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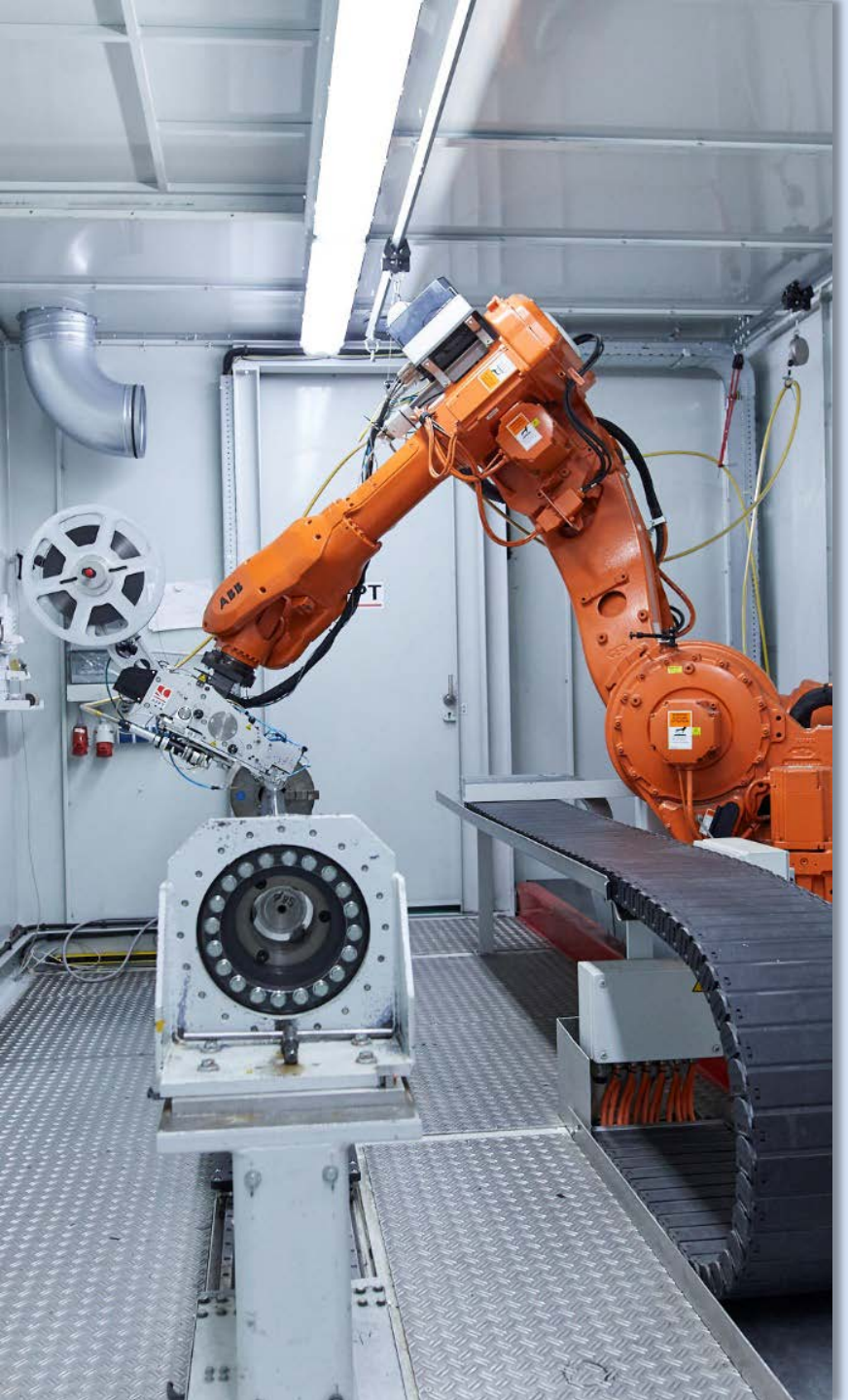

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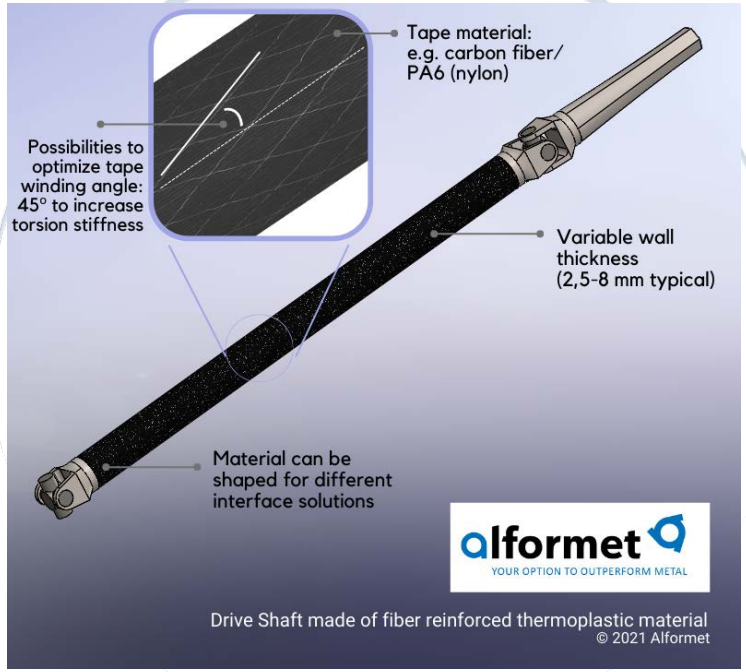
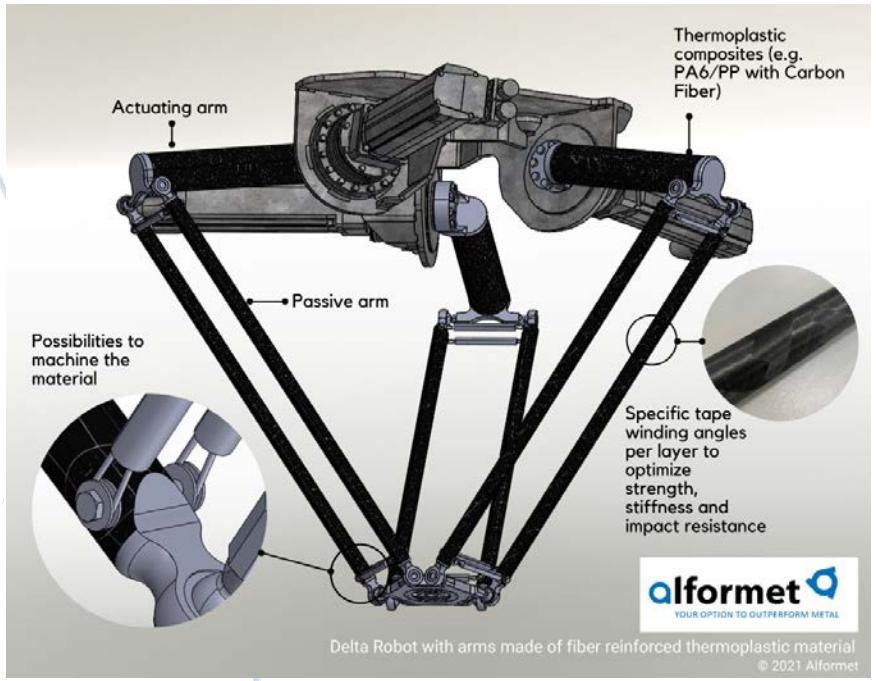
Applications of Wound Thermoplastic Composites for Injection Molding

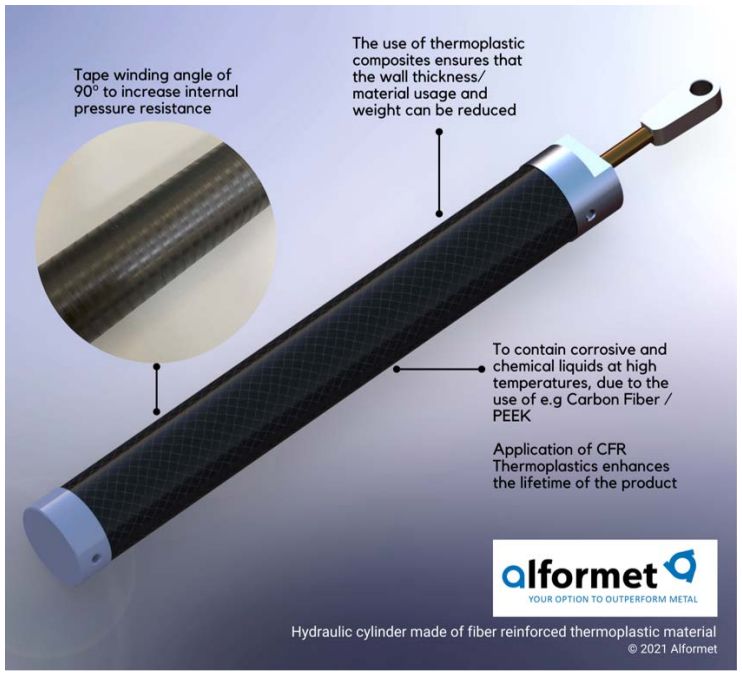
Lucas Ciccarelli, M.Sc.

Our Purpose

"To promote product improvement and development by offering products made with the most modern, smart, high performing and environmentally friendly materials and technologies available."







>>> https://www.alformet.com/tubes/create-your-own-tube <<<

AFPT / Alformet

5

Machines in our application center

>300

Miles of tape material processed in a year

... offers automated solutions for the (mass) production of ***thermoplastic*** composite structures using ***laser-assisted*** deposition technology since 2003 .

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AFPT
ADVANCED FIBRE PLACEMENT TECHNOLOGY

10

Open & Completed Public research projects

>50

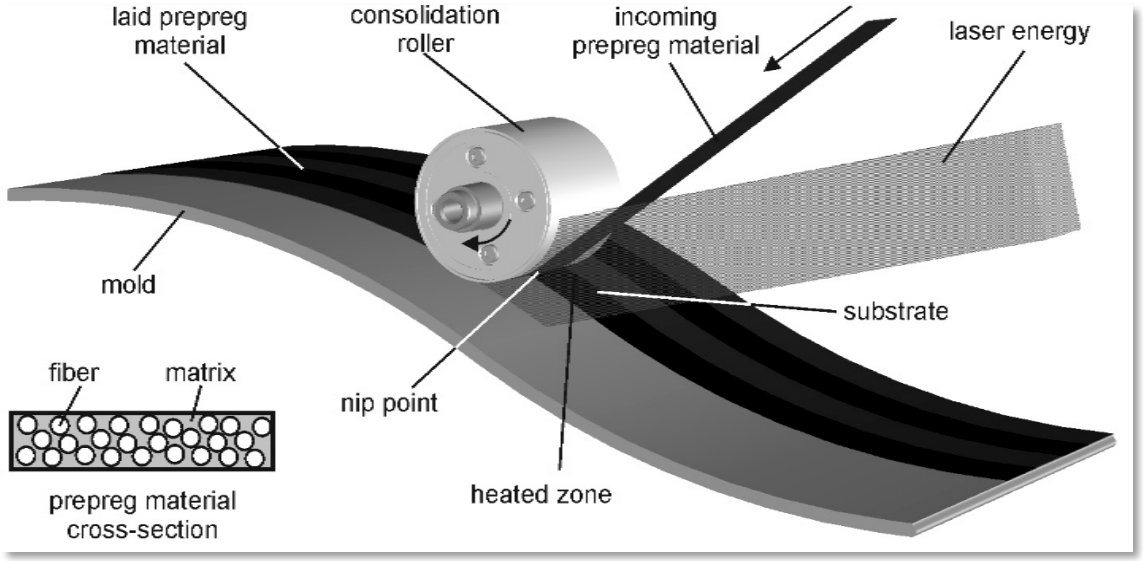
Deposition tools integrated in industry and academia

Laser-Assisted Tape Deposition and The Thermoplastic Advantage

- Low Density
- Corrosion Resistant
- High Impact Resistance
- Dampening Properties
- Electrical Shielding (CF)
- Re-Formable
- 100% Recyclable

The Laser-Assisted Tape Winding / Placement (LATW/LATP) Process

- A placement head positions the pre-impregnated tapes, on the required mold or mandrel
- The thermoplastic pre-impregnated tape material is heated by a laser to the processing temperature
- A fast control system maintains the desired parameters such as process temperature, consolidation pressure and tape tension.
- The LATW process results in a composite component which is ready to use (**in-situ consolidation**)
- All process parameters are logged to be used for quality assurance.



Primary Product Focus

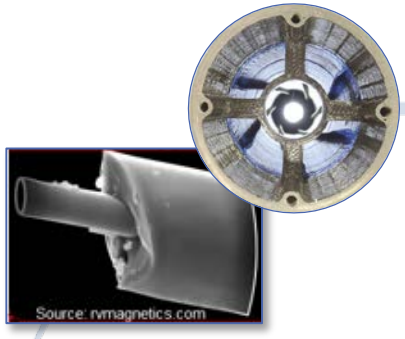
Thin-Walled Inserts

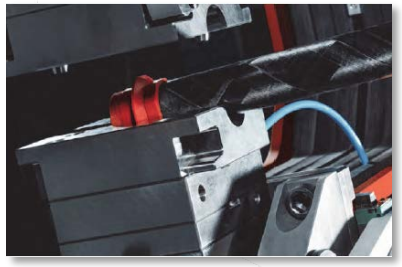
Thick-Walled Structures

Pressure Vessels

Functionalized Tubes

Value-Add Potential of CFR Thermoplastic Products





Source: Anybrid

LATW Machine

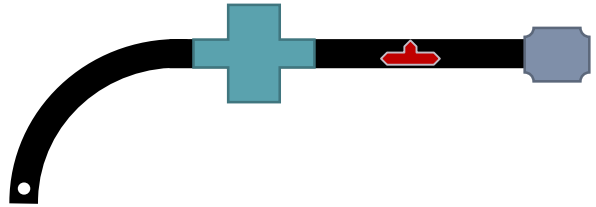
3-D Print Over-Winding with Sensing Tape

Cutting & Extraction

In-Process Overmoulding

Secondary Steps

Bending & Secondary Overmoulding

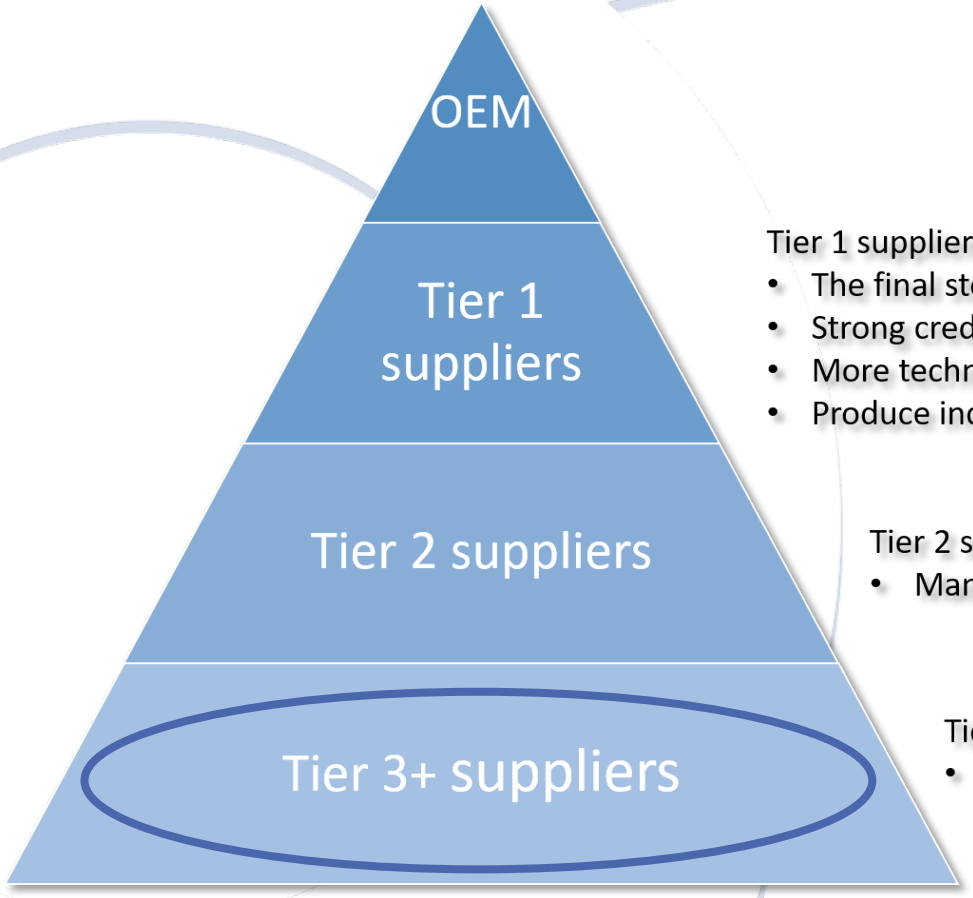


Machining and Circuit Printing

Source: Mitsui

Source: nScrypt

Location in Value Chain



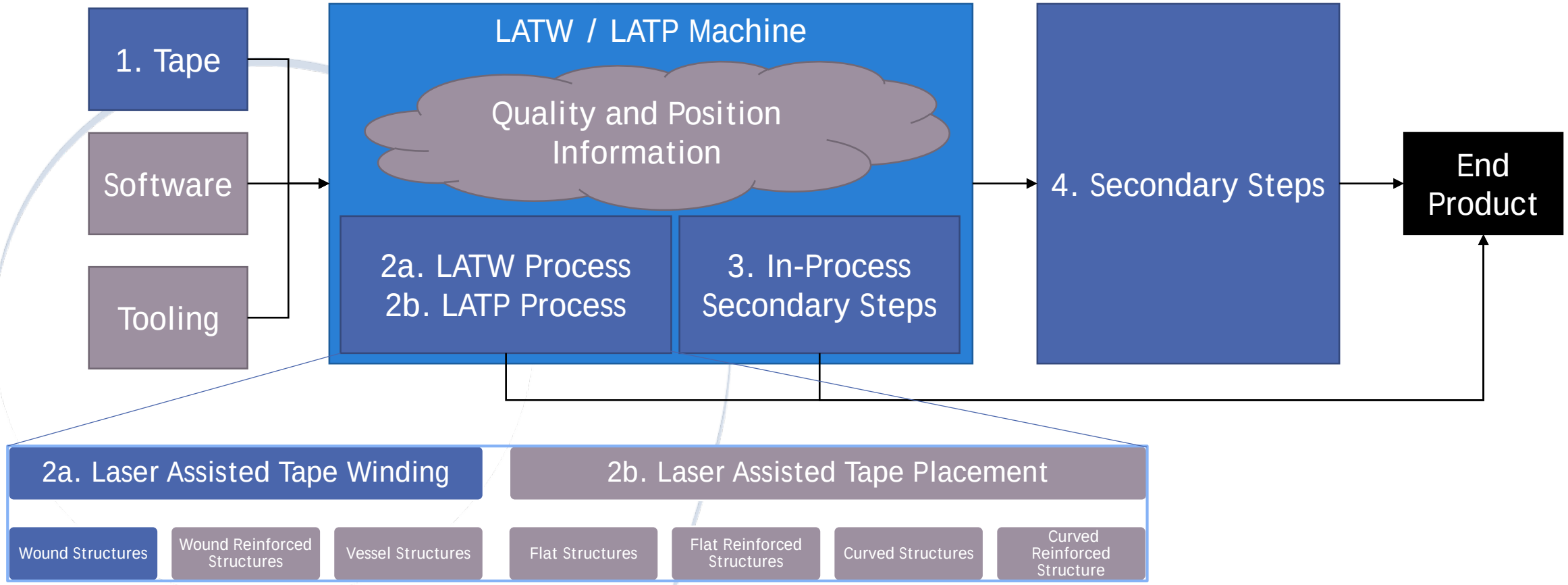
Source: insightsolutionsglobal.com

Tier 1 suppliers, or module/system suppliers:
- The final step before the product reached the OEM;
- Strong credibility with the OEM;
- More technical advantages;
- Produce individual components or complete devices.

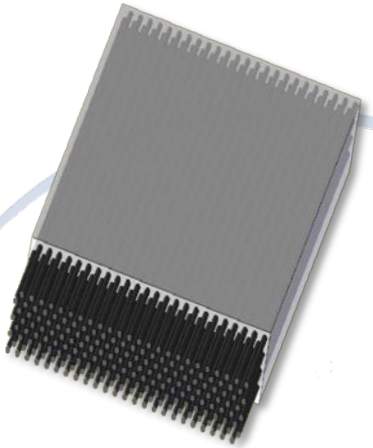
Tier 2 suppliers or component suppliers:
- Manufacturer of individual components of the end product.

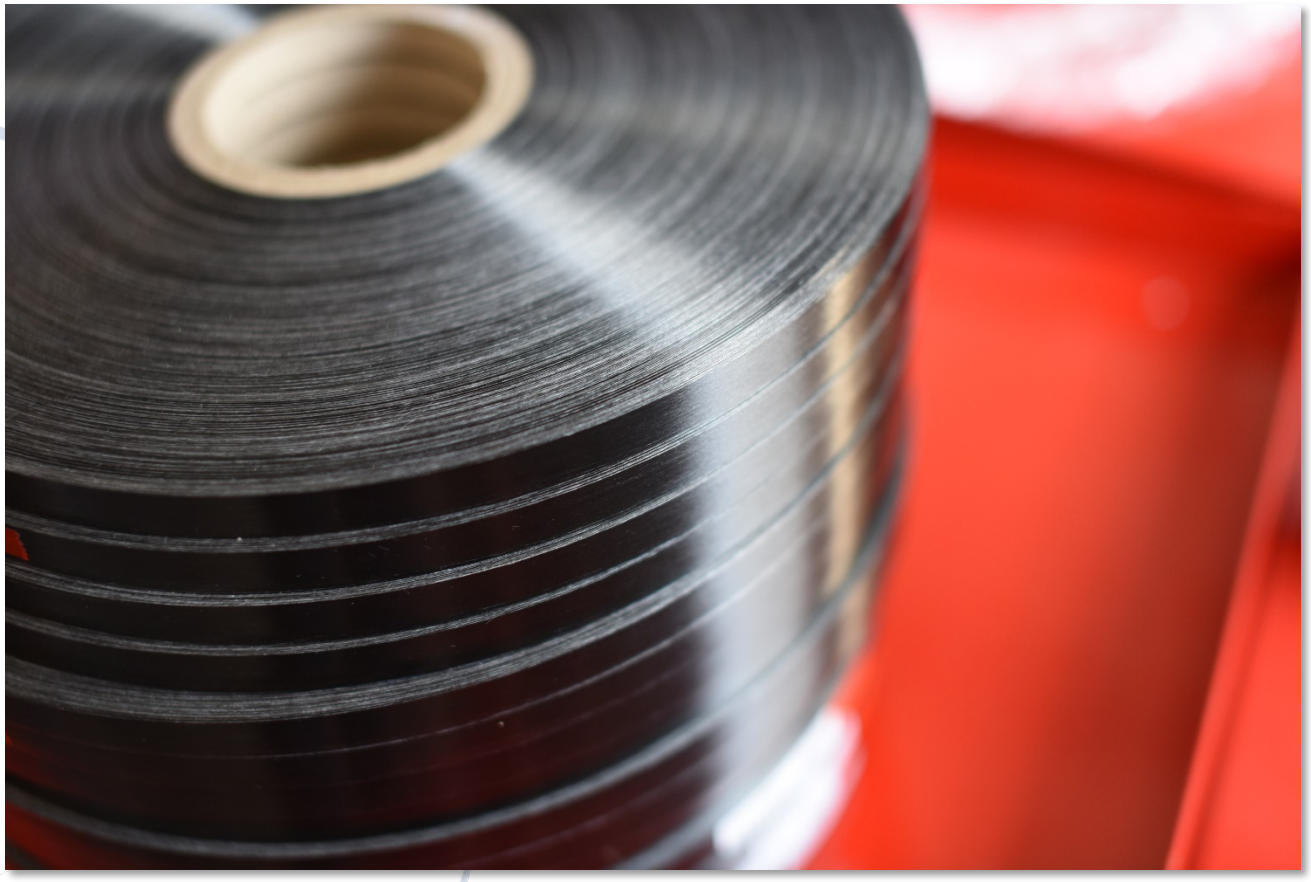
Tier 3 suppliers, parts suppliers:
- Manufacturer of individual parts that is required in the OEM's components.

LATW/LATP Value Map

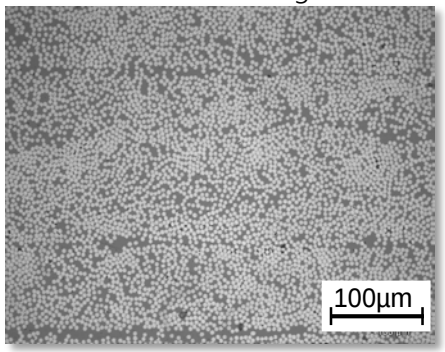


1. Tape

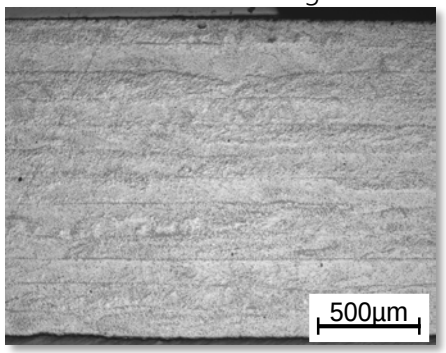




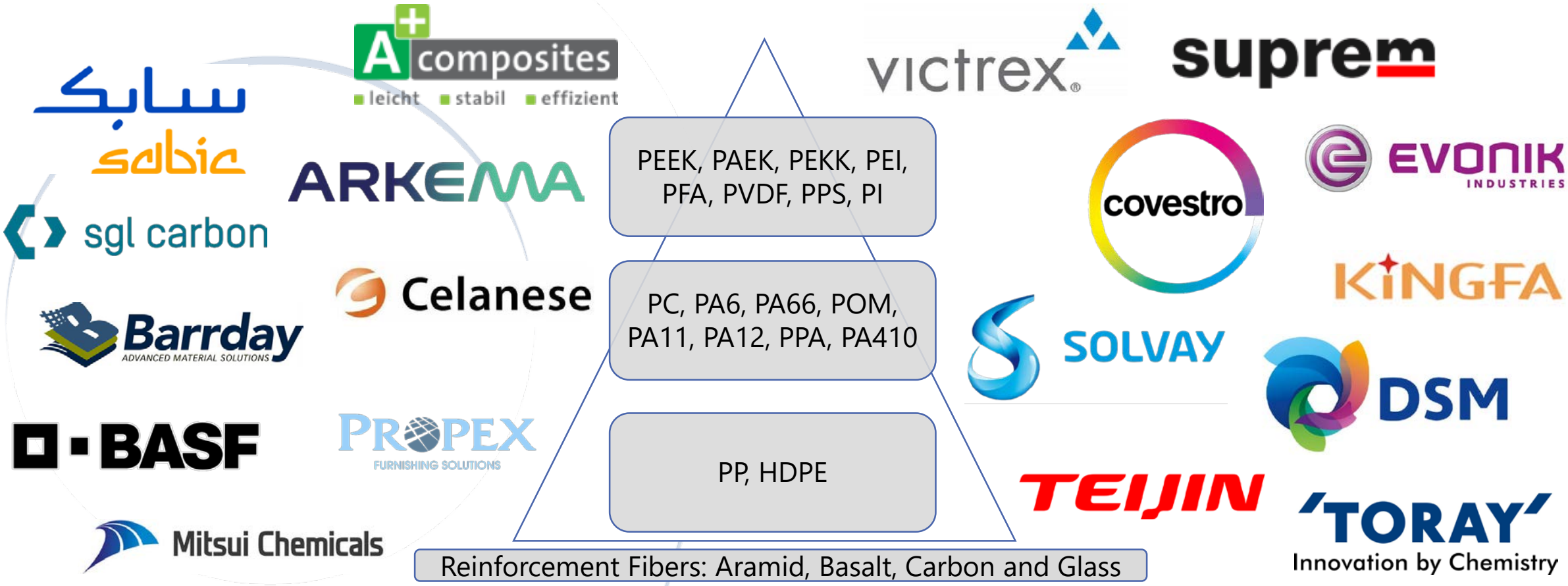
Perpendicular Cross Section
After Processing



Parallel Cross Section
After Processing

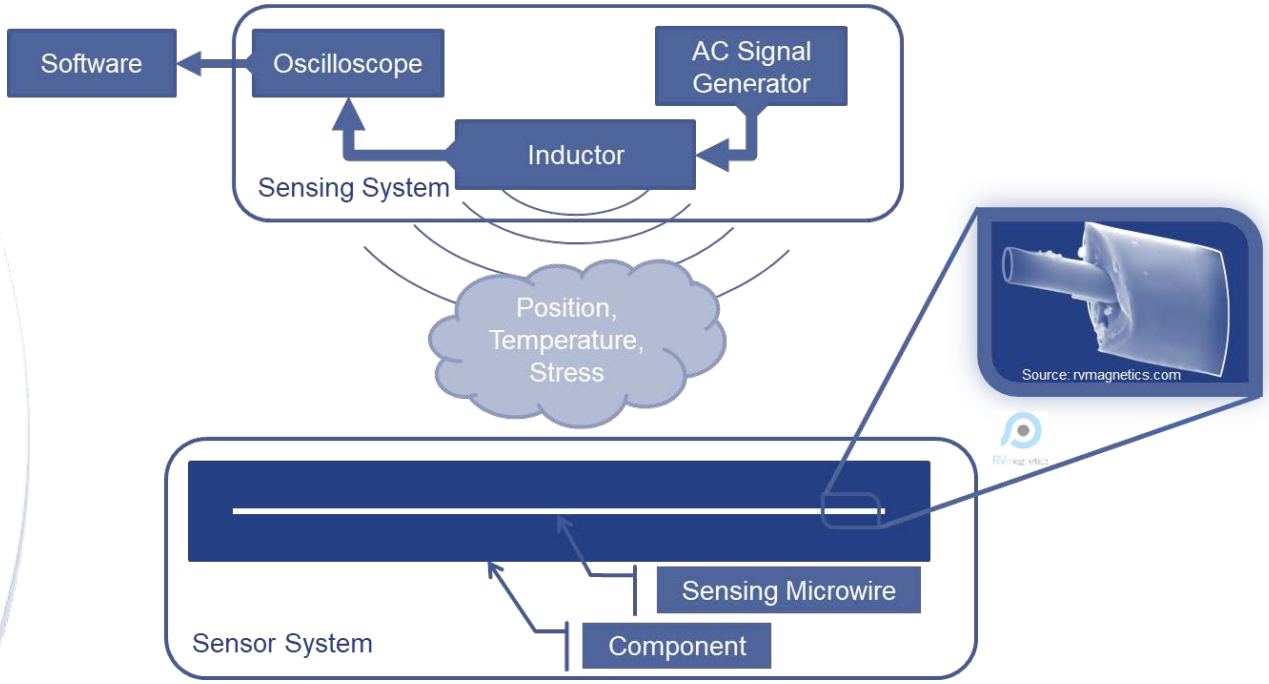


1. Tape: The Input Material



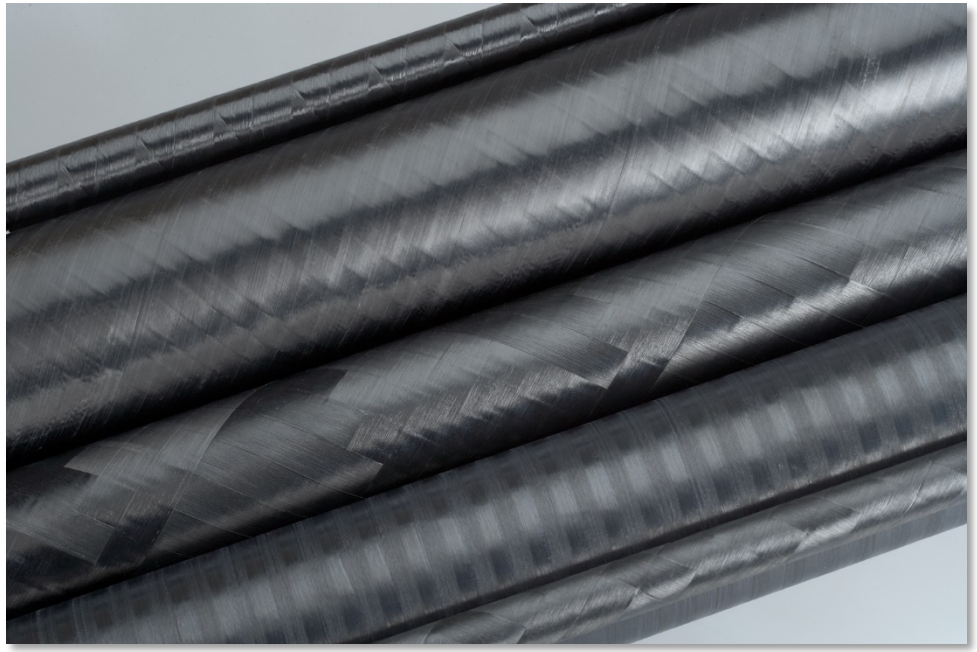
1. Tape: Sensor Integration – Contactless Sensing Microwire

- Structure: Passive Bicomponent Fibre:
  - Metallic Nucleus (1-50 um)
  - Glass Coating (2-20 um)
- Measurement Range: -273 to 600°C
- Lifetime: ∞
- Integrating the sensing wire during combination of the fibre and polymer at the tape supplier

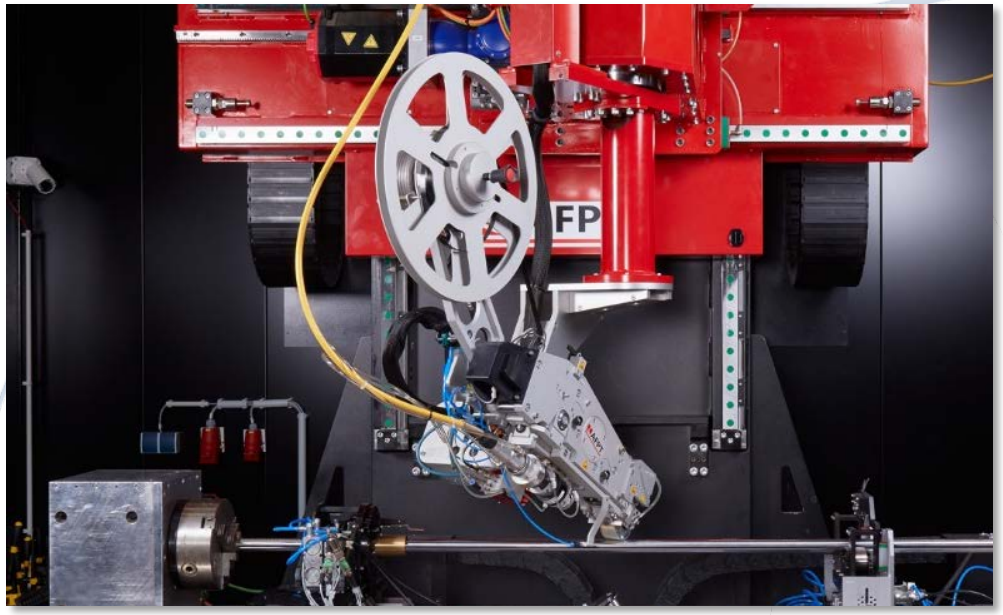


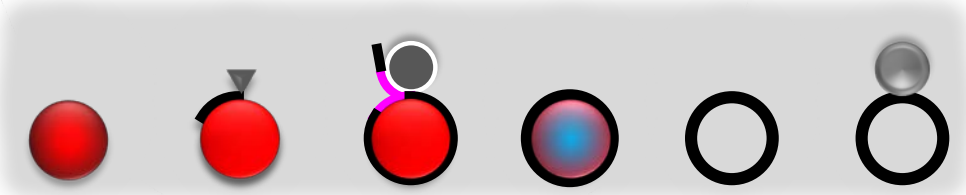
2a. LATW Process: Discontinuous Tubes

- Pipes for Fluid or Gas
- Containers
  - Gas spring
  - Pressure cannister
- Rotor Sleeves
- Rollers



2a. LATW Process: Automated Production Process





- Minimal operator input
- Polymer tempering possible
- In process separating and extraction
- Highly-cost effective for thin-walled sleeves
- Flexible system for different diameters, lengths and wall-thicknesses

3. LATW Process: Part Functionalization: Anybrid ROBIN System

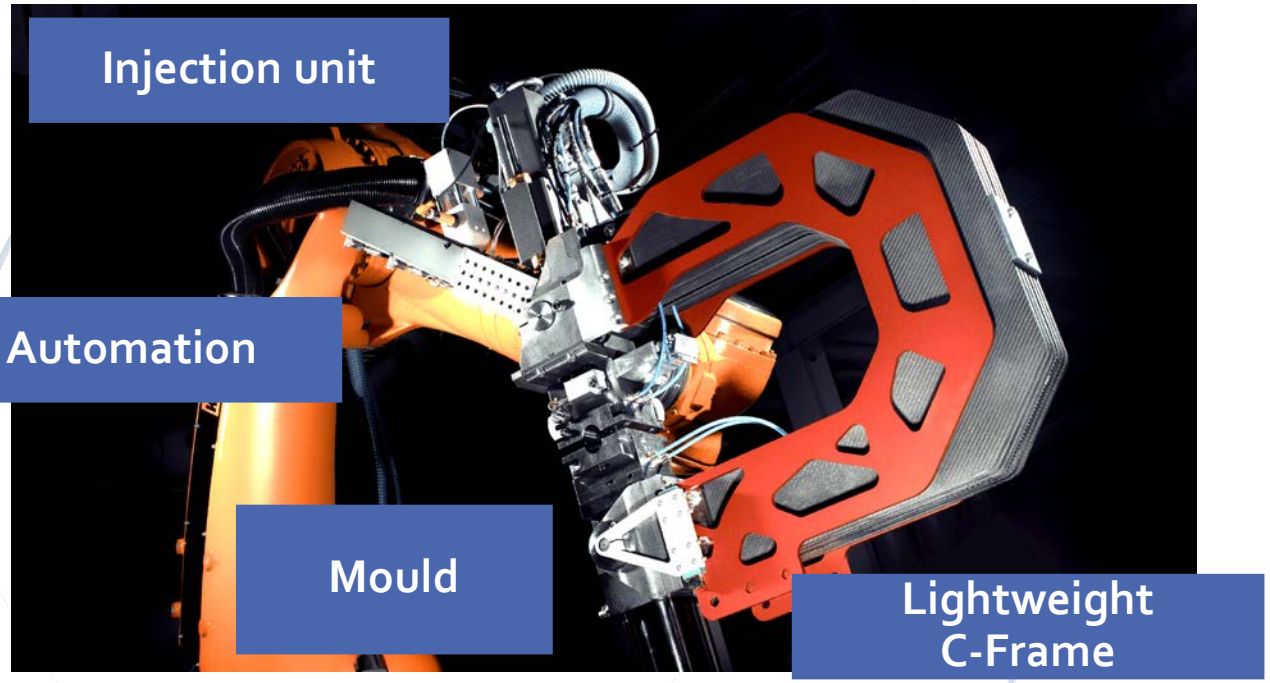
- Modular system for on-the-fly overmolding even in-process with high automation
- Low mold costs with quick changing system
- High value add for CFR TP production

Source: Anybrid

Cooperating ROBIN systems on the assembly line

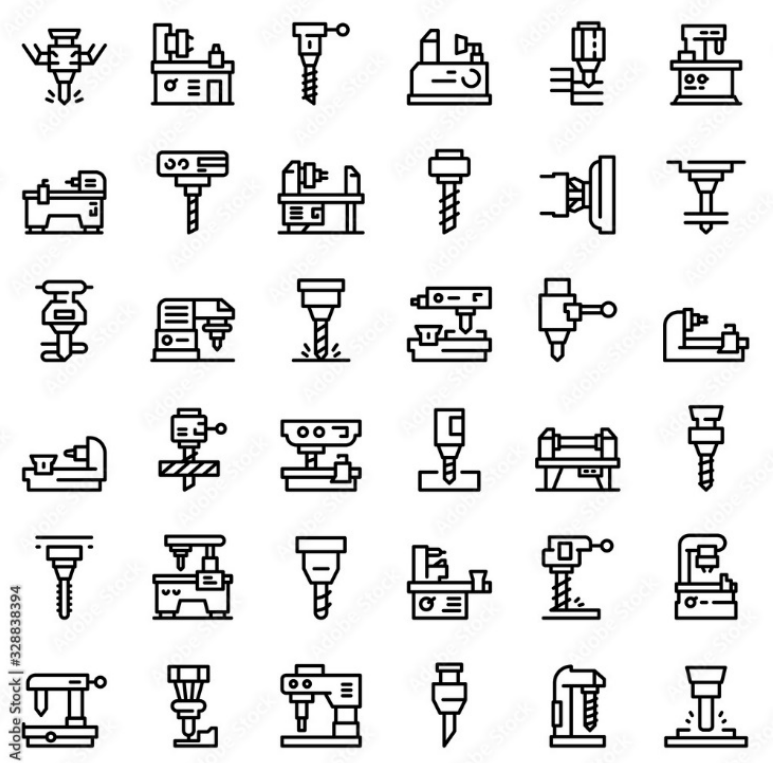
Source: Anybrid

3. LATW Process: Part Functionalization: Anybrid ROBIN System



3. Secondary Processes

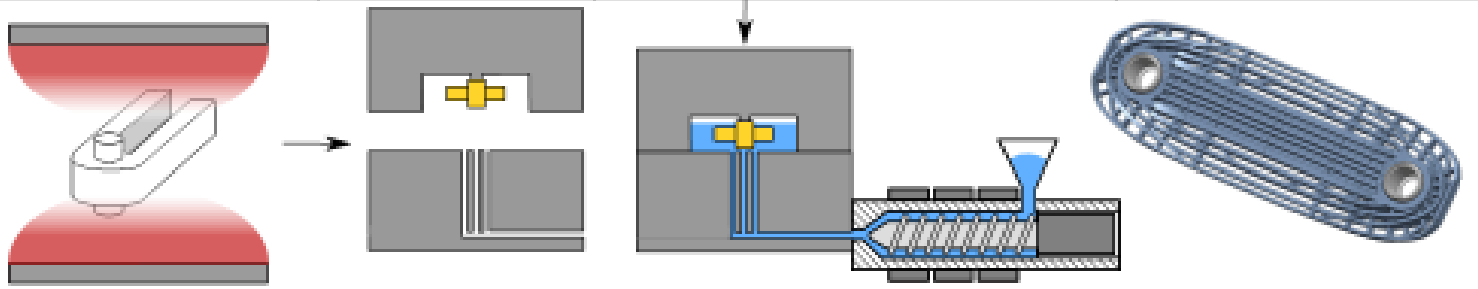
- Injection Moulding
  - Over Moulding
    - Machining
    - Reforming
      - Bending
- Circuit integration



Hybrid Process for a Coupling Rod at IVW

Inserter production	Preheat	Transport	Injection molding	Ejection

Tape laying
UD-3D-printing



Process:

- Production of the loop
- Preheating the aluminum sleeves
- Warm up and preload in IR-oven
- Transport to the mold
- Overmold with short fiber reinforced polymer
- Cool down
- Quality control and ejection event according to temperature specification

Further development of the process with regard to:

+ Overmolding on all sides
+ More flexible manufacturing process thanks to simpler molds and master mold concept
+ Continuous temperature recording by pyrometer in IR oven, robot gripper and injection mold

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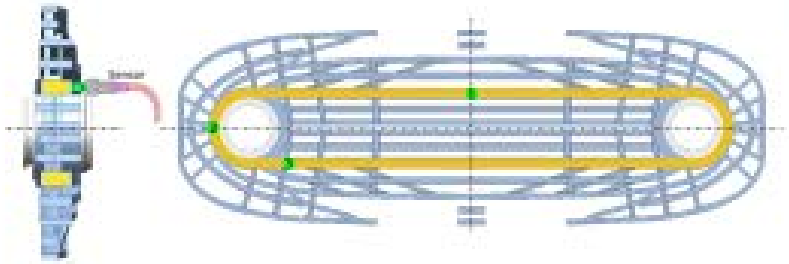
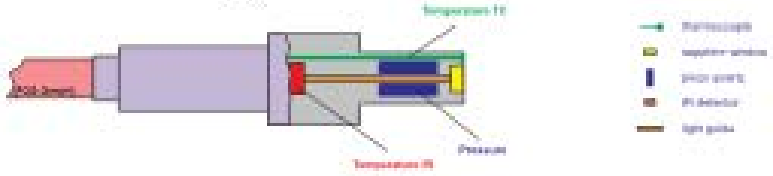
Hybrid Process for a Coupling Rod at IVW



- Temperature-resistant
- 3 sensor positions (near and far from sprue)
- Sensor points vertically to insertion surface
- Pressure and temperature are measured simultaneously at one location
- Minimum cooling times via real time temperature data recording to the machine



Injection molding tool

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3. Secondary Processes Overmolding: Coupling Rod

Funding agency

Das Projekt zu Investitionen in Wachstum und Beschäftigung

pro-TPC-Struktur

wurde von der Europäischen Union aus dem Europäischen Fonds für regionale Entwicklung und dem Land Rheinland-Pfalz gefördert.

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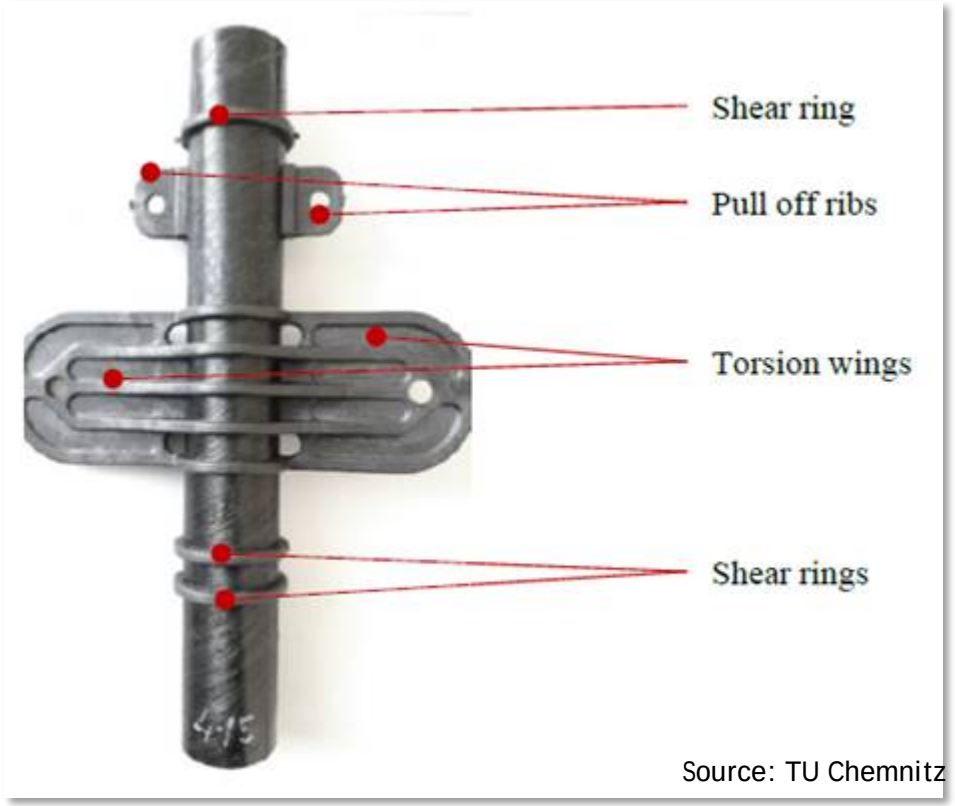
3. Secondary Processes: Overmoulding

- For larger, more complex functionalization
- Advantage to overmolding from metals while chemical activation or structuring not needed.
- Equivalent surface temperature distribution leads to high bonding strength under tension as well as shear.


Source: Mitsui


Source: Mitsui



Source: TU Chemnitz

3. Secondary Processes: Overmoulding

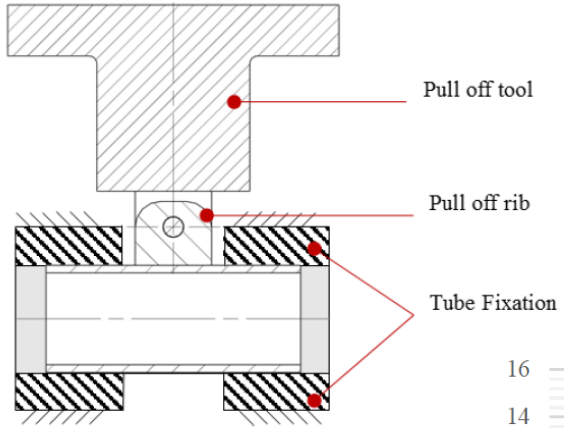


***Fig. 8**: Pull-off setup*

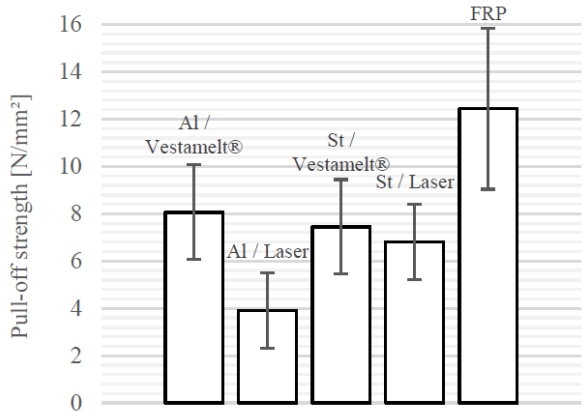


***Fig. 10**: Comparison of pull-off strength between: Aluminum / Vestamelt®, Aluminum / laser structured surface, Steel / Vestamelt®, Steel / laser-structured surface, FRP*

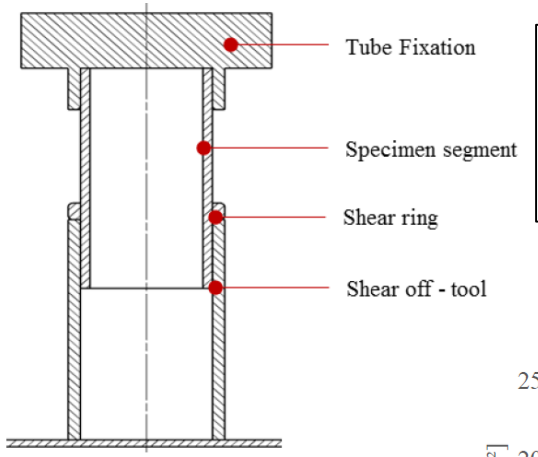


***Fig. 9**: Shear-off setup*

Englemann U, et. al. (2020) "Process and bonding modification for media-based forming of complex continuous fiber reinforced hybrid parts" *ITEC 2020, MESSE BREMEN*

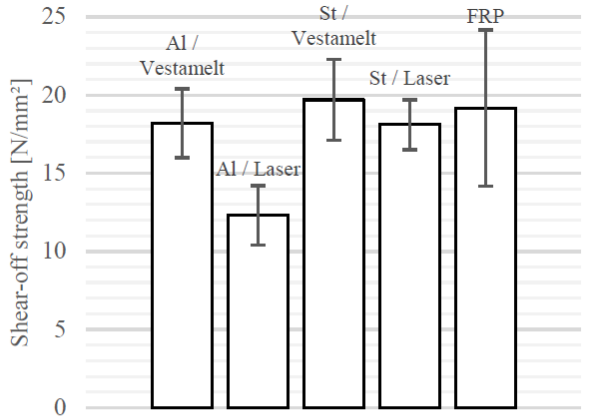
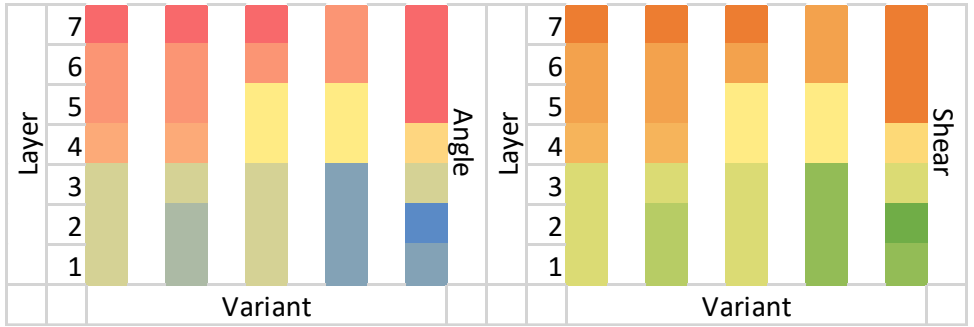


***Fig. 11**: Comparison of shear-off strength between: Aluminum / Vestamelt®, Aluminum / laser structured surface, Steel / Vestamelt®, Steel / laser-structured surface, FRP*

3. Secondary Processes: Bending

- High surface quality with little disturbance to laminate
- Highly automated with heat sources such as induction with CNC machine
- Design for fatigue and compound loading



3. Secondary Processes: Coating

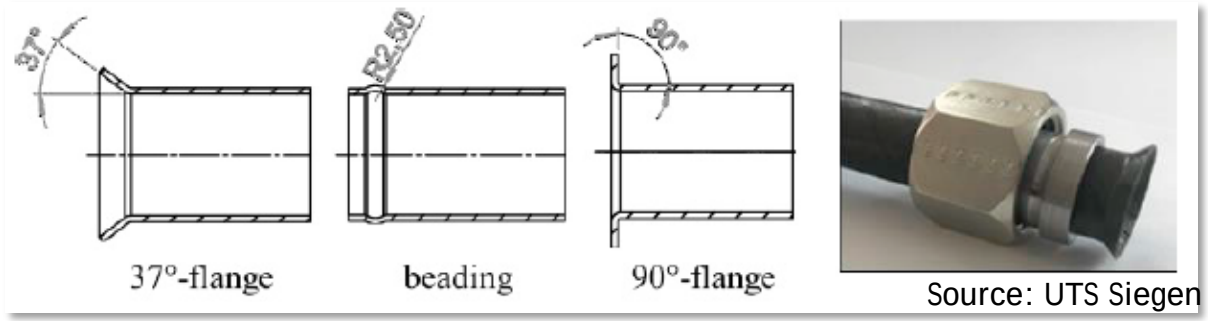
- Impact protection
- Weathering
- Tactile improvement

Source: Strohm

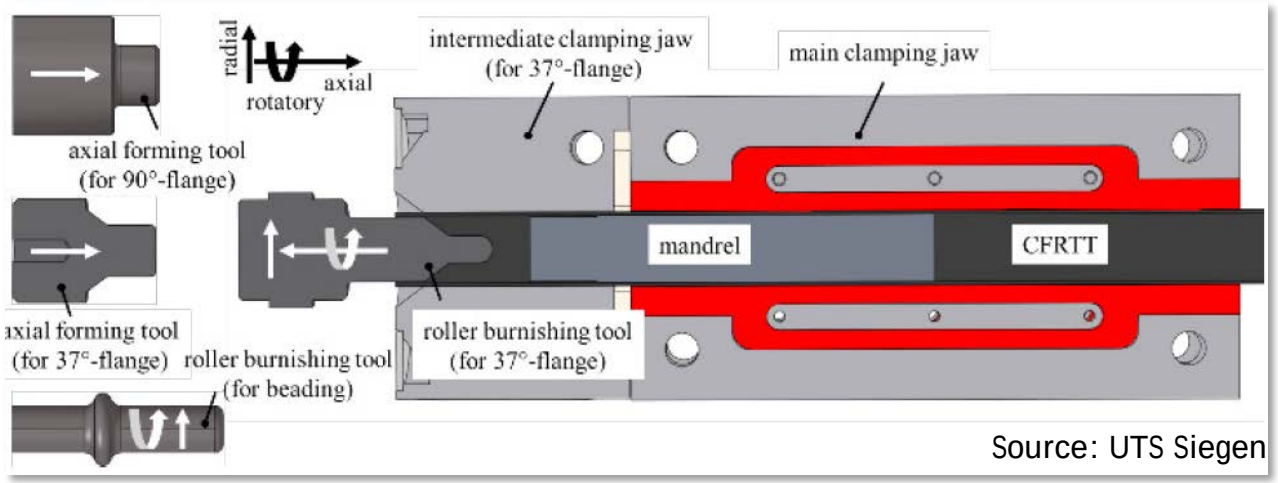
Source: Alformet

3. Secondary Processes: Reforming

- When tubes can hold loads of 1500 bar, the joining connectors needs to do so as well
- Changing axial or radial shape of the cross section through automated heating and forming
- Functionalization of tube ends enables load applications with tight hydraulic fittings



Source: UTS Siegen



Source: UTS Siegen

3. Secondary Processes: Reforming

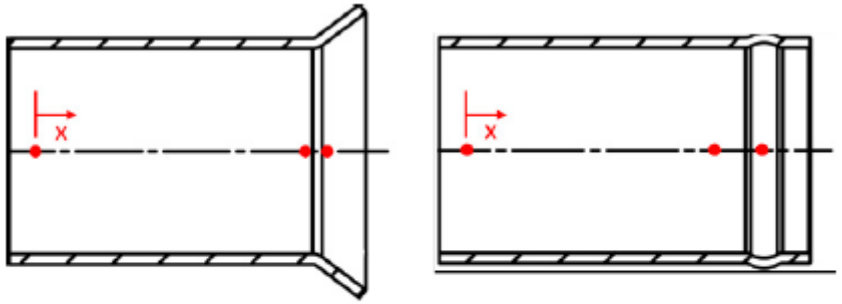
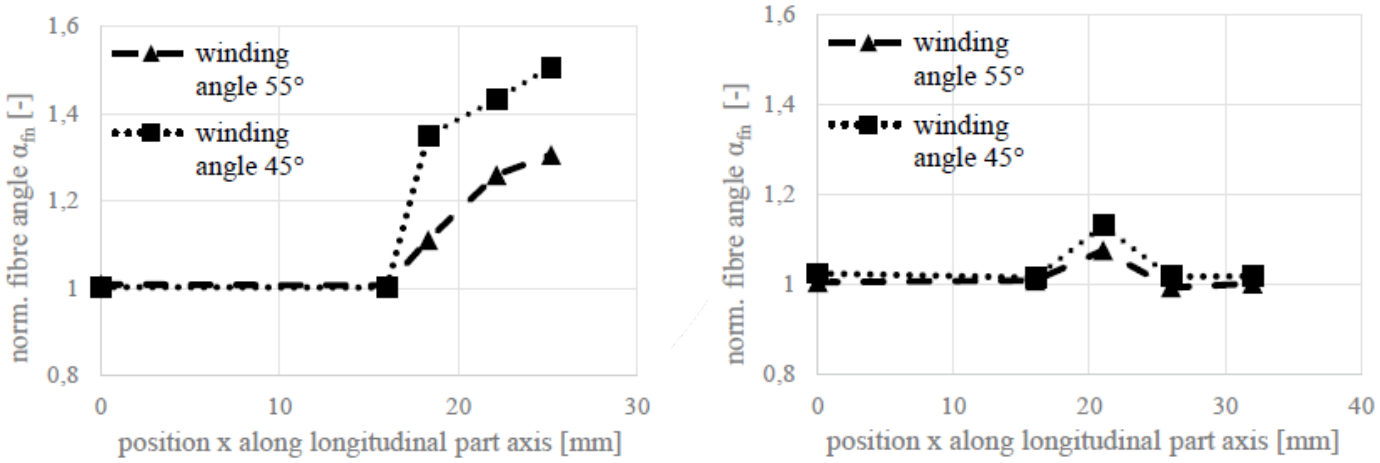


Fig. 5. Schematically depiction of measuring points for the determination of fibre angles in the outer layer of the 37°-flange (left) and the beading (right)



Reuter J, et. al. (2020) "End-forming of Continuous Fibre-reinforced Thermoplastic Tubes" *ESAFORM 2020*

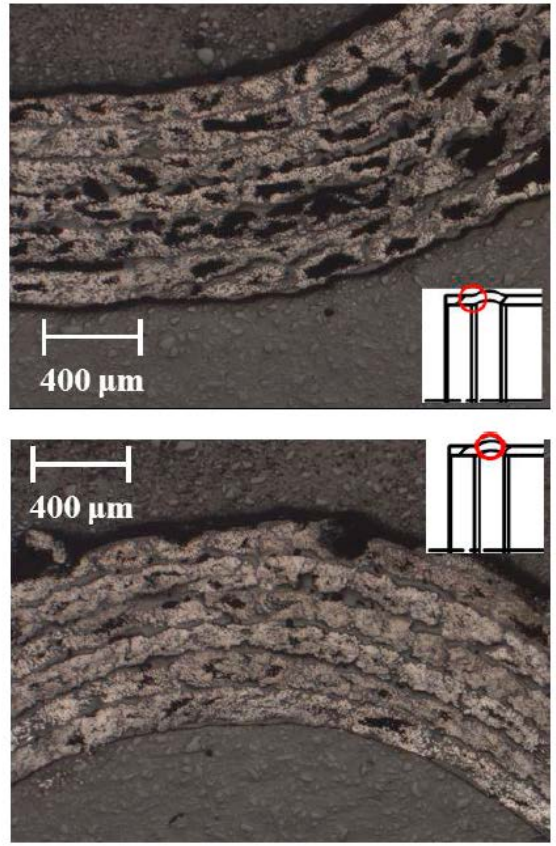


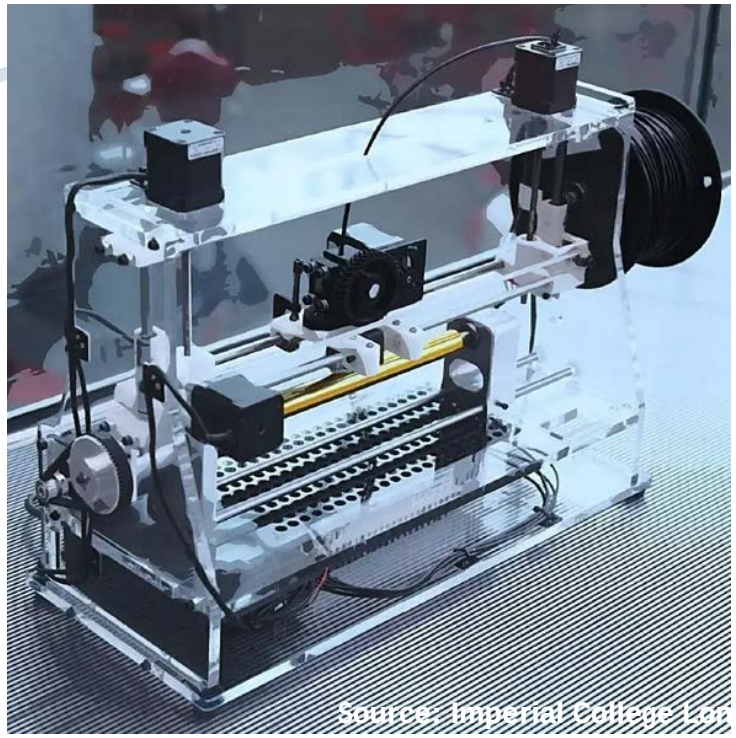
Fig. 10. Longitudinal section polishes of a beading with a nominal winding angle of 45°.

3. Secondary Processes: Machining

- Cutting
- Milling
- Turning
- Drilling
- Grinding

Source: Automated Dynamics

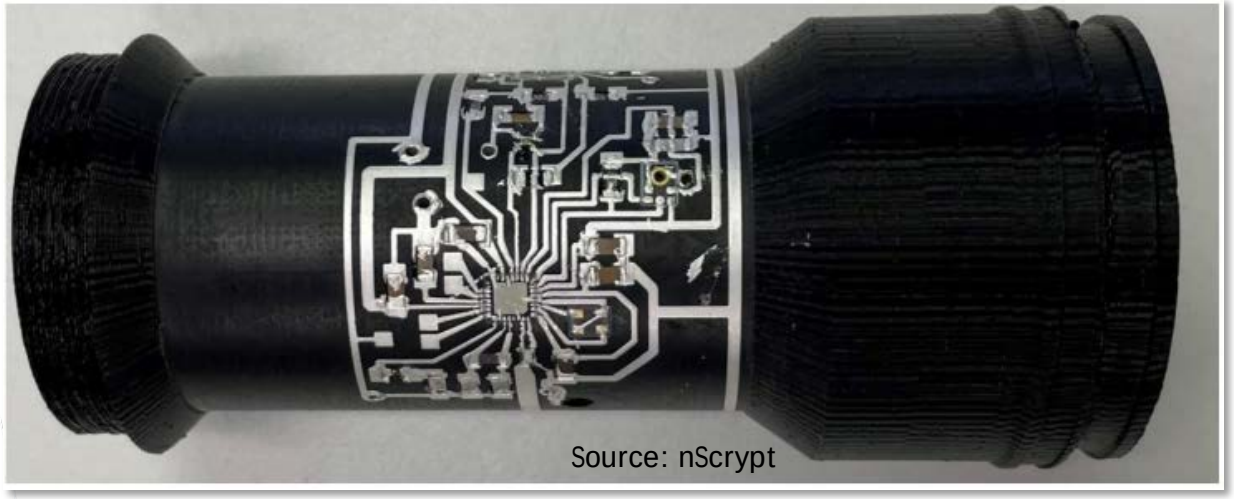
3. Secondary Processes: Over Printing



Source: Imperial College Lon

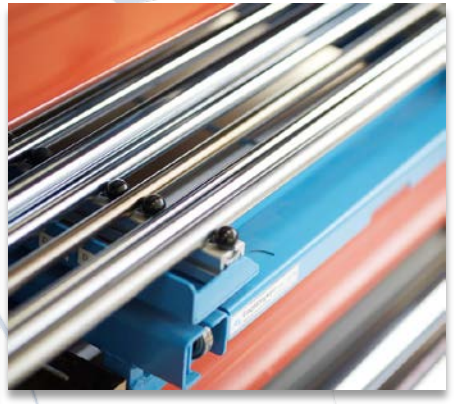
3. Secondary Processes: Circuit Integration

- Process of milling, pick-and-place, printing of connections
- Form fit for single/double curved surfaces
- Bluetooth, microcontroller, sensor, antenna, embedded circuits


Source: nScrypt


Source: nScrypt

Production Overview



- Production of composite components on one of five Tape Placement & Winding Machines
- Specialty temperature controlled winding tools
- Heating oven and demoulding station
- Large range of different products & shapes like tubes, profiles, vessels or laminates possible
- Small-Medium Serial Production

Production Geometric Range

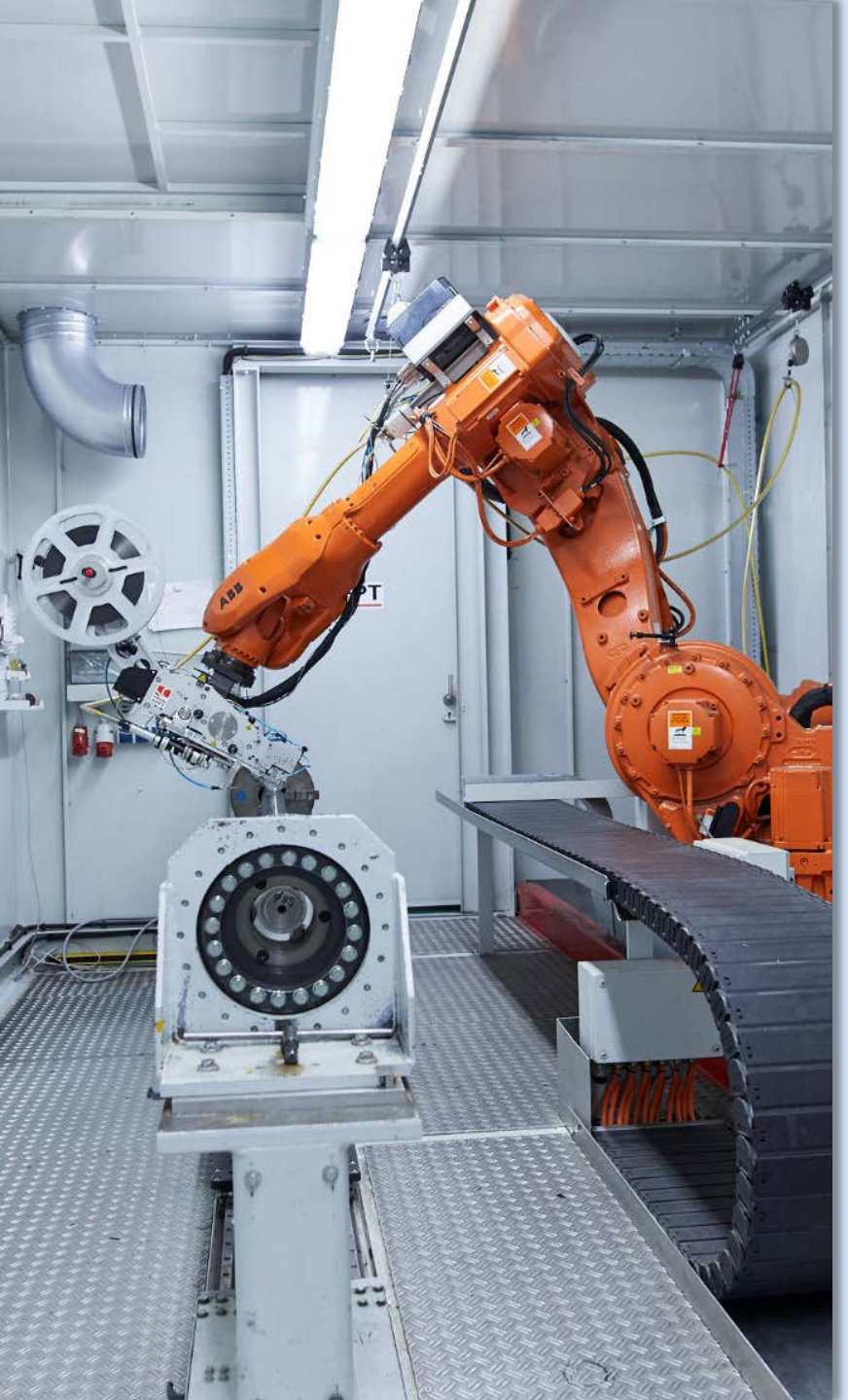
Winding

- Max. diameter 1.200 mm
- Max. length 3.500 mm
- Vessel max. diameter 500 mm
- Vessel max. length 2.000 mm

Placement

- Max. area 1.000 × 2.000 mm
- Heated tooling
  - Max. Temp: 120 °C
  - Heated area 650 × 650 mm

Tape Width 3-26 mm



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Thank you for your attention! Questions?

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