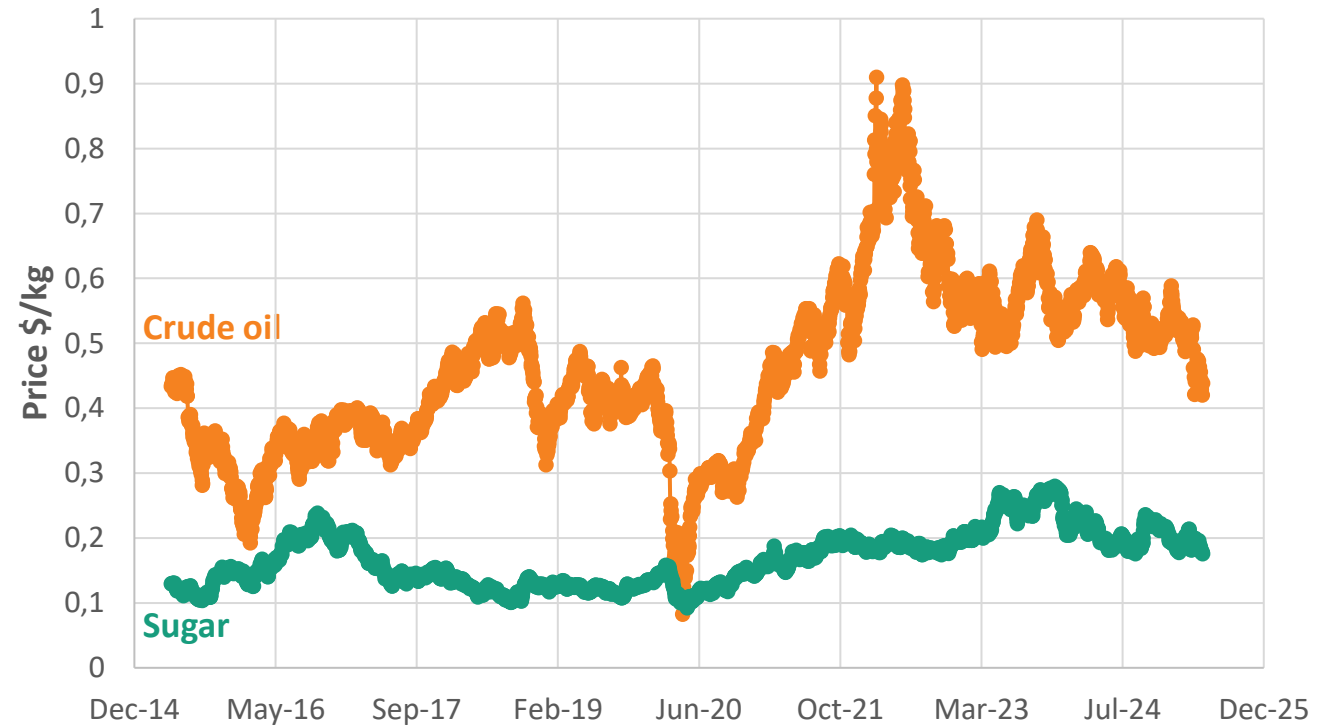
# Motivation – Why?

## Independence from fossil resources

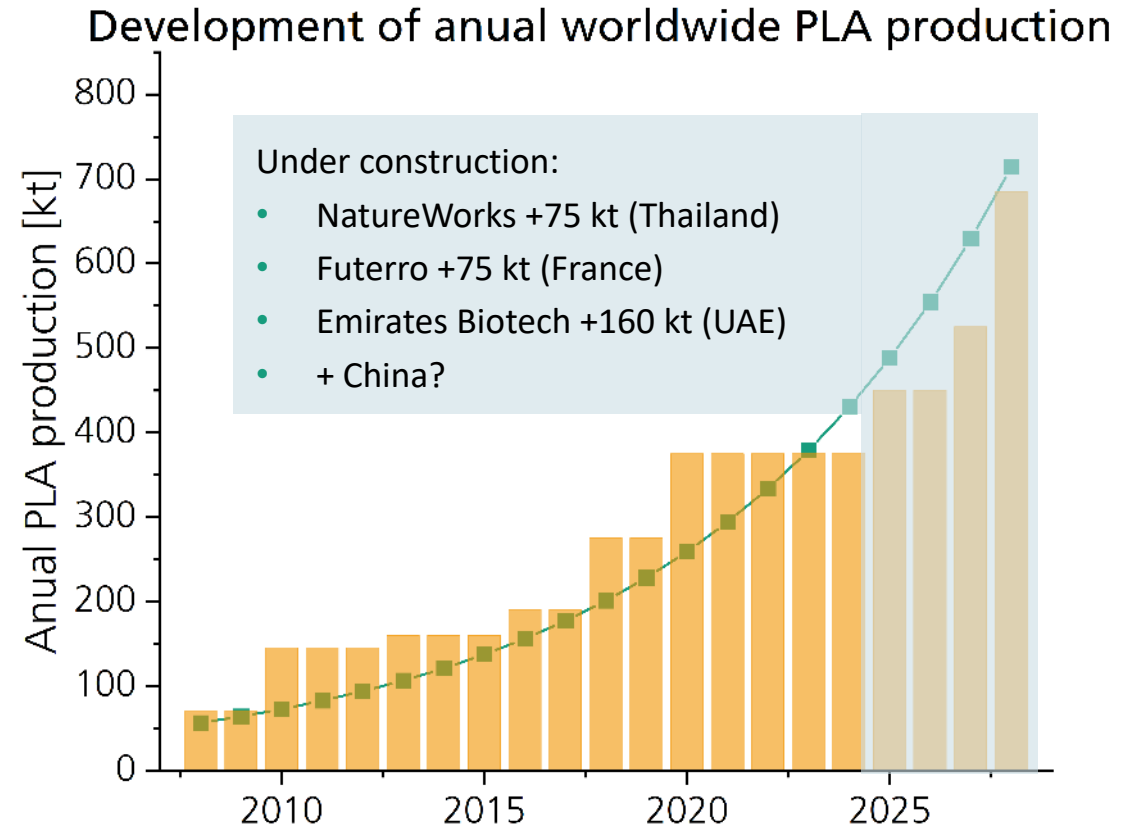
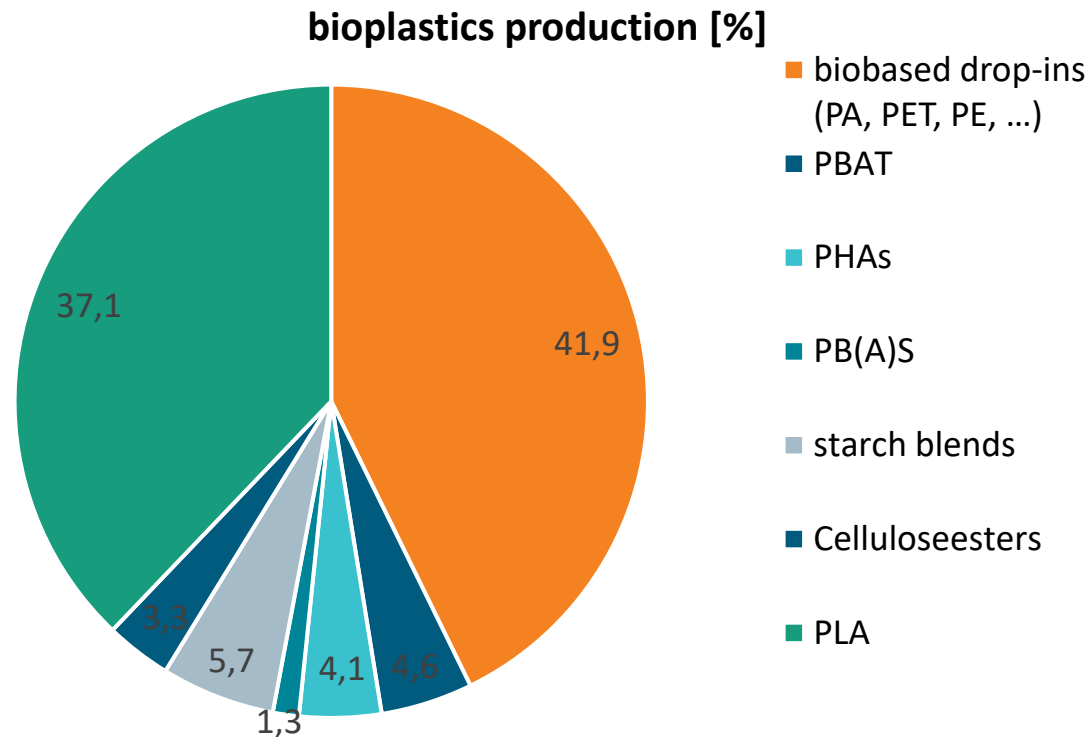


## Robustness

### Crude oil and sugar prices of the past 10 years



# Industrial significance of PLA



# Sustainability – the social dimension

## The Generations of PLA – eliminating the competition to food

### 1. Sugars

- Current industrial standard
- TRL 9



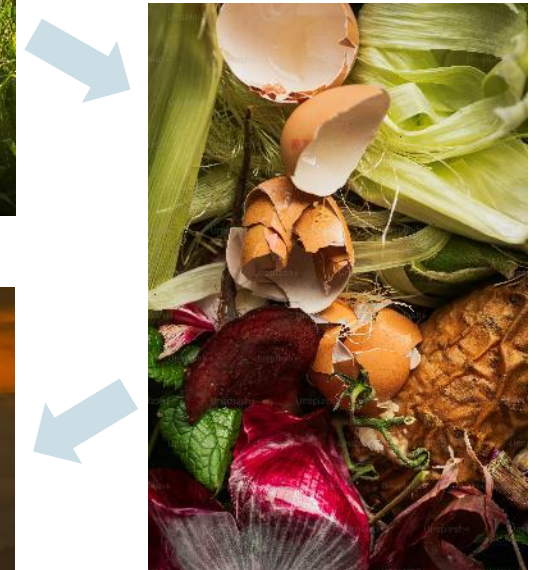
### 2. Waste stream

- Currently under development/upscaling
- TRL 6
- → technically feasible!



### 3. PLA from CO<sub>2</sub>

- lab scale development running
- TRL 2-3



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## EPLA: development of a biobased drop-in material



# 2017: BioFLIP

## Bio Foam Light Pallet

**Goal:** Development of a lightweight and sustainable pallet made from EPLA for use in transportation and storage logistics.

**Advantages:** Reusable, easy to clean, contributes to reduced transport costs and improved ecological footprint.

→ biobased

→ recyclable (monomaterial)

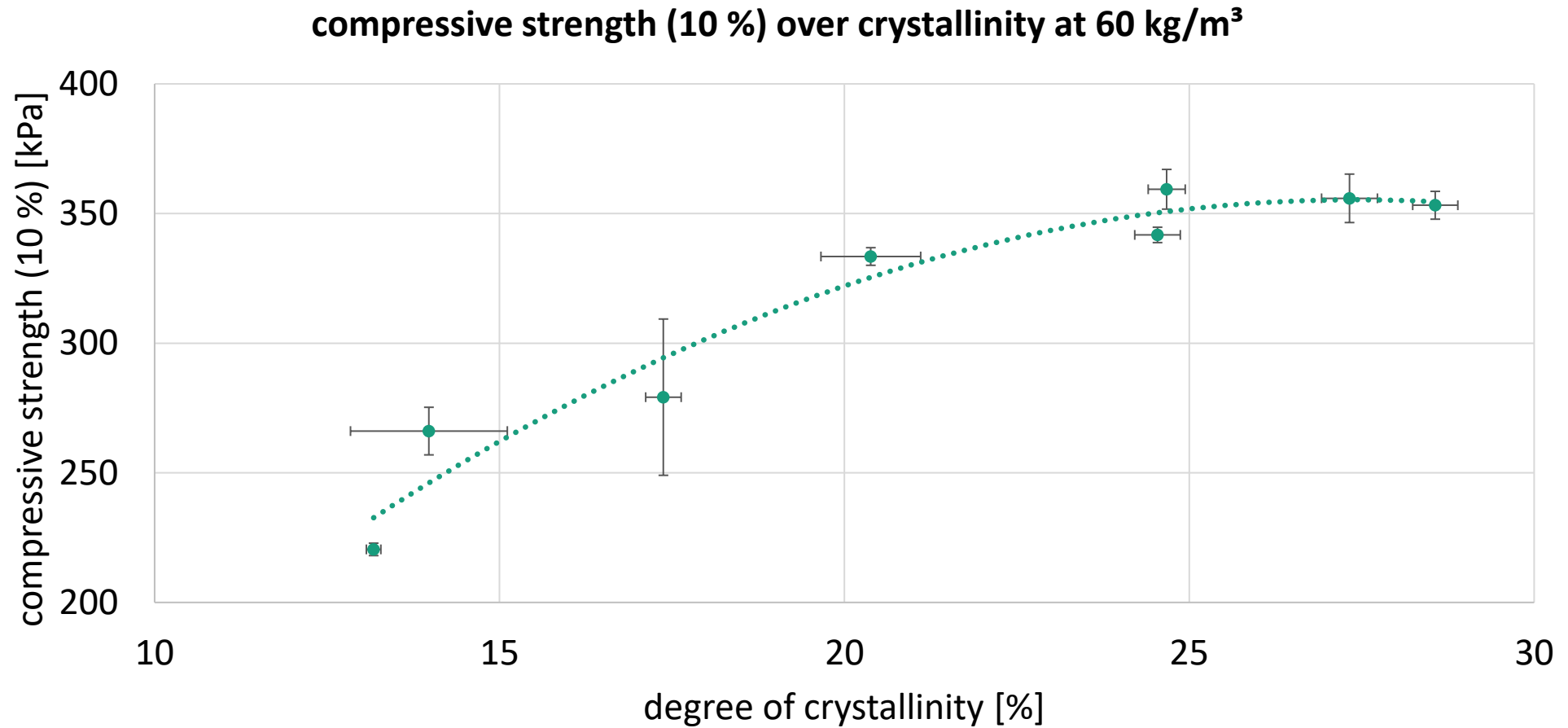
→ Showcase the drop-in solution (pre-foaming, EPS tools)

→ Inefficient processes



# Influence of crystallinity

## Tailoring crystallisation to improve mechanics



# Flame retardancy

## Intrinsic class E



Class E without flame retardant (5 cm and 33 kg/m<sup>3</sup>)

### Small burner test

- EPLA reaches European class E without added flame retardants
  - Minimum requirement for building and construction approval
- EPS needs halogenated FRs to reach the same class

# 2019: BioPCM & InnPressMe

## Biobased cooling boxes from EPLA

### BioPCM

**Goal:** To combine the thermal insulation of foams, the moisture-regulating properties of clay, and the heat storage and temperature-regulating abilities of natural phase change materials (PCMs) into one integrated system.

**Features:** High heat/cold storage capacity, passive temperature regulation, energy savings, lightweight and durable construction, reuse capability, and functional, easy-to-integrate design.

### InnPressMe

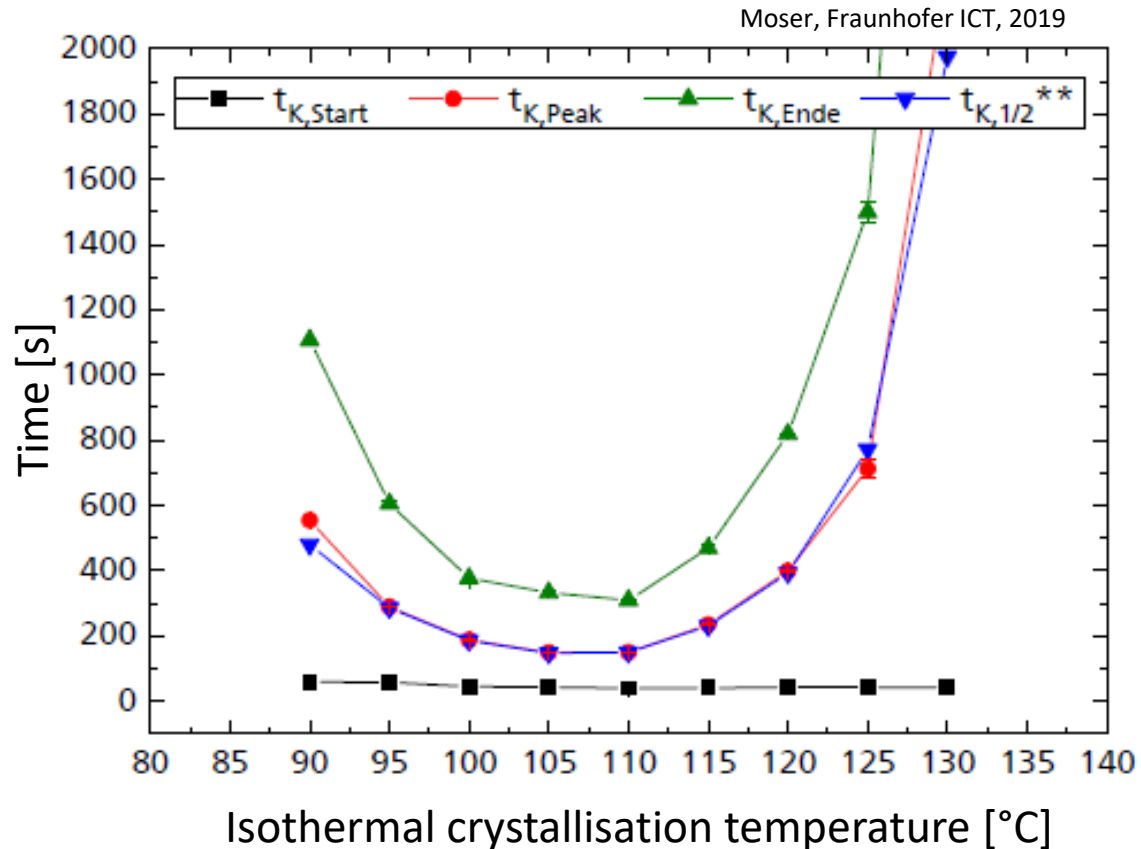
**Goal:** Upgrade bead foaming line for special purposes of biofoams with sensors, dryers and a database system (Schloms). Improve properties of EPLA.

→ Improve material formulation and process efficiency



klöckner pentaplast

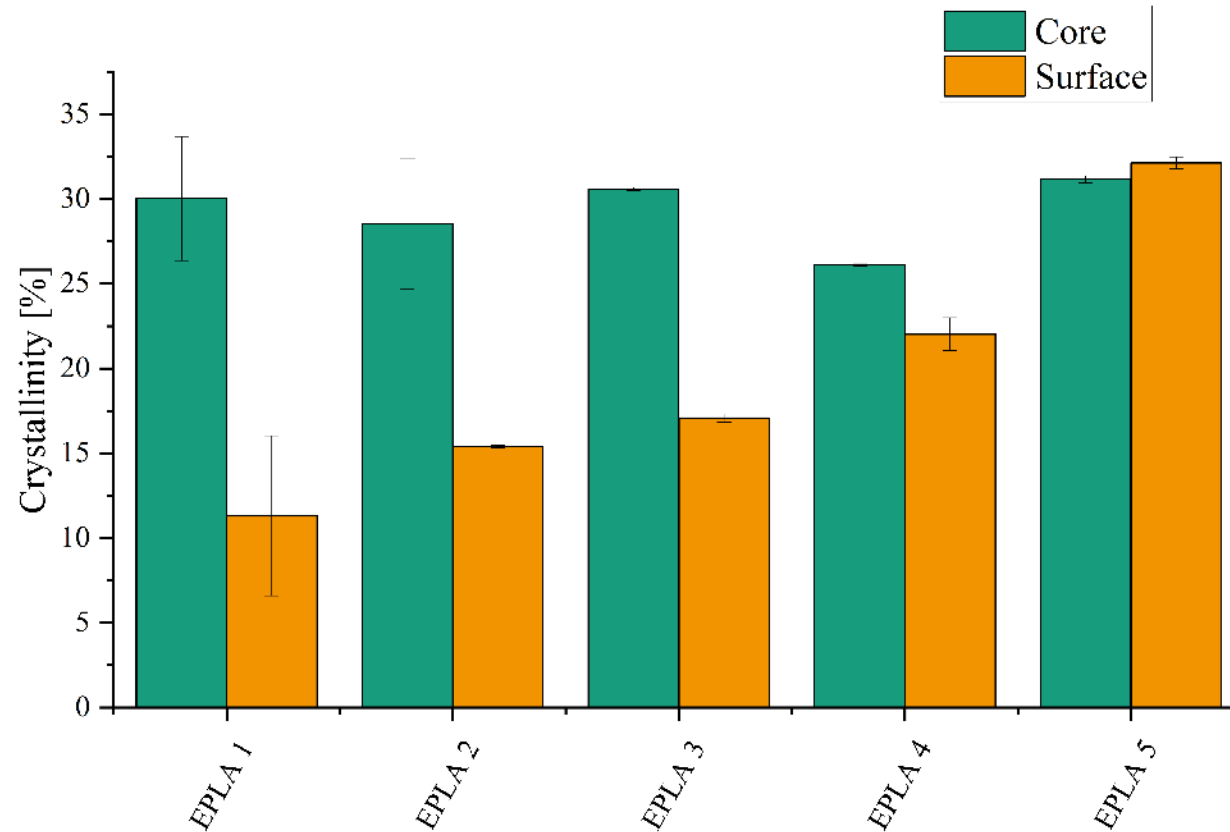
# PLA crystallisation optimisation



## Crystallisation halftime

- PLA + talc needs at least 300 s (= 5 min) to crystallise completely
  - Typical cycle time for EPS = 60 s
  - Fully crystallised PLA is not efficient, but full potential of mechanical properties is desired
- Conflict of goals

# Crystallisation optimisation



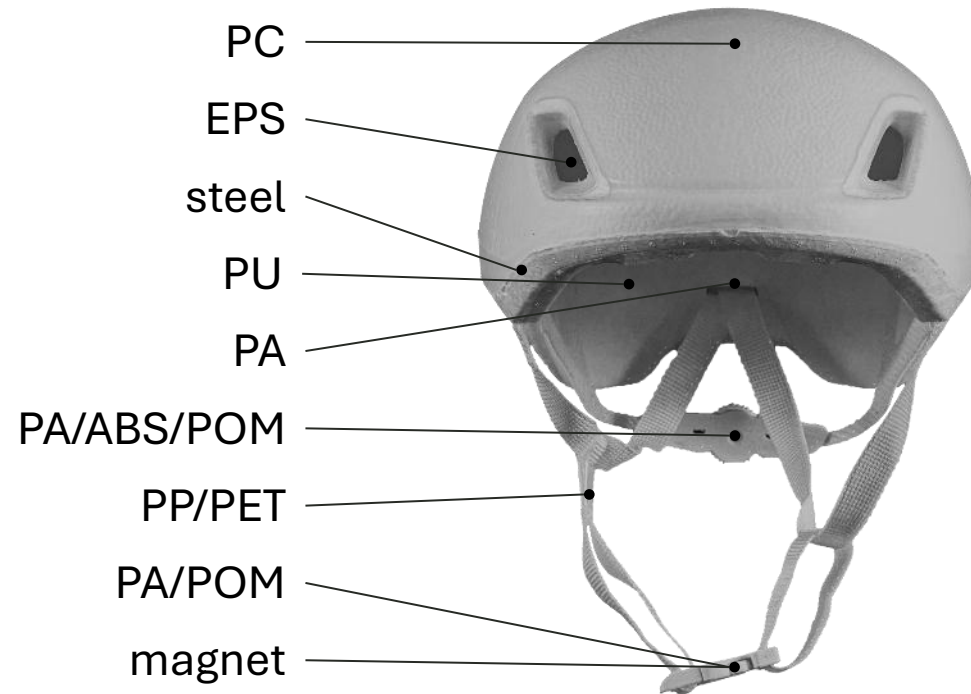
## Recipe optimisation

- Offset between core crystallinity and surface crystallinity due to thermal insulation of the moulded part (thickness = 50 mm)
  - Successful iterative development to reach a very fast crystallising EPLA
  - Full crystallisation within steaming time (~ 30s)
- Cycle time down to 2 minutes

# PLA foams in applications

# State of the Art: Multi-Material-Approach

## Motivation



# Multi-morphology design

## Motivation

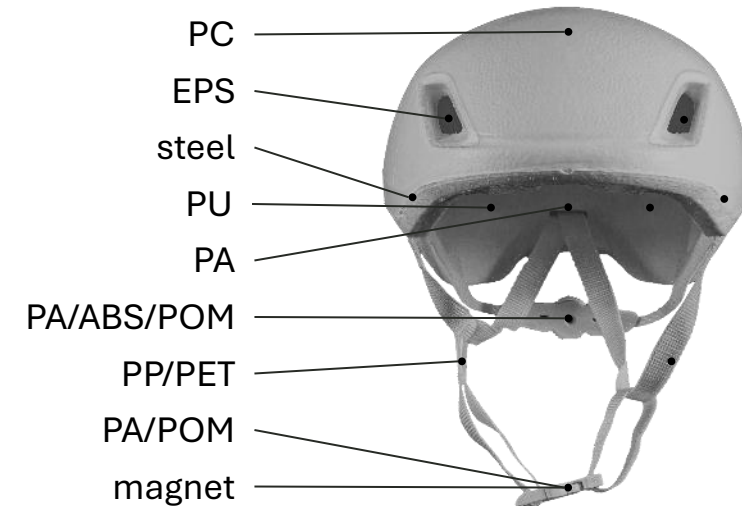
### State of the art:

- recycling of multi-material products is only possible with a high disassembly effort
- cannot be implemented technically and economically on an industrial scale

### Target of current developments:

- circular-ready products
- manufactured from one material in different morphologies

### Multi-Material-Approach

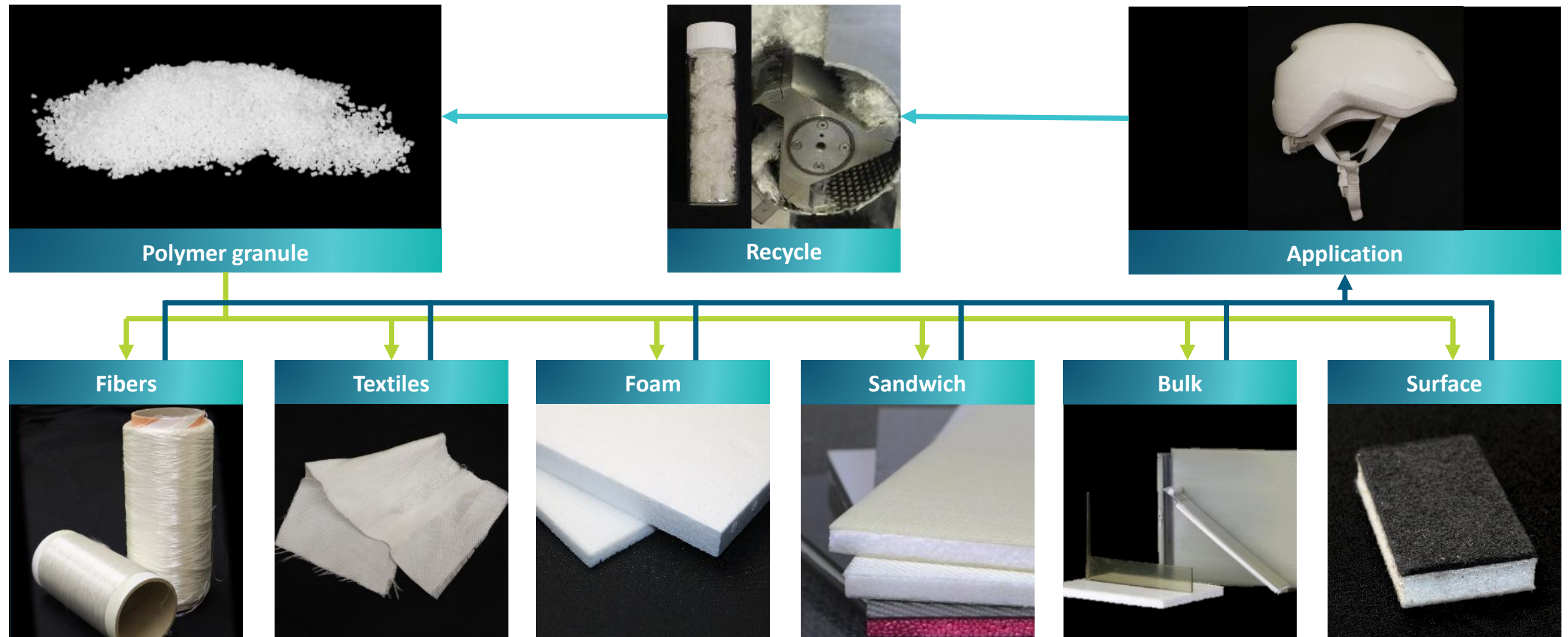




Imagine, there would be one material that could be shaped in different morphologies to enhance its specific performance.

# Morphology lightweight design

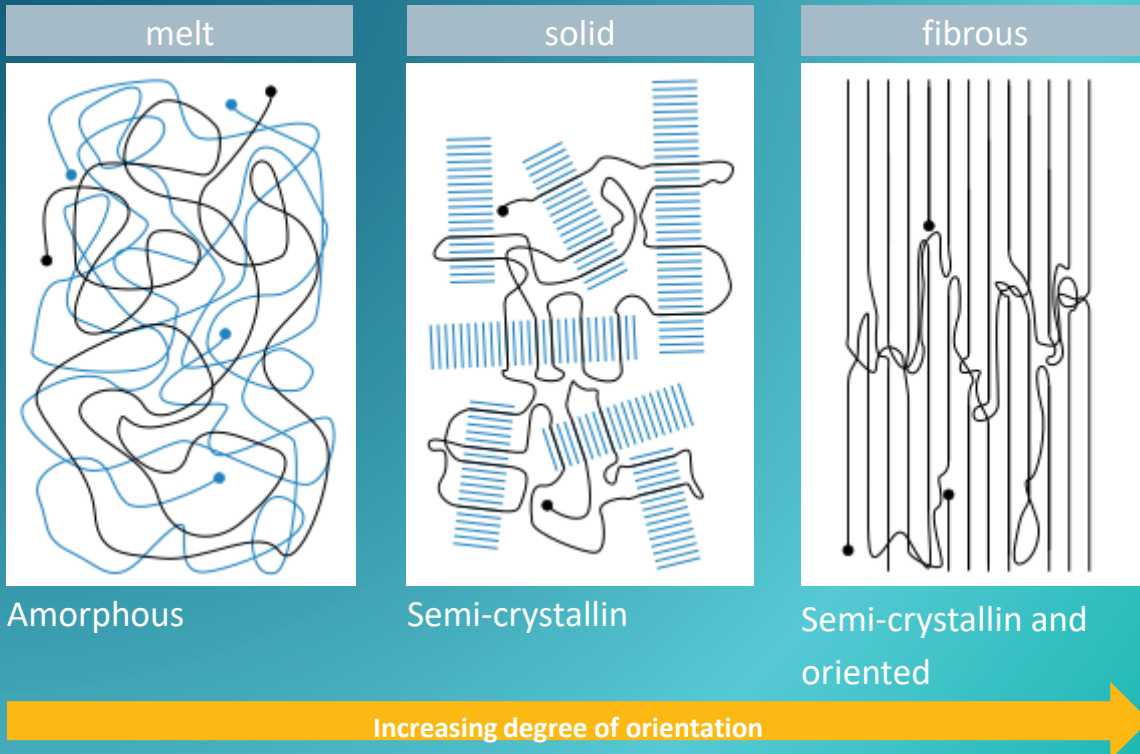
One material → different morphologies → circular-ready lightweight design



# Self-Reinforced Plastics (srP)

## Working Principle

### Orientation of polymeric molecules



# Self-Reinforced Plastics (srP)

## Working Principle

### Structure and working principle

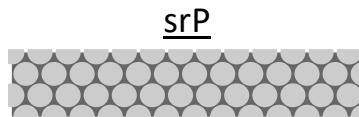
#### Hot compaction [3]

Melting of boundary layer of reinforcing fibers/ tapes

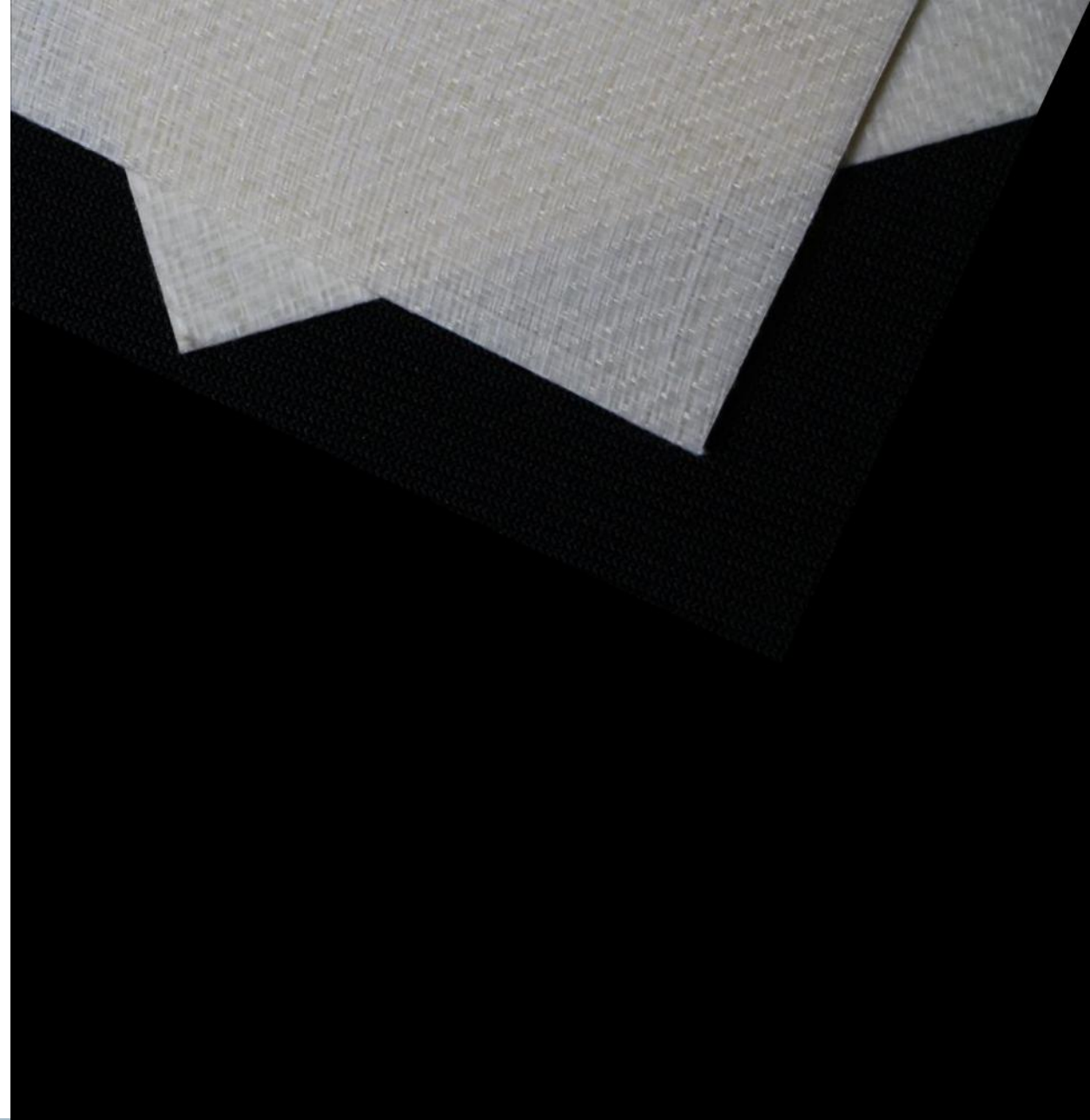


#### Co-polymer [4]

Melting of matrix fibers with lower melting temperature



- consolidation of textiles results in mono-material organo-sheets
- variation in fiber content is possible without changing the overall density



# Thermoforming of srPLA

## Multi-morphology design

- Temperature control as main challenge
- to prevent thermally induced fiber relaxation
- while enabling forming of the material
- Helmet shell:
- manufactured in a vacuum assisted thermoforming process
- possibility for plastic fiber elongation allows for wrinkle-free forming



# Foam

## Multi-morphology design

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### biobased, thermoplastic foams

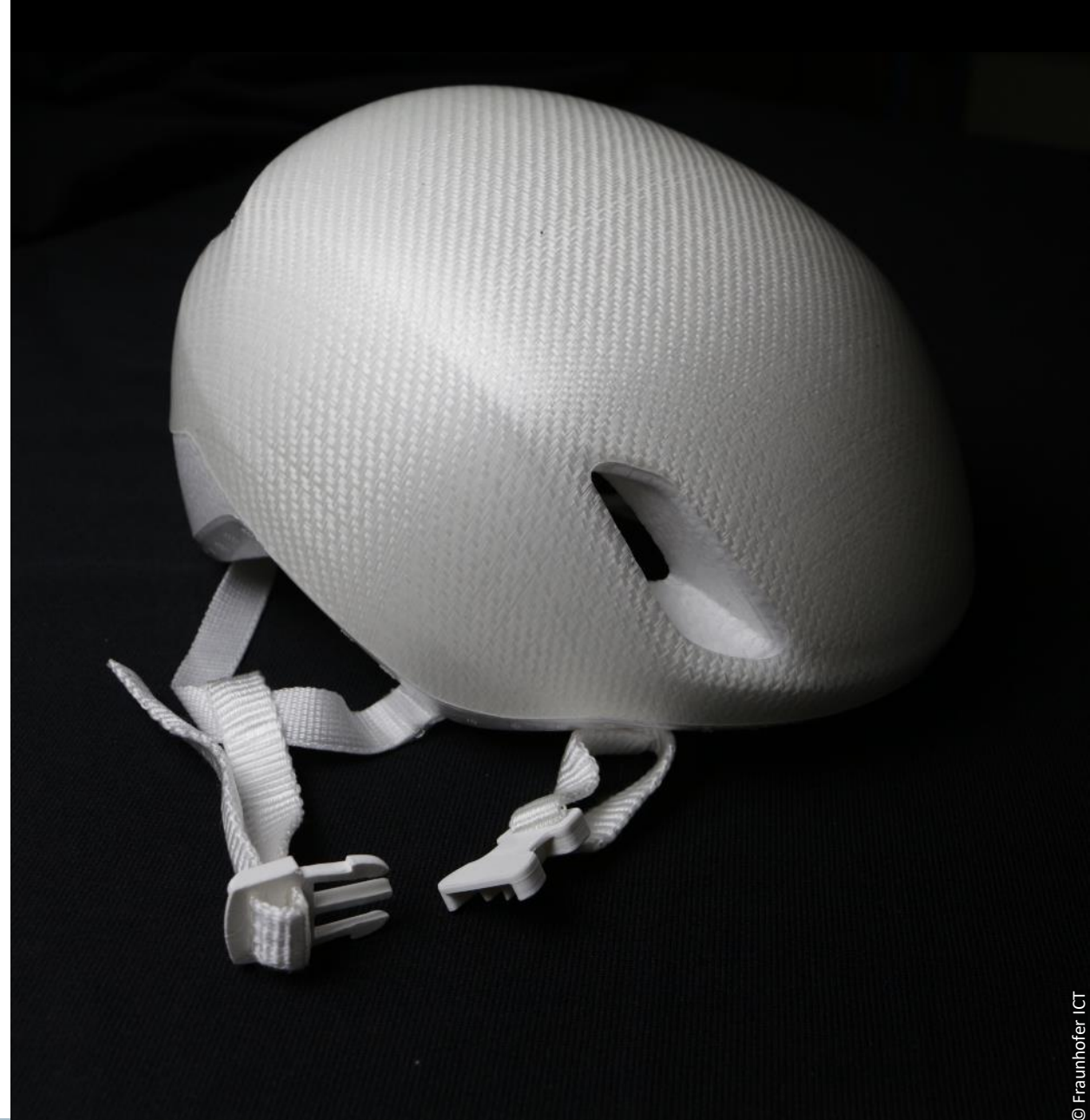
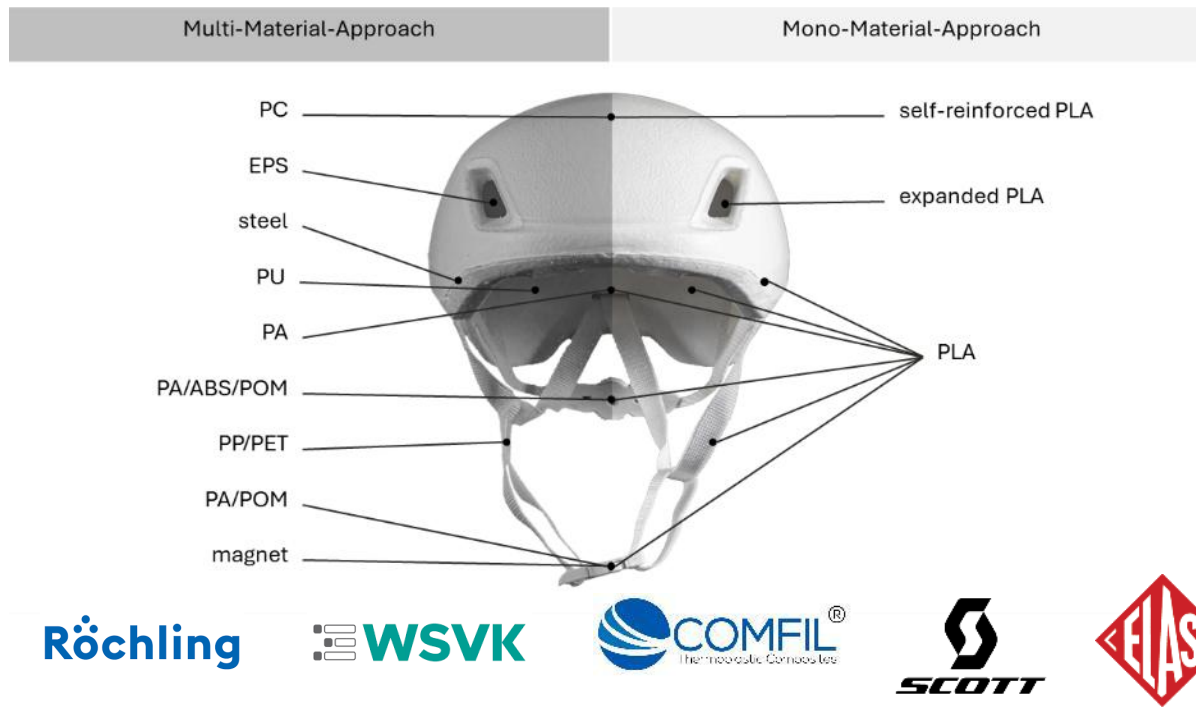
- particle foams
  - EPLA (expandable polylactic acid) is a biobased drop-in solution for the substitution of EPS: comparable mechanical properties, same machinery and tooling like EPS
  - EPLA can be used in density ranges from 30 kg/m<sup>3</sup> up to 150 kg/m<sup>3</sup>



# Complex Combination of Morphologies

- considering the specific component and process requirements, all morphologies can be freely combined

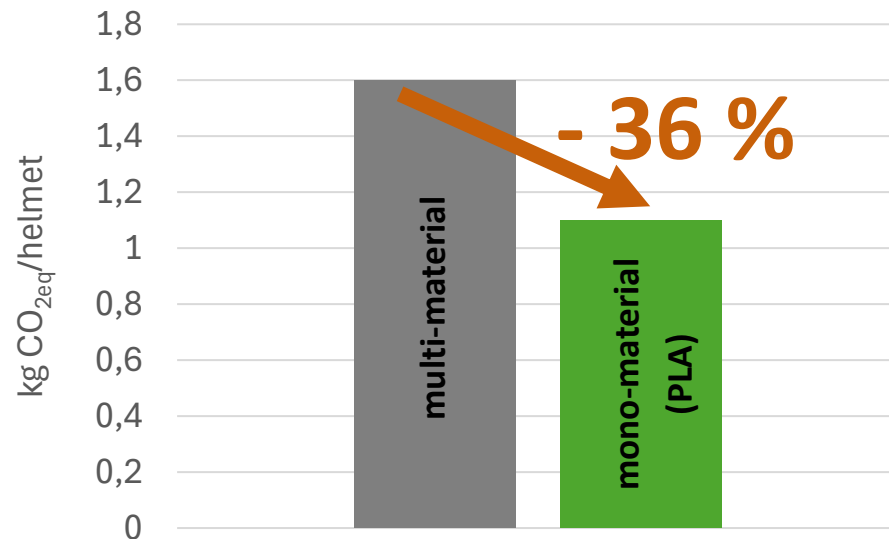
- hike helmet made of 100 % bio-based PLA



# Complex Combination of Morphologies

environmental impact:

- significant reduction due to mono-material approach



# Outlook

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Multi-morphology approach with PLA is applicable in

- Sports & leisure
  - Helmets, surfboards, boats, pickleball paddles etc.
- Automotive
  - Interior door panels, seat-back structures, trunk trims
- Furniture, Transport, etc.

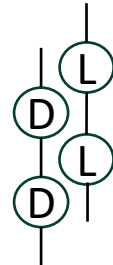


# What we are working on

## Product performance

### Stereocomplex PLA

Improving mechanical properties and heat resistance



### Steamless moulding

Moulding EPLA by radiofrequency and variothermal methods



### Weight optimized process development

Robust processing of PLA-based products



## Commercialisation

### Validation in more industrial applications

Finding partners to evaluate EPLA for various applications



Increase and transfer knowledge

### Spin-off company

Smaller quantities available from 07/26 for pilot products



→ Reach out to us!

# Contact

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# Your partner for sustainable, circular-ready process developments

Fraunhofer ICT

## Monomaterials

- process chain from semi-finished product to final component:  
consolidation, fusion bonding, thermoforming, injection moulding
- consultation with morphology-based product design

## Lightweight design

- foaming technology
  - particle foaming: extrusion, batch foaming, autoclave technology
  - extrusion foaming
- structural composites
  - process development for high performance composites

## Circular plastics

- support with re-formulation of recyclates
- reduction of odour and VOC
- mechanical and chemical recycling technologies
- Life-Cycle-Analysis

## Material-Development

- formulation development: tailor made formulations for polymers and recyclates
- functional compounds: antibacterial and antifungal