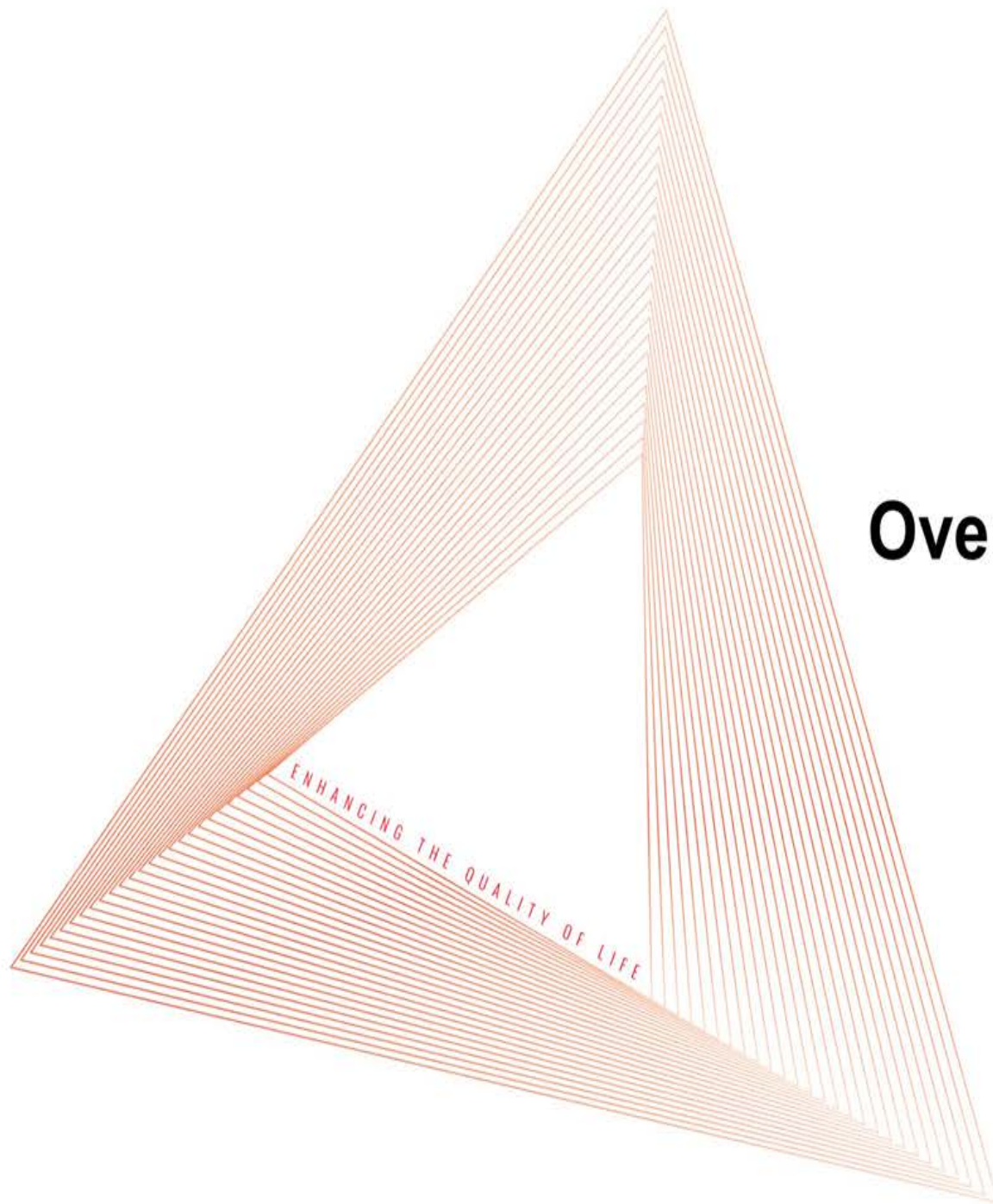




## Painel Aeroespacial 20 de setembro de 2021

Teijin Carbon America  
Compósitos em Fibra de Carbono  
Oportunidades na construção de aeronaves

- Agenda
  - Teijin Group Introduction
  - Teijin Carbon Overview
  - Teijin Carbon Special Materials
    - NCF
    - Thermosets for rapid cure
    - Thermoplastics
      - PEEK
      - LM-PAEK
      - PPS



# Overview of the Teijin Group

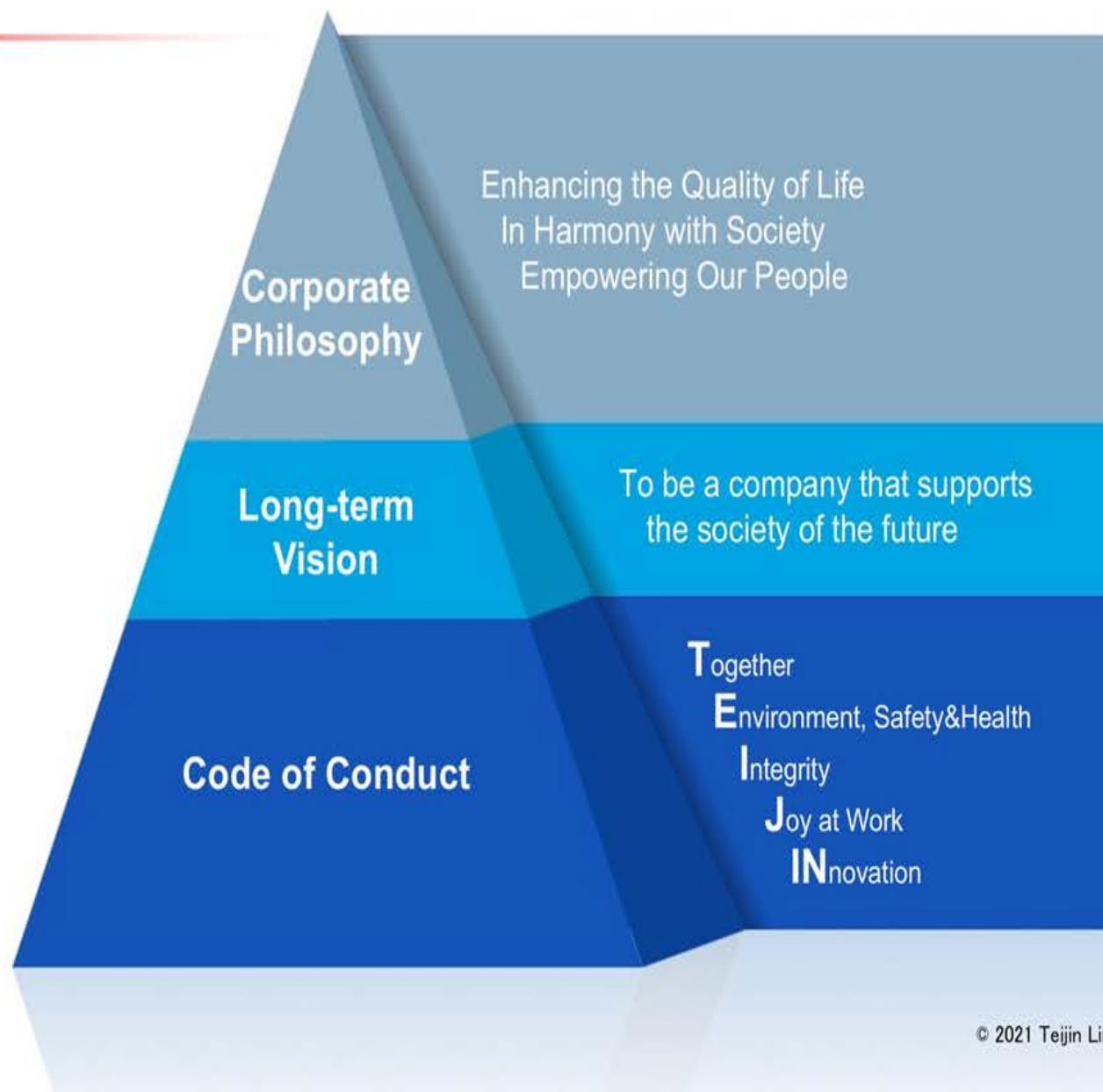
# Our Philosophy

Human Chemistry, Human Solutions **TEIJIN**

*Human Chemistry,  
Human Solutions*

## Brand Statement

A concise expression  
of the value and corporate  
stance we promise  
to our stakeholders



# Business Fields

Our four business fields include the two major “Materials Business” and “Healthcare Business” fields, as well as the “Fibers and Products Converting Business” and “IT Business.”

## Strategic Focus



Composites for Automotive



Carbon Fiber Intermediate Materials for Aircraft

## Profitable Growth



Aramid



Resin and Plastics Processing



Carbon Fibers



Separators/Membranes

### Materials Business



## Strategic Focus



Comprehensive Community Healthcare Related Business



Functional Food Ingredients



New Healthcare Business for Orthopedics and New Medical Devices

## Profitable Growth



Pharmaceuticals



Home Healthcare

### Healthcare Business



## Profitable Growth



High-value-added Sports and Fashion Textile Fibers



High-performance Materials and Products that Support Safe and Secure Living



New Business Combining High-performance Fibers and Sensing Technologies

### Fibers and Products Converting Business



## IT Business



## Profitable Growth



Internet-based Business



IT Services for Healthcare

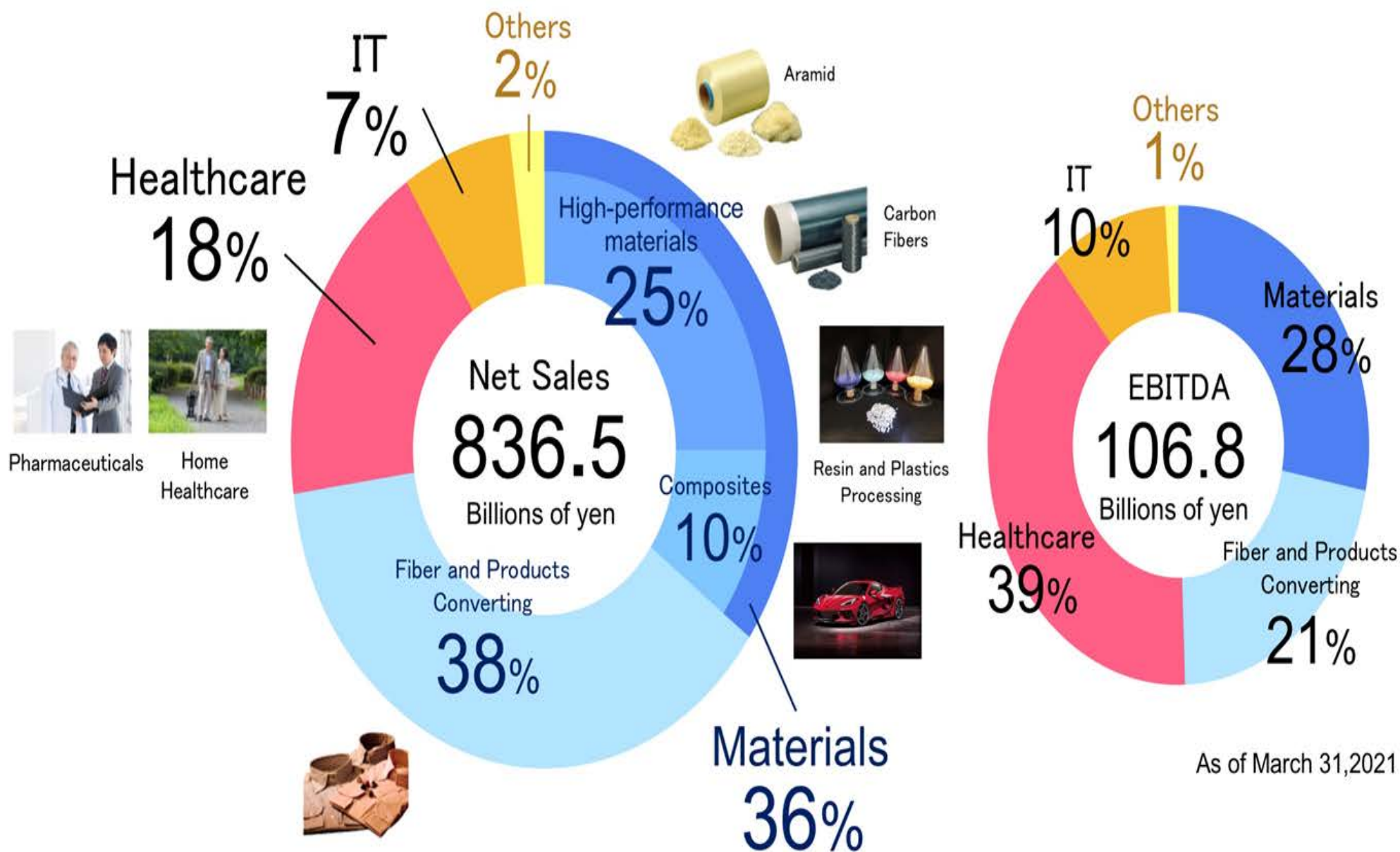


IT Services for Enterprises



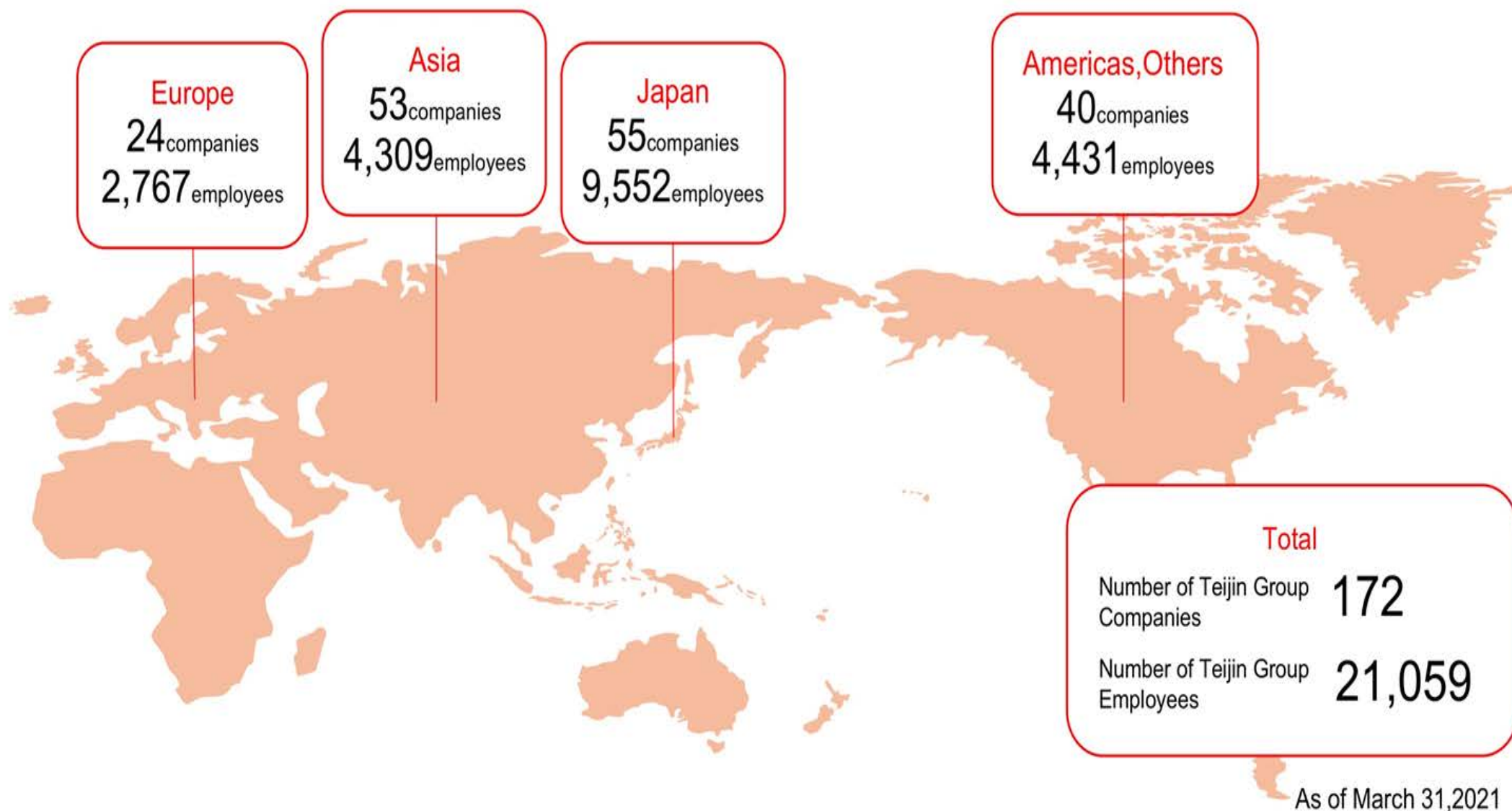
# Business Domain & Earnings Structure

Human Chemistry, Human Solutions **TEIJIN**



# Global Network

Human Chemistry, Human Solutions **TEIJIN**



# Diversity & Inclusion

We promote diverse working styles, advancement of women, and diverse human resources necessary to accelerate innovation creation.

## Key Measures

- Restructure the HR organization to support global strategy
- Develop and deploy the next-generation global leaders
- Manage working hours appropriately and design flexible HR and benefits systems to support diverse human resources and working styles





# Teijin's History

Human Chemistry, Human Solutions **TEIJIN**

**1918**

Establishment of Teikoku Jinzo-Kenshi Kaisha, Ltd.  
Beginning Japan's first commercial production of rayon fibers



**1971**

Rayon fibers business is discontinued  
Beginning of PET film business  
Beginning of meta-aramid fibers, *Teijinconex* business



**2000**

Expansion of the para-aramid fibers business by starting *Twaron* business



New corporate brand is introduced including new logo and brand statement



Entered the functional food Ingredients business

**100 2018**  
100th Anniversary

1952



**1958**

Beginning of polyester fibers, *Tetoron* business

Beginning of trading business

1962

Company name changes to Teijin Limited



**1973**

Beginning of pharmaceuticals business

**1960**

Beginning of polycarbonate resin, *Panlite* business



1983

Beginning of IT business

1987

Beginning of para-aramid fibers, *Technora* business



1993



**1999**

Beginning of carbon fibers, *Tenax* business

**1982**

Beginning of Japan's first home oxygen therapy (HOT) business

Establish of the Teijin Group Corporate Philosophy

2003

World first in establishing mass production technology for carbon fiber-reinforced thermoplastics (CFRTP)



2011

2016

2019

Transfer of Films Business

**2017**

Acquisition of US-based Continental Structural Plastics Holdings Corporation  
Expansion of composites business



# **Teijin Carbon America. Inc**

## **(Toho-Tenax America - April 01, 2018)**

- **Filament**
  - standard, intermediate, high performance
  - EP, PU, **TP** sizes, nickel coated
- **Short Fiber**
  - **Chopped fiber** (thermoplastic and thermoset)
  - **Milled Fiber** (un-sized, free-flowing)
- **Oxidized PAN Fiber (OPF)**
  - filament, staple yarn, town
- **NCF – Dry reinforcement**
- **Thermoset prepregs**
  - Epoxy
  - BMI
  - New Grades – rapid cure
- **Thermoplastic - PEEK/PAEK/PPS**
  - TPUD
  - TPWF
  - TPCL

- Dry reinforcements for infusion (NCF)
  - Non-crimp fabrics with 2 to 5 carbon fiber layers and customer specified ancillary layers
    - Glass scrim surfacing, thermoplastic toughening veils, conductivity layers, other....
- Thermoset matrix materials
  - Rapid cure epoxy with fabric or unidirectional carbon fiber reinforcement
    - Specific for AEROSPACE and automotive applications
- Thermoplastic matrix materials
  - Carbon fiber tape (TPUD), fabric prepregs (TPWF) and consolidated laminates (TPCL)
  - Polyetheretherketone (PEEK)
  - Low Melting Polyaryletherketone (LM-PAEK)
  - Polyphenylene sulfide (PPS)
  - Other engineering grade polymers available for industrial application



# Tenax® Dry Reinforcement (NCF)

**TEIJIN**



TEIJIN CARBON AMERICA, INC.

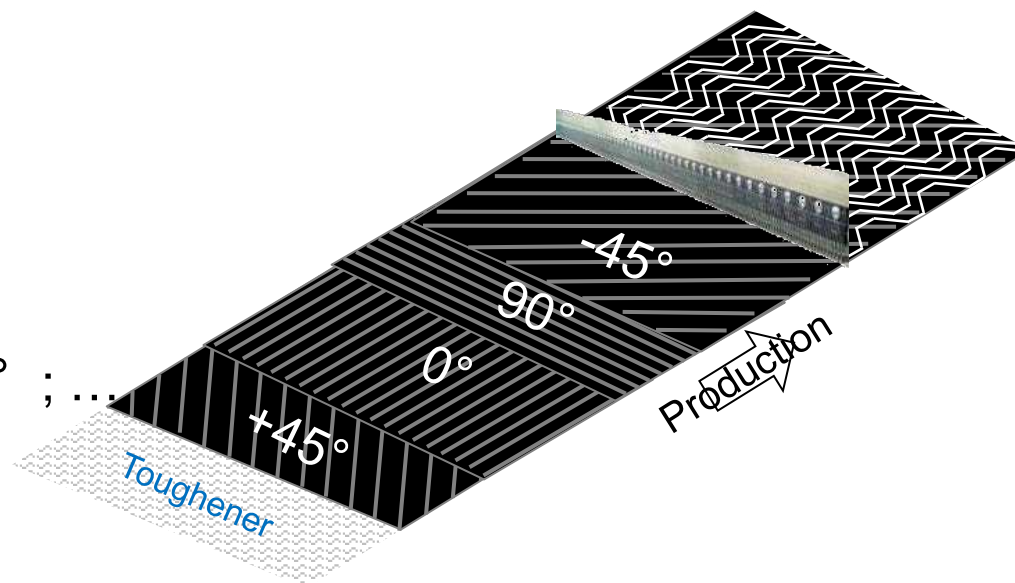
# Non-Crimp Fabrics, definition

Non-crimp fabrics (NCFs) are semi-finished textile products for composite applications.

Individual layers of reinforcement weft yarns are placed on top of each other, in defined orientation and fixed by means of knitting yarns

Typical NCF stacking possibilities:

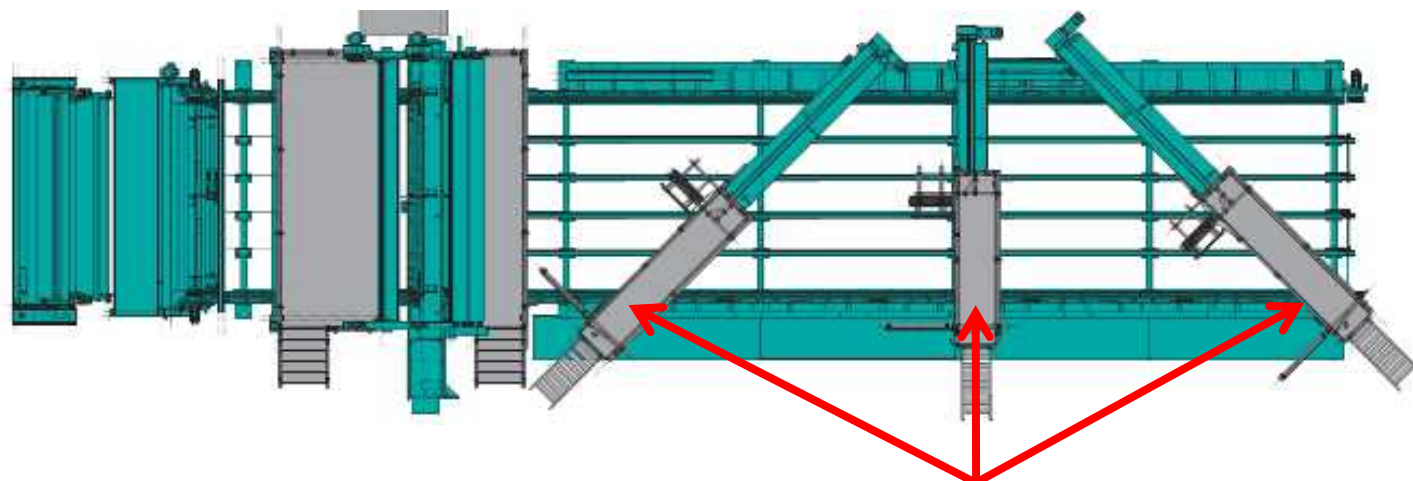
- Bidiagonal (BD)  
e.g.  $+30^\circ / -30^\circ$  ;  $+45^\circ / -45^\circ$  ; ...
- Biaxial (BA)  
e.g.  $90^\circ / 0^\circ$  ;  $+45^\circ / 0^\circ$  ; ...
- Triaxial (TA)  
e.g.  $+30^\circ / 90^\circ / -30^\circ$  ;  $+45^\circ / -45^\circ / 0^\circ$  ; ...
- Quadraxial (QA):  
e.g.  $+45^\circ / 90^\circ / -45^\circ / 0^\circ$  ; ...
- Tailor - Made



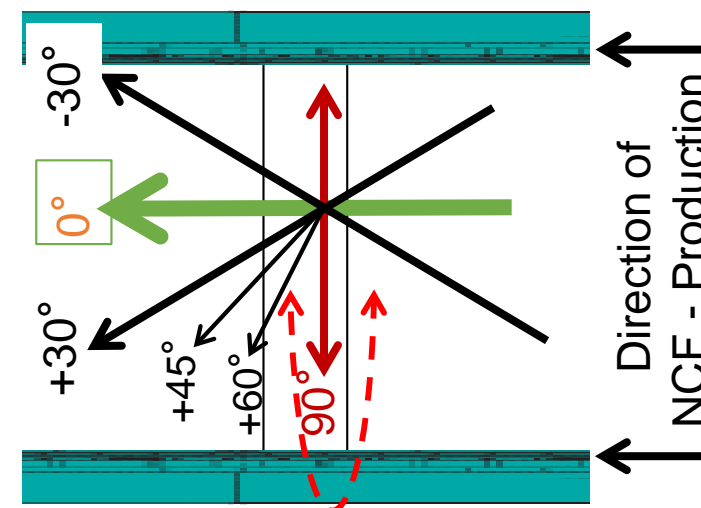
Possibility to add toughening veil to each CF layer

# NCF - Manufacturing Route

Textile production width: 2,54 m (largest machine for carbon fibre processing)



Three weft insertion devices allowing angles between  $-30^\circ$  until  $+30^\circ$



- Teijin's NCF equipment has been designed with versatility in mind
  - Layer order – choose your stack sequence
  - Layer angle – to  $\pm 30^\circ$  from zero
  - Layer area weight- as low as **97 gsm**
  - Stitching pattern – choose based drape requirements
  - Interlayer veil or surfacing ply –Increases toughness if needed, add surfacing aids or conductivity
  - Roll width – 254 cm allows large area for kiting or slit to 127 cm inline during production

## Layer orientation sequences

Bidiagonal (BD) any non-orthogonal stack

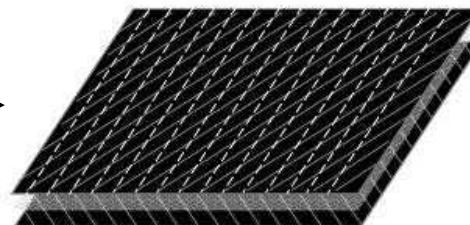
- $+30/-30$  ;  $+45/-45$  ;  $+60/-60$  ; ...
- Biaxial (BA) orthogonal stacks
  - $0/90$  ;  $90/0$
  - Triaxial (TA) any combination of 3 layers
    - $30/90/-30$  ;  $+45/0/-45$  ;  $+60/-60/+60$  ; ...
  - Quadax (QA) any combination of 4 layers
    - $+30/90/-30/0$  ;  $+45/0/-45/90$  ; ...
  - **Multiaxial 5 layers**
    - (must have two zero layers)
    - $0/+45/0/-45/90$



- The stitching style can be tailored for different characteristics

- Pillar stitch

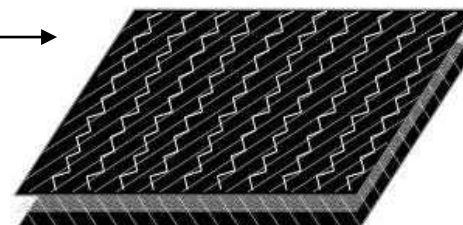
- Highest dimension stability
- Limited drapeability
- Lowest degree of carbon fibre undulation



Top side

- Tricot Stitch

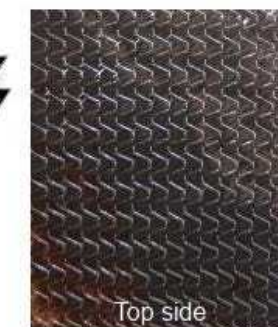
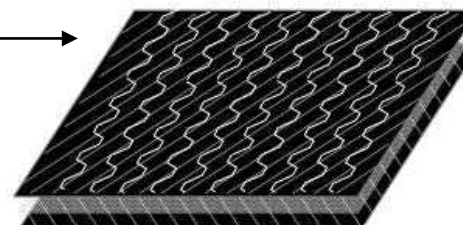
- Best material drapeability
- Optimize drape by adapting the stitch length and loop stitch
- increases drapability and sleaze



Top side

- Tricot-Pillar Stitch

- Best compromise between material performance and drapeability

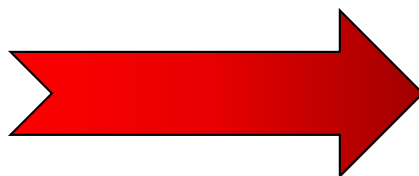


Top side

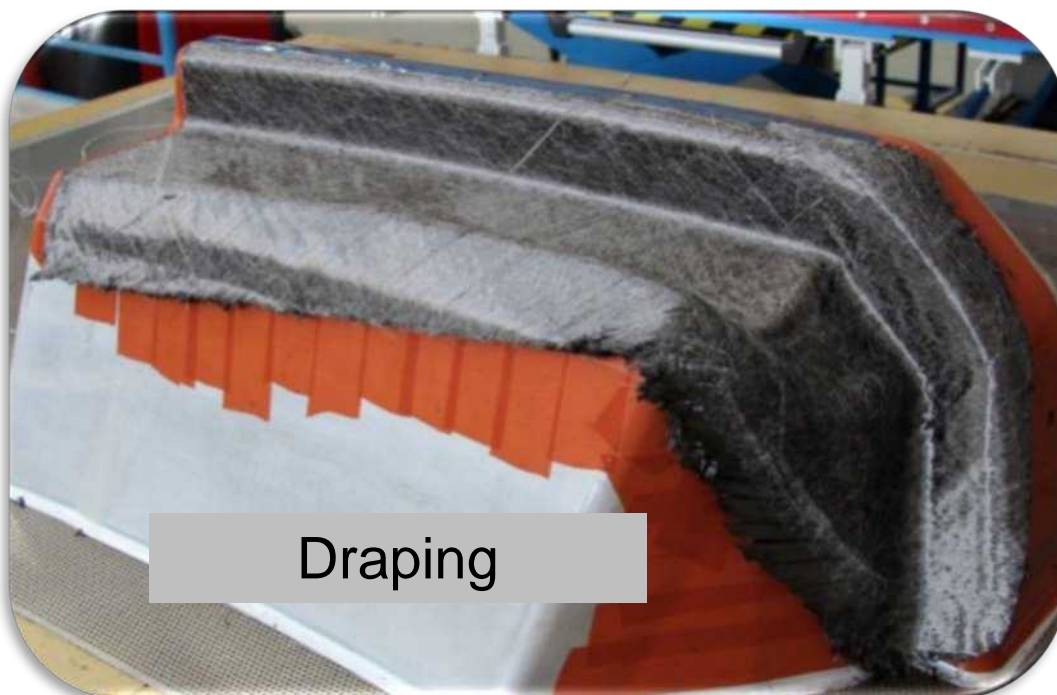
# NCF Processing > Preforms



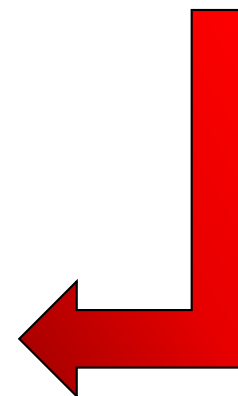
Carbon fibre Textile



Cutting

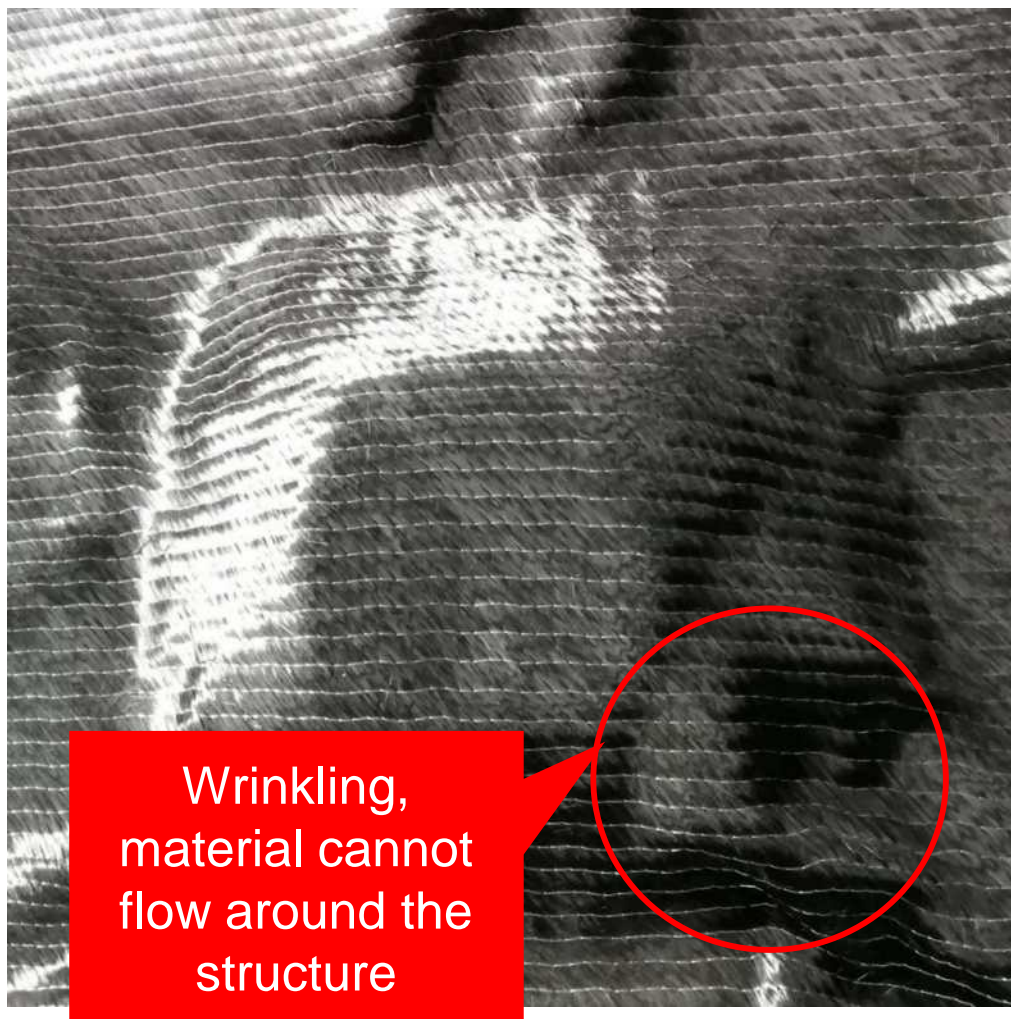


Draping

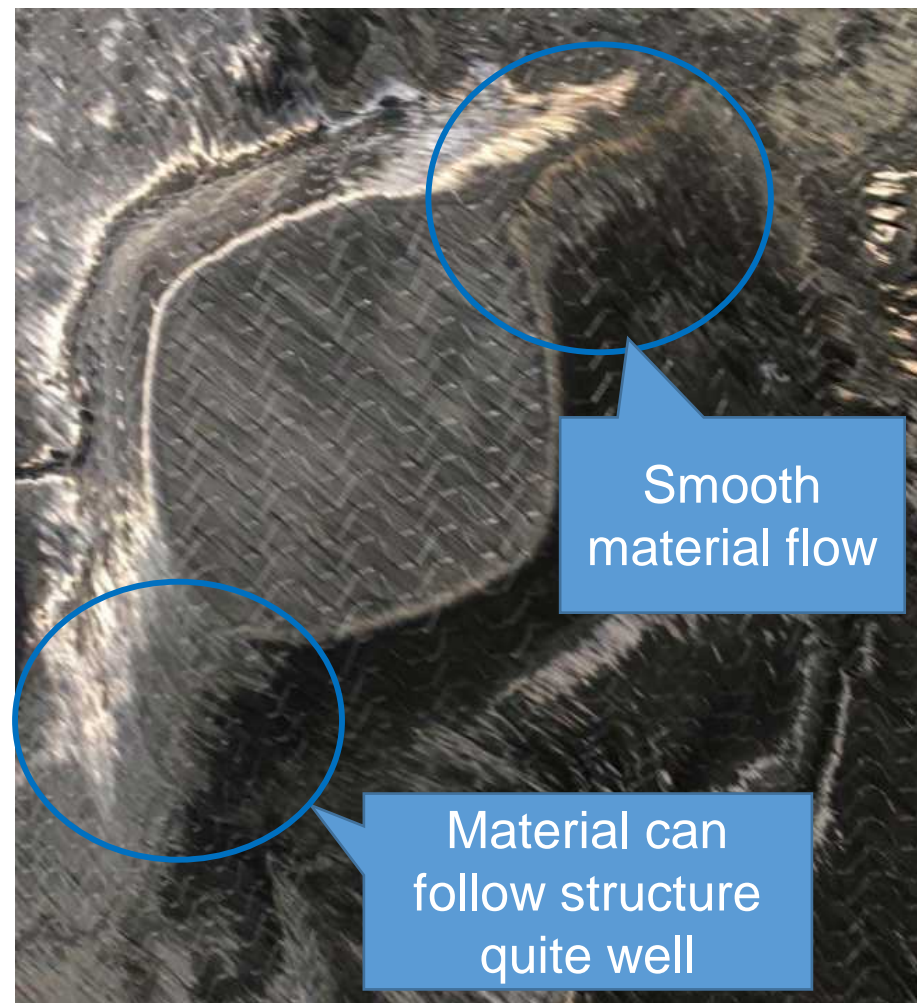




Standard stitching



Improved stitching parameters



# Latest Applications - 2021

**Tenax Dry Reinforcements NCF's have been down-selected** by NIAR and the industry for the first NCAMP qualification of this type of materials



Material based on:

- Intermediate modulus carbon fibre: IMS65 E23 24K
- +/-45, -/+45, 0/90, 90/0 NCF configurations
- 190 gsm per layer
- Powder binder and toughening veil
- 127 cm and 254 cm wide NCF
- Special resin system
- RTM and VARTM processing





# Latest Applications - 2021

**Tenax Dry Reinforcements NCF's are qualified for several aerospace applications:**

A320 Spoiler produced by Spirit Aerosystems in Prestwick, Scotland

Highly integrated structures enable remarkable cost saving:

- Production in one-shot RTM
- Far less assembly effort
- High level of automation: reduced labour cost compared to prepreg/honeycomb sandwich structures



Spirit AeroSystems' resin transfer molded Airbus A320 spoiler, finished, assembled and painted.

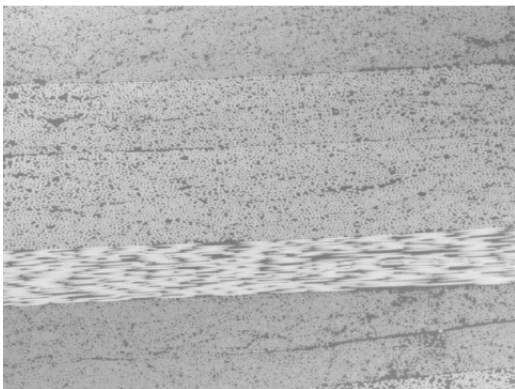
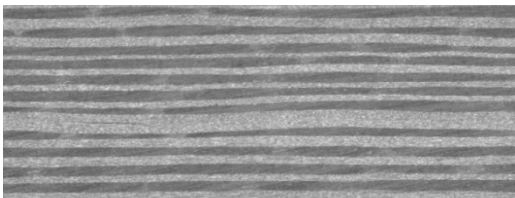
For details see:

<https://www.compositesworld.com/articles/high-rate-automated-aerospace-rtm-line-delivers-next-gen-spoilers>

## Product benefits



- **Smooth and even material surface quality with lowest grade of material undulation**
- **Lower and flexible adaptable areal weights possible**
- **Improved preforming and toughness behaviour allowing excellent mechanical properties**
- **Adapted drapeability even for complex shaped parts**
- **Mechanical properties matching today's Prepreg baseline due to very straight and parallel fibre alignment**
- **Low level of material bulk factor for preforming**
- **High fibre volume content (~58%) even with toughened and powder bindered material in infusion technology (e.g. via pure vacuum process) demonstrated**



The advantages of Teijin Carbon Fibre NCF products:

- NCF enables high production volumes at reduced total part costs
- NCF has Long shelf life, no cooled storage required
- High mechanical performance, no fibre undulations
- High FVC even with interleave toughening
- Possibility to tune the material choice and processing parameters to optimize material processability and laminate properties
- Teijin has all expertise for production of aerospace qualified carbon fibres and NCF in house

- Dry reinforcements for infusion (NCF)
  - Non-crimp fabrics with 2 to 5 carbon fiber layers and customer specified ancillary layers
    - Glass scrim surfacing, thermoplastic toughening veils, conductivity layers, other....
- Thermoset matrix materials
  - Rapid cure epoxy with fabric or unidirectional carbon fiber reinforcement
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  - Other engineering grade polymers available for industrial application



# Tenax® Thermoset prepreg - Rapid Cure

**TEIJIN**

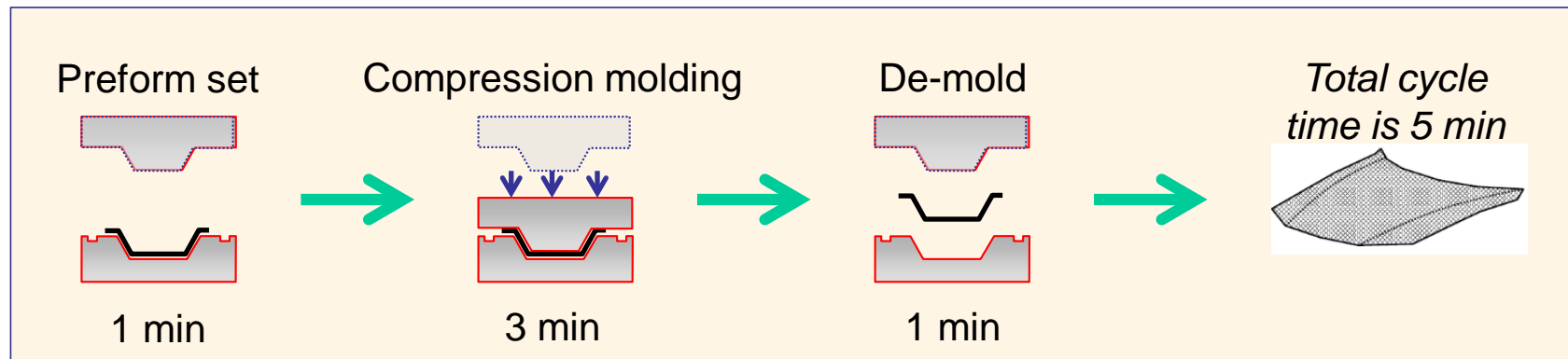


TEIJIN CARBON AMERICA, INC.

- Teijin Carbon has several families of rapid cure prepregs for reduced process time
- For automotive applications Q-182 is normally preferred as it has the lowest process time of 3-5 minutes, higher properties are available with Q183 and Q181

**Q181** *(This presentation covers Q182, please let us know if you have interest in 183 or 181 s for higher Tg and mechanical properties considering increased 15–20-minute process time)*

## Q182 process time for press molding



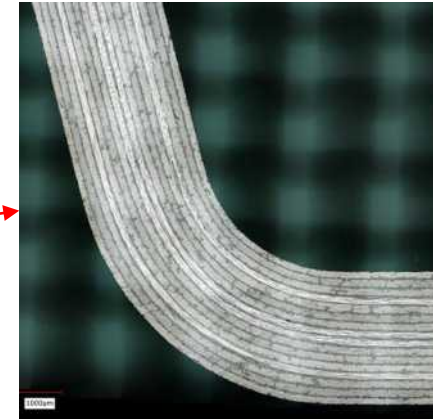
## Tenax® Q182 Prepreg Forming



Skin stiffener

Press @ 350 psi, 302° F, 5 min

Good consolidation  
No fiber undulation  
No radius wrinkles  
Excellent surface quality



39.4 in

Rear Spoiler

press @ 74 psi, 266° F, 30 min



13.8 in

Bonnet Hood ¼ section  
demo

press, 302° F, 435 psi,  
5min ]

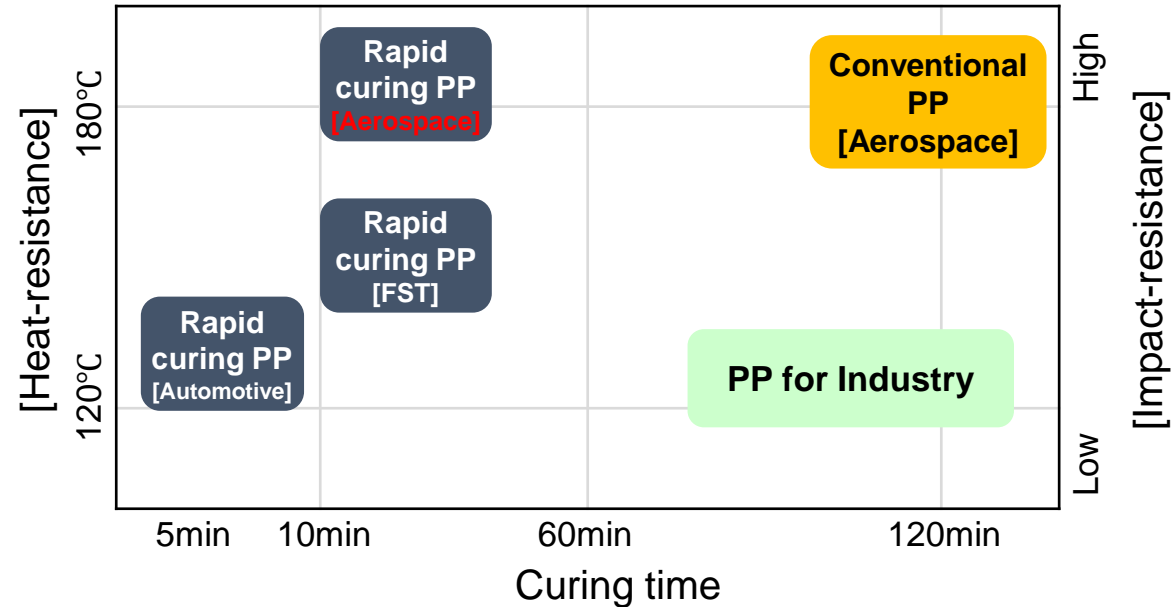





13.8 in

# Rapid curing prepreg families

## ■ Development grade of rapid curing prepreg

- ✓ Industry, Automotive (1)
  - Outer panel, structure
- ✓ Aerospace (2)
  - Primary/Secondary structure
- ✓ Flame retardant (3)
  - Interior parts

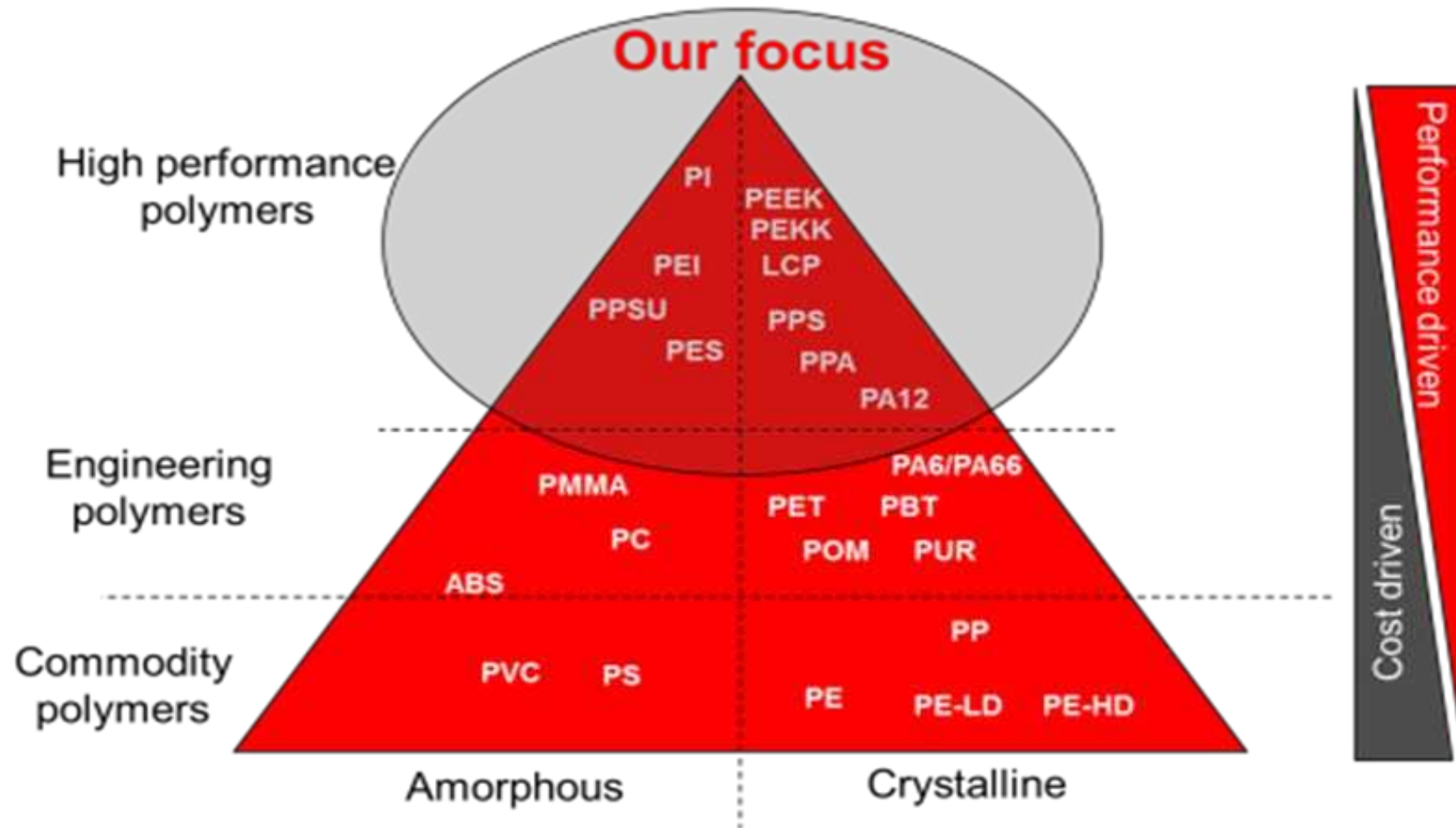


	(1) Industry, Automotive grade	(2) Heat/Impact Aerospace grade	(3) FST grade
	Q-110-315	Q110	Q-181
Application	Automotive 	Aerospace structure 	Interior for aerospace 
Curing time	150°C × 3~5min	160°C × 20min	150°C × 15~20min
Tg	~160°C	180-190°C	~150°C





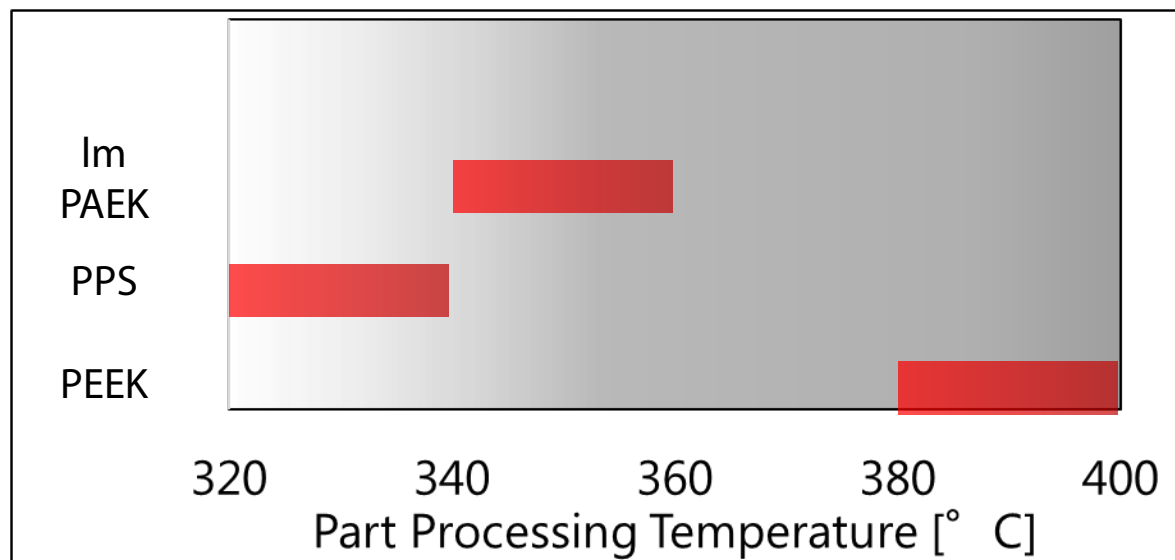
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  - Polyetheretherketone (PEEK)
  - Low Melting Polyaryletherketone (LM-PAEK)
  - Polyphenylene sulfide (PPS)
  - Other engineering grade polymers available for industrial application



Reference data sheets for **PEEK**, **PAEK** and **PPS** thermoplastics for more detailed information about Tenax thermoplastic carbon fiber materials

## Wide product portfolio independent from polymer suppliers

- Focus on high performance Polymers: PEEK, low melt PAEK and PPS
- Not dependent on Polymer source
  - Competitive price structure
  - Flexibility with regard to customer applications
- In combination with Tenax® high tenacity or intermediate modulus fibers, with specially developed thermoplastic sizing

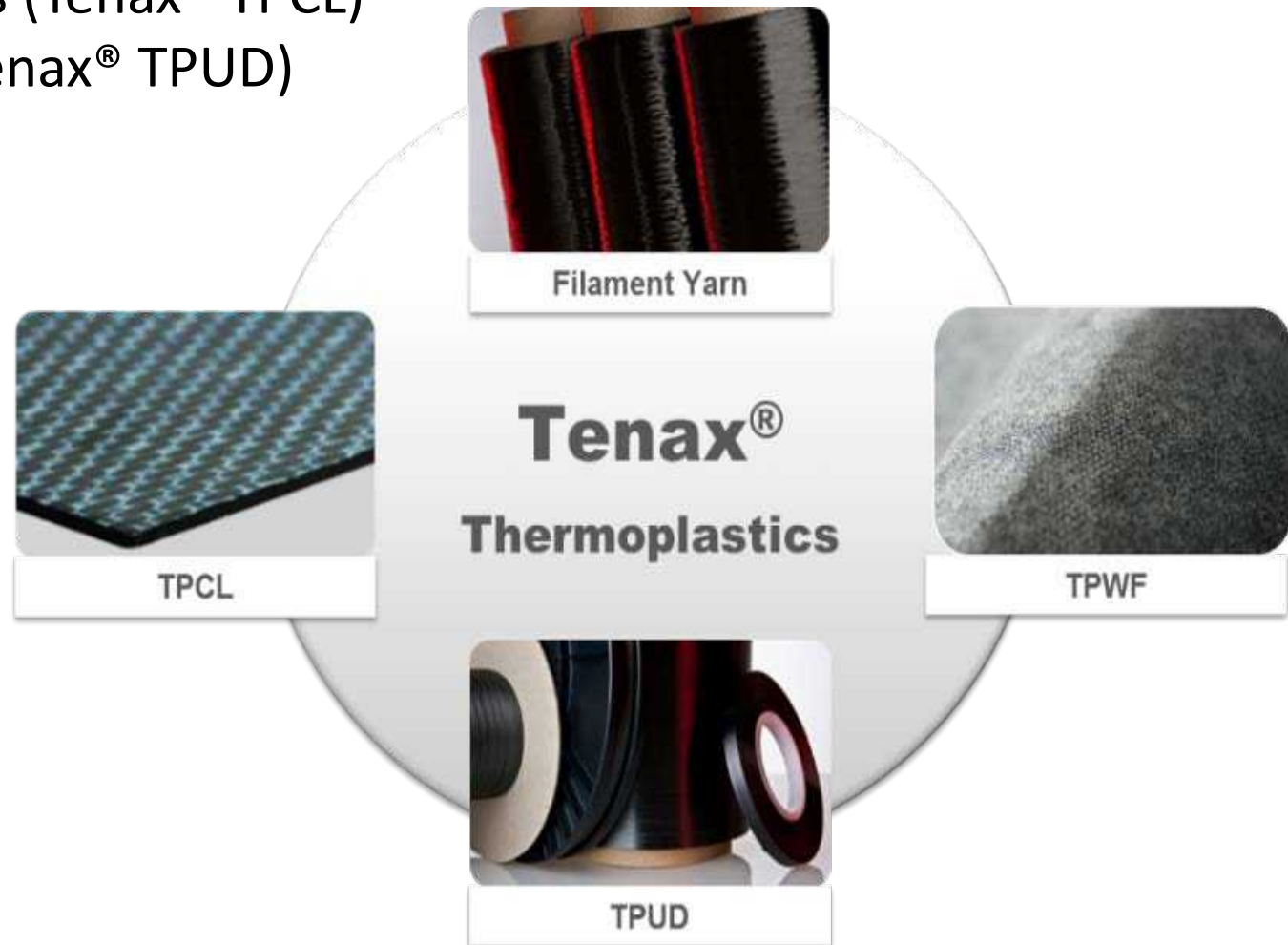


# Tenax® Thermoplastics

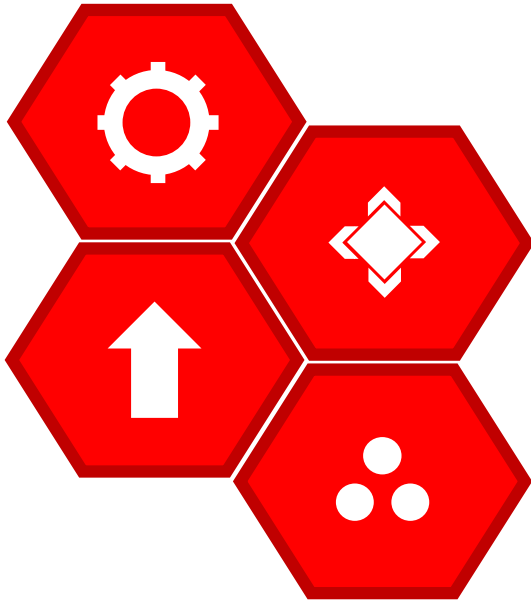
TEIJIN

In the Teijin Carbon product portfolio, TPC refers to a variety of products:

- carbon fiber with **tailored sizing** for Thermoplastics polymer (Tenax® Fiber)
- powder coated woven fabric (Tenax® TPWF)
- pre-consolidated Laminates (Tenax® TPCL)
- unidirectional (UD) tape (Tenax® TPUD)



### Teijin's continuous improvement of TPUD production technology leads to large customer benefits



- Efficient processing through improved FAW and RC homogeneity and close to zero defects
- High output rates
- Availability of up to 61 cm wide tape and roll lengths of more than 1.000 lm
- Wide range of polymer options in combination with Tenax® P-sized fiber, optimised for thermoplastic applications



### Thermoplastic Unidirectional Prepreg

- Tenax® Carbon Fiber with **tailored sizing** (P12) with **PEEK**, low melt **PAEK** and **PPS** matrix
- Variety of width: 6.35 mm – 610 mm
- Fiber areal weights from 120 to 190 gsm
- Roll lengths from 100 up to 1,000 linear meters
- High mechanical performance (fracture toughness, hot/wet)
- Resistant to chemicals and solvents
- Room temperature storage and shipping
- Recyclable



## State of the art production technology

### **Continuous process optimization leads to high quality tape**

- innovative fiber guidance technology for gap reduction
- optimized thermal management during impregnation with improved control systems

# Main reasons behind the increase of TPC usage

Technical reasons, mature part processes:

✓ Reduce Processing time and cost combined with automation:



Going from the magnitude of **hours** for standard thermoset systems, down to standard tack time of the magnitude of **1 minute**

At the moment the main mature processes are using high pressure part consolidation during the cooling from the melt stage:



Laminate

## □ Thermoforming



PREMIUM  
AEROTEC



preform

IR



stamping tool



semi finished part



final trimming

# Main reasons behind the increase of TPC usage

**TEIJIN**

Technical reasons, mature part processes:

✓ Reduce Processing time and cost combined with automation:



□ UD tape winding:

✓ No post treatment needed after the lay-up





# Main reasons behind the increase of TPC usage

Technical reasons, mature part processes:

- ✓ Reduce Processing time and cost combined with automation and reduction of assembly time and total weight:



Main mature technologies:

- Resistance welding
- Induction welding
- Ultrasonic welding

## ☐ Welding of TPC parts:

- ✓ No post treatment needed after the lay-up



Teijin Carbon have own equipment for  
Radiant welding

# Main reasons behind the increase of TPC usage

**TEIJIN**

Last and not least, there are other product benefits, especially when compared with thermoset products:

- ✓ low flammability, smoke and toxicity
- ✓ room temperature storage and shipping
- ✓ compliant to Health, Safety and Environment requirements
- ✓ recyclability



# Tenax® ThermoPlastics - Summary

**TEIJIN**

Product Name	Type of product	Polymer	Fiber
Tenax®-E TP <sup>UD</sup> PEEK-HTS45	UD tape	<b>PEEK</b>	HTS45 P12 12K
Tenax®-E TP <sup>UD</sup> PEEK- <b>IMS</b> 65	UD tape	<b>PEEK</b>	IMS65 P12 24K
Tenax®-E TP <sup>CL</sup> PEEK-HTA40	Laminate based on Fabric prepreg - Tenax® - E TPWF	<b>PEEK</b>	HTA40 E13 3K (de-sized) Fabric: 5HS
Tenax®-E TP <sup>WF</sup> PEEK-HTA40	Fabric prepreg	<b>PEEK</b>	HTA40 E13 3K (de-sized) Fabric: 5HS
Tenax®-E TP <sup>UD</sup> PAEK-HTS45	UD tape	<b>LM PAEK</b>	HTS45 P12 12K
Tenax®-E TP <sup>UD</sup> PAEK- <b>IMS</b> 65	UD tape	<b>LM PAEK</b>	IMS65 P12 24K
Tenax®-E TP <sup>UD</sup> PPS-HTS45	UD tape	<b>PPS</b>	HTS45 P12 12K
Tenax®-E TP <sup>CL</sup> -PPS-HTA40	Laminate based on Fabric prepreg - Tenax® - E TPWF	<b>PPS</b>	HTA45 E13 6K (de-sized) Fabric: 2x2T
Tenax®-E T <sup>WF</sup> -PPS-HTA40	Fabric prepreg	<b>PPS</b>	HTA45 E13 6K (de-sized) Fabric: 2x2T

# Teijin Carbon America

<https://www.tejincarbon.com>

<https://www.teijin.com/>

<https://www.linkedin.com/company/teijin>

Instagram: #teijinmaterialsmedia

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